Naturschule Region Bodensee e.V.

GLS

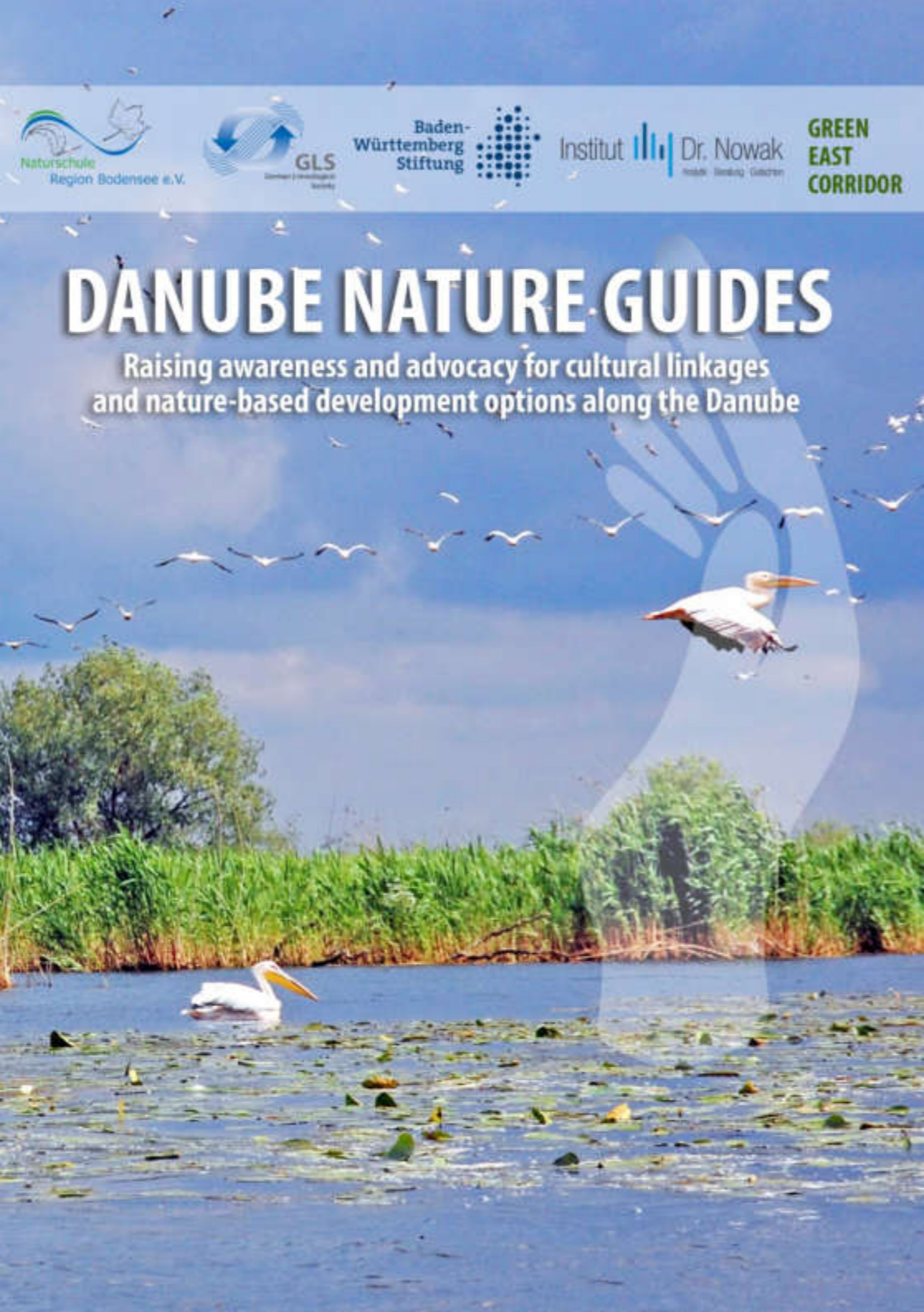
Baden-Württemberg Stiftung

Institut Dr. Nowak

GREEN EAST CORRIDOR

DANUBE NATURE GUIDES

Raising awareness and advocacy for cultural linkages and nature-based development options along the Danube



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Impressum

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1. Danube Nature Guides – project concept

Better use of existing information - Effective forms of communication and addressing to a diverse audience are needed

The Danube basin still harbors a broad variety of landscapes with an outstanding rich biodiversity, even it is under great pressure from a diverse range of human activities. The societal, economic and environmental value of the wetland has not much been recognized so far by local communities and stakeholders, especially in the lower part of the Danube.

Rural areas along the Danube in south east Romania are still very poor, with a lack of perspectives for the professional development of social and economic skills for young people, often resulting in emigration. Understanding aquatic ecosystem structure and natural processes is crucial to identify the economic and cultural options that are possible based on the ecosystem services offered by the unique riverine landscape of the Danube.

Another important recognition is that human activities may either degrade or improve the health of an aquatic ecosystem. Grasping the importance of water quality, animal populations, and riparian zones in a specific area may help to prepare today's young adults to become effective advocators for ecological sustainability in the future. Large amounts of information and data-sets on the Danube and its basin have already been collected but are useless without qualified interpretation and long term efforts to enhance public knowledge of nature's values.

In Germany, environmental education is carried out mainly by private conservation associations and government conservation centers with full-time employed educative staff. They are supported by trained voluntary and honorary helpers with several expertises including a special branch of environmental education: water guides - „Gewässerpädagogik". Trainings are offered by the WBW- Fortbildungsgesellschaft für Gewässerentwicklung (mbH), private conservation associations such as BUND (Bund für Umwelt und Naturschutz) and the NABU (Naturschutzbund Deutschland), and promoted by the Umweltakademie Baden-Württemberg (State Academy on Environment B.-W). The State Academy as well certifies nature guide trainers (Landschaftsführer).

In Baden-Württemberg, there are also mobile educative offers such as the „Ökomobile" and the science truck „Expedition N". Furthermore there are regional conservation organisations (e.g. Naturschule Region Bodensee) offering education for schools and kindergardens, leisure activities, and adult education.

In Romania there exists so far no attestation/certificate for water guides, nature guides or ecotourism. Only the curators from museums, biologists and educators from visitor centers or some NGOs are involved in that type of communication activities. However, they are often involved in many other priority activities and responsibilities. Hence, there is a need for this kind of informal education which otherwise cannot be covered by them.

Thus this project represents an initiative which could be further offered at a larger geographical level to offer and improve training and certification for people interested to act as nature or river guides for protected areas from the region.

The Danube Nature Guides project aims to improve the knowledge and understanding, as well raising awareness and appreciation of the social and economic benefits of the Danube ecosystems. For this purpose, bridges between generations are established, which foster lifelong learning between already trained adult guides for aquatic ecosystems of the Danube area ("wbw Gewässerführer") from Upper Danube in Baden-Württemberg, and young people from the Lower Danube in Romania. This will also support the future establishment of certified nature guides in Romania and furthermore contributes to the raising of the visibility of nature-based tourism in general. Danube Nature Guides project addresses at least two from the sustainable development goals of the United Nations: life below water (no 14) and partnerships for the goals (no 17).

This brochure is the result of the Donau NaturführerInnen – Danube Nature Guides project financed by Baden-Württemberg-Stiftung and Deutsche Gesellschaft für Limnologie (German Limnological Society) and provides basic information on the typical characteristics of nature and cultures along the Danube, and on options to promote and further develop the natural capital for the benefit of both nature and people.

2. Danube river

The Danube is formed by its two source rivers Brigach and Breg which meet near the town of Donaueschingen in the southern part of the Black Forest. A rhyme helps German speaking people to remember this fact: „Brigach and Breg bringen die Donau zuweg" meaning Brigach and Breg create the Danube. There is, however, some competition with regard to the title „Source of the River Danube". The place to represent the source of the Danube is claimed both by a spring in the park of the castle of Donaueschingen (Fig.1) and by the spring of the longest headwater stream, the Breg, near the town of Furtwangen. The first source is considered the more symbolic one, the second one to be the hydrographic correct one.

Figure 1. The Spring of the Danube in Donaueschingen (photo by Schnellbächer-Bühler A.)

The question of the location of its source is not the only hydrological difficulty of the upper Danube we are faced with. Just 30 km downstream of its formation, a considerable portion of the Danube's waters disappear near the town of Tuttlingen (Fig.2). It sinks into the karstified rocks of the Schwäbische Alb (the Swabian Jura) through underground cracks, crevices, and caverns and flows for 12 km subsurface, until it re-emerges in Europe's largest spring, the Aachtopf (Fig.3 a-b). From there the River Aach takes it into Lake Constance, which means that a certain part of the waters of the Danube ends up in the River Rhine rather than the Black Sea.

Figure 2. The sinkhole of the Danube near Tuttlingen (photo by Schmidt-Halewicz S.)

Figure 3a. The map shows the routes of underground flows of Danube water through caves from the Danube to the Aach river, a tributary of Rhine (Wikipedia.org)

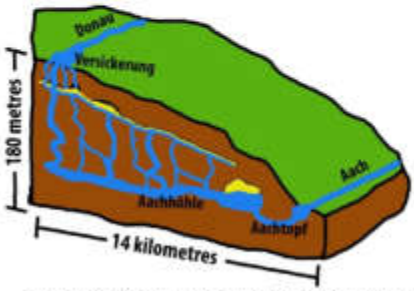


Figure 3b. Vertical section of the caves system (http://www.medienwerkstatt-online.de)

On its way to the Black Sea the Danube passes many geological formations. According to geo-morphological, hydrological, slope features the Danube is usually structured into four sections, as the Upper, Middle, Lower Danube and the Danube Delta.

The Upper Danube section extends from the source in Germany to the "Porta Hungarica" (Hungarian Gates) east-ward of Vienna. The "Porta Hungarica" represents a gate between the eastern foothills of the Austrian Alps and the small Western Carpathian Mountains, below the Morava confluence. Here the river has high flow velocities due to the steep gradient and the high water run-off during the snow melting period, and the substrate of the bed of the stream is stony or rocky.

The Middle Danube section stretches from "Porta Hungarica" to the "Iron Gate" where the river breaks through a canyon formed between the southern Carpathians and the Balkan Mountains. Between these two gates, the Danube shows a reduced gradient and a more winding river course with marked erosion and sedimentation processes which develop larger gravel and sand banks.

In the **Lower Danube** section the river crosses the Romanian and Bulgarian plains. In that lowland river reaches, the longitudinal gradient is so small that the river mainly carries sand and finer solids, the current speed is low and the riverbed deep. Formerly that section had a wide inundation area with floodplain forest characterized by numerous side channels which harboured a rich flora and fauna. Due to the smaller gradient, inundation phases during floods last longer than in the upper- and middle courses.

As it approaches its river mouth, the Danube has practically no gradient anymore, and huge amounts of fine suspended solids have been deposited in the Danube's delta. There, the Danube spits up into several river channels, as the three major arms (Chilia, Sulina, and Sf. Gheorghe), which encompass a mosaic of reed marshes, lakes, canals and sand dunes between them. Among those, the Sf. Gheorghe arm is the oldest one, with well-developed meanders. The youngest, the Chilia arm, forms its own delta on Ukrainian territory. With its wetlands and estuaries, the Danube Delta provides unique habitats for a variety of biological communities.

On its way to the Black Sea the Danube passes through, or touches the borders of ten countries, more than any other river in the world: Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Romania, Bulgaria, Moldova and Ukraine.

The length of the River Danube from the source of the Breg to its estuary in the Black Sea measures 2,857km (Fig.4).

Figure 4. Map of Danube river basin (modified after willzuzak.ca)

On its way, the river crosses diverse landscapes and cultures and was the witness of the history of the region.

The Danube represented a major commercial waterway already in Roman times, which connected trade centers and military forts along the river. The Danube hosts a great diversity not only in terms of landscapes but also in terms of culture, history and ethnicity. **The biodiversity of the Danube doesn't mean only the diverse landscapes with many unique plants and animals, but also the important functions of the aquatic and floodplain ecosystems for the human well-being**.

However, the rich and unique biodiversity in riverine habitats and floodplains have been under severe pressure due to human activities. Therefore, a proper understanding of the complexity of the system and the interaction of its elements is very important for our common goal of protecting and preserving the Danube Region's natural heritage and cultural diversity. The Danube Nature Guides project aims to advocate and disseminate such approaches and knowledge. Due to its small scope, it could only deal with two short sections of the Upper and Lower Danube, and seeks to generate synergies by collaboration.

3. Natural and cultural hightlights in the Upper and Lower Danube

The Upper Danube in Baden-Württemberg and the Lower Danube in east Romania are not only linked by the Danube water flowing to the east. The legend of the beautiful mermaid Lau (Schöne Lau) additionally establishes a cultural link bridging that distance of more than 2000 km: the Schöne Lau was exiled in Blautopf, the source of a Danube tributary river near Ulm, as a punishment for not having children by her husband, the Danube Waterman – Wassernix Emperor who lives in the Danube delta. As she finally overcomes the curse, her husband personally travels to the Schwäbische Alb to guide her home to the delta again. Following that pattern, the present project tries to create bridges between the Upper and Lower Danube through the education of nature guides in both regions, who explain and promote nature and culture of the Danube (Fig.5).

Figure 5. The mermaid Lau "Schöne Lau" (photo by Der Reisende, commons.wikimedia.org) and "Blautopf" in Blaubeuren (photo by B. Appel, wikipedia.org), Germany

This chapter specifically presents the characteristics of the:

- **"Upper Danube"** river section in Baden-Württemberg which crosses the **Upper Danube Nature Park** and the **plateau of the Schwäbische Alb**, and the
- "**Lower Danube**" in south-east Romania, with the associated protection areas of the RAMSAR area "**Small Wetland of Braila**", the "**Lower Prut Floodplain Natural Park**", the "**Danube Delta Biosphere Reserve**", which represents the single delta in the world entirely declared a biosphere reserve, and by the "**Macin Mountains National Park**" with its contrasting dry and humid vegetation complexes, a feature which is comparable to the "Schwäbische Alb" Biosphere Reserve from Upper Danube.

3.1. The Upper Danube Nature Park

In the Upper Danube Nature Park, the river winds its way through a narrow valley lined with steep lime-stone cliffs, which is protected due to its striking natural beauty and rare fauna and flora. The protection was initiated by an association dedicated to the preservation of the region's unmatched beauty and its cultural heritage called „Naturpark Obere Donau e.V.", which was founded in 1980 (Fig.6).

Figure 6. View on Danube from Knopfmacherfelsen (photo by Costea G.)

A Nature Park for the People

For local residents, this park represents the place where they live and work, while others come here for holidays, to relax, enjoy and explore. The Nature Park Association's aim is to preserve and develop the region in an exemplary way. The Upper Danube Nature Park comprises not only the valley of the Danube, but extends to the plateau of the Schwäbische Alb (Swabian Jura) with its tributary streams. The cultural heritage places, such as Kloster Beuron, a Benedictine monastery (Fig.7), or Sigmaringen Castle, a palace of the Hohenzollern dynasty in Sigmaringen (Fig.8), numerous medieval castles and the „Heuneburg", a restored Celtic settlement, add additional values to the Upper Danube Nature Park. The remoteness of the place, which lasted until the 1950s, allowed the Benedictine monks to pursue their way of life and worship in peaceful seclusion.

Figure 7. Danube and the Benedictine Monastery Beuron (photo by Costea G.)

Already more than 2500 years ago, the Danube enabled the Celts to establish extensive trade routes all the way to the Black Sea, the Alps and the Mediteranean, thus connecting the region, which was at that time quite rich, with all of Europe. Remote as well as cosmopolitan – even today the region is characterized by these two traits. The Visitor Centre in Beuron called „Haus der Natur" is both a conservation center and the nature park association's headquarters. It offers information on the unique landscape as well as on the cultural heritage. Visitors can even sample the culinary treats typical for the region. Nature guides offer guided tours and many other activities which enable visitors to get to know the region, and learn to appreciate and preserve its beauty.

Figure 8. Sigmaringen Castle (photo by T. Theusch, pixabay.com)

A Nature Reserve

The beauty of nature and many of its treasures worthy of our protection have been preserved here. Conservation efforts are proving successful: the lynx and the beaver, extinct in Germany for more than a hundred years, have returned. Strategies for environment-friendly tourism were developed to ensure that tourism does not affect too much the values to be preserved. It is not easy to reconcile tourist activities and conservation, but conflicts were resolved and compromises reached. As an example, rock climbing is permitted in certain areas, while other parts of the cliffs are left to the owls and falcons for nesting and rearing of their offspring, and to rare rock-dwelling plant species which thrive there. Canoeing, a very popular pastime, had to undergo some restrictions to protect nature while granting professional canoeists access with the groups they accompany and lead by canoes on the Danube´s waterbody. There are many nature trails for hiking, biking or horseback riding, featuring stunning scenic views and places where people can rest or even have a barbecue. Consideration and respect for nature are rewarded by nature's untouched beauty (Fig.9).

Figure 9. The Danube near Gutenstein (photo by M. Sepp, commons.wikimedia.org)

Biosphärenreservat Schwäbische Alb, the Swabian Jura Biosphere Reserve

The mountain ridge of the Schwäbische Alb (Swabian Jura) located approximately 50 km southeast of Stuttgart spans over 150 km until to the Upper Danube. Meadows and pastures, juniper heaths, nutrient-poor grasslands, beech forests and crop fields characterize this traditional cultivated landscape mosaic. The central part of the Biosphere Reserve is represented by the former military area near Münsingen. Because the land was not farmed there and has not changed in over 100 years, it has become a refuge for rare or nearly extinct plants and animals. The region also has a rich cultural heritage, stunning geological features and breathtaking landscapes. The area became a Biosphere Reserve in 2008, aiming at sustainable regional development: nature preservation and at the same time as creating an income for people by, for example, growing organic products. The Biosphere Reserve is fully accessible for visitors. It serves as a model for regions where wilderness meets culture.

Special treats

The Schwäbische Alb (Swabian Jura) offers a variety of of gastronomic specialities and special treats. This formerly rather poor region today offers a large variety of organic produce, agricultural products, and regional specialities. Visitors appreciate the special care which goes into the production of apple juice, sheep milk and wool, bee-products, mare's milk and savor products which are unique and regional. Thereby, the characteristics of the cultured landscape are preserved and the unique landscape does not decline into global uniformity. Local producers undergo voluntary controls, preserve habitats and forego the use of artificial fertilizers and herbicides to obtain the label „Naturpark Obere Donau" for their products.

The region is also known for its many inventors and small craftsmen's businesses. Efforts are made to preserve and subsidize these. New business enterprises such as the Coop „Beuroner Filz" (Felt made in Beuron) which produces and sells arts and crafts made from local sheep wool, offer new income possibilities in an economically not very developed region.

3.2 Lower Danube

Romania is bordering the Danube on a river section of more than 1000 km. This river section crosses the Valachian plain, heading eastward. Near the town of Calarasi, the Danube splits into two branches (Borcea and Old Danube), encompassing a large island (Borcea Island) mostly used for agriculture. The Danube is then forced by the hills of the Dobruja plateau, which separate the river from the Black sea, to flow north. The river forms another islands, the small and big Islands of Braila, from which the small Wetland of Braila is sit RAMSAR, which is still mainly covered by floodplain forest and swamps. This area is the latter natural sample left in free-flooding regime on the inferior Danube's course, after having drained the former Interior Delta (Braila Wetland and Borcea Wetland), which currently preserving aquatic and terrestrial complexes ecosystems in a manner similar to the original.

Figure 10. Lower Danube - Ferry boat from Galati to Tulcea (photo by Matei F.)

At the city of Galati, near the northernmost point of the Danube's turn around the geologically old (hercynic) Macin mountains, Danube is about 1 km wide. Here the river receives its two last tributary rivers, the Siret (470 km total length) and the Prut (953 km total length). The lower section of the Prut forms a ca 300 km long floodplain (with still >400 km^2 functional floodplain) with a still free-flowing river, which is about double as long due the extensive meanders formed. The river thus consists an important north-south migratory route, and a gate to the Biosphere Reserve of the Danube Delta. The Prut also marks there the frontier between Romania and Moldova. The lowermost section of this floodplain is protected on the Romanian side within the 'Lower Prut Floodplain Natural Park' (Romania), and on the Moldavian side the Scientific Reserve "Lower Prut" and Lakes Beleu and Manta - Ramsar sites with 14.400 ha of wetlands.

Thus, the river turns east there, splitting into several channels crossing the Danube Delta, in order to reach the Black Sea. At the end of its course, the Danube builds for more than 16,000 years one of the most beautiful deltas in Europe and in the world with a total surface of 580.000 ha. It is constituted by a mosaic of river branches, lakes of different types and sizes, reed beds, sand dunes, oak forests with Mediterranean vegetation, beaches, also harbouring some traditional settlements. It is a paradise for more than 340 species of birds, among those 218 are nesting here, and 45 species of freshwater fish, many of them considered rare or endangered species.

The Danube Delta system represents one of the largest and most important stepstones of the north-south migration corridor used by millions of birds from Europe, Asia, Africa, and Mediterranean Sea. Many of them stay there even for a longer time period for breeding or overwintering. In springtime storks arrive here from sub-Saharan Africa, herons from the Mediterranean basin, pelicans from Ethiopia, the Nile valley and Madagascar, eagles, swans and the great cormorants from Asia. During the winter season, the Danube delta hosts large populations of swans and geese, also including most of the population of red-breasted goose in the wider area.

Figure 11. Danube Delta (Danube Delta Biosphere Reserve Administration-ABRD Tulcea)

The lower Danube it is not only an important bird migration route, but also represented since ancient time an important commercial route for the transport of commercial goods, as grain, animals, honey, wax, wood and fish that were needed in the Mediterranean countries. That favourable geographical setting for trade has been used throughout times by Greeks, Bulgarians, Russians, Lipovans, Italians, Germans and Armenians who settled there, creating a mixture of fascinating cultures and populations which is unique in the region. This combination of natural and cultural diversity has created a complex landscape picture that fascinates many visitors.

Traditional ways of agriculture and fish cultivation

Along the Lower Danube the local people traditionally have used the natural resources, namely forest and mineral resources, and have made their living based on crop agriculture on fertile clay-dominated soils of the floodplain, cattle grazing, fisheries, and merchandising of vegetal and animal products in local area markets. Many of traditional life and work forms are still alive. The animals, bullocks and horses, are still used in some places for carrying, for field and forest work. The houses, the tools, and the objects which are used in day to day life are made by using the local materials and a traditional technique.

Figure 12. Fishing on Lower Prut (photo by Nasab F.)

As the area is lacking other building materials, locals have developed historically housing styles that have been mostly built from clay, common reed and willow, resulting in very picturesque buildings. Rural life as also developed original ethnic traditions, local (organically-produced) food and wines and sustainable fishing techniques.

Figure 13. Traditional houses made of clay (Danube Delta Biosphere Reserve Administration-ABRD Tulcea)

3.2.1. The Natural Park "Small Wetland of Braila"

The Natural Park "Small Wetland of Braila", which is **considered a second Danube Delta**, is the last remaining part of the former larger wetlands of Braila which preserves 10 % of the former interior Danube Delta - the former wetland between the two branches (Old and New Danube) that used to cover still in the 1970s a compact wetland of 62,413 km². From its current area of 241 km², more than 50% are represented by natural ecosystems and approximately 30% are semi natural ecosystems.

The Natural Park Small Wetland of Braila is composed, alongside the Danube River and its channels, of 7 large and small islands with a total surface area of 15,000 hectares and many temporary or permanent lakes.

Figure 15. The Natural Park "Small Wetland of Braila" (Small Wetland of Brăila Natural Park Administration)

Figure 14. The Natural Park "Small Wetland of Braila" (Small Wetland of Brăila Natural Park Administration)

Each of the seven islands represents a distinct geo-morphological entity, which determines a diversity of aquatic, terrestrial and mixed habitats characteristic for each island that is flooded at different water levels of the Danube: when the water level increases, the terrestrial ecosystem becomes aquatic and vice versa. Each of the seven islands has a particular attraction, as the quality of the habitats represents shelters for an extraordinary biodiversity and astonishing landscapes which could be enjoyed from boats, canoes or kayaks on the tourist routes, from the observation towers and from floating observatories. From the area, 208 bird species have been reported, which represent 52% of the Romanian bird fauna, which use the area for migration or resting. Among them are red list species like the dalmatian pelican, ferruginous duck or red-breasted goose. From the second part of the October on, large flocks of until 50 000 of red-breasted geese (*Branta ruficollis*) are arriving from Siberia for winter roosts in Dobrudja.

The tourist offer in the reserve includes 15 touristic routes, of which eight are terrestrial and seven on water, with many camping options. They offer the chance to see the nest of the white-tailed eagle, or on horseback the legendary and splendid world of Terente, a renowned bandit from the interwar period, named also- "the King of the Swamplands". Angling is possible, too, and unlike the Danube Delta, where it is considered a form of exploitation of the renewable natural resources, in the Small Wetland of Braila it is perceived as a leisure activity.

Figure 16. The Natural Park "Small Wetland of Braila" (Small Wetland of Brăila Natural Park Administration)

3.2.2. Lower Prut Floodplain Natural Park, a huge wetland at the margin of the steppe

The Lower Prut River winds in numerous large meanders southward until it joins the Danube near the city of Galati. The Romanian Lower Prut Floodplain Natural Park, with a length of about 145 km and a surface of 8247 ha, includes forested areas (2627 ha), ponds and lakes (4925 ha) as well as reed-marshes stretching until the flood protection dyke. Additionally, it includes a small section of the Danube shore from the Prut confluence upstream until Galaţi city, and also Lake Brateş.

With its unregulated river dynamics, lush floodplain vegetation and numerous animal species the Prut river and its floodplain still represent widely unknown gemstones of nature. The high sedimentation of clay particles near the river banks has led to the formation of a number of shallow floodplain lakes and fish ponds which exhibit a high level of biodiversity, especially in terms of birds. The Lower Prut Floodplain represents an important resting area for migratory bird species. During migration in spring and autumn, over 20'000 birds can be recorded. An impressive number of 239 bird species out of the total of about 500 European bird species inhabit in the site for breeding, nesting, wintering or during migration.

In early June there is the unique opportunity to enjoy on a magic evening the 'Blooming of the Prut', when thousands of Europe's largest mayfly, *Palingenia longicauda* (specimens measuring up to 12 centimeters) form during their wedding flight a huge cloud of flying petals over the Prut river.

Figure 17. Lower Prut Scientific Reserve - Moldova (photo by Matei F.)

A visit to the fishponds will make anyone's heart leap for joy who loves fishing. Most of the larger stagnant waters (lakes, ponds) of the area have been transformed into fish farms, the biggest one being managed in Lake Brateş (presently about 2'400 ha). Thus, aquaculture represents an important income for local people of the village along the Prut river valley. The fish farms are managed by former state companies now converted into private companies. This variety of unique experiences may be enjoyed through a tour through the Lower Prut Floodplain Natural Park. Excellent opportunities for bird watching are offered by strolls around the lakes. The visitors may not only enjoy excellent views on the large meandering river, but may also observe more closely the bustling activity in a colony of richly-colored bee-eaters or of cute ground squirrels.

Figure 18. Lower Prut Floodplain Natural Park (photo by Costea G.)

The most fertile valley of the Prut is framed by villages where still the colorfully painted traditional houses of the region can be seen, as well as typical farm animals, rural practices and village traditions. Near Galati, the Village Museum "Petru Caraman" and the Fishing Museum reconstitute under ethnographic aspect the traditional characteristics of the settlements in the Low Prut area. A tour to the Prut's impressive nature may be topped by a visit to the Natural Sciences Museum Complex in Galati. This impressive museum not only enables you to immerse even deeper into the natural treasures of this region, but also to enjoy the surrounding magnificent, sunny botanical garden with a stunning panoramic view on the majestic Danube river.

3.2.3. Macin Mountains National Park

The Macin Mountains National Park harbors the oldest hercynic hills of Europe situated in the neighborhood of the youngest land surfaces of Romania, the Danube delta.

The Măcin Mountains were formed 300-400 million years ago as a result of Hercynian orogeny, at the end of the Paleozoic after the collisions caused by the displacement of the Laurasia and Gondwana continents.

Under the influence of subsequent tectonic tensions, the hercynic mountain chain was lifted and formed as mountains. While they were initially about 3000 m high, nowadays only small hills remained, with a maximum heights of little above 400 m, which appear as islands (inselberg) among plains with agricultural crops and pastures neighboring of the Danube. The current Macin Mountains have a spectacular and varied landscapes with arid rocks and rising ridges, with old and bizarre shapes and canyons washed out by the watercourses.

The landscape originality is spiced by megalithic granite formations, as well as by the contrast between mesophilic beech forests and the xerophile steppe-like pastures.

Foto 19. Macin Mountains National Park (photo by Nasab F.)

The climate of these mountains shows marked local variation, which has produced a neighboring presence of Black Sea-sub-Mediterranean, Central European and Asian ecosystem types. This gives the Măcin Mountains the look of a miniature synthesis of two great continents – Europe and Asia, with distinct characteristics in terms of flora and vegetation that represent half of Romania's flora on that relatively small area (0,05%) of the country's territory. Here species meet that are specific to wetlands, steppes, forests and alpine regions. Of these, 72 plant species are protected as rare or vulnerable species, and 27 species are found only here (endemic). The Macin Mountains are also the most important breeding area for raptors in Romania. It also harbors a large population of the longest snake species from the country, the blotched snake (*Elaphe sauromates*).

This region is hence very distinct from landscape, geological, faunistic or botanical points of view, thus represents an ideal place for those who want to contemplate and discover, who like to sleep at the tent and enjoy evening stories around a fire. There are six marked trails in the Măcin Mountains, including a thematic route that facilitates hiking, and marked trails for practicing cycling and equestrian tourism.

Figure 20. Cycling in Macin Mountains National Park (source photo BikeWorks.ro)

At the foot of those hundreds of millions of years old mountains, there are vineyards which produce wines very appreciated by those who come to taste them and listen to their story in the wine cellar of Macin.

The traces of the different civilizations and cultures in this area between the Danube and the Black Sea has also made it a bridge between ethnic, cultural and religious groups. Also, the area has served as a link and a migration and trade route between the peoples from the north and those from the southern Mediterranean. During historic times, the area was inhabited by Dacians, who traded with the arriving Greek settlers, a model which still continued during the occupation period by the Romans.

After the fall of the Roman empire, goths and Slavs arrived. The Danube Delta became part of the Ottoman Empire in the 15th century, and in 1812 the borders of the Ottoman and Russian Empires were set by the branches of the delta. After the defeat of the Ottoman Empire, in 1878, the Delta was split between Romania and Russia.

Several Roman-Byzantine fortresses, a paleo-christian Basilica, the numerous monasteries, the places of worship of the ethnic groups in the region, and the museums in Tulcea offer amazing complex cultural, historical and ethnographic offer in the region which represents a image of the old European civilizations and of the evolution of the Romanian nation.

3.2.4. The Danube Delta Biosphere Reserve

The Danube Delta Biosphere Reserve represents a Noah's Ark with more than 7400 species of flora and fauna) in the second largest Delta of Europe, after that of the Volga. Descriptions of the Danube Delta have appeared since the earliest times in the writings of Herodotus, who referred to the Danube under the name of Istros. During his time (5th century A.D.) the Danube flowed into the sea by five arms (versus three currently).

Figure 21. Danube Delta (Danube Delta Biosphere Reserve Administration-ABRD Tulcea)

The wonderful natural habitats developed here which are the most varied in Romania: the world's largest floating islands of vegetation (plauri), formed of reed and other associated plants that cover more than 200 km^2, the sand dunes of Caraorman, the northernmost subtropical forest in Europe (Letea forest), ancient hill-like mountains, such as those of Betespe or Babadag; freshwater lakes, saltwater lakes, marine littoral zones, canals, the branches of the Danube. Almost 45% is permanently covered by water, 50% of its territory is temporary under water, especially during spring time, and only 5% represents dry, never flooded land. These characteristics make the area the best preserved wetland in Europe, acquiring a triple international status, as Man and Biosphere UNESCO MAB Programme, Ramsar Site, and UNESCO World Heritage Site.

The Danube Delta represents not only the paradise for birds with the largest number of white pelicans and Dalmatian pelicans in Europe, but also habitats for nesting, spawning and feeding of many migratory bird and fish species, habitats for 2,383 plants and 4,029 animal species, and also provides a wide range of renewable resources, water purification functions and flood control.

There are 7 fish, 4 mollusc and 21 insect species that are endemic to the Danube Delta or to the associated Black Sea.

Figure 22. Danube Delta (Danube Delta Biosphere Reserve Administration-ABRD Tulcea)

Within that stunning nature, there are few isolated settlements spread in the area, which thrive on the local natural resources.

The lowest population density of Romania of about 3 inhabitants/km^2, which occurs in this area, is made up by 14 ethnic groups living in harmony, represent an example of multi-ethnic tolerance.

Housings constructed in the specific styles of the respective ethnic groups living in this region (Romanian, Ukrainian, Russian-Lipovan) with reed roofs are spread in all localities in the Danube Delta. Also remarkable are specific buildings in the area, as the "cherhanale" constructed for commercial fishing activity), ChiliaVeche's church, which very much resembles that in the city of Donaueschingen near the springs of the Danube in Germany, the multi-confessional cemetery in Sulina, which tells the true history of the place by the tombstones, the Sulina and Sf. Gheorghe light houses, the palace of the European Danube Commission (CED) in Sulina, are only some of the examples in this matter.

Figure 24. Borsch Fish Festival in Jurilovca - Tulcea (source photo ANTREC Tulcea)

Figure 25. Tourists boating in Danube Delta (Danube Delta Biosphere Reserve Administration-ABRD Tulcea)

Figure 23. Reed harvesting tradition in Crisan village (Danube Delta Biosphere Reserve Administration-ABRD Tulcea)

Hence, the villages in the Danube Delta Biosphere Reserve may represent tourist attractions that satisfy a wide range of motivations in eco- and ethno-tourism. The unique character of the region combines natural attractions with recreational facilities (fishing, beaches) and ethnical-cultural attractions, reflected in folk architecture, traditions, gastronomy and traditional cuisine with many influences from ethnic groups. In each year in September the Danube Delta Fish Soup Festival promotes the local traditions and cultural customs by organizing gastronomic contests, presenting folklore and traditional dances or parade of costumes. The vast complex of reed beds, willow forest, and wetland, crossed by a network of channels can be explored, both by foot and using different types of boats. Within the reserve, 24 tourist routes have been established, of which 15 routes can be performed only by naval transportation (boat routes), while 9 trails that can be enjoyed by hiking or road transport (hiking trails).

4. Ecosystem services provided by aquatic ecosystems

Nature's services – Nature's contributions to people

Nature provides us with an amazing and wide range of services, as food, water, clean air, energy, clothing, housing and medicine, as well as cultural and aesthetic experiences. These services equip us with everything that is vital for us humans to live on planet Earth. Plants, animals and micro-organisms perform a multitude of ecological functions that we use in order to support our survival and prosperity. Many of these so-called ecosystem services are impossible to replace by technological processes.

What are ecosystem services?

Ecosystem Services (ES) are described in Millennium Ecosystem Assessment (MEA, 2005) as the benefits that ecosystems provide to people. Human well-being depends from ecosystem services in numerous different ways.

The food we eat, the clean water we drink, fuel, fibre are direct "presents" of nature that we receive for "free" from nature and are named **provisioning services**. In addition, we benefit from "nature's services" that result from complex processes and interactions which keep environmental conditions in an equilibrium - **regulating services** - such us the formation of soil, the natural decomposition of organic waste, storage of water in landscapes, prevention of soil erosion, or the maintaining of a stable climate on earth. **Cultural services** make up the third group of ecosystem services. These reflect opportunities provided by nature to improve people's physical and mental well-being by offering recreational, spiritual, cognitive information and other non-material benefits.

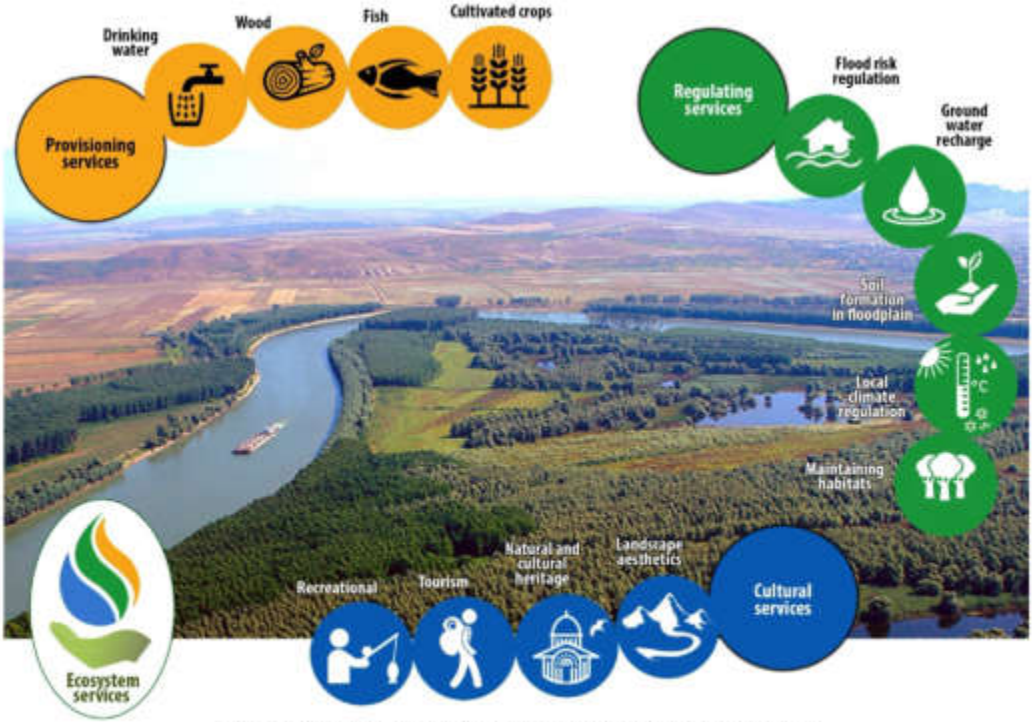


Figure 26. Examples of ecosystem services offered by the Lower Danube

Ecosystem services offered by Danube and its floodplains

The Danube river encompass the ecosystems of the main river channel and those of its floodplains, which originally formed a complex mosaic of habitats with a wide transition zone between land and water. Throughout history, Danube floodplains have provided local societies abundantly with products such as wood, fish, and game. During flood events, water and sediment are transported onto the floodplain and provide a variety nutrients that render floodplain ecosystems highly productive. Conversely, floodplains constitute important sinks of river nutrients and sediments and, hence, contribute substantially to a river's self-purification. They act as a sponge and regulate the water stage, as they flood peaks are mitigated by the spreading of the water into wide floodplain areas, which then release water during low-flow conditions. Through the entanglement of aquatic and terrestrial areas in floodplains, the river is provided with organic matter produced from floodplain forests which is essential for riverine productivity e.g. of fish. Due to this linkage, the yield of fisheries historically always was highest in years when the floodplain was flooded by high river discharge. Danube and its floodplain offer also a wide range of recreational activities and offer the possibility to enjoy many type of tourism.

4.1 Examples of Provisioning services offered by Upper and Lower Danube sections

Provisioning services are material products provided by the ecosystems that we humans can directly use and need to survive - such as food and water. For those services, often a viable market exists in which provided goods are bought and sold.

Provisionary services are not distributed equally along the Danube

In the Danube basin land is mostly used for agriculture (42%) and forest (35%). The rest of the basin is either covered by grasslands and heathlands (16%), urban areas (5%) or water bodies (less than 2%) (Karabulut et al. 2016). The highest level of water yield (surface and groundwater) originates in the forest areas (73%), in direct proportion to the precipitation they receive.

In contrast, only 17% of renewable water is produced in the agricultural lands despite the large surface they cover (42%) and the fact that they receive about one third of the precipitation of the basin. When looking at the water abstractions by different sectors in the Danube basin, most water (44%) is used by the energy sector while 26% goes to the food production (sum of agricultural and livestock) (Karabulut et al. 2016). The areas along the Danube suffering from water scarcity are mostly located within the territories of Romania and Hungary, also including some subbasins in Bulgaria, Croatia, Moldova and Ukraine. Almost in the same area, according to a study of the ICPDR (2012; 2013b), lesser precipitation in summer season is projected and severe water stress is expected in the lower parts of the Danube basin due to climate change. Hence, water availability in the lower Danube will increasingly depend on the water yield by in the upper part of the Danube, which however, will be influenced by climate change, too, especially in the Alps.

Floodplains provide local societies with abundant products

The Danube is not only the largest river in Europe after the Volga, it also represents the home of the most species rich fish fauna of our continent. According to Kottelat and Freyhof 2007, about 115 fish species occur in the Danube basin, which represent about one third of all fish species in Europe. The number of species increases from source to mouth, as in the Lower Danube 77 fish species are known (Năstase and Navodaru 2017). Historically, the Danube has been home to 7 endemic fish species (found nowhere else in the world), including the Danube Salmon (Huchen), and 10 long-distance migratory fish including 5 sturgeon species, and altogether fish species.

Fisheries represent a major provisioning service provided by freshwater ecosystems (MEA, 2005; TEEB, 2013). Records of Danube fisheries date back to 335 BC when Greek traders commercialized the fishery in the Lower Danube. Still today, approximately 30.000 tons of fish are caught each year by commercial and sport fishermen (Sommerwerk et al. 2009). The Danube catch yield has declined seriously after the constructions of several big dams which affect the natural habitats and interrupt the continuity of the routes for the migratory species.

Figure 27. Distribution map of the Danube Beluga – Huso huso
Legend: yellow – resident, red - extinct (www.iucnredlist.org)

Danube is one of the last refugia for sturgeons, a group which is 200 million years old and hence may be seen as living fossils.

The river provides access to some of the most important remaining spawning habitats in the Black See basin for the four migratory sturgeon species, and hosts another two resident sturgeon species.

However, five out of six species native to the basin are critically threatened by extinction and one species is already extinct in the basin.

The construction of the Iron Gate hydropower dams (1972, 1984) has had a great impact on sturgeon populations in the Middle Danube. In parallel, sturgeon fisheries over-exploited populations at the end of the last century, also by poaching and unreported fishing, which both represent an ongoing pressure due to the high commercial value of sturgeon products, as like its meat and eggs (caviar). When it comes to fish diversity, Romania represents the hot spot within the Danube basin, and it is the single country which hosts 4 species of sturgeons.

Figure 28. Distribution map of the Danube salmon - Hucho hucho (www.iucnredlist.org)

Huchen (Danube Salmon) is a strictly freshwater salmonid, endemic to the Danube basin. Very limited occurrence is documented in Romania as well as Germany where at least 90% of its natural distribution has been eliminated. Danube Salmon is also an indicator and symbol for the integrity of river systems, which is incompatible with hydropower development and their combined effects, as alteration of habitats, hydrologic regimes, and the loss of the river continuity. The largest remaining areas of the Huchen habitat are found in the Balkans.

4.2 Examples of Regulating services offered by the Upper and Lower Danube

Regulating services are ecosystem processes contributing to stable and safe living conditions for humans. Some key benefits obtained from the regulating services of the Danube floodplain forests are flood protection, ground water recharge and climate regulation. These forest ecosystems contribute to the improvement of the local and regional air quality, too, as forests can provide shade, reduce air temperatures, increase air humidity and create cooler microclimates, and prevent overheating of water bodies in summer by shading them as well. Also, forest ecosystems act as sponges, intercepting rainfall and facilitating the infiltration of water into the soil through the formation of organic soil. Through these processes, floodplain forests facilitate recharge groundwater supplies with clean water, lower peak flows during heavy rainfall or flood events, and support base flow through exfiltration from groundwater aquifers at low levels of river discharge.

Forests thus also help keep soil intact and prevent it from eroding into nearby water bodies. Leaves and natural debris on the forest floor slow down surface water runoff and trap soil washed away from nearby fields. Tree roots can hold the soil in place and stabilize stream banks, thus reducing soil erosion.

Which potential for regulating services do the different sections of the Danube have?

The Upper Danube has been generally assessed to have a lower ecological status or potential (ICPDR, 2015) because it has been altered by the construction of a series of weirs and hydropower plants, so that only few unregulated sections are remaining which still have natural inundation areas in the floodplains.

The relatively narrow former floodplains in this river section are subject to intensive agricultural use. Downstream of the gorge at the Iron Gate, the lower Danube is characterized on the Bulgarian side, by relatively narrow floodplains with very marked valley slopes. In contrast, on the Romanian side there are a large-scale morphological floodplains up to 15 km wide. In the 1960s and '70s, more than 80% floodplain areas on the Romanian side have been embanked and drained for agricultural purposes. As a consequence their ecological value has decreased dramatically, and active floodplain areas **have remained particularly in Dobrudja**, as on the Large and Small Islands of Braila, **and in the Danube Delta**. The 5 km wide recent floodplain of the **small Wetland of Braila** is the largest on the lower Danube. It represents a valuable ecologic area, even however only about 10 % of the formerly recent Balta Braila floodplain have been preserved (Vadineanu et al. 2001).

Other valuable areas exist in **the lower Prut with its adjacent floodplain lakes**. Also there, large areas of the lower Prut floodplain have been embanked and drained, including the larger part of Lake Brates. Strong changes of the local climate have occurred after the decrease in wetland area and have led to steppe-like conditions and large brackish areas.

4.3 Examples of Cultural services offered by the Upper and Lower Danube sections

Cultural services are non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences, which include ecotourism, education and research, religious inspiration, pilgrimage and enjoying the aesthetics of nature. The scenic beauty and gorgeous riverine landscape along the Danube are complemented by the cultural ones with fortresses, castles, museums, cathedrals, churches, monasteries, religious sites and thousands of years of history from Ancient Romans, Greeks, Thracians and Slavs to the Ottomans, Austro-Hungarians and Jewish settlers along the Danube.

Supported by a network of protected nature parks along the river and its tributaries, including the Romanian **Danube Delta Biosphere Reserve**, an UNESCO world nature Heritage site, the Danube is the natural habitat for over 300 species of birds. **The Danube Delta is the second largest and best preserved wetland habitat on the European continent, together with lower Prut and Small Wetland of Braila** boast a remarkably diverse flora and fauna. These areas are of particular interest for **birdwatchers**, as they offer observation opportunities for typical wetland avian species who meet there bird species typical for steppe landscapes. During bird migration in spring and autumn, over 20,000 birds can be recorded.

Figure 29. Birdwatching in Lower Prut Floodplain Natural Park (photo by Costea G.)

The Roman Emperors and Danube Wine Routes leads through four countries of the Middle and Lower Danube Region – Croatia, Serbia, Bulgaria and Romania – encompassing 20 archaeological sites and 12 wine regions. The route links the archaeological sites with their individual (unique) histories that are monuments to the leadership of the Roman emperors in the introduction of Roman culture along the northern frontier of the Empire. Wine, as the key sub-theme, blends in conceptually with the introduction of Roman culture and habits into the Danube region.

According to wine experts, Dobrudja has the best conditions for wine growing in Romania. Its continental climate with warm, dry summers, moderate winters, early springs and late autumns allow for long vegetation periods, good soil structure and fertility, plenty of sun and low precipitation, which do make a difference, so it is no wonder viniculture has had already a long pre-Roman tradition here.

Whether you are **hiking, cycling**, driving, travelling by boat or train, or combining those, a cross-border journey along the Roman Danube Frontier (Limes) will reveal the outstanding natural beauty of the river and its hidden historic and archaeological treasures, many of which are off the beaten track. The flora and fauna, towns, villages, historic buildings, architectural treasures and monuments may additionally be observed from a different perspective – from the river by **cruising** the Danube. Also, cycling on the Danube Bike Trails offers fascinating views along the meandering banks of the Danube.

The Danube Bike Trail connects nine Danube countries, beginning with the German section from Donaueschingen to Passau, and ending at the coast of the Black Sea in Romania. Many thousands of cyclists ride certain parts of this trail, which make it the most popular long-distance cycle route in Europe.

Figure 30. Cycling in Beleu Lake - Lower Prut Scientific Reserve Moldova, Republic of Moldova (photo by Matei F.)

Due to its popularity, the Danube Bike Trail has a considerable economic importance, too: the results of a survey from 2010 in 17 places along the Danube Cycle Track show that 437,000 cyclists use the Austrian Danube Cycle Route, of which 33 per cent were holidaymakers, 33 per cent day trippers and 34 per cent everyday cyclists. Austria's annual economic successes, which are generated by cyclists according to the study, amounts to 71.8 million euros (https://de.wikipedia.org/wiki/Donauradweg). The Danube attracts over 1.5 million tourists annually to the most famous section between Passau and Vienna area. In contrast, the Romanian/Bulgarian sections, which represents one third of the river's length, is visited by only a few hundred foreign cyclist tourists annually.

The cycle tracks here are still considered as route under development' according with EuroVelo 6 certification. However there are initiatives and projects which support and promote further development of this tourism sector, which allows to enjoy relaxed riding in a peaceful landscape and experience the hospitality of the local people (www.eurovelo.com, www.cyclingromania.ro, www.danube.travel). As bike tourists have only small baggage with them, they fully depend on local offers for accommodation and food provision, which represents clear economic opportunities for small regional providers of such services, among which typical regional products are often preferred by tourists.

Canoeing and kayaking have a long tradition on the Danube, and the Danube Delta is highly frequented. The delta also offers lots of opportunities for **fishing** in a relaxing atmosphere, where tourists may also enjoy authentic, local **culinary culture** based on regional, fresh products from the Danube region.

Figure 31 & 32. Fishing on Danube Delta (Danube Delta Biosphere Reserve Administration-ABRD Tulcea)

As eco-tourism aims to be a non consumptive economic activity in the nature based on resources available in the area, eco-tourism will contribute to biodiversity conservation and help to raise the economic situation of the local population.

4.4 Ecosystem Services Trade-offs

In nature, all components are mutually inter-dependent (A. v. Humboldt). Similarly, the various services that are obtained from ecosystems are also inter-linked and depend on each other. As a result, the use of any specific services may enhance or affect other services, whereas it may also create synergistic conditions of both services. This effect caused by the intense use of specific services leading to increase or decrease of other services is known as ecosystem services trade-offs. Hence, management practices for certain ecosystem should seek to maintain the whole range of ecosystem services.

Examples of ecosystem services trade-offs are created by human activities like hydropower, navigation, agriculture etc. which always reduce the supply of different types of ecosystem services such as the provisioning of timber, fuel wood, air quality regulation, fresh water etc. For a sustainable management, priority must be given to ways of human use of ecosystem services which will cause minimal negative impacts on other services. Preferentially, the use of those services should be promoted which have synergistic effects on other services.

The following two examples from Upper and Lower Danube show how Ecosystem Service concept could be used as support for decision-making in the water management practice.

4.4.1. Case study at the Upper Danube

In the Upper Danube, an integrated study has been conducted quantifying multiple ecosystem services in a section of the upper Danube downstream of Ulm within the framework of the research project 'River Ecosystem Service Index' (RESI) (Podschun et al. 2018, Pusch et al. 2018) .

For this river section, as for the whole Bavarian section of the Danube, the Bavarian State Ministry of the Environment and Consumer Protection strives to increase the flood retention capacity, as in 2013 a century flood of the Danube has caused damages of more than 1 billion Euro, which has shown a significant need for the improvement of flood protection. Therefore, a concept was developed to establish three regulated polder areas and up to six unmanaged flood retention areas. Two scenarios were developed by the water management agency and then compared with each other and with the status quo in terms of the availability of ecosystem services. For both scenarios and the status quo the respective availability of 13 ecosystem services was assessed, and based on this the 'River Ecosystem Service Index' was calculated. In this way, this ecosystem assessment was performed for every river kilometer of this 80-km section.

Thereby, **scenario 1** reflects an integrated planning where especially the requirements of nature conservation and of agriculture were respected: the flood retention areas, which will be flooded by a 100-yearly flooding event, cover only the land use types forest, wetlands and water bodies, but no crop fields; for purposes of nature conservation these areas will be additionally flooded regularly by so-called 'ecological floodings', approximately 3 times a year in order to mimic natural floodplain conditions.

In contrast, **scenario 2**, maximizes flood protection in a larger area also including agricultural fields, but which will be flooded solely at extreme flooding events (> 100 years return time) without further ecological compensation.

Figure 33 represents the assessment (in 5-step scale) of the availability of three selected ecosystem services in three states (status quo, scenario 1, scenario 2) in a 7-km section of the Bavarian Danube river corridor. Please note that for the status quo the assessment scores represent the levels of ecosystem service availability (1: red, 2: orange, 3: yellow, 4: green), while for the scenarios the differences are shown compared the status quo scores (-1: orange, +1: yellow; +2: green).

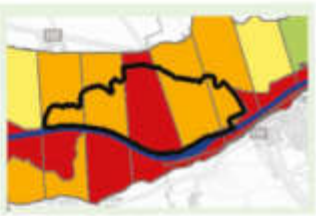
Ecosystem service and comment	Status quo	Scenario 1	Scenario 2
Agricultural crops - Status quo and scenario: very low values (1-2), as almost no crop fields are included. - In scenario 1 no change is visible, as no agricultural fields are enclosed in the polder - Scenario 2: Two 1-km sections are affected during an extreme flood, with all crop yields then lost.			
Flood retention - Status quo: very low values, as dykes are located close to the river - Scenario 1 and 2: improvement up to 2 points due to regular floods or very high retention capacity			
Habitat provision - Status quo: heterogeneous distribution of score levels ranging between 2 and 4 - Scenario 1: improvement (+1 or +2) in all 1-km sections due to near-natural frequent floods - Scenario 2: deterioration (-1) for all 1-km sections due to the strong negative effects of impoundment			

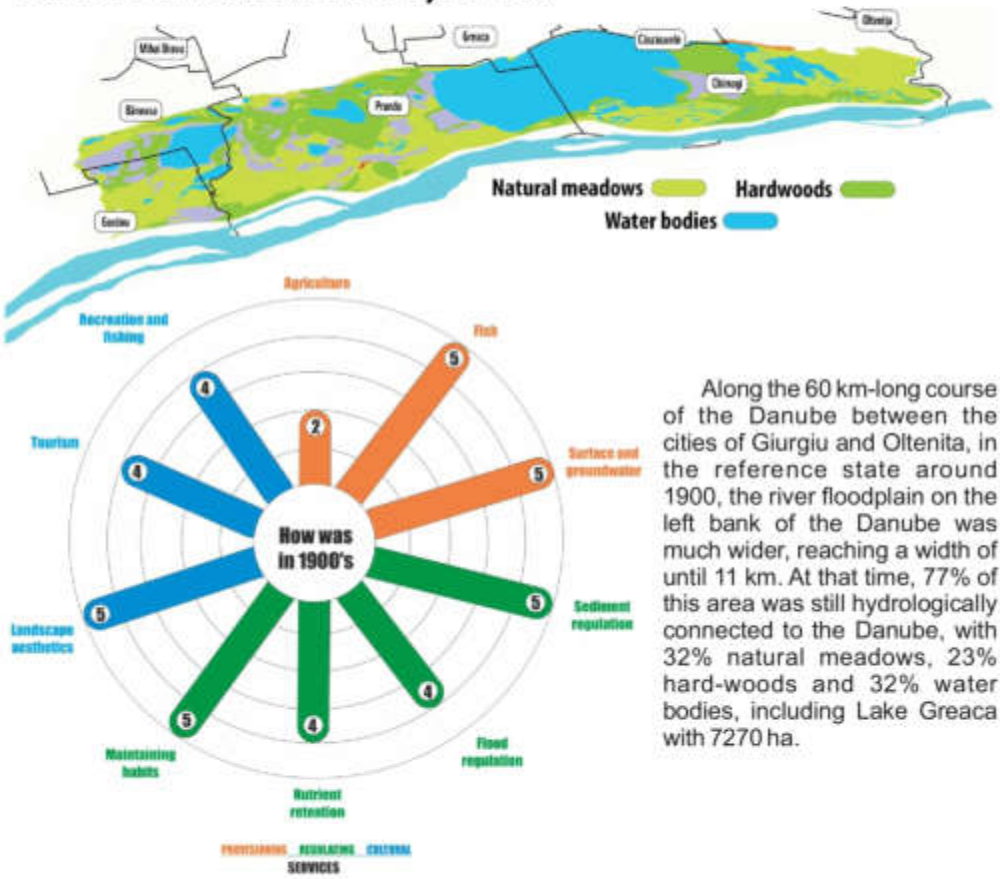
Figure 33. Detailed maps of three ecosystem services in the status quo and two different scenarios. Figure reproduced with the permission of the authors from Podschun et al. 2018. The figure is based on maps from Federal Agency for Nature Conservation maps (2009) using © GeoBasis-DE/BKG (2016). Colour cod: red - very low,orange - low, yellow - moderate, light green - high, green - very high. Please note that the colour code in the scenarios refers to the differences to the status quo.

4.4.2. Case study "Gostinu–Prundu–Greaca polder" in the Lower Danube

There, an analysis on the effects of management scenarios on the availability of ecosystem services has been performed for the flood polder Gostinu-Prundu-Greaca established in arable agricultural area.

This study was based on pre-feasibility studies initiated by WWF Romania and conducted by the Research Centre in Systems Ecology and Sustainability of the University of Bucharest (Preda et. al. 2015).

1. Historic reference state in the year 1900



Along the 60 km-long course of the Danube between the cities of Giurgiu and Oltenita, in the reference state around 1900, the river floodplain on the left bank of the Danube was much wider, reaching a width of until 11 km. At that time, 77% of this area was still hydrologically connected to the Danube, with 32% natural meadows, 23% hard-woods and 32% water bodies, including Lake Greaca with 7270 ha.

The availbility of ten ecosystem services on a scale from 1 to 5 (1 = very low, 5 = very high) for the time period around the year 1900 (reconstructed)

Figure 34. Case study Gostinu-Prundu-Greaca polder.
Map and polar graph illustrating the historic reference state in the year 1900.
Map reproduced from Preda et al. 2015 report.

2. Status quo today

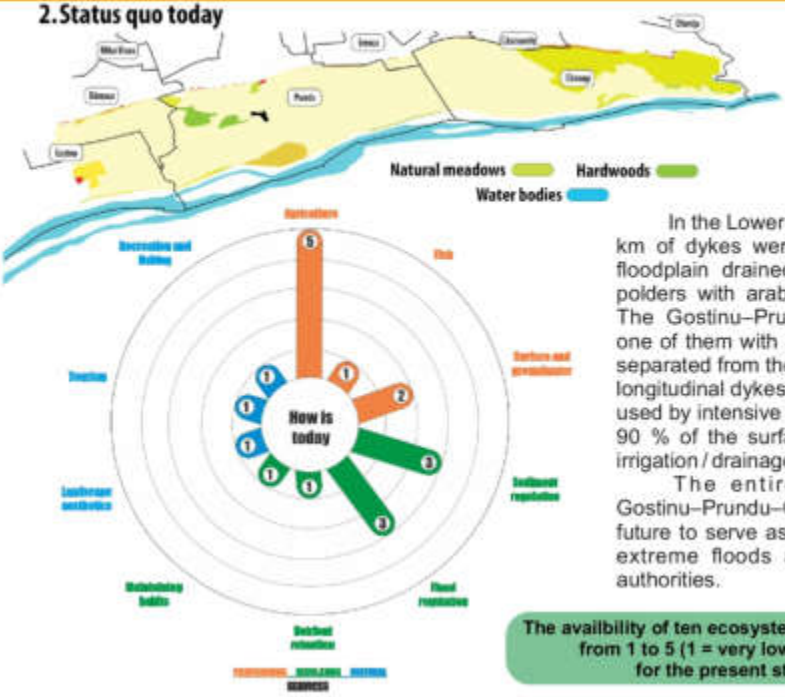


Figure 35. Case study Gostinu-Prundu-Greaca polder. Map and polar graph illustrating the status quo today. Map reproduced from Preda et al. 2015 report.

In the Lower Danube, in 1960s 1200 km of dykes were constructed and the floodplain drained in order to form 53 polders with arable land for agriculture. The Gostinu–Prundu–Greaca polder is one of them with a surface of 27'830 ha, separated from the Danube by 41,4 km of longitudinal dykes. The polder is currently used by intensive agriculture practices on 90 % of the surface, including a dense irrigation / drainage network.

The entire arable polder of Gostinu–Prundu–Greaca is designated in future to serve as retention areas during extreme floods according to national authorities.

The availbility of ten ecosystem services on a scale from 1 to 5 (1 = very low, 5 = very high) for the present status quo

3. Restoration scenario involving partial dyke relocation.

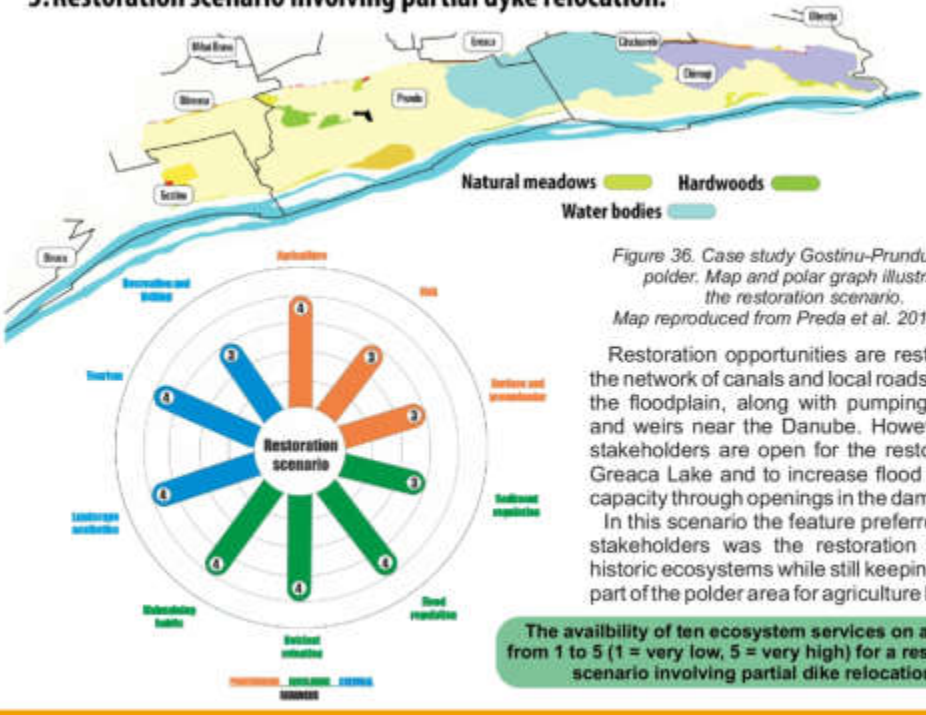


Figure 36. Case study Gostinu-Prundu-Greaca polder. Map and polar graph illustrating the restoration scenario. Map reproduced from Preda et al. 2015 report.

Restoration opportunities are restricted by the network of canals and local roads crossing the floodplain, along with pumping stations and weirs near the Danube. However, local stakeholders are open for the restoration of Greaca Lake and to increase flood retention capacity through openings in the dam.

In this scenario the feature preferred by the stakeholders was the restoration of some historic ecosystems while still keeping a major part of the polder area for agriculture land.

The availbility of ten ecosystem services on a scale from 1 to 5 (1 = very low, 5 = very high) for a restoration scenario involving partial dike relocation

5. Who and what is limiting the provision of natural goods and services? Human pressures and their impacts on the Danube ecosystem

The previous chapter showed that ecological goods and services are benefits arising from the ecological functions of ecosystems and rivers that are essential to human well-being. Rivers provide a wide range of social, economic and strategic benefits to society, but have often been modified to deliver a narrow range of services only, to the detriment of river health and other human needs. Freshwater ecosystems are thought to be the most altered ecosystems across terrestrial or aquatic realms, mostly in terms of water quality and loss of connectivity in wetlands. In Europe, more than half of the freshwaters in Europe are in a degraded state and are affected by pollution and modifications to water courses (EEA, 2012). Hence, a morphologically degraded river or at risk, undermines their ability to provide critical ecosystem services and related benefits. Various human activities threaten and affect ecosystems in many ways.

Human activities that introduce these pressures come from **agriculture, urban areas**, **energy production**, **transport**, **commercial fishing**, **the waste sector**, **tourism**, **species trade**, **flood protection**, etc. (EEA, 2018, Costea et al. 2018).

The main impacts on surface water bodies are **nutrient enrichment**, **chemical pollution** and altered habitats due to **morphological changes** (Figure 37).

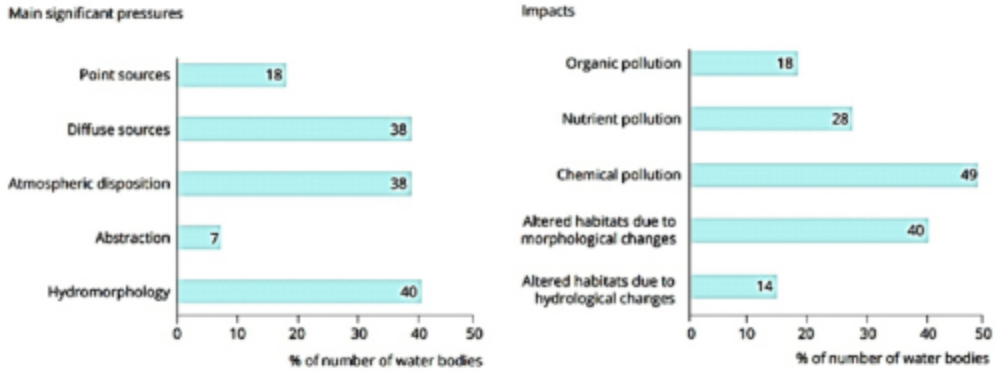


Figure 37. Proportions of the pressures and their impacts of the European surface water bodies in the second River Basin Management Plan: main significant pressures (left) and impacts (right) (after EEA 2018)

The Danube River Basin Management Plan concluded that 80% of the Danube River Basin District's former wetlands/floodplains are disconnected, largely due to the expansion of agricultural uses and river engineering works for flood control, navigation and power generation.

Major Pressures to Water Quality in the Danube River Basin

5.1. Pollution and water quality

Artificial chemicals are used for products which we make use of in many different ways to improve our quality of life, from food production to health protection to transport and heavy industry. At some point in their lifetime, chemicals can enter the water cycle, by deliberate discharge with waste water treatment, or as a result of processes such as leaching from soils into groundwater, run-off from surfaces, or atmospheric deposition (through which pollutants, including gases and particles are deposited from the atmosphere in the form as dust or in precipitation, ultimately entering fresh water systems).

Some chemicals can be very harmful through direct toxicity, which affect an organism's healthy functioning, or can become problematic as they accumulate up the food chain.

Chemicals used in industrial processes and products sometimes enter sewers and, via waste water treatment plants, are discharged into water bodies. Burning of fossil fuels and waste leads to emission of some hazardous substances, as e.g. mercury, and subsequent deposition from the atmosphere. This can represent a major pathway for such substances to move long distances before entering the water environment. Pesticides used in agriculture have been widely detected in groundwater and surface water. Mining can exert locally significant pressure upon the chemical quality of water resources in parts of Europe, particularly with respect to the discharge of heavy metals.

Landfill sites and contaminated land from historical industrial and military activities can be a source of pollution for the aquatic environment. Shipping, harbour and port activities, and aquaculture can lead to the emission of a variety of chemical pollutants (EEA, 2012).

Figure 38. Sources of Water Pollution (from EEA, 2012)

Organic and nutrient pollution are mainly caused by emissions from insufficiently or untreated wastewater into surface waters from communities (cities and towns), industry and agriculture. Atmospheric deposition is also significant.

Many agglomerations in the Danube River Basin still have no, or insufficient, wastewater treatment and are therefore key contributors to organic pollution. Nutrient pollution, particularly by nitrogen (N) and phosphorus (P), can cause *eutrophication* – an enrichment of water causing an accelerated growth of algae and vascular plants that later may degrade again and thereby produce oxygen deficits. This represents an undesirable disturbance to the biotic communities present in the water and to water quality. Eutrophication is hence a major problem threatening the biodiversity and ecosystem services in the Danube Delta and in the Black Sea. Shallow lakes and slow-flowing channels have experienced due to this eutrophication a shift from submerged plants, water lilies, etc. to planktonic algae which caused oxygen depletion in the bottom layers followed by a severe drop of aquatic biodiversity. Coastal eutrophication reduces the fish productivity, as e.g. a decrease has been documented from 28 species of economically valuable fish to 19 species (Vadineanu et al. 2001). The quality of the Black See beaches has declined because of excessive growth of algae and jellyfish (Suciu et al. 2002) .

The nutrient loads discharged from the Danube river basin (DRB) represent an important factor responsible for the deterioration and eutrophication of parts of the Black Sea ecosystem. Emissions from the agricultural sector represent the most important diffuse source of nutrient inputs, especially from mineral and organic fertilizers and livestock manure. Nitrates in particular leach easily into water from soils that have been fertilized with mineral fertilizers or treated with manure or slurry. The levels of diffuse pollution are not only dependent on anthropogenic factors such as land use, and land use intensity, but also on natural factors such as climate, flow conditions and soil properties. These factors influence pathways that are significantly different. **For nitrogen, the major pathway of diffuse pollution is groundwater, while for phosphorus, it is erosion** (Liska 2015).

Hazardous substances are man-made chemicals, metals, oil and its compounds, organic micropollutants, pesticides and medications stemming from wastewater, industry, urban run-off and combined sewer overflows, agricultural practices, mining operations and accidental pollution, that are often very persistent and harmful even in low concentrations.

While the use of fertilizers dropped significantly after the economic collapse in the early 1990s in almost all Danube countries, new measures could become necessary to prevent a rise of pollution in the future. The main sources of nutrients in the Danube are agriculture (50%), municipal wastewater (25%) and industry (25%) (Liska 2015). From the whole course of the Danube, 58% of the Danube River length was categorized at risk due to organic pollution, 65% due to nutrient pollution and 74% due to hazardous substances (Liska 2015) (Figure 39).

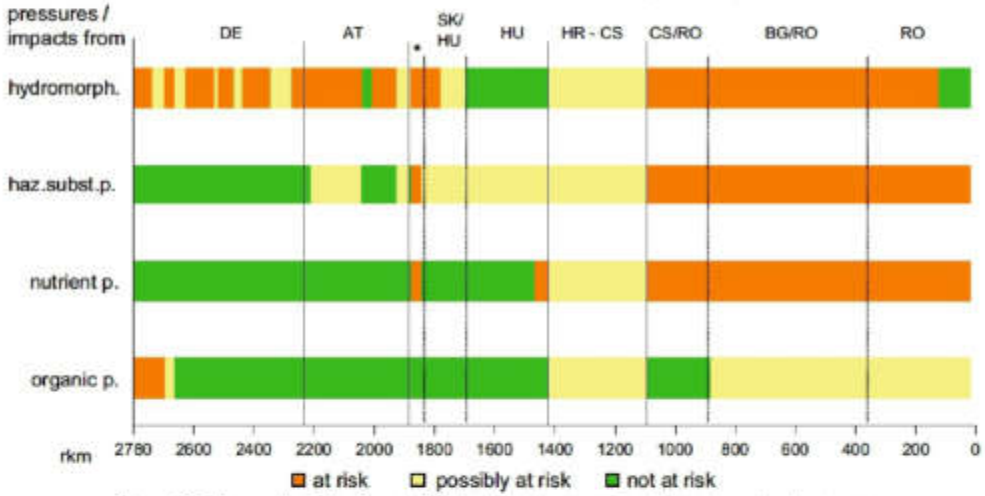


Figure 39. The results of the Danube Basin Analysis, according to the categorised pressures for the entire length of the Danube River itself (from M. Popovici in Liska 2015)

5.1.1. Mitigation measures

As a result of considerable investment in upgrades of sewage treatment plants especially in the upper basin, the phosphorus and nitrogen levels have markedly dropped throughout most of the river system, although levels remain above the levels of 1960s, but lower than in the late 1980s.

A large number of measures supported by EU policies are currently implemented, including elimination of phosphorus in detergents in some countries, farm-level nutrient planning, fertilizer standards, appropriate tillage, nitrogen-fixing and catch crops, buffer strips, and crop rotation. Due to the political as well as economic changes in the middle and lower DRB, including the application of economic mechanisms in water management (e.g. the polluter pays principle also applied in the middle and downstream Danube River Basin countries) and the improvement of wastewater treatment (especially in upstream countries) contributed to the decrease of nutrient load comparing with situation from the 1990s.

River restoration and less-intensive land uses such as afforestation (planting trees) are also increasingly recognized as effective means to tackle diffuse pollution pressures as they increase nutrient retention and recycling.

5.2 Hydromorphological pressures

For decades, humans have altered the shape of water bodies and flow of river courses in order to facilitate farming of the land, facilitate navigation, construct hydropower plants and protect settlements and agricultura land against flooding or in order to create ponds for fish farming. Changes to the physical (morphological) and hydrological characteristics of a water body like has become now one of the main factors responsible for river degradation (Figure 40).

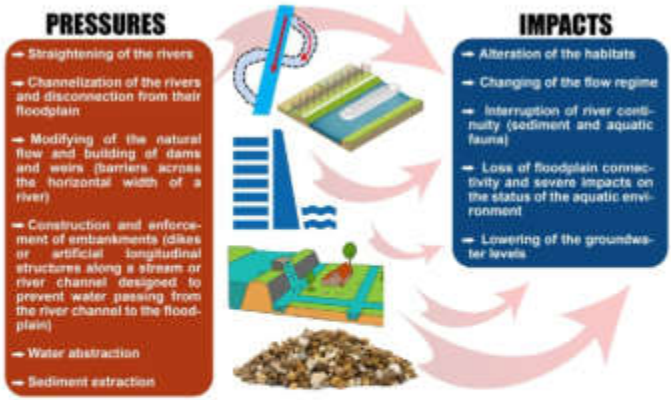


Figure 40. The main hydromorphological pressures and their impacts in Danube River Basin

These activities have resulted in altered habitats, changed flows, interruption of river continuity, loss of floodplain connectivity and severe impacts on the status of the aquatic environment. In the Danube Basin, the main causes of change are flood protection, hydropower generation, and navigation.

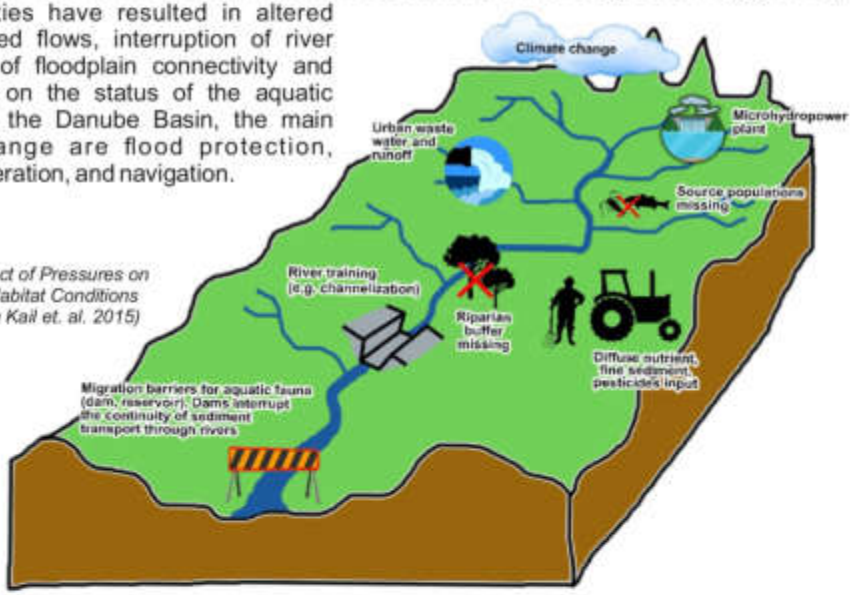


Figure 41. Effect of Pressures on River Abiotic Habitat Conditions (Redrawn from Kail et. al. 2015)

Hydromorphological pressures include physical alterations (structures which impact longitudinal continuity as barriers, obstacles and transverse structures) and hydrological alterations.

Barriers are mainly used for hydropower, flood protection and irrigation purposes. Obstacles in rivers cause disturbances and have impacts on river continuity: sediment transport, movement of aquatic fauna.

In general, the blockage of the sediment transport creates an imbalance in the river dynamics and affects the bed morphology. Running waters are transformed into a series of impoundments (reservoirs formed by dams) of stagnant water that reduce natural flow dynamics and at the same time increase temperature changes and eutrophication.

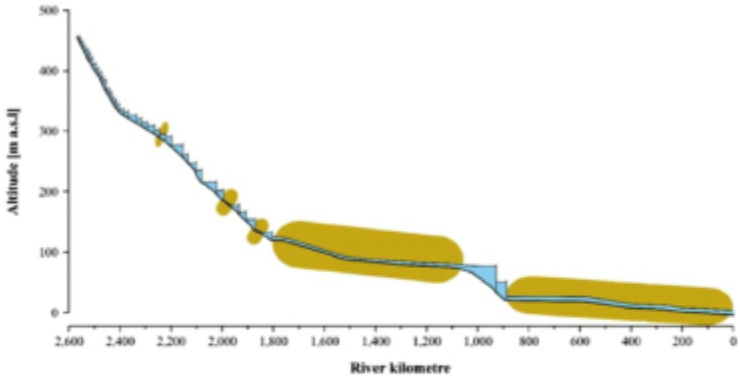


Figure 42: Danube River in longitudinal section with 78 barriers (blue) and 5 free-flowing sections (yellow) (from Habersack et al. 2016)

One example is the chain of run-of-the-river dams on the upper Danube and the two large dams between the middle and lower section that trap sediments and aggravate riverbed incision downstream (Figure 42).

The opportunities for the movements of species are drastically reduced by the transversal obstacles. The Danube River itself and its tributaries represent a key migration route. The Iron Gate Dams I & II, in part the Gabikovo Dam, and the chains of hydropower plants in Austria and Germany are 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 fragmentation of their habitats results also in reduction of fish population habitat range and facilitates the isolation of populations, preventing any genetic exchanges between different groups of the same species.

A total of 1030 migration barriers are located in the Danube River Basin District (DRBD), of which 78 are located in the Danube River itself. More than 120 fish migration aids have been constructed, whereas 667 barriers remain unpassable out of a total 1,030 barriers. (ICPDR 2015).

The straightening and impoundment of rivers, bank protection, for flood protection, agriculture and navigation can lead to different impacts such as the diminution of mobility area for the rivers, impact on lateral river continuity, the loss of floodplains as retention spaces for flood water, alter natural flow levels and sediment dynamics, the removal of habitats for riverine species, and to the loss of connectivity between habitats resulting in loss of biodiversity and recreational uses.

Flood protection

Specifically as a result of measures for flood protection, the Danube has been shortened in length considerably (Bavarian Danube by 21%; the Hungarian Danube by ~12%; WWF, 2002), river width has decreased, and the resulting increase in shear stress/flow velocity has led to bed degradation (river incision).

The Lower Danube appears to be in a moderate state, as the river bed is not regulated, although flood dikes (to protect against the 1 in 100 year flood) were constructed in Romania in the 1960s, inundation of the Danube Delta was possible (Habersack et al., 2010).

Whilst new management plans allow inundation of some areas of floodplain, the former flood protection structure remains along a significant proportion of the river.

The embankments can prevent sideways erosion, and thus sediments are not taken from the floodplains so the river itself sinks as water takes sediments from the riverbed (deepening of the river bed-incision). As the river sinks, groundwater levels are lowered in the riverbanks and floodplains, causing sidearms to fall dry, worsening or even disrupting the connection between the main river and floodplain lakes and tributaries and reducing water flow to the river wetlands.

Thus there are affected the riparian forests which suffer from decrease of the groundwater levels, typical wetlands habitats, whose biogenesis depends on the periodical change between dry and wet periods, may disappear and species typical for the wetlands could therefore become rare or extinct.

Danube floodplains in danger

Historically, more than 68% of the floodplains of the Danube River have been lost by construction of dykes and hydropower plants.

Human alterations have caused fundamental changes in the hydromorphology of the river-floodplain ecosystem, especially in the upper and middle parts (Figure 43).

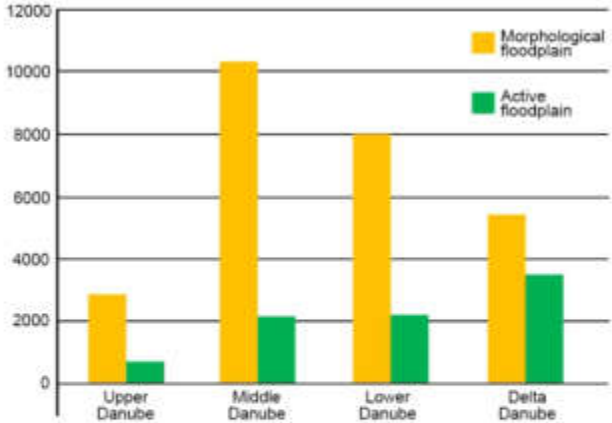


Figure 43: Floodplain loss (in km²) for the different Danube sections, as compared with remaining active floodplain area. Morphological floodplain - Potentially flooded area without flood defences , Active floodplain - Floodplain area between current flood defenses - dikes (from WWF Restoration Potential Danube, 2010)

Navigation

Another aim for these infrastructure measures is for supporting the navigation. There is a long history of navigation on the Danube: in 1845 construction of the 'Ludwig-Main-Danube- Canal' linked the basins of the Danube and Rhine. One of the first European institutions -the European Commission of the Danube, established on 1856, with initial headquarters in Galati (Romania)- was the first — and for a long time the only — international body to have serious police and juridical powers over private vessels and individual people.

Currently, 87% of the Danube's total length is navigable, for 2414 km, from Sulina in Romania to Kelheim in Germany. The annual transport in 2010 was 43 × 106 t over a mean distance of ~600 km. By far the largest transport volume is chalked up by Romania (Ex. for 2010 -21.6 million tons -via Donau, 2013) (Figure 44).

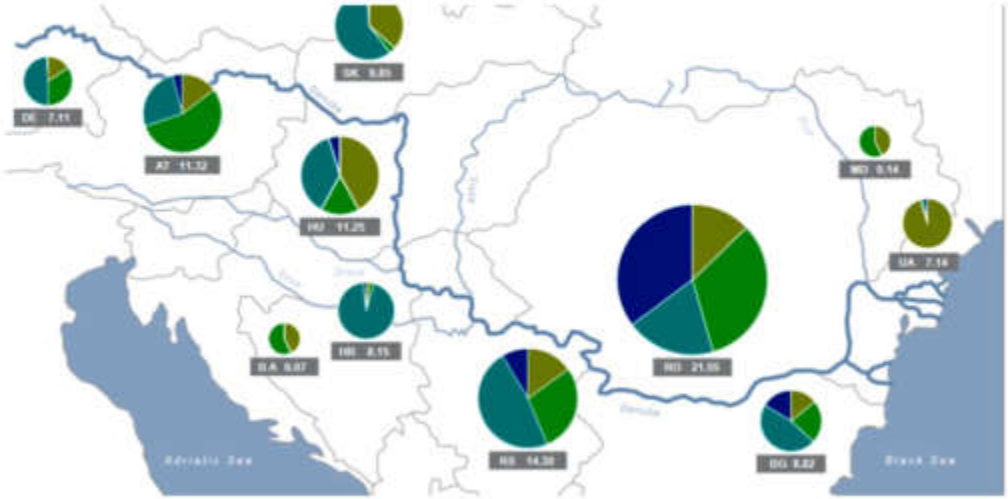


Figure 44: Transport volume on the Danube and its navigable tributaries in 2010 (via Donau, 2013)

At present, there is a strong economic interest to increase navigation on the Danube, however, weather and climate have an impact on inland navigation (Koetse & Rietveld 2009). During low water periods, the capacity of inland navigation vessels is reduced and therefore the transport amount is limited. Those are areas with sub-optimal shipping conditions e.g. due to solid rock formations in the river that lead to a reduced water depths. Bottlenecks can be found in all segments of the Danube and they are predominantly located within Natura 2000 areas (nearly all natural river sections) (Habersack et al. 2015).

The other factor is the weather (and, on a longer time scale, the climate) which, mostly depending on precipitation and evaporation, can lead to low water levels as well. Consequently, common river regulation techniques and practices aimed at improving navigability as canalization and **dredging**, particularly in the lower reaches of the basin, tend to negatively impact the hydromorphology, and consequently the ecology of the river system. At present, the extent of navigation infrastructure generally decreases from the upper to the lower reaches of the Danube before becoming more numerous again in the Delta near the Black Sea (Habersack et al. 2013). For example, reinforcement of the riverbank between Iron Gate II (rkm863) and Calarasi (rkm375) for the navigation project along the common Romanian-Bulgarian border on the Lower Danube ("ISPA2") will destroy natural river banks causing the complete loss of pioneer habitats of typical plant and animal species being strictly bound to such conditions. At least nine Natura 2000 sites will be impacted by the ISPA 2 project. Moreover, the so-called Bystoye project along the Kylia branch in the Danube Delta threatens to severely impact the Romanian and Ukrainian Delta Biosphere Reserves and endangered bird and fish species (WWF 2009).

Hydrological alterations are pressures that alter the flow regime and/or the water levels of surface and groundwater. Where water flows and levels are not in a good condition, this can affect the abundance and diversity of aquatic plants and animals by reducing the extent, quality, diversity and connectivity of aquatic habitats. The main pressures on flows and levels are from water abstractions (for public water supply, agriculture or industry) and reservoirs used mainly for hydroelectricity generation and irrigation.

Irrigation can have many negative feedback effects on rivers and provision of other ecosystem services.

Impounded river sections for hydropower use may also be the result of barriers on rivers, disrupt ecosystems and negatively affect other services. A specific type of hydrological pressure related to hydropower comes from **hydropeaking** activities.

Hydropeaking occurs through the generation of peak energy supply by hydropower stations (i.e. stations store as much water as possible before releasing it to create maximum energy surges causing significant water level fluctuations).

Figure 45 (a,b). Changes of the discharge and therefore of the water level and flow velocity on a daily basis due to hydropower production (hydropeaking) (River Piva in Montenegro - Danube basin, foto by Hudek H.)

The distribution of fish in various floodplain habitats depends on water level, vegetation and the spawning and feeding requirements of adult fish. There are:

- **rheophilic species** - mostly fairly large, that make extensive river migrations but usually make only limited use of the floodplain (Ex. sturgeons, Danube salmon or mayfish - *Alosa sp.*);
- **limnophilic species** - that mostly live on the floodplain lakes and backwaters, so they tolerate high temperatures and low dissolved oxygen; they tend to leave the floodplain only when the water is too low (Ex. mudminnow, tench, rudd);
- **eurytopic species** - that mainly live in the rivers but move on the floodplains during flooding (species that occur in both broad habitat types: pike, perch, giebel carp).

The loss of lateral connectivity between the river and its floodplain due to the transformation in agricultural land and fish ponds mostly affects limnophilic fish, but the effects are wide-ranging since eurytopic fish species also use the floodplain for spawning and rheophilic fish species visit the floodplain during the wet season to search for food.

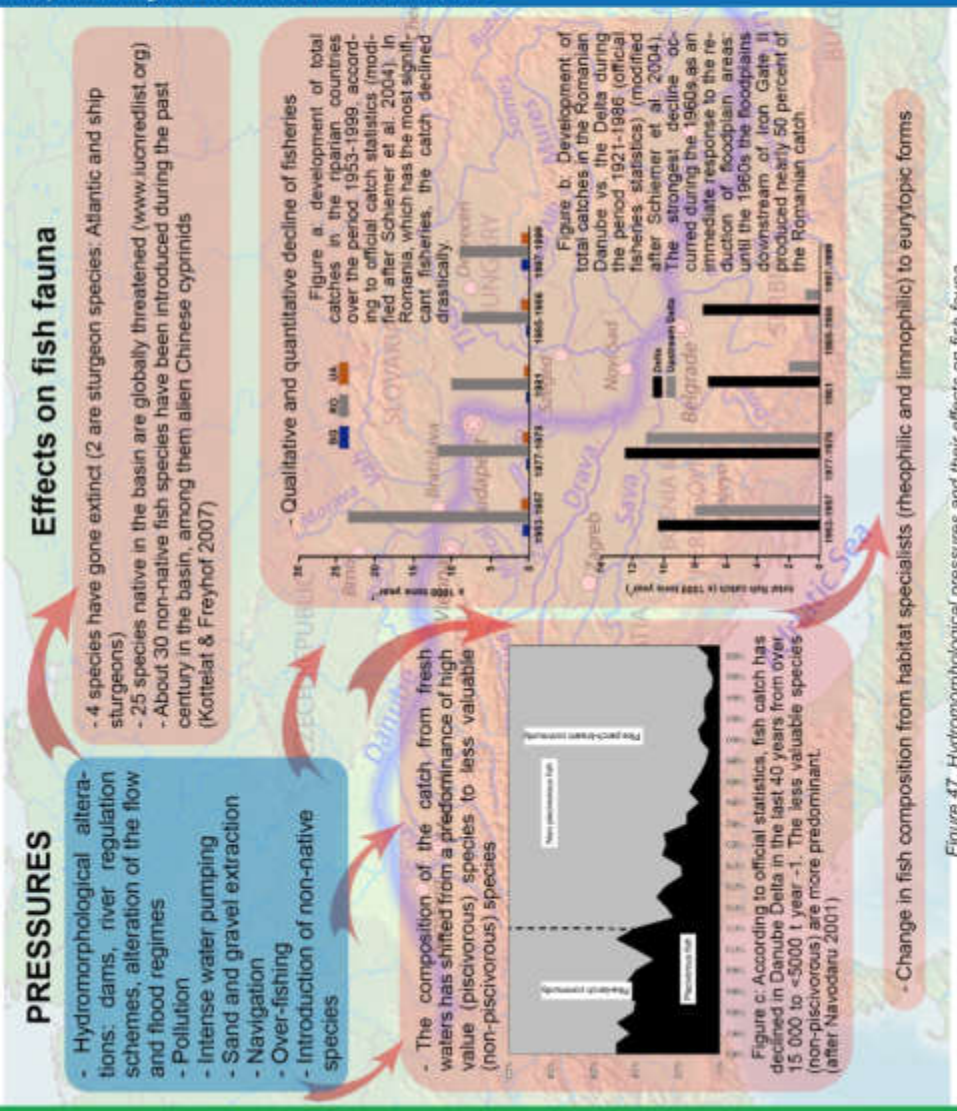


Figure 47. Hydromorphological pressures and their effects on fish fauna

The decline of sturgeons

The decline of Danube sturgeons is clearly documented by the rapidly decreasing catches. Anadromous populations of beluga, Russian sturgeon and stellate sturgeon, in the Upper Danube were heavily damaged by overfishing and habitat degradation during previous centuries, and were then completely eliminated from the middle and upper Danube by the disruption of their migration routes through the construction of Iron Gates Dams I and II (Hensel and Holcik 2002). On the other hand the pollution and over-fishing are the major threats in the Lower Danube and the Black Sea (Bloesch 2006). Intensive fishing caused the decline in the populations of sturgeons since the early 19th century and in the 20th century, the catch of sturgeons in Romania (the lower reaches of the Danube River) dropped catastrophically to only 11.5 metric tons in 1994 compared to about 200 metric tons per year in the 1960s, (Bacalbasa-Dobrovici 1991) (Bacalbasa-Dobrovici 1997) (Figure 48). Not only the size, but also the structure of sturgeon populations in the Danube River changed dramatically. Besides intensive fishing, other aspects of human activities have negatively impacted Danube River sturgeons, especially the construction of hydropower dams, but also deforestation and pollution.

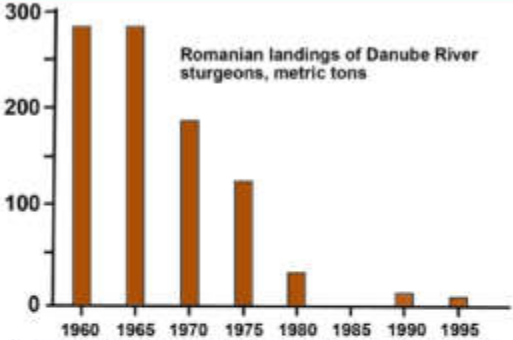


Figure 48: The decline of sturgeon catch in Romanian part of the Danube river (modified after Bacalbasa-Dobrovici 1991b)

Figure 49. Fish market in Galati, 19th century (source "Fish and Fishing in Romania" by Grigore Antipa, 1916)

5.2.1. Measures to mitigate hydromorphological pressures

The protection and restoration of floodplains is encouraged by several important water-related policies in Europe: the EU Water Framework Directive (WFD), the EU Floods Directive, the EU Habitat and Birds Directives, the EU 2020 Biodiversity Strategy, the EU Green Infrastructure initiative, and the EU Climate Change Adaptation Strategy. The EU Water Framework Directive (WFD) aims to protect and improve the ecological status of water bodies, as rivers, lakes, transitional waters and coastal waters. The directive requests to reach at least a good ecological status by the end of 2027 for all water bodies in the EU-member states. Currently, the ecological status, as assessed by the biological indicator groups (Figure 50), does mostly not meet this goal. The Danube River Basin Management Plans (RBMPs) (ICPDR 2015) elaborated under the WFD include lists of restoration actions aiming at the main pressures identified.

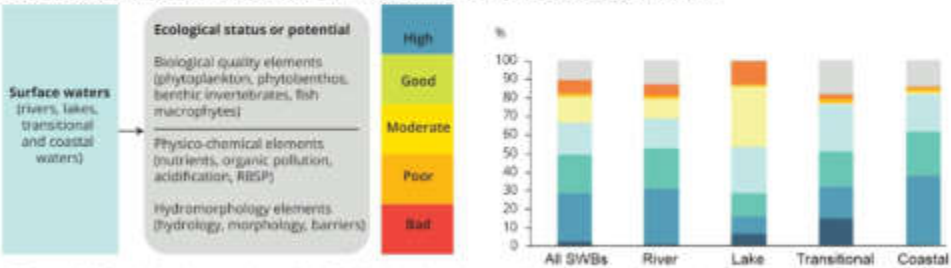


Figure 50: Ecological status/potential of biological and supporting quality elements in rivers bodies in the second River Basin Management Plan (from EEA 2018)

One of the key measures to mitigate hydrological impacts from water abstractions or hydromorphological pressures is the **establishment of ecological/environmental flows** (water flows required to sustain freshwater ecosystems and the human livelihoods and well being that depend on these ecosystems). The flow regime is the most important determinant of ecosystem function and services provided by these functions.

Restoring aquatic ecosystems such as **'making room for the river'**, river restoration or floodplain rehabilitation, has multiple benefits for the water ecosystems as flood and nutrient retention. These natural water retention measures are cost effective and viable alternatives to structural flood protection. In addition, they support multiple ecosystem functions and services needed to achieve the objectives of several EU policies.

The current situation for European floodplains is critical, with 95% of the original floodplain area converted to other uses. Many of the remaining European floodplains are far from pristine and have lost most of their natural functions. For example, of the former 26 000 km² of floodplain area along the Danube and its major tributaries, about 20 000 km² are isolated by dikes (summary by Tockner et al, 2008).

How to Liberate a River – Example of restoration of an Upper Danube reach between Hundersingen and Binzwangen

The River Danube had been regulated between the villages of Hundersingen and Binzwangen since 1827 for land reclamation purpose in the Danube floodplains. Problems soon emerged: as the Danube carved a deeper bed for itself, the groundwater levels dropped. After heavy rains the water rushed forth at enormous speed and high waves threatened to flood the villages downriver.

Figure 51. Restoration of the Danube. Work in progress between Hundersingen-Binzwangen (photo by Schnellbächer-Bühler A.*)*

This part of the river was restored in 2009 as a measure of the Intergriertes Donauprogramm - an initiative of the state of Baden-Württemberg for the restoration of the Danube wetlands and flood regulation (Fig.51). For the length of three kilometers the river was once again allowed to carve its own bed and after nearly two hundred years now flows in a wide curve which can absorb large quantities of water during flooding and buffer waves (Fig.52).

Three kilometers are only the thousand's part of the Danube's 2857 km long journey, but are beneficial for the regulated river: Homes for many kinds of animals are provided: spawning grounds for fish, safe nesting for birds on the river's islands, and the region is much more attractive for people. The joined efforts of the communities, the state of Baden-Württemberg, nature conservation, and hydro-engineering are bearing fruit.

Figure 52. Restoration of the Danube. Hundersingen-Binzwangen today (photo by G. Costea)

Reconnecting backwaters, such as oxbows and side channels, and wetlands aims to restore the lateral connectivity between the main river channel, the riparian area and the wider floodplain and to re-vitalise natural processes.

Among the Danube countries Romania has the biggest surface potential area with reconnection potential, where despite negative impacts of human interventions, especially regulation of the river ecosystems through embankment and land reclamation for agriculture, forestry and aquaculture, the Danube floodplain still offers opportunities for restoration (around 70 000 ha) (Figure 53).

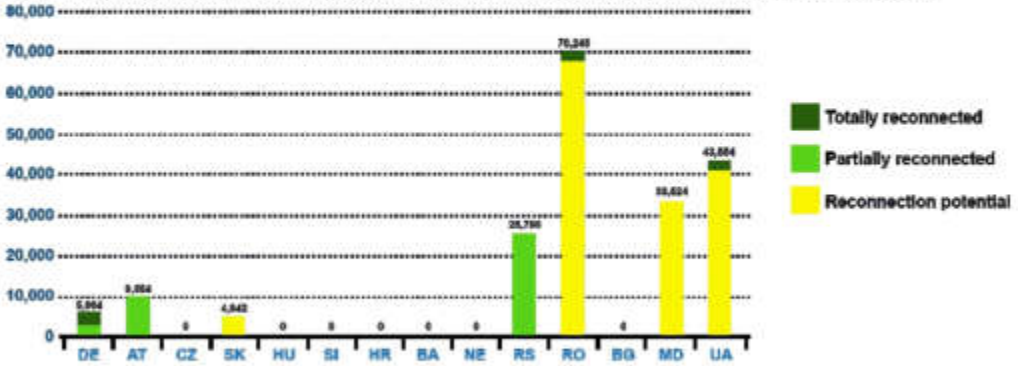


Figure 53: Area (ha) of Danube River Basin District (DRBD) (with an area larger 500 ha or of basin-wide importance) which are reconnected or with reconnection potential (WWF, 2010)

Developing master plans or conservation plans for restoring the population of threatened fish species

Measures focused on restoration of aquatic habitats, such as improving physical habitats and sediment management that ensures sediment transport along the length of the river. In many rivers, habitat quality at the river banks is poor due to bank fixation. Removal of bank fixation is a prerequisite for many other measures like re-meandering or widening as well as initiating later channel migration and dynamics. Also tree-planting and/or preserving riparian zones aim to reverse the impacts of land use change by improving channel stability, aquatic habitat and terrestrial biodiversity. In Germany good experiences have been achieved by dyke relocation projects to allow the river inundating a greater share of its former floodplain again, as already implemented. It is estimated that 40 to 56% of lost floodplain areas may potentially be re-gained again by dyke relocation that is mainly motivated and financed by flood protection (Ehlert & Natho 2017) (Fig. 54).

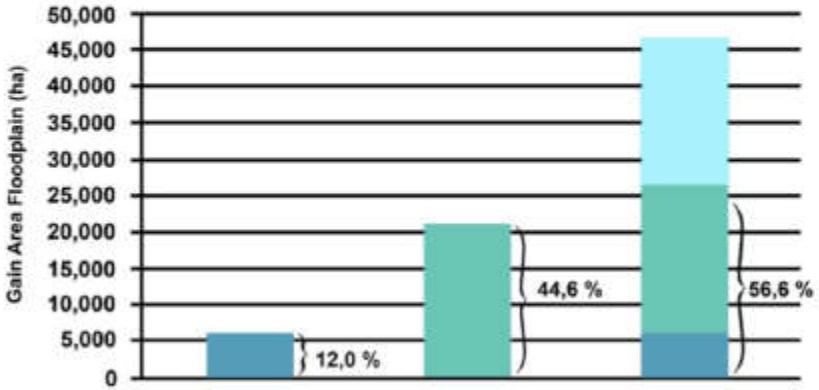


Figure 54: Gain in floodplain area by dyke relocations, after Ehlert & Natho 2017
Legend: light blue - via national strategy biological diversity; middle blue - via national flood protection strategy; dark blue - already accomplished by dyke relocation until 2018.

5.3 Invasive Alien Species

Invasive alien species are plants or animals that are introduced by man, accidentally or intentionally, outside of their natural geographic range into an area where they are originally not present.

They are often introduced by trade via ships, by shipping of wood products infested with insects, or by the transport of ornamental plants that then establish themselves into the wild and spread (www.iucn.org). Such species introductions may impact regional biodiversity, resulting in the decline or even elimination of native species - through competition, predation, or transmission of pathogens - and in the change of ecosystem structure, and in the disruption of ecosystem functions.

Since the construction of the Rhine–Main–Danube Canal, the Danube is a part of the Southern Invasive Corridor connecting Black Sea through the Danube - Danube/Main/Rhine Canal - Rhine with the North Sea), thus being exposed to intensive colonization by invasive species.

When invasive species are first introduced to habitats suitable for their ecological range, they are not limited by enemies or diseases, which causes massive growth.

Thus invasive species become a major concern in the Danube. Non-indigenous species were recorded among algae, aquatic macrophytes, macroinvertebrates, fish and fish parasites.

During the Joint Danube Survey 3, a joint survey conducted by many countries and authorities along the Danube organized in 2013, 25 neophytes (4 aquatic), 34 non-native aquatic macroinvertebrates and 12 non-native fish species were recorded.

The overview of the situation of bioinvasions over the period 2001-2013 (Paunović et al. 2015), based on the results of four Danube Surveys, clearly showed continuous impact of alien species to native biota and considerable rise of number of non-native aquatic macroinvertebrate species (from 20 species in 2007 to 34 species in 2013).

Considering the number of individuals, there are differences among the three sections of the Danube. The upper part is the most affected from invasion, where the share of neozoa relative numbers is between roughly 45 to 85 % (Figure 55).

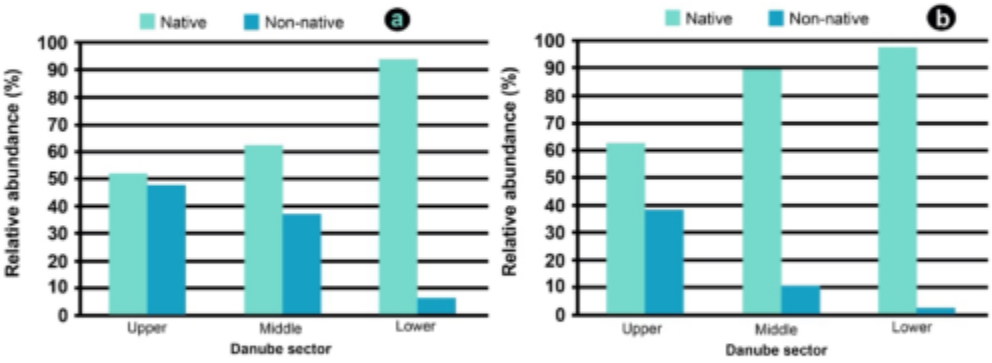


Figure 55: Average percentages of alien macroinvertebrates (a) and fish (b) within the three main Danube sections (Danube Joint Survey 3) (Modified after Paunović et al.)

The Danube River is inhabited by 4,5% non-indigenous macroinvertebrate species (according to Joint Danube Survey JDS2), belonging to the systematic orders Molluscs or Crustaceans. Most of them are taxa originating in the Ponto-Caspian area.

Some examples are the floating prawn (*Limnomysis benedeni*) (Figure 56) and the round goby (*Neogobius melanostomus*), both with maritime origin. But also from other origins invasive species were recorded, for example the Asian clam (*Corbicula fluminea*) (Figure 57).

Figure 57. Corbicula fluminea, the Asian clam (photo by Franco F.)

The non native goby fish species was found in high or even dominating abundance along the artificial rip-rap protection of river banks in the upper and middle course of the Danube, and gibel carp, were found to be extremely abundant in the Lower Danube (Danube Joint Survey 3- 2013).

Figure 58. Dikerogammarus villosus, the killer shrimp. Its origin is the Ponto-Caspian area (photo by Giesen S.)

The Joint Danube Survey in 2007 (JDS1) found killer shrimps, *Dikerogammarus villosus* (Figure 58), which was sampled along the river at 93% of the sites, Asian clams (*Corbicula fluminea*) sampled at 90% of the sites and carpets of weeds *Eichhornia crassipes* sampled at 69% of the sites.

Killer shrimps can adapt to a wide range of habitats and cause significant ecological disruption such as species reduction.

The water hyacinth (*Eichhornia crassipes*) is considered to be one of the worst aquatic weeds in the world.

Figure 56. Limnomysis benedeni, Ponto-Caspian (ANEBO - http://www.neozoen-bodensee.de/neozoen)

5.3.1. Mitigation measures

A convention for international ballast-water handling has been ratified in 2013, but it is valid only for marine navigation.

So far there does not exist a similar methodology of assessment for freshwater biota. A provisional methodology to identify biocontamination with invasive species is available only for macroinvertebrate animals (Arbačiauskas et al. 2008).

In many cases of species living in the lower Danube it is not clear if species are originate from the area or are invasive to that region (Paunović et al. 2015). Due to the already high abundances of invasive species, conservationists therefore need to act against bioinvasion or at least inform and educate the local communities and regional agencies at several levels.

6. Danube Nature Guides training weeks in images

In the framework of the 'Danube Nature Guides' project, two joint thematic field courses were organized in Germany and Romania under the motto "Discover the Danube floodplain – field trips", which specifically refer to conditions in both the nature park „Upper Danube" along the Danube in Baden-Württemberg and in the protected areas of the Lower Danube in south-east Romania, as the Lower Prut Floodplain Natural Park, Danube Delta Biosphere Reserve, and the Macin Mountains National Park.

During these trips, ecological field methods there were applied in order to recognize and assess the biodiversity, the ecological status of a riverine landscape, ecosystem services offered by Danube and its floodplain, human impacts on habitats and, as well as, self-initiative and development of nature-based economic practices with a focus on nature-based tourism.

Thereby, the young Romanian participants are supported even after the finish of the project by the German Gewässerführer through voluntary individual collaboration, which thus leads the development of a lasting network of trained naturalists from both endpoints of the Danube corridor.

Discover the Upper Danube – Beuron field trip

Getting to know each other in the Nature Friends Hause (Naturfreundehaus) Beuron (photo by Mormocea O.)

Intercultural dinner: food & heritage – regional food from regional areas of the participants (photo by Schmidt-Halewicz S.)

Activities for developing a "Danube Vocabulary" (photo by Mormocea O.)

Ecological Network - games (photo by Mormocea O.)

Assessment of the habitat structure (photo by Mormocea O.)

Assessment of the water quality (photo by Mormocea O.)

Aquatic organisms and their importance (photos by Schmidt-Halewicz S., Costea G.)

Danube restoration example in Hundersingen-Binzwangen (photo by Mormocea O.)

Naturschutzzentrum Beuron (photo by Mormocea O.)

Nature based handcrafting workshops - Willow and felt crafts (photo by Costea G.)

Canoeing on Danube between Riedlingen and Zwiefaltendorf (photo by Schmidt-Halewicz S.)

Discover the Lower Danube floodplain – Galati field trip

Presentations and role games: aquatic ecosystem services, storytelling - developing an attractive nature guide tour (photo by Mormocea O.)

Danube Delta Eco-Tourism Museum Center Tulcea (photo by Mormocea O.)

The structure and the functions of the floodplain - Danube Delta Biosphere Reserve (photo by Nasab F.)

The structure and the functions of the floodplain - Danube Delta Biosphere Reserve (photo by Costea G.)

Assessment of the structure of the habitat, water chemistry and aquatic invertebrates, in Lower Prut river floodplain (photo by Nasab F.)

Comparing Naturpark 'Obere Donau' with 'Macin Mountains National Park': Vegetation gradients from the river through humid forests until hot steppe vegetation (photo by Costea G.)

Learning, discover and experience in Natural Science Museum Complex Galati (photo by Costea G.)

Nature based handcrafting workshops at Village Museum Garboavele Forest' Galati (photos by Hänle G., Schmidt-Halewicz S.)

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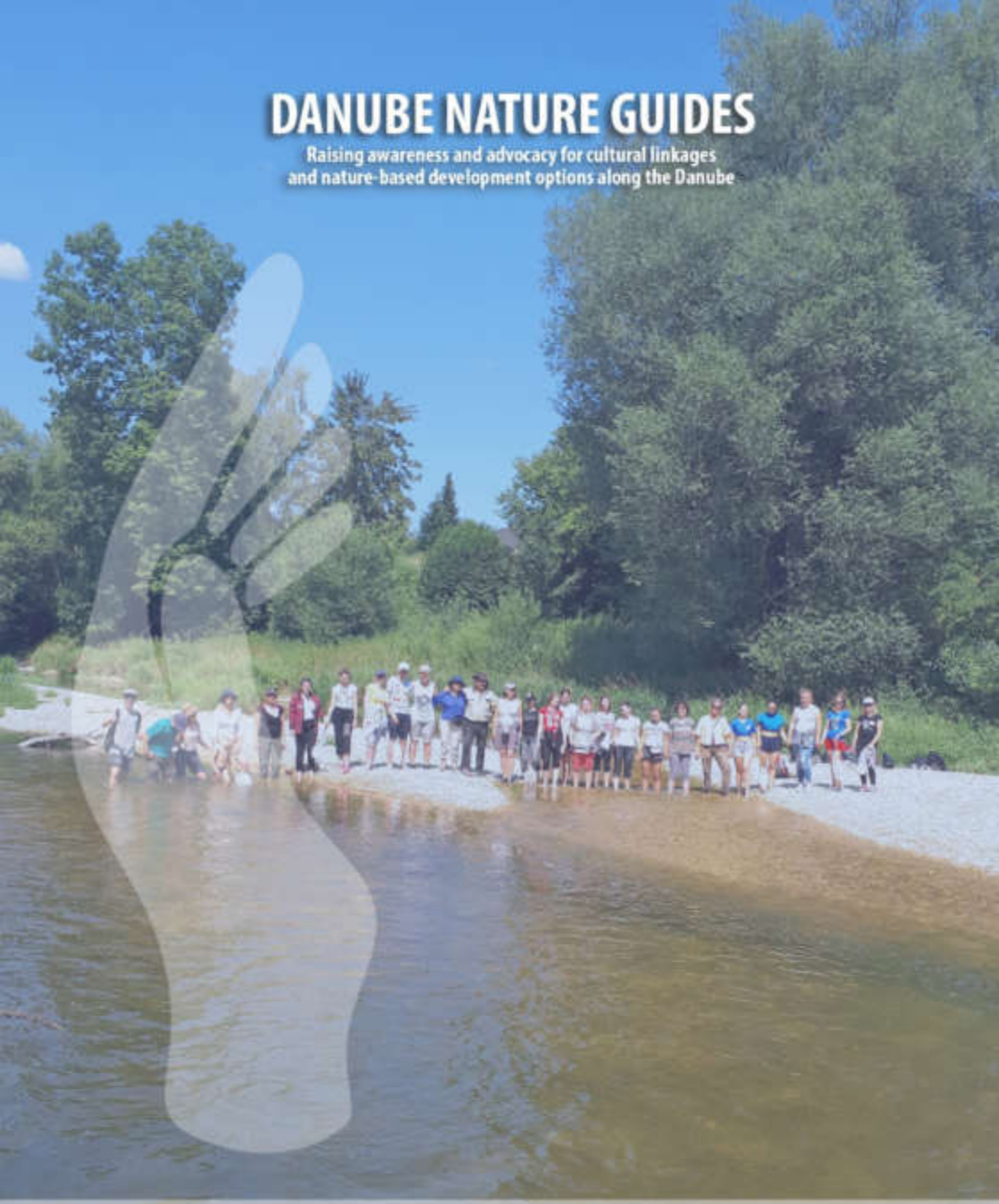
DANUBE NATURE GUIDES

Raising awareness and advocacy for cultural linkages
and nature-based development options along the Danube



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