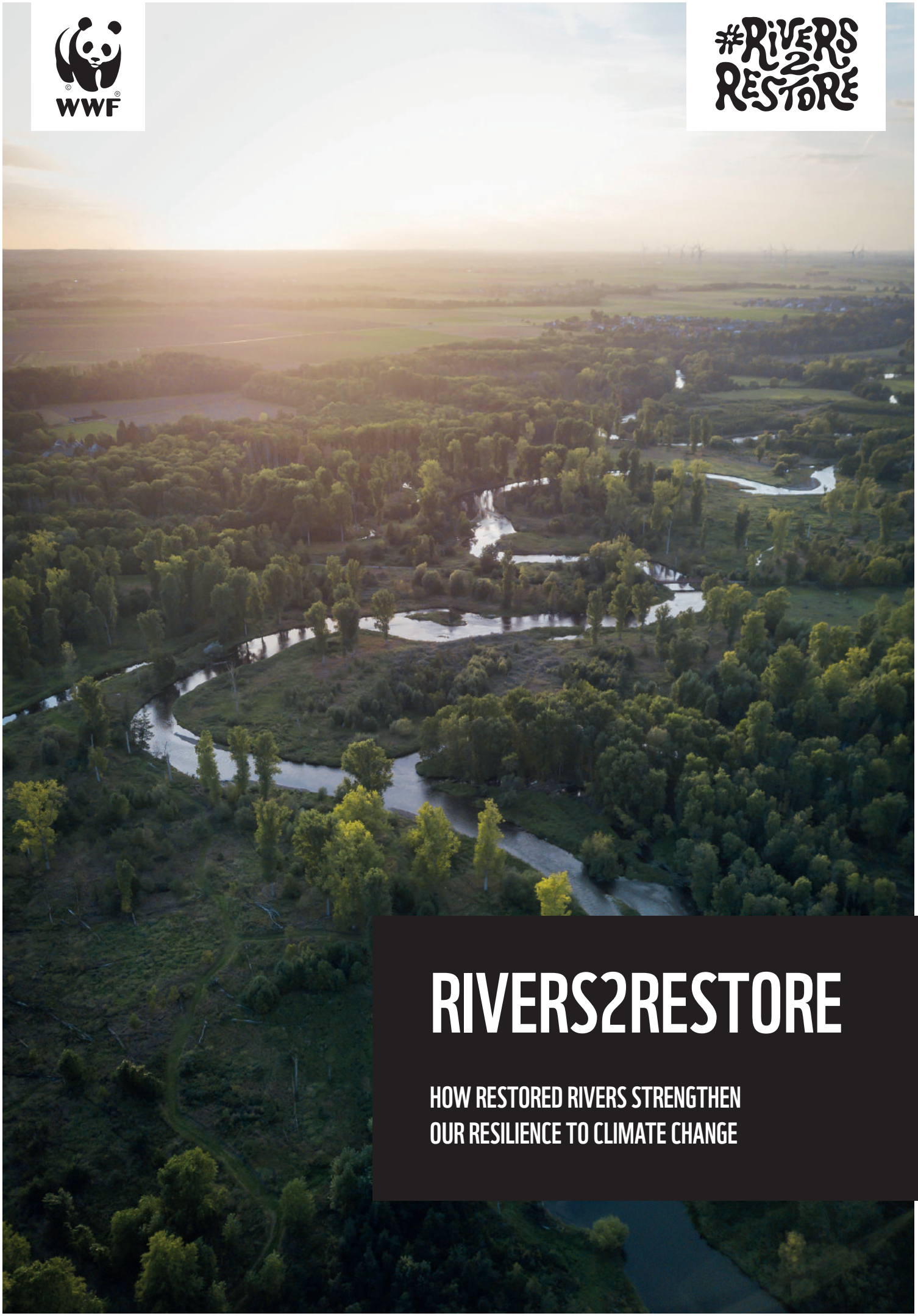

RIVERS2RESTORE

HOW RESTORED RIVERS STRENGTHEN OUR RESILIENCE TO CLIMATE CHANGE

Written by Claire Baffert and Zoë Casey, WWF European Policy Office based on invaluable contributions from all the WWF offices in countries covered in this report – Austria, Finland, Germany, Greece, Italy, Latvia, Netherlands, Portugal, Romania, Slovakia and Spain – and from Trinomics.

WWF is an independent conservation organisation, with more than 38 million followers and a global network active through local leadership in over 100 countries.

Our mission is to stop the degradation of the planet's natural environment and to build a future in which people live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

The WWF European Policy Office wishes to thank the colleagues for their contribution and support, in particular WWF-Netherlands and the Living European Rivers initiative.

Design: Doug Dawson Creative, www.dougdawson.co.uk

Maps: created by Jelena Milic

Cover photography: A naturally meandering river © Adobe stock

The Palokki Reservoir © Heidi Volotinen

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FOREWORD

© Joakim Wang-Erlandson

"Rivers are the cradle, the lifeblood, and the heart of European civilisations, but nowhere in the world are river systems as afflicted as in Europe. Dams have been built to generate power and control flows; canals have been made to facilitate transport and navigation; and wetlands have been drained to make space for other uses. These engineered waterways prevent fish from reaching their spawning grounds, freshwater from taking a meandering route back to the ocean, and sediment from replenishing the strange and beautiful seashores. Astonishingly, today's European rivers are fragmented by over one million barriers, such as dams, weirs, sluices, culverts, fords, and ramps. Add invasive species, fertilisers, pollutants, and rising temperatures, and it is no wonder that 70-90 % of Europe's floodplains are found in a degraded state and more than half of European rivers have failed to achieve a good ecological status. Today, more than a third of European fish species are currently at risk of extinction, far greater than the extinction threat faced by birds and mammals.

Schleier-Falls © Sigrun Lange

The state of rivers is a mirror to the state of the planet, an expression of the assaults along water's long journey from oceans, through the sky, the soil, the living, the built environment, and the great landscapes. To date, six of nine planetary boundaries have been breached: climate change, biosphere integrity, novel entities, biogeochemical flows, land system change, and freshwater change, whose transgression is indicated by unprecedented water extremes and widespread water-driven ecosystem degradation. Human pressures have pushed the Earth system outside the quasi-stable conditions of the past 11,700 years and the only state of the planet known to be able to support large-scale, agriculture-based civilisations. Restoring river systems to healthy states is necessary for reversing the transgression of the freshwater boundary, and will also enhance carbon sinks, benefit functional and genetic biodiversity, limit nutrient overloads, and revitalise soils. In other words, mending the delicate web of river systems will also help bring humanity back within the planetary safe zone across all fronts.

A paradigm shift is now within sight, as the importance of nature for societies is recognised across fields and societal sectors, not only in ecology and civil society, but also in economics, peace and security, and governance. In Europe, major policies and programmes are in place to restore, rewild, and revitalise rivers. The European Union's Biodiversity Strategy aims to reconnect 25,000 km of Europe's rivers by 2030, which if achieved, could mean that the ecological state of European rivers may be on the cusp of a big turn-around. Building on this momentum, the WWF Rivers2Restore flagship river restoration projects in Europe are timely efforts to breathe life back into hundreds of kilometres of Europe's rivers. This report shows that a new respectful and healthy alliance with rivers is not only a moral and beautiful endeavour, but also a clever and rational one. Through 11 inspiring case studies, the report shows how rivers can be revitalised, holistically and systematically. I call on all those involved to show the ambition needed to make these projects a reality for nature, for people and for a more climate and water-resilient Europe.

Now is the time to heal the planet, one vibrant river at a time."

Lan Wang-Erlandsson, PhD

Theme leader and researcher at Stockholm Resilience Centre, Stockholm University

EXECUTIVE SUMMARY

Europe's rivers are in crisis. They have been deeply altered from their natural form and function with dams, embankments, dredged river beds and drained floodplains. Their mismanagement means they are prone to devastating floods and damaging dry spells, worsened by climate change. Restoring the natural shape, habitats, flow and functioning of the river system, including its floodplains, by removing river barriers and creating more space for nature in and along the river, offers a multitude of benefits and is urgently needed to improve our resilience to climate change impacts and bring back biodiversity.

Small dam on the wiselce. Wisla, Silesian Beskids. Poland © Adobe stock

WHY RESTORE RIVERS?

Restoring rivers helps mitigate the risk of flooding by allowing rivers to expand in upstream areas during heavy rains, reducing the flood risk for towns and cities downstream. It helps prevent drought by allowing groundwater to recharge and water to be stored in the soil. Revitalising and enhancing the natural flow and ecosystem of rivers provides improved water quality, which, in turn, supports diverse aquatic life and addresses freshwater biodiversity loss. Restored rivers provide cleaner sources of drinking water, and support food production. Restoring rivers provides substantial economic benefits since healthy river ecosystems can stimulate tourism and recreation industries, attracting visitors interested in activities like fishing, boating, and hiking.

WWF'S RIVERS2RESTORE PROJECTS

#RIVERS2RESTORE

Rivers2Restore is a collection of 11 flagship river restoration projects across the EU that are bringing rivers degraded by human activity back to health by restoring nature. WWF selected the 11 projects for their strong potential to help address freshwater biodiversity loss in Europe, while boosting our resilience to the impacts of climate change. They provide inspirational examples of the ecological and societal benefits of restoration and demonstrate that river restoration can be replicated across more countries and other river basins. The sites cover 2,200 km of rivers whose restoration to a free-flowing state – where barriers are removed and rivers are reconnected to their floodplains[1] – would make a significant contribution to the European Green Deal, the United Nations climate and biodiversity goals and the Freshwater Challenge[2]. Rivers2Restore are projects that EU governments should include in their National Restoration Plans, helping them meet their commitments under the new EU Nature Restoration Law by 2030, which includes a target to restore 25,000 km of free-flowing rivers.

RIVERS2RESTORE IS A COLLECTION OF

11

FLAGSHIP RIVER RESTORATION PROJECTS ACROSS THE EU THAT ARE BRINGING RIVERS DEGRADED BY HUMAN ACTIVITY BACK TO HEALTH BY RESTORING NATURE.

1. See definition of a free-flowing river on p.13.
2. https://www.freshwaterchallenge.org/

THE 11 RIVERS2RESTORE SITES

OUR ASKS

We call on national governments in the EU to include Rivers2Restore projects in National Restoration Plans and work towards their implementation by 2030. We are looking forward to collaborating with governments in the coming years to work together towards this goal. We call on governments to ensure that the necessary permits and authorisations for the restoration works are delivered, that funding is secured, and that governments engage more broadly in planning and delivering river restoration beyond Rivers2Restore projects in order to achieve the objectives of the EU Nature Restoration Law and the Water Framework Directive.

We call on the European Commission to support and encourage national governments to include Rivers2Restore sites in National Restoration Plans. We also call on the European Commission, when assessing those plans in 2026-2027, to flag any insufficient ambition on river restoration.

IF WWF RIVERS2RESTORE SITES ARE MADE FREE-FLOWING,

THEY WILL DELIVER NEARLY 10% OF THE EU OBJECTIVE OF RESTORING 25,000 KM OF FREE-FLOWING RIVERS BY 2030.

INTRODUCTION

River delta © Adobe stock

People and nature in Europe are increasingly vulnerable to the impacts of climate change

Floods, droughts, and forest fires are becoming more intense and more frequent across Europe. These extreme weather events drive food prices upwards, destroy infrastructure and ecosystems and affect our personal choices like where we want to live.

We are experiencing the climate crisis mainly through water: either through a shortage leading to chronic drought, or an excess leading to devastating floods, and these events are hitting all parts of Europe. The floods caused by storm Daniel in Greece in September 2023 caused a death toll of at least 17 in the country and massive damage to people's houses, crops and infrastructure. About 75,000 hectares of land were flooded and the cost of repairing the damage is estimated at several billions of euros[3]. Navigation was disrupted on the Rhine river in Summer 2022 because of low water levels, resulting in higher carrying costs which increased the risk of an economic recession in Germany[4]. Between 1980 and 2021, weather and climate-related extremes have cost an estimated €560 billion, with floods representing over 45% of the total[5].

HEALTHY, NATURAL RIVERS ARE A CLIMATE SOLUTION - BUT THEY ARE HEAVILY DEGRADED

To increase our resilience to extreme weather events, and make sure humanity and nature can continue to thrive for generations to come, we need to act on the way we manage our water resources and freshwater ecosystems. We can no longer take our rivers and their floodplains for granted by "fixing" them with concrete flood defences, severing them with dams, draining them for agriculture and urbanisation, and straightening them when it suits our short-term economic needs. We need to allow room for rivers to flow freely and naturally, so they can become our best allies to cope with climate change by buffering the impacts of extreme weather.

Europe's addiction to heavily engineering its rivers began in the nineteenth century[6]. As people started to settle closer to rivers, massive infrastructure was built across them, partly for flood protection (artificial dikes and dams), and partly to allow for farming (e.g. wetlands drained for intensive agriculture), river transport (rivers straightened and stabilised for navigation), hydropower and urbanisation on and along rivers and their adjacent floodplains. Rivers and their surrounding environment started to be seen as resources to exploit. 70-90 % of Europe's floodplains have been environmentally degraded as a result of flood protection, river straightening, disconnection and draining of wetlands, agricultural land use and urbanisation over the past two centuries[7].

With more than one million barriers clogging Europe's rivers[8], and almost no large free-flowing rivers left[9], Europe's rivers are the most fragmented in the world. Most of Europe's rivers also have partially artificial courses and are cut off from their floodplains meaning that they are no longer able to act as natural buffers to extreme water shortages or excesses.

In addition to degradations in their shape and flow, rivers have been altered by other human pressures such as pollution, abstraction, and climate change. Only 40% of Europe's surface water bodies are in good ecological status and wetlands are widely degraded. The recovery of European freshwater species has come to halt due to pressures on freshwater ecosystems, including new pollutants, climate change and the spread of invasive species[10].

"We need to allow room for rivers to flow freely and naturally, so they can become our best allies to cope with climate change by buffering the impacts of extreme weather."

Claire Baffert, Senior Policy Officer, Water and Climate Adaptation, WWF European Policy Office

3. WWF Greece.
4. Central Commission for the Navigation on the Rhine, 2023, and Binnenschifffahrt: Niedrigwasser erschwert Frachtverkehr | tagesschau.de
5. European Environmental Agency, 2023, Economic losses from climate-related extremes in Europe (8th EAP), 2023.
6. Maaß, AL., Schüttrumpf, H. & Lehmkuhl, F. Human impact on fluvial systems in Europe with special regard to today's river restorations. Environ Sci Eur 33, 119, 2021.
7. European Environmental Agency, Floodplains – a Natural system to preserve and restore, 2019.
8. AMBER Consortium. The AMBER Barrier Atlas. A Pan-European database of artificial instream barriers. Version 1.0 June 29th 2020.
9. Grill, G., Lehner, et. al. Mapping the world's free-flowing rivers. Nature, 569(0), 215-221, 2019.
10. Haase et al. The recovery of European freshwater biodiversity has come to halt. Nature Vol. 620, August 2023.

Moreover, scientists have recently found that the freshwater planetary boundary has been crossed for both 'blue' water – water transiting in rivers, lakes and aquifers – and 'green' water – the water available to plants through precipitation, evaporation and soil moisture[11]. These freshwater dynamics, which are fundamental to supporting and regulating water, energy and carbon cycles, are now extensively perturbed by human pressures, such as deforestation, land and soil degradation, or water withdrawal for irrigation, to a degree that the earth system can no longer absorb those modifications. However, the trend can still be reversed and river restoration can contribute to returning to a safe point where planetary boundaries are not transgressed.

WE NEED RESTORED RIVERS TO MAKE SOCIETY AND NATURE RESILIENT TO CLIMATE CHANGE

WHAT IS RESILIENCE TO CLIMATE CHANGE?

According to the London School of Economics, resilience to climate change is defined as "the capacity to prepare for, respond to, and recover from the impacts of hazardous climatic events while incurring minimal damage to societal wellbeing, the economy and the environment."

Restoring the natural conditions and dynamics of rivers means restoring the natural shape (for instance, restoring their meanders when they have been artificially straightened), habitat, flow and functioning of the entire river system, including its floodplains. In a nutshell, it means removing river barriers and creating more space for nature in and along the river, which improves our resilience to climate change during periods of excess and shortage of water.

Giving room to natural, free-flowing rivers provides:

- **Protection against floods:** More nature around rivers helps absorb excess water. Natural meanders slow down the river and help prevent rivers from bursting their banks during heavy rains. Recreating side-channels along the main river channel creates room for the river in case of higher flows. Removing lateral barriers such as dikes, or relocating them further away from the river bank to reconnect the river to its floodplain also means that excess water has room to spread into the floodplain area, reducing the flood peak downstream. Removing weirs or dams does not necessarily increase flood risks if it goes together with providing more space to the river downstream. On the contrary, studies show that in some rivers, dams may actually worsen flooding downstream, because fine particles are removed from the water, which causes riverbeds to coarsen and can worsen flooding[12].
- **Protection against storm surges and/or sea level rise:** When barriers such as weirs or dams are removed, rivers are more able to carry sediment downstream to nourish, replenish and rebuild floodplains, estuaries and beaches[13].
- **Protection against droughts:** Because nature absorbs water like a sponge, water is retained in the floodplain for longer, leading to increased infiltration and groundwater recharging, and improved soil moisture when the weather dries again. Natural rivers and floodplains therefore contribute to securing our drinking water supplies, and to reversing the decline in soil fertility.
- **Protection against heat waves:** Rivers have a cooling effect on the environment, and this effect is greater when the rivers are connected to green spaces[14]. Natural river vegetation also provides useful shading and helps limit river warming, which threatens many aquatic organisms[15].

Restoring rivers also contributes to building climate resilience by reducing carbon emissions. The riparian zones of rivers, such as riparian forests, floodplains (which cover 7 % of the continent's area), deltas, and estuaries can significantly contribute to carbon uptake and storage[16], while drying inland waters release carbon emissions to the atmosphere[17].

WE NEED RESTORED RIVERS TO SLOW DOWN THE BIODIVERSITY CRISIS

According to WWF's Living Planet Index, freshwater biodiversity is the most threatened on earth, with a 83% decline in freshwater populations globally since 1970[18]. In Europe, migratory fish populations, including salmon, sturgeon and eel, have declined by 93% since 1970[19], 60% of EU rivers, lakes and wetlands are not healthy[20] and Europe's rivers are the most fragmented on the planet. Addressing the freshwater biodiversity decline is therefore crucial if we want to halt biodiversity loss and achieve EU and global biodiversity goals. Restoring riverine habitats, and addressing pollution, can help restart the recovery of freshwater species which has come to a halt in the last decade in Europe[21].

11. Stockholm Resilience Centre, 2023.
12. Ma, H., Nittrouer, J.A., Fu, X. *et al.* Amplification of downstream flood stage due to damming of fine-grained rivers. Nat Commun 13, 3054, 2022.
13. Dam Removal Europe, Dam removal: a growing trend to fix Europe's rivers, 2022.
14. Guo F, Xu S, Zhao J, Zhang H, Liu L, Zhang Z and Yin X Study on the mechanism of urban morphology on river cooling effect in severe cold regions. *Front. Public Health*. 11:1170627, 2023.
15. G. Kalny et al., The influence of riparian vegetation shading on water temperature during low flow conditions in a medium sized river, Knowl. Manag. Aquat. Ecosyst. 2017, 418, 5.
16. Tockner et al. Introduction to European rivers. In Rivers of Europe, 2022.
17. Paranaíba et al. Cross-continental importance of CH4 emissions from dry inland-waters: Cross-continental importance of CH4 emissions from dry inland-waters – ScienceDirect, 2022.
18. WWF, Living Planet Index 2022.
19. Deinet, S., Scott-Gatty, K., Rotton, H., et. al. The Living Planet Index (LPI) for migratory freshwater fish – Technical Report. World Fish Migration Foundation, The Netherlands, 2020.
20. European Environment Agency, European waters — Assessment of status and pressures, 2018.
21. Haase et al. The recovery of European freshwater biodiversity has come to halt.. Nature Vol. 620, August 2023.

Removing longitudinal barriers such as dams helps fish populations recover as fish are able to move freely to reach their feeding and spawning grounds and fish mortality is reduced. Species which had previously moved away due to the lack of, *inter alia*, suitable habitats, can return within relatively short timespans[22]. It also improves water quality, as temperature fluctuations are lessened, and flow velocity, oxygenation and nutrient composition increases[23,24].

Removing lateral barriers, renaturing riverbanks and recreating side-channels also helps improve habitats for freshwater species in a much more efficient way than a simple adaptation of the existing lateral infrastructure would[25].

Finally, restoring floodplains can also help biodiversity thrive, especially if prioritised in the areas the most in need for restoration. In Europe, currently only 17% of floodplain habitats achieve good conservation status under the Habitats Directive[26]. Where the natural conditions of floodplain areas are restored, nitrate and phosphorus retention (which cause eutrophication) may also improve, thus enhancing the overall ecological quality of the water[27].

BENEFITS FOR CLIMATE AND NATURE; BENEFITS FOR PEOPLE AND THE ECONOMY

Restoring rivers, renaturing their banks and the floodplains, also improves the natural and aesthetic river environment. By improving people's experience of rivers, it can enhance the positive benefits for both physical and mental health associated with spending time in nature, which have been demonstrated by numerous studies[28]. Restoration can lead to benefits to fishers (enhanced catch), tourism (enhanced recreation), farmers (due to higher levels of water retained in the landscape, reducing exposure to drought) and reduction in flood damage and water treatment costs to local communities[29].

While restoring rivers has a cost, these investments in our future should be seen in the context of the long-term benefits of restoration. These include avoided flood and drought damage costs, improved health for people, gained tourism income and job creation during and after the restoration process. Studies that have looked at job creation from river restoration in Europe are limited, yet available studies indicate that at least eight extra full-time employment equivalents (FTEs) are created for every one million euros spent on river restoration[30]. The costs of restoring rivers also needs to be compared to the costs of alternatives, which in many cases entail maintaining hard infrastructure. Estimates in the USA show that removing 36,000 dams would be 10-30 times cheaper than repairing and maintaining them to keep up with safety standards[31]. In the Netherlands, planting alluvial forests on the river banks, for instance, often has a marginal cost compared to elevating or maintaining dikes – in addition to offering extra space for recreation[32]. Based on a study from Dordrecht municipality and numbers from the Dutch National Institute for Public Health and the Environment, it is estimated that renaturing 40,000 hectares across the Rhine and Maas delta (Haringvliet), could save €400 million a year in healthcare costs[33].

THE RIVERS2RESTORE PROJECT - A TURNING POINT FOR EUROPE'S RIVERS

Rivers are part of our heritage and we believe they are part of our future too. They have magnificently carved our landscapes and will continue to do so. They used to host rich wildlife and provide fertile ground, they still replenish our drinking water supplies and nourish our crops, and they are highly relevant to our economies and energy production. But they need our help to nurse them back to health and turn them into **free-flowing rivers**.

With Rivers2Restore, WWF presents 11 flagship rivers in 11 EU Member States, which have been degraded by human activity but can be made free-flowing and alive with nature again.

WHAT IS A FREE-FLOWING RIVER?

The European Commission suggests defining a free-flowing river as "one that supports connectivity of water, sediment, nutrients, matter and organisms within the river system and with surrounding landscapes, in all of the following four dimensions: 1. longitudinal (connectivity between up- and downstream); 2. lateral (connectivity to floodplain and riparian areas); 3. vertical (connectivity to groundwater and atmosphere); and 4. temporal (connectivity based on seasonality of fluxes). A free-flowing river is not impaired by anthropogenic barriers and is not disconnected from its floodplain when a floodplain is present."[34]

22. Dam Removal Europe Samlesbury Weir, Ribble River, UK, 2020. Available at: https://damremoval.eu/portfolio/samlesbury-weir-ribble-river-uk/
23. Dam Removal Europe, Dam removal: a growing trend to fix Europe's rivers, 2022.
24. Birnie□Gauvin et al. River connectivity reestablished: Effects and implications of six weir removals on brown trout smolt migration, 2018.
25. A study in the Danube analysed the effectiveness of four different restoration measures, across three years, finding that bank re-naturalization and side-arm reconnection were much more efficient than adaptation of groynes in the sense that it significantly increased both abundance and ratios of rheophilic (flow loving) fish species. Ramler and Keckeis (2019). Effects of large-river restoration measures on ecological fish guilds and focal species of conservation in a large European river (Danube, Austria).
26. European Environmental Agency, Floodplains: an ecosystem to protect and restore, 2019.
27. REFORM (2015) D1.4 – Inventory of restoration costs and benefits- Inventory of river restoration measures: effects, costs and benefits. REstoring rivers FOR effective catchment Management.
28. https://www.worldwildlife.org/stories/can-the-outdoors-help-our-health-wwf-s-elisabeth-george-reflects-on-nature-and-well-being
29. Nijland and Cals River restoration in Europe. Available at: https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=ECRR_conference_river_restoration_2000.pdf, 2001.
30. Spörri et al. The economic impacts of river rehabilitation: a regional input–output analysis, 2007.
31. Grabowski, Z; Chang, H; Granek, E.L. Fracturing dams, fractured data: Empirical trends and characteristics of existing and removed dams in the United States. Portland State University, 2018.
32. WWF Netherlands et. al., Room for Living Rivers manifesto, 2023.
33. WWF, ARK Rewilding Nederland, De Rijn-maasmonding natuurlijker, veiliger en leefbaarder, 2022.
34. European Commission, Guidance on barrier removal for river restoration, 2021.

Artist Petra Braun's illustration of a free-flowing river landscape where nature and people live in harmony

Our flagship river restoration projects, chosen for their ecological benefits and their potential to address societal challenges[35], as well as opportunities for restoration, are coming together across Europe for the first time to draw attention to the significant gains river restoration holds. Together, they cover 2, 200 km of Europe's rivers. We believe they can contribute to making Europe more resilient to the climate crisis, and to restoring freshwater biodiversity – while supporting peoples' well-being and the economy.

35. IUCN Global Standard for Nature-based Solutions.

WHAT DOES A RESTORED RIVER LANDSCAPE LOOK LIKE?

In upstream areas (such as Portugal's Vascão river, Slovakia's Belá River and Finland's Palokinkosket rapids), the restoration will often take the form of dam removal in order to recreate a natural flow, improve water quality as well as aquatic species' habitats. In middle river sections, the restoration will often take the form of recreating former meanders (Austria's Morava river), removing or relocating dikes (the Kalentzis river in Greece) to restore the natural characteristics of river banks, retain water and prevent flooding. In middle sections the natural vegetation can be replanted on the river banks (such as on the river Adige in Italy). The restoration can also entail restoring the natural functions of the floodplains by stopping drainage practices (like on the Geul in the Netherlands) and allowing the floodplain to take on excess water, or reconnecting a side-branch. The removal of dams (Latvia's Dienvidsusēja river) or weirs (as on Germany's river Ammer) may also happen in those middle sections. In rivers near their end in estuaries (Spain's Guadalquivir river) and deltas (Romania's section of the River Danube), restoration can take the form of allowing more space for the river.

"We envision healthy rivers and wetlands in blue-green landscapes as crucial components for building resilience on land."

Wageningen University & Research, Imagining a nature-based future for Europe in 2120, August 2023.

A MOMENTUM FOR ACTION – HELPING GOVERNMENTS TO DELIVER ON THEIR LEGAL COMMITMENTS

In March 2024, the EU adopted the **Nature Restoration Law** which sets legally binding requirements for every Member State to restore ecosystems, a key pillar of the European Green Deal. Each Member State is required to deliver a national restoration plan detailing concrete actions to achieve the objectives set by the law for each ecosystem (a first draft shall be submitted in mid-2026). In these plans, Member States will need to highlight how they plan to contribute to the target of restoring at least 25,000 km of free-flowing rivers by 2030 through barrier removal and floodplain restoration – an objective which is part of the EU Biodiversity Strategy for 2030. We call for Rivers2Restore sites to be included in the National Restoration Plans, and restoration should be conducted by the end of 2030 to feed into the EU 2030 target and inspire governments to plan, finance and undertake similar other projects on their territory.

Rivers2Restore will help achieve other commitments under EU laws, including the **Water Framework Directive and the Habitats Directive**.

Rivers2Restore will also help governments to deliver on their international commitments on climate and biodiversity. The **United Nations Framework Convention on Climate Change (UNFCCC)** commits all Parties to formulate, implement, publish and update climate adaptation measures, as well as to cooperate on adaptation. In December 2022, all EU Member States also signed the Kunming-Montreal Global Biodiversity Framework (GBF), a landmark agreement where they committed to "ensure that by 2030 at least 30 percent of areas of degraded terrestrial, inland water, and marine and coastal ecosystems are under effective restoration, in order to enhance biodiversity and ecosystem functions and services, ecological integrity and connectivity"[36]. Although most Member States still have to submit their revised and updated National Biodiversity Strategy Action Plans outlining their national contribution towards delivery of those targets, Rivers2Restore may also help achieve the restoration objectives. Rivers2Restore can also feed into the Freshwater Challenge, a country-driven initiative supported by WWF and various partners to leverage the support needed to restore 300,000 km of degraded rivers and 350 million hectares of degraded wetlands by 2030 and protect intact freshwater ecosystems.

Rivers2Restore is a turning point for Europe's rivers designed to provide inspiration and show the benefits[37] of river restoration for nature and society that can be upscaled far beyond the 25,000km of free-flowing rivers called for in the EU Biodiversity Strategy. WWF is willing to engage with governments at national, regional and local level to work together on these restoration projects to bring Europe's rivers back to life, to increase the climate resilience of our landscapes, our economies, and our very own health.

36. Kunming-Montreal Global Biodiversity Framework, target 2.
37. A description of the methodology used to select the Rivers2Restore sites and assess their expected benefits is provided in an annex.

A natural section of the river Danube © Adrian Lungu, WWF-Romania, 2023

"The better the ecological state of our freshwaters, the greater resilience they have to the impacts of climate change."

RIVERS2RESTORE

Chiese river © Adobe stock

AUSTRIA: THE MORAVA

A ONCE WINDING RIVER, CUT OFF FROM ITS MEANDERS

The wetlands of the Morava floodplains (March-Auen), together with the Dyje floodplains (Thaya-Auen), cover an area of 60,000 hectares on the border shared with the Czech Republic, Austria and Slovakia. Before the river was regulated (1940-1970), the meandering lowland river shaped the landscape, and created wide floodplains with side branches, meadows, forests and oxbow lakes. Because of the presence of many different climate and soil types, and the varied elevation of the land, the area was characterised by an extraordinarily high biodiversity, which attracted the attention of many scientists in past centuries. More recently, the area was part of the iron curtain, which meant it was inaccessible and/or neglected, which helped biodiversity to survive. Today, the floodplain area is mainly composed of forests and meadows. The river and its floodplains are part of the Natura 2000 site March-Thaya-Auen, and of the Ramsar site Donau-March-Thaya-Auen.

DID YOU KNOW THAT...

in total, about 1 million m^3 of stones were used to stop the river banks from shifting? That is almost ½ of the amount of stone needed to build the Cheops pyramid.

A stone embankment on the Morava © WWF

ID CARD

Name of river:
Morava (March in German)

Length of the river:
about 358 km from source to its end in the Danube

Average discharge:
officially 108 m^3/s, however closer now to 80 m^3/s due to climate change, and in summer mostly only 20-30 m^3/s

Tributary to the Danube

Protected area:
Natura 2000 site March-Thaya-Auen (AT1202V00 and AT1202000), Ramsar Site.

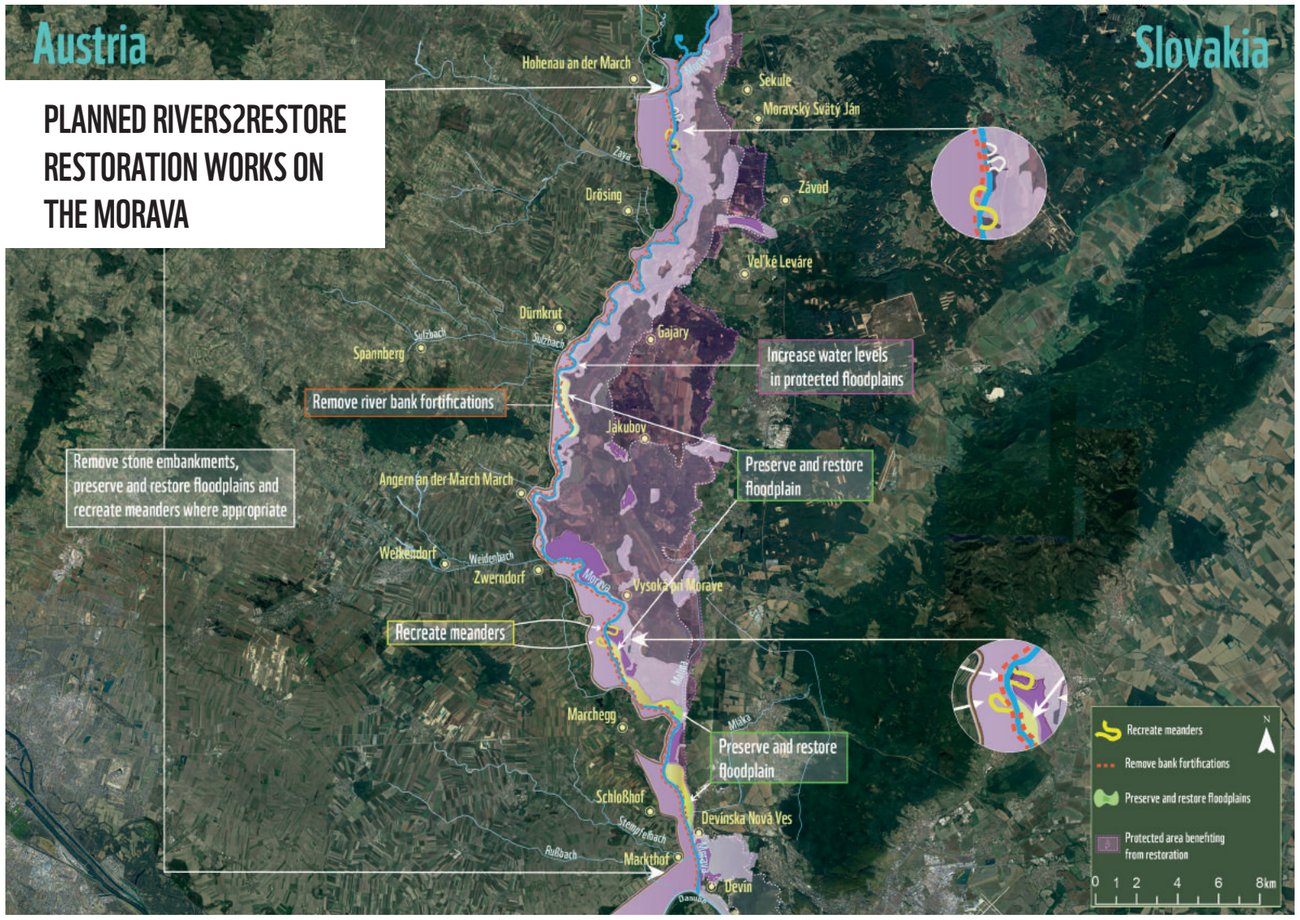
The Morava © WWF

A RIVER STRAIGHTENED WITH BOULDERS

The regulation of the river in the past century had a significant impact on the ecosystems of the Morava wetlands. Meanders were cut off, the river was straightened, and the embankments were fixed with heavy stones.

As a result of the regulation, the lower Morava lost 15% of its length. This means that water retention is reduced, natural dynamics have largely disappeared, the river bed is being deepened by soil erosion, the river is cut off from its floodplains, and the groundwater table is gradually falling. These negative impacts are intensified by climate change. During summer, water levels now fall to historically low levels, and the floodplain ecosystem suffers from drought.

The Morava river in 1942 shortly before regulation (above), and its straightened course in 2020 (below)



On average, due to the cumulative effects of the regulation of the river and climate change, average water surface levels in the Morava river have fallen by one metre since the 1960s. Together with these steadily falling river water levels, the water level in the surrounding floodplains is also falling, down to a level where there is no water left in the former wetlands. As a result, species dependent on open water and temporary ponds, like amphibians, fish and water birds, are decreasing in number.

Although the water quality improved in the last 30 years due to the construction of wastewater treatment plants, the river's status was reported as 'moderate' between 2016 and 2021, not meeting the requirements of the EU Water Framework Directive, mainly due to the alterations to the river's natural morphology. After the fall of the Iron Curtain in 1989, the status of the Morava as an inland navigation channel, and plans to turn the river into a part of the proposed Danube-Oder-Elbe Canal, posed a serious threat, and hindered nature restoration projects. But in 2022, these plans were cancelled, and for the first time in history, there is a political consensus between Austria and Slovakia to restore the river and its floodplains into a natural floodplain landscape.

REMOVING STONES ALONG THE MORAVA WILL RECREATE NATURAL RIVER BANKS

Removing river embankments © WWF

The lower Morava stretch, between the confluence with the Thaya and the Morava mouth in the Danube, is now 69 km-long, which compares to approximately 85 km before the regulation. 90% of the river banks on the Austrian side, and about one third on the Slovakian side are fixed with stones. By removing all the stones along 60 km on the Austrian side and about 20 km on the Slovak side, the river will get the chance to shape its own bed again, and create natural banks with shallow and steep slopes, and gravel islands.

The leading principle should be to let nature do the rest of the work. However, the reconnection of old side branches and meanders, and closing the artificial cut-offs, can make sense in some locations, since the erosive force of the Morava is not very high, and the spontaneous establishment of meanders and other natural structures would probably take a very long time. By reconnecting old meanders, the length of the river will increase, therefore creating more nature and reducing water velocity. New room will be made for the river to expand safely on adjacent river banks (forest and meadow) in the case of floods, allowing nature to benefit. The old dikes will stay, as most of them are located 300 to 500 metres away from the river bed and therefore do not impede the free-flowing character of the river.

Glancing to the other side...

On the Slovak side of the Morava, the riverbanks suffered similar alterations to the ones on the Austrian side, along about 20 km. A LIFE project is currently underway to remove 2.4 km of bank fortifications and improve the water regime of the river arm on the Slovak side. In addition, as part of the Recovery and Resilience Plan of the Slovak Republic, plans are in place to recreate two meanders, remove 17 km of bank fortification and improve the hydrological regime of six other former meanders or side-arms. WWF supports these plans and recommends their full implementation.

NATURE RESTORED AND HIGH WATER QUALITY


An artistic impression of what the future of the Morava floodplains might look like © WWF.

After three-quarters of a century of being fixed in an artificial bed, the Morava will be able to shape its own bed and floodplain landscape again. River and groundwater levels will be expected to rise again over the course of the time, and the regular inundations of the floodplains will increase in number. In this way, the rich wetlands that were

Drought on the Morava © WWF

once present everywhere alongside the river, and that still survive in some places, will be revitalised, and the Morava floodplains can once again become the biodiversity hotspot that they used to be. The restoration of the Morava banks could also help achieve the objectives set by EU Law under the Water Framework Directive, improving the ecological status of the river from "moderate" or "good".

About 200 km² of floodplains will be restored due to the removal of 60 km of artificial stone embankment on the Austrian side of the Morava and about 20 km on the Slovak side.

Barrier removal will also improve the conservation of the habitats protected under the Habitats directive, such as floodplain forests and meadows. An infringement procedure against Austria is currently ongoing for the poor implementation of the EU Habitats Directive in this part of the country.

About 60 km of free-flowing Morava will contribute 0.28% of the EU's objective of restoring 25,000 km of free-flowing rivers in Europe.

A restored river will also boost local tourism and create jobs. The consequences of extreme weather events, such as excessive rainfall and drought, could also be reduced by increasing the flooded area.

The restoration is expected to provide 10 jobs for pre-restoration, 20 for restoration and about five jobs for the management of the restored area.

WHERE WE ARE AT AND NEXT STEPS

WWF is currently doing planning work and pre-feasibility studies together with the water management authority Via Donau, and will assess options in the coming year.

THE EXPECTED BENEFITS OF RIVER RESTORATION ON THE MORAVA

SOCIETAL BENEFITS	INDICATORS	ASSESSMENT
Improved water supply	Water quality improvement	Significant potential to move from currently 'poor' to 'moderate' or even 'good' ecological status.
Improved ecosystem functioning, ecological connectivity, and habitat status	Presence of significant species and/or habitats in the restoration area	Enhanced conservation by maintaining the current level of diversity. 13 different habitats are reported on this site, mainly floodplain forests and meadows.
	Reconnected length of river	Achieved connectivity will be about 60 km, which will contribute 0.28% to EU's objective of 25,000 km of free-flowing rivers.
	Quality of land adjacent to river restored	About 200 km² of floodplains will be restored. The restoration of meanders and the removal of barriers is likely to result in more frequent floodplain inundation. This is expected to enhance habitat complexity and biodiversity in the area.
Improved socio-economic benefits	Full-time jobs created	The restoration is estimated to provide 10 jobs for pre-restoration, 20 for restoration and about five jobs for the management of the restored area[38].
	Additional revenue generated by tourism	Growing trend in visitors indicates substantial potential. Revenues are expected to reach €800,000 per year[39].
Climate adaptation	Drought mitigation	Drought events have occurred every year since 2015. Due to enhanced water storage in the floodplain, restoring longitudinal connectivity is expected to have a positive impact on reducing the occurrence of hydrological drought in the immediate vicinity.

38. Estimate based on [34].
39. Estimate based on TU Vienna / Stadtland, "Regionalwirtschaftliche Effekte eines Schutzgebiets March-Thaya-Auen", 2012, on the expected benefits of the creation of a large protected area around the Morava river, assuming 40,000 visitors/year. The results (€678,000) have been adapted to reflect the inflation.

FINLAND: THE PALOKINKOSKET RAPIDS

A FORMER FISHING HOTSPOT DEVOID OF FISH

The Palokinkosket rapids used to be perhaps the longest continuous section of free-flowing rapids in Southern Finland and probably the most important reproductive habitat for riverine fish in the Vuoksi waterway. The Palokinkosket rapids consisted of nine separate rapids over eight kilometres, which offered immense catches of fish for local communities, including the nearby monasteries. Furthermore, it provided viable opportunities for exporting fish to national and international markets. From the early 19th century, the rapids gave rise to international angling tourism. Fishers from across Europe visited the banks of the rapids. Later, a sport fishing association from the region privatised access to rapids after which local interest in the rapids started gradually to diminish.

DID YOU KNOW THAT...

since the Palokinkoski rapids were only dammed in 1961, some people still remember the free-flowing river? Manu Räsänen is from the Palokki village. As a young boy, he fished on the rapids and later worked on the construction of the hydropower dam.

However, in his later years, Manu became a avid critic of the dam, and continues to advocate for restoring the free-flowing rapids in Palokki.

A salmonid fish caught on the Palokinkosket rapids. © With the permission of the heirs of Sulo Piironen, family photo archive. More historical photos: https://www.palokinkosket.fi/

ID CARD

Name of rapids:
Palokinkosket rapids (Heinävesi Palokinkoski in Finnish)

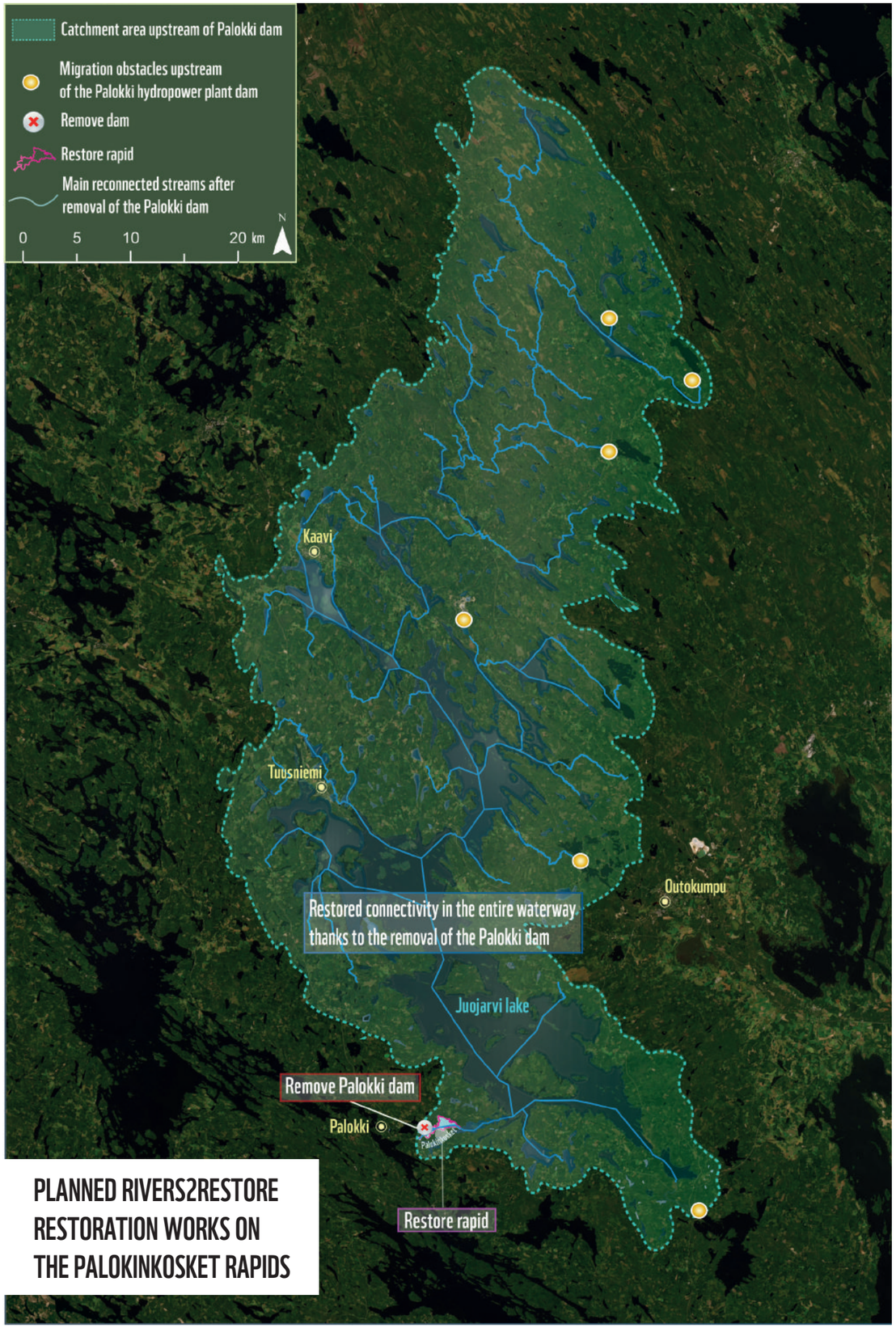
Length of the rapids:
8 km with a fall height of 20m

Average discharge:
about 20 m^3/s on average, and 684 m^3/s in the Vuoksi waterway

Tributary to the Vuoksi watershed and connected to the Great Lake District of Saimaa

Protected area:
Juojärvi archipelago (FI0600031) and Vaikkojoki River, Vaikko old Forests and the mire of Aittalamminsuo Natura 2000 sites (FI0600010)

The Palokki Reservoir © Heidi Volotinen



PLANNED RIVERS2RESTORE RESTORATION WORKS ON THE PALOKINKOSKET RAPIDS

The Palokinkosket rapids used to be a long whitewater section located between large lakes and is part of the Vuoksi catchment, which consists of hundreds of lakes. The Vuoksi River itself is a transboundary river in southeast Finland that flows into Lake Ladoga in Russia and eventually into the Baltic Sea.

Historical picture of the uppermost part of the Palokinkosket rapids showing the area before the dam was constructed in 1961. © Sulo Piironen Estate

THE END OF THE RAPIDS

In 1961, a hydropower dam was built in Palokki to support the energy supply of a local mine owned by the company Outokumpu. The hydropower plant is located on the side of the rapids and the water is directed through a pipeline. The construction of the dam immersed most of the rapids under the reservoir behind the dam while some of the downstream rapids ran dry. The Palokki rapids are thus in moderate ecological status, and they do not meet the requirements of the EU Water Framework Directive, even though the water quality at the larger lakes upstream and downstream of the dam are in high ecological status.

The dam has caused the total loss of the riverine habitat and fish migration and the free movement of other aquatic animals such as macroinvertebrates has been totally blocked. The local fish stocks that had adapted to the Palokinkosket rapids vanished. In the period following the damming, all the migratory fish species in the Vuoksi watershed, such as the landlocked salmon, brown trout, Arctic char and migratory white fish became officially endangered. Furthermore, different stream habitats have also become endangered as a result of damming, dredging of the stream beds and removal of stone material. In the Palokinkosket rapids, other uses of the rapids such as fishing ceased and future recreational use of the rapids became close to impossible.

The Nälönvirta dam © Heidi Volotinen

THE PALOKINKOSKET RAPIDS CAN BE ENTIRELY FREE-FLOWING ONCE MORE

Removing the 400 metres-wide, eight metres-high Palokki dam could restore the connectivity in the Juojärvi waterway, and bring back the entire rapid system. The removal, and the restoration of the rapids, is recommended by the Fisheries Authority in the region and currently mentioned in the national plan of the new Finnish government. In addition to dam removal, the work to restore the rapids includes bringing back all the stone material that was removed from the rapids while dredging them for log floating. This would allow the rapids to become an effective spawning ground for migratory fish once more.

Three feasibility studies have already been made about the restoration of the Palokinkosket rapids. Today, the hydropower plant generates just 0.04 % of Finland's total electricity production so it can be considered insignificant. The original turbines from 1961 are now at the end of their lifespan and need to be replaced. Therefore, the right conditions are in place for the removal. If the power company instead decides to invest in turbines, the plant will stay in place for the next 70 years.

RESTORED FISH POPULATIONS AND BOOSTED TOURISM

Removing the hydropower dam and restoring the nine whitewater rapids would recreate up to 32 hectares of reproductive habitat for endangered land-locked salmon and Brown trout. In addition, it would open 1523 km of new area for fish migration, upstream alone. This could result in the production of 20,000 to 32,000 new salmon and trout smolts every year. The aim of restoration is to improve the poor conservation status of freshwater biodiversity in Vuoksi waterway and to boost local economies at the same time.

At least 20,000 new salmonid smolts per year expected thanks to the restoration.

1,523 km of free-flowing Palokinkosket rapid will contribute 6% of the EU's objective of restoring 25,000 km of free-flowing rivers in Europe.

It is estimated that the removal of the dam and the subsequent impact of additional spawning grounds on fish populations would enhance recreational fisheries in the area, bringing in €330,000 of additional income per year. This is calculated on the basis of a modelled increase in tourism (2,295 tourists) and the average spend per tourist on recreational fishing (€145/day)[40]. The figures may turn out to be strong underestimates, as we now have an example from the River Hiitolanjoki in Finland, where over 20,000 people visited the banks of the two restored rapids in just eight months (data from the Municipality of Rautjärvi).

Around €330,000 additional income per year estimated thanks to the restoration.

In 2019, a citizen survey on perceptions around dam removal conducted by WWF Finland asked whether hydropower dams, insignificant in terms of energy production, should be removed to revive migratory fish stocks. 71% of respondents supported the removal of the dams, and just less than 10% were against[41].

Furthermore, in March 2023, 23 NGOs that have hundreds of thousands of members in Finland, demanded the environmental authorities to change Palokki hydropower plant fisheries obligations so that the watershed is restored to enhance fish populations[42].

WHERE WE ARE AT AND NEXT STEPS

- The two past and present governments have acknowledged the problems related to migratory obstacles and a funding instrument (NOUSU-programme) was developed. Approximately €18 million has been used for dam removals so far. More than 200 obstacles have been removed in Finland during the years 2021-2022 alone (e.g., in NOUSU- and Helmi Habitats Programmes).
- The Finnish Forest Administration aims to remove 970 obstacles by 2030 (Helmi Habitats programme). Together with other organisations, WWF Finland has removed 50 obstacles within six years.
- The removal of the Palokki dam and the restoration of the nine rapids is currently outlined in the national plan of the new Finnish government. The government has earmarked €20,45 million for the project. The total budget is €27-36 million.

40. Palokin koskireitin ja vesivoimalaitoksen kalataloudelliset kehittämismahdollisuudet. Pohjois-Savon ELY-keskus ja Pohjois-Karjalan ELY-keskus. (2023)
41. https://www.epressi.com/tiedotteet/ymparisto-ja-luonto/yli-70-prosenttia-suomalaisista-kannattaa-pienvesivoiman-purkamista.html
42. https://www.sll.fi/pohjois-karjala/2023/03/28/vireillepanovaatimus-palokin-voimalaitoksen-kalatalousvelvotteiden-muuttamiseksi/

EXPECTED BENEFITS OF RIVER RESTORATION IN THE PALOKINKOSKET RAPIDS

SOCIETAL BENEFITS	INDICATORS	ASSESSMENT
Improved water supply	Water quality improvement	Significant potential to reach 'good' ecological status.
	Sediment carried by the river	Vuoksi river basin already records good water transparency up to depths of 3.5 - 4.5 m in the water column. The removal of the dam will not significantly affect the water quality.
Improved ecosystem functioning, ecological connectivity, and habitat status	Change in population levels of fish species	Significant positive impact on migratory salmonids: 20,000 to 32,000 new smolts expected each year.
	Presence of significant species and/or habitats in the restoration area	Enhanced conservation of some of the 11 protected habitats reported in the two Natura 2000 sites, mainly swamps and rivers.
	Number of barriers removed	The project will remove 1 hydropower dam.
	Reconnected length of river	Achieved connectivity will be 1523 km, which will contribute 6% to the EU's objective of 25,000 km of free-flowing rivers.
Improved socio-economic benefits	Drought mitigation	Drought events have occurred every year since 2015. Due to enhanced water storage in the floodplain, restoring longitudinal connectivity is expected to have a positive impact on reducing the occurrence of hydrological drought in the immediate vicinity.
Climate adaptation	Flood mitigation	Project is likely to have no influence on decreasing flood occurrence as no floods have been recorded in the last 8 years. However, floods should be monitored post restoration works to see if the flooding, inundation, and flow status changes.

GERMANY: THE AMMER

ONE OF GERMANY'S LAST WILD RIVERS SUFFERS FROM STREAM REGULATION AND BARRIERS

The Ammer flows through the Northern Limestone Alps and Alpine foothills in Bavaria. Located southwest of Munich, between the two large rivers Isar and Lech, the river runs through the natural areas of the Ammer Mountains, the Lech foothills, the Ammer-Loisach-Hill-Country and the so called "Land of the Five Lakes" (Fünfseenland). Some parts of the river were straightened, and several weirs and two small hydropower stations were built in the past. Other sections of the Ammer remain wild, and are surrounded by a relatively untouched landscape. The deep and narrow canyon-like "Ammerschlucht" offers a hidden glimpse of a wilderness spared from human intervention. The river's 715 km² catchment constitutes a national biodiversity hotspot, and is therefore of national importance.

DID YOU KNOW THAT...

Lake trout, an ecotype of the brown trout (*Salmo trutta*), migrates from the Ammer lake up the river Ammer to spawn? It was once abundant but is rare today.

Reintroduction programs have been initiated by the Bavarian Fishery Association but will only be truly successful if impassable barriers are removed or adapted so that fish can pass.

Brook trout (Salvelinus fontinalis) © Adobe Stock

ID CARD

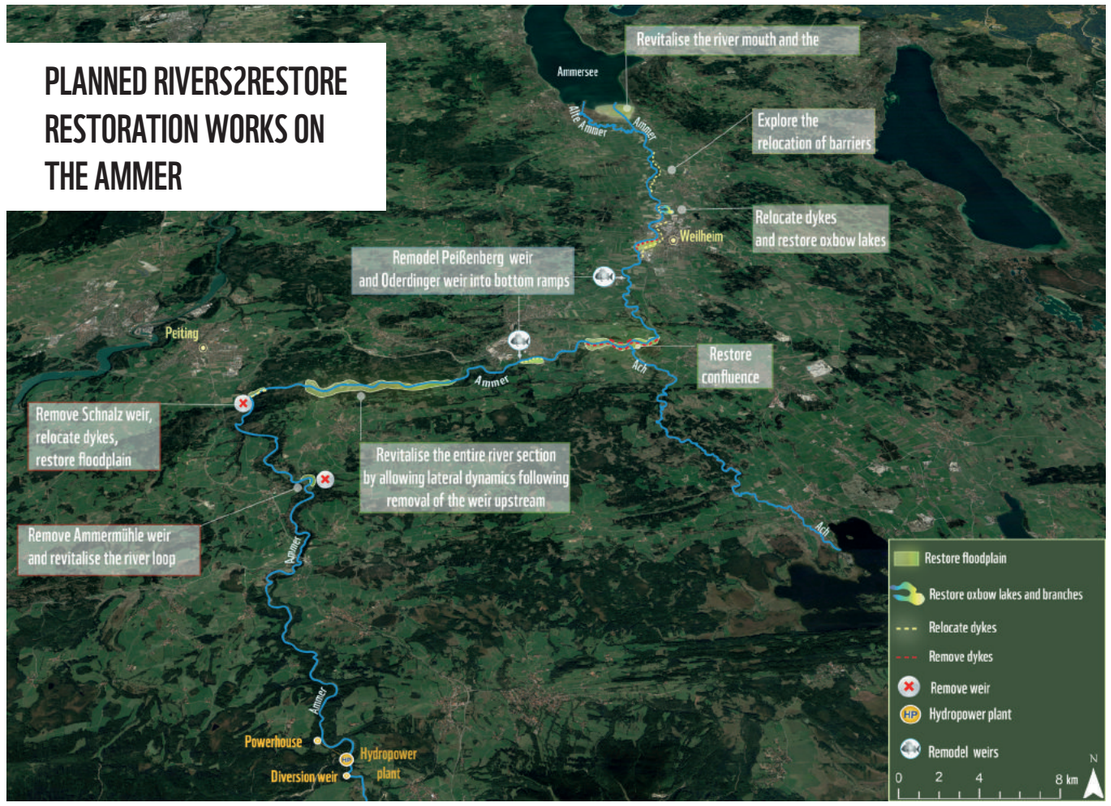
Name of the river:
Ammer

Length of the river:
about 70 km, flowing into the Ammer Lake in Upper Bavaria

Average discharge:
3.69 m^3/s (stream gauge upper Ammer), 15.3 m^3/s (stream gauge lower Ammer)

Protected area:
The river crosses three Natura 2000 sites: Ammerseegebiet (DE7932471); Moränenlandschaft zwischen Ammersee und Starnberger See (DE8033371); and Ammer vom Alpenrand b. zum NSG 'Vogelfreistätte Ammersee-Südufer (DE8331302). Other protected sites along the river include national biodiversity hotspots, and nature and bird protection reserves.

The Ammerschlucht canyon © Karl Seidl



A STEP BACK IN TIME

Since the 16th century, the Ammer has been modified, for example to establish the first mill between Rottenbuch and Böbing (Ammermühle), which is used for electricity generation today.

In fact, modifications have taken place along the entire length of the Ammer. Close to its source, for example, the Ammer used to meander through moorlands, but in the 1920s and 30s, this stretch of the river was straightened to prevent flooding.

Further downstream, between Altenau and Peißenberg, the river still flows quite naturally, but is disrupted by two hydropower plants: “Kammerl” and “Ammermühle”. Close to the “Ammer-Knee” where the river turns to the East, excavation material from a former coal mine was deposited on the nearby slope many decades ago. In the 1960s, however, it slid into the river and the river had to be relocated to prevent contamination. Its course was straightened and a weir (“Schnalzwehr”) was built to stabilise the stream bed and halt further dredging.

Upper Ammer before (above) and after (below) straightening works © Karl Seidl

Schnalz weir © WWA Weilheim

The Lower Ammer, below Peißenberg, used to wind through the land, forming large meanders and strong riverbed dynamics, before it drained into the Ammer Lake. In the 1920s and 1930s, downstream from Oderding, the Ammer was straightened and dredged again to gain and protect agricultural land. Engineering works cut the length of the river between Weilheim and the river estuary almost in half (from 25 km to 13 km), and several stabilising weirs had to be built. Relics like oxbow lakes, evidence of the large space previously taken by the river, can still be found there.

The Ammer used to drain into the Ammer lake at Dießen through a 7 km long, meandering river bed known as the "Old Ammer". However, between 1901 and 1904, here, too, the course of the Ammer was relocated and straightened. Nowadays, over a length of only 1.5 km, the "New Ammer" runs straight north and flows into the lake at the town of Pähl. The "Old Ammer" was cut off the "New Ammer" and subsequently silted up.

The modifications have caused precious meadows and marshland to disappear and with them many species now rare throughout Germany, for example the Siberian Iris (*Iris sibirica*), Common Snipe (*Gallinago gallinago*), Meadow Pipit (*Anthus pratensis*) or treefrog (*Hyla arborea*). Many habitats like gravel banks, overhanging trees, pools or still water zones were altered or displaced. Once, 25 fish species were native in the middle course of the Ammer between Böbing and Weilheim. Nowadays, there are only 13 species left[43] and migratory fish like the Danube salmon (*Hucho hucho*) or lake trout (*Salmo trutta*) are severely impacted by barriers.

DID YOU KNOW THAT...

the Siberian iris (*Iris sibirica*) can only thrive in flooded meadows? In the past, flooded meadows were frequently used as agricultural land. When it gets too dry the iris is unable to flower. The "Ammermoos", a swampy meadow by the Ammer delta, still shelters a substantial population, but the flower is endangered in Germany.

© Sigrun Lange

43. Hanfland, Sebastian (2017): Die Ammer als Lebensraum für Fische. In: LBV, Blaues Band, Die Ammergemeinden bandeln an.

The ecological status of the Upper Ammer has deteriorated from 'good' in 2015, to 'moderate' in 2021 due to a degraded fish fauna.

THE AMMER CAN BE FREE-FLOWING ONCE MORE

Building on some of the measures already planned by the Water Management Authority (WWA Weilheim), partly in cooperation with WWF, our vision is to restore the continuity of the entire Ammer river and to contribute partly to the free-flowing river target of the European Biodiversity Strategy. This means:

- **Restoring continuity**. Currently, the continuity of the Ammer is only prevented by three major barriers: the Peißenberger and Oderdinger weirs as well as the Ammermühle hydropower plant; all other barriers are passable for fish. WWA Weilheim started restoration measures at Oderdinger weir in winter 2023. One year later, the Peißenberger weir will be remodelled. However, the small, privately-owned "Ammermühle" hydropower plant still forms a major fish migration barrier. Due to the worsening ecological state of the river, the plant owner is obliged to implement connectivity measures by 2027. However, eternal hydropower rights and the current focus on renewable energy production make it difficult to enforce ecological improvements.
- **Contributing to the EU objective of restoring free-flowing-rivers**. By removing the Schnalz-and Ammermühle weirs, almost 30 km of the river between the Kammerl hydropower plant and Peißenberg will become free-flowing .
- **Contributing to lateral connectivity**. In addition to these measures, work should be done in the Lower Ammer to reconnect branches and oxbow lakes. Widening the river by relocating lateral dams and restoring the natural functions of the floodplain would greatly enhance the river's ecological function.

25 FISH SPECIES WERE NATIVE IN THE MIDDLE COURSE OF THE AMMER. TODAY, THERE ARE ONLY

13

SPECIES LEFT

OVERVIEW OF RESTORATION MEASURES RECOMMENDED TO RESTORE THE CONTINUITY OF PART OF THE AMMER.

Barriers/problem	Recommended measures	Responsible entity	Timeline for completion
PLANNED MEASURES			
Schnalzwehr weir	Widening of river through relocation of about 300 metres of lateral dams; reconnection of Ammer with ten hectares of floodplain[44].	Water management authority (WWA Weilheim), in cooperation with WWF	Expected by 2026
Peißenberger weir	Passability for fish, and removal of about 200 metres of lateral dams in order to restore one hectare of floodplains.	Water management authority (WWA Weilheim)	Expected by 2024
Oderdinger weir	Passability for fish; remodelling of weir into three bottom rough ramps.	Water management authority (WWA Weilheim)	Expected by 2024
RECOMMENDED MEASURES			
Hydropower plant "Ammermühle"	Compensation for water rights and removal of weir and hydropower plant. Minimum solution: installation of a nature-like fish pass to enhance passability for fish.	Water management authority (WWA Weilheim), maybe in cooperation with WWF.	Unclear – WWF recommends completion of minimum solution by 2030 if the plant is not removed
Schnalzwehr weir	Removal of the weir once the Ammer is reconnected to its floodplain	Water management authority (WWA Weilheim)	Unclear – WWF recommends completion by 2030
Dynamization of the estuary between Ammer, Eyach and Ach	Restoration of about 10 to 12 estuary areas	Water management authority (WWA Weilheim) and WWF	WWF recommends completion by 2030
Floodplain area within the city of Weilheim	Restoration of Weilheimer Floodplain; Relocation of about 500 metres of lateral dams.	Water management authority (WWA Weilheim) and WWF	WWF recommends completion by 2030
Lower Ammer, straightened river course	Reconnection of branches and oxbows; widening of river by means of relocation of lateral dams; relocation of about 2 km of lateral dams.	Water management authority (WWA Weilheim) and WWF	WWF recommends completion by 2030
Old Ammer delta	Restoration of the estuary of the "Old Ammer"	Water management authority (WWA Weilheim)	Expected in 2024

- Measures planned by the Water Management Authority without the support of WWF
- Measures planned in cooperation between WWF and Water Management Authority
- Measures which WWF Germany recommends (fundraising ongoing)

44. Clip which demonstrates the planned removal of the lateral dams can be watched here: Hotspotprojekt Alpenflusslandschaften | WWF (lower part of the site, German language)

A RESTORED AMMER WOULD SET AN EXAMPLE FOR OTHER RIVERS TO FOLLOW

If the measures are fully implemented, the improved state of the Ammer would make it a reference river system in the northern pre-Alpine region. As a result, the biologically diverse landscape of many fen areas and terrestrial protected areas would be enhanced, creating a real refuge for endangered species and for people to enjoy.

Restored ecosystems and connectivity for fish: The restoration would help achieve the objectives set by EU Law under the Water Framework Directive, improving the ecological status of the whole river to “good”.

Significant potential to reach ‘good’ ecological status.

The restoration will also improve the connectivity of the river for fish and their habitats. It is expected that this may contribute to stabilising the populations of Danube salmon and the lake trout, as well as other endangered and protected fish species.

If the Ammermühle hydropower plant and the Schnalz weir are removed, and the Peißenberger and Oderdinger weirs are remodelled, this will result in a free-flowing river stretch of about 30 km. It will contribute 0.12 % of the EU’s objective of restoring 25,000 km of free-flowing rivers in Europe.

Improved flood protection: The restoration measures conducted by the Weilheim Water Management Authority are developed in combination with flood protection measures. The reconnection of the river to its floodplains is expected to reduce flood peaks in Weilheim by up to 45 cm. All sections in which lateral dams will be removed will also improve soil moisture, rewet drying out peatlands, and improve groundwater recharge.

Meeting citizens’ demand for nature: A survey on the importance of river restoration in Germany indicated that, in full awareness of the cost of restoration projects, 70% of participants regarded restoration projects as useful and only 6% considered them as not useful[45].

45. Deffner and Haase (2018). The societal relevance of river restoration.

WHERE WE ARE AT AND NEXT STEPS

- Since 2010, several Bavarian Ministers for the Environment, such as Markus Söder in 2010, or Ulrike Scharf in 2017, affirmed that the restoration of the Ammer has priority over hydropower[46]. Both presented the Ammer as a natural jewel with an outstanding inventory of species which shall be preserved and freed from barriers in order to serve as a reference ecosystem for Alpine rivers in Germany.
- Subsequently, the responsible Water Management Agency already remodelled several ground weirs into rock ramps. The last two weirs at Oderding and Peißenberg will be remodelled by 2025.
- The reconnection of the Ammer with its floodplains at the Schnalz-Weir, which was elaborated and planned by WWF Germany, has been approved by the authorities and is expected to be implemented by 2026.
- Once the mentioned restoration measures have been carried out successfully, the following measures would be required to allow for a free flowing Ammer stretch: the removal of the Schnalz weir and the hydropower plant Ammermühle, as well as the removal of as many lateral dams in the Lower Ammer as possible.

THE RECONNECTION OF THE RIVER TO ITS FLOODPLAINS IS EXPECTED TO REDUCE FLOOD PEAKS IN WEILHEIM BY UP TO

45 CM

46. Ammer soll ungehindert fließen – Umweltminister Dr. Markus Söder: »Renaturierung hat Vorrang vor Wasserkraftnutzung« (kreisbote.de) and Ulrike Scharf, MdL – Die Ammer wird eine intakte Flusslandschaft (ulrike-scharf.de)

EXPECTED BENEFITS OF RIVER RESTORATION ON THE AMMER RIVER

SOCIETAL BENEFITS	INDICATORS	ASSESSMENT
Improved water supply	Water quality improvement	Significant potential to reach ‘good’ ecological status in the whole river.
Improved ecosystem functioning, ecological connectivity, and habitat status	Change in population levels of fish species	At least 24 species of fish can benefit from river restoration in the Ammer (18 in the lower section and 6 in the upper one), including migratory species such as the Danube salmon and lake trout as well as other protected species such as bullhead and grayling.
	Presence of significant species and/ or habitats in the restoration area	Enhanced conservation by maintaining the current level of diversity. Nearly 20 different protected habitats and over 12 protected species are reported to occur in this site.
	Number of barriers removed	The restoration will entail removing a weir and a hydropower plant. Two other weirs will be dismantled and remodelled into rock ramps.
	Reconnected length of river	Achieved lateral and longitudinal connectivity will be about 30 km , which will contribute 0.12% to EU’s objective of 25000 km of free-flowing rivers.
Climate adaptation	Flood mitigation	The reconnection of the river to its floodplains is expected to reduce flood peaks in Weilheim by up to 45 cm.

GREECE:
THE KALENTZIS

A RIVER LANDSCAPE DRAINED DRY, NOW PRONE TO FREQUENT AND MASSIVE FLOODS

The river basin of the Kalentzis covers an area of 654 square kilometres, and it hosts four rivers: Kalentzis, Karambalis, Gavras, and Lipsimos. Kalentzis is the primary watercourse, while the other three rivers converge and flow into the Kalentzis which then flows northeast into the Karditsa plain.

Thousands of years ago, large parts of the Thessaly plain (considered the birthplace of Achilles) were covered with forests but the plain has been progressively converted into agricultural land, becoming the most intensively farmed area in Greece and the site of massive flooding in 2023. Today, the vast majority of the lowland part of the catchment area is being used to produce cotton, arable and forage crops. The only relatively natural parts are the riparian forests along the upper stretches of Kalentzis and Karambalis.

Following the September 2023 floods, which caused billions of Euros of damage to property, infrastructure and farmland, the European Investment Bank recommended a return to nature-based solutions to flood management.

A LOCAL VIEW

"When we were children, we used to place stones and dirt in the river, creating small ponds, we called them "desis". We used to water our animals in these constructions, but we also used them to gather the fishes and catch them."

Testimony from a resident of Thessaly

ID CARD

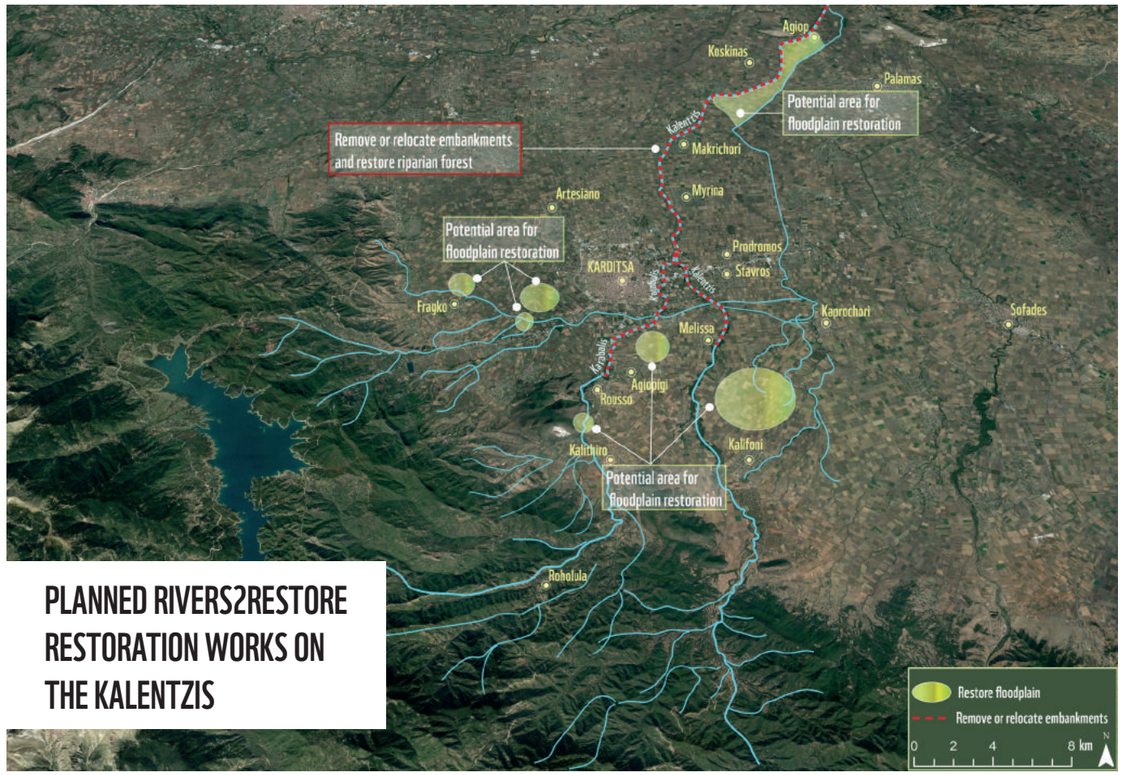
Name of river:
Kalentzis and its tributary, the Karambalis (Καλέντζης and Καράμπαλης in Greek)

Length of the river:
39 km (31 km of the Kalentzis and 8 km of the Karambalis)

Average discharge:
about 7 m^3/s ($2m^3/s$ for the dry months)

The Kalentzis river is a tributary to the Pinios river

A large part of the Kalentzis river is confined by high embankments which cut-off the river from its adjacent floodplains
© Thanos Giannakakis / WWF-Greece



PLANNED RIVERS2RESTORE RESTORATION WORKS ON THE KALENTZIS

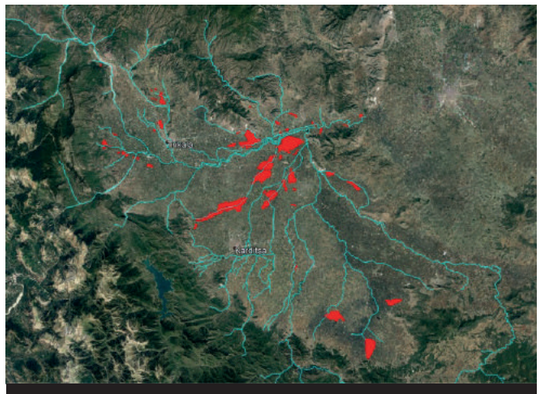
A STEP BACK IN TIME

Since the 1920s, the Western Thessaly plain has been considerably transformed, with a profound impact on the area. The goal of the extensive interventions was to drain extended floodplains and wetland areas and convert it to agricultural land. To protect the farmland from flooding, a comprehensive set of flood protection measures were taken, including channelling all the rivers and constraining them between high embankments, and constructing a wide network of drainage channels. Significant rivers such as Pliouris, Kalentzis, Farsalitis, Sofaditis, Enipeas, Lithaios, Neochoritis were redirected. During the late 1960s and early 1970s, further landscape works were carried out in Thessaly, to increase the agricultural land through land reclamation.

According to scientists: "Wetlands were drained, riverbeds were redesigned and managed, and smaller streams receded and disappeared. At the same time, irrigation canals were constructed, roads and streams were redesigned to accommodate the new architecture of the area, and where the land presented hills, steep slopes and steep relief, extensive and sweeping earthworks were carried out, destroying forever, among other things, archaeological sites such as the "Magoules". Only one wetland was spared, named "Mati" (the "Eye"), near the village of Agioi Theodoroi, as it was thought to have magical and healing properties"[47,48].

47. Halstead (2019) https://www.researchgate.net/publication/337685706_Reclaiming_the_land_belonging_landscape_and_i n situ_displacement_on_the_plain_of_Karditsa_Greece.
48. Krahtopoulou et al. (2020) https://www.researchgate.net/publication/308952998_Land_reclamation_and_the_archaeological_recor d_of_the_Kambos_western_Thessaly_central_Greece_ANADASMOS_TES_GES_KAI_POLITISMIKO_TOPIO_STON_KAMPO_TES_KARDITSAS_In_Greek_with_English_summary

In the plain where the Kalentzis rivers flows, a 1933 report notes the area was covered with permanent marshes of 6500 ha while the flooded agricultural land encompassed an area of 53500.[49] After the extensive transformations, the marshes and floodplains were all gone.



The river system in Western Thessaly today. The red depicts the floodplains and marshes that existed in the area before the extended draining (source: British War Office and U.S. Army Map Service, 1944)

49. Galanis, 1933 http://library.tee.gr/digital/techr/1933/techr_1933_4_40_801.pdf?fbclid=IwAR1Sfo2Zt_7KoWRHnoMUO 6VULITzWrbeXy13Kj3SQMF-5Xk4jFnxbcyHiN8

The extensive changes in hydrological conditions are one of the main causes of the floods in the area, which have caused major damage to people and the economy in a region which is largely dependent on agriculture. In 2020, the "Ianos" storm flooded more than 15,500 ha of land resulting in economic losses of over €1 billion, and more recently, in September 2023, storm "Daniel" flooded nearly 75,000 ha, resulting in an estimated cost of more than €5 billion.

In addition, the extensive changes in the landscape combined with the agrochemical pollution, have resulted in the problematic ecological and chemical status of the Kalentzis River. According to the fir1st revision of the River Basin Management Plan (RBMP) for Thessaly RBMP, a large part of the river is in a "poor" ecological state and an "unknown" chemical status, while in the second 2nd revision currently under preparation, both the ecological potential and the chemical status are is characteriszed as "less than'below good". Unfortunately, despite the fact that the Water Framework Directive and the RBMP aim to improve and maintain good water quality, no measures are taken to improve the hydromorphological characteristics of the river.

RECREATING A SPONGE LANDSCAPE IN THE THESSALY

By restoring floodplains along the River Kalentzis, a sponge landscape can be recreated, which will make the area more resilient to climate change by absorbing excess water during heavy rains and storing it for dry periods. The restoration plan was prepared by a coalition of partners after the storms in 2020,[50] while the efforts to advocate for its adoption by the Regional Government and the relevant ministries at a national scale are ongoing.

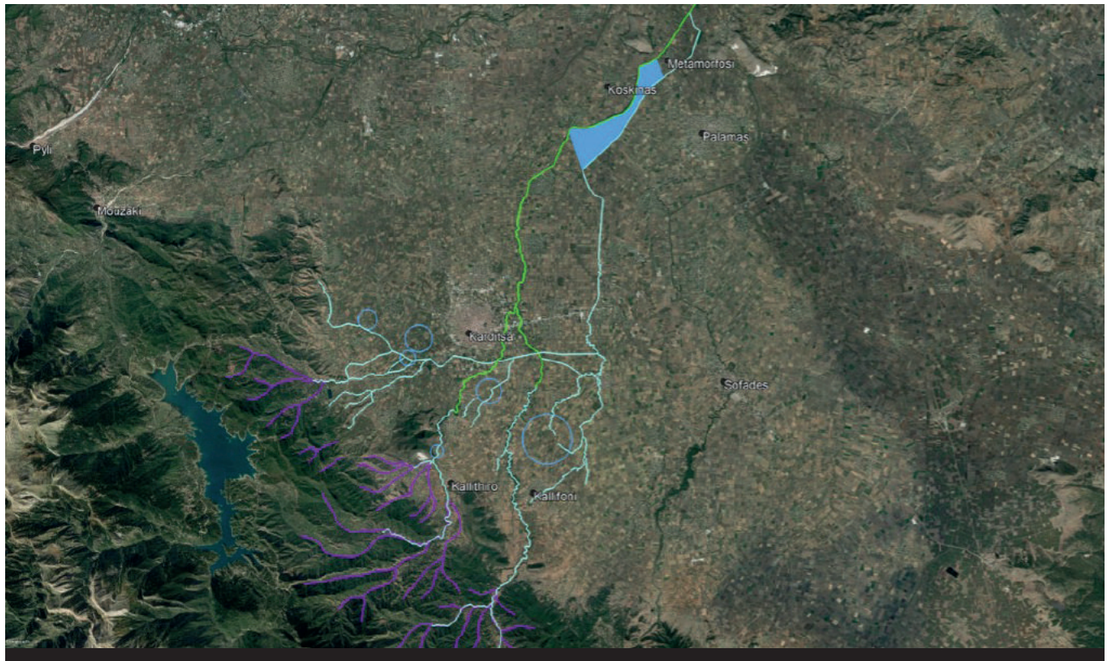
The upper part of the rivers Kalentzis and Karambalis, up to the villages of Melissa and Rousso, is wide and has a well-developed riparian forest. However, as the rivers flow downstream, they become narrow and blocked from connecting with the nearby floodplains by tall soil-based barriers that are currently up to 10–12 metres high. As part of the plan to restore the area, about 80 kilometres of these lateral barriers (embankments) – 40 kilometres on each side of the rivers Kalentzis and Karambalis – are proposed to be removed or relocated further away from the river banks.

ABOUT

80 KM

OF LATERAL BARRIERS COULD BE REMOVED OR RELOCATED AWAY FROM THE RIVER BANKS

50. Jurik at al. 2022. https://wwfeu.awsassets.panda.org/downloads/2022_nbs_thessaly_pre_feasibility_study.pdf



The hydrographic network of the river basin of Kalentzis. The proposed restoration interventions are indicated with green lines (relocation of embankments) and light blue shapes (floodplains) while specific actions are foreseen for the mountain part of the rivers (purple lines) © WWF Greece

A dyke 10-metres-high along the Kalentzis river (left), and one of the last wild sections of the Kalentzis, which illustrates how the river used to be (right).
© Thanos Giannakakis / WWF Greece

Following these interventions, the river is expected to be naturally connected with the adjacent farmlands that will function as floodplains, thus letting the river expand safely and reducing the likelihood of flooding further downstream. Incentives and compensation for farmers for the use of their farmland as floodplains should be set up. As part of the feasibility phase, relevant technical studies are expected to be implemented by the Region (e.g. topographic, hydrological, and hydraulic studies) to figure out exactly the size and the location of the floodplains.

Since there are no longitudinal barriers on these parts of the Kalentzis and Karambalis, removing the lateral barriers and reconnecting the floodplains will make the river stretches free-flowing. Additionally, the restoration involves planting trees and plants along the free riverbed in order to create a riparian forest that will help stop erosion.

The proposed interventions on each side of the river foresees the restoration or creation of approximately 1600 hectares of floodplain to allow the river to flood safely during extreme rain and storm events.

1600ha of floodplain restoration and/or creation.

40 km of free-flowing Kalentzis will contribute 0.16% of the EU's objective of restoring 25,000 km of free-flowing rivers in Europe.

IMPROVED FLOOD PROTECTION AND RESTORED ECOSYSTEMS

The restoration measures aim to retain the water in the catchment area and lower the amount of sediment that flows into the lower land, thereby lowering the risk of flooding in the area. Furthermore, the restored ecosystems are expected to provide benefits to the local community. For example, they will enrich the aquifers and help lower the risk of drought, increase biodiversity, improve the microclimate, and offer recreational opportunities.

Removing lateral barriers along the rivers will restore their connectivity to the whole river system in the area. This is expected to improve their ecological status, possibly to 'good' for the lower section of the Kalentzis.

Dykes, big dams, and other grey infrastructure that are used to reduce the flood risk cannot provide the same number of services, and they are not as cost-effective, as nature-based solutions. A 2022 report by the Nature-Based Infrastructure Global Resource Centre studied the cost-effectiveness of Nature-based Solutions like river restoration, connection with the adjacent floodplains and restoration of riparian forests. The study compared this to the continuation of business-as-usual practices like dykes in the region of Thessaly to address the flood risk. It found that nature-based solutions have a much higher benefit-to-cost ratio compared to grey infrastructure, and that reconnection is also expected to have economic benefits including reduced costs associated with flooding.

Potential to reach 'good' ecological status in the lower Kalentzis.

Significant potential to reduce flood risks

EXPECTED BENEFITS OF RIVER RESTORATION ON THE KALENTZIS RIVER

SOCIETAL BENEFITS	INDICATORS	ASSESSMENT
Improved water supply	Water quality improvement	Significant potential to reach 'good' ecological status in the whole river.
Improved ecosystem functioning, ecological connectivity, and habitat status	Change in population levels of fish species	Multiple species present in the river basin: barrier removal is likely to positively influence many of these.
	Number of barriers removed	The project will remove 80 km of lateral barriers, 40 km on each side of the rivers.
	Quality of adjacent land restored	Restoration of floodplains – approximately 1600 ha.
	Reconnected length of river	Achieved connectivity will be 40 km, which will contribute 0.16% to EU's objective of 25,000 km of free-flowing rivers.
Climate adaptation	Damage costs incurred	Significant reduction in flood damage likely, compared to the current average of €2.6 million/year.
	Flood mitigation	Flood occurrence likely to be reduced due to enhanced flow dynamics through greater floodplain area.

IN 2020, THE "IANOS" STORM FLOODED MORE THAN 15,500 HA OF LAND RESULTING IN ECONOMIC LOSSES OF OVER

€1 BILLION

ITALY:
THE ADIGE

ID CARD

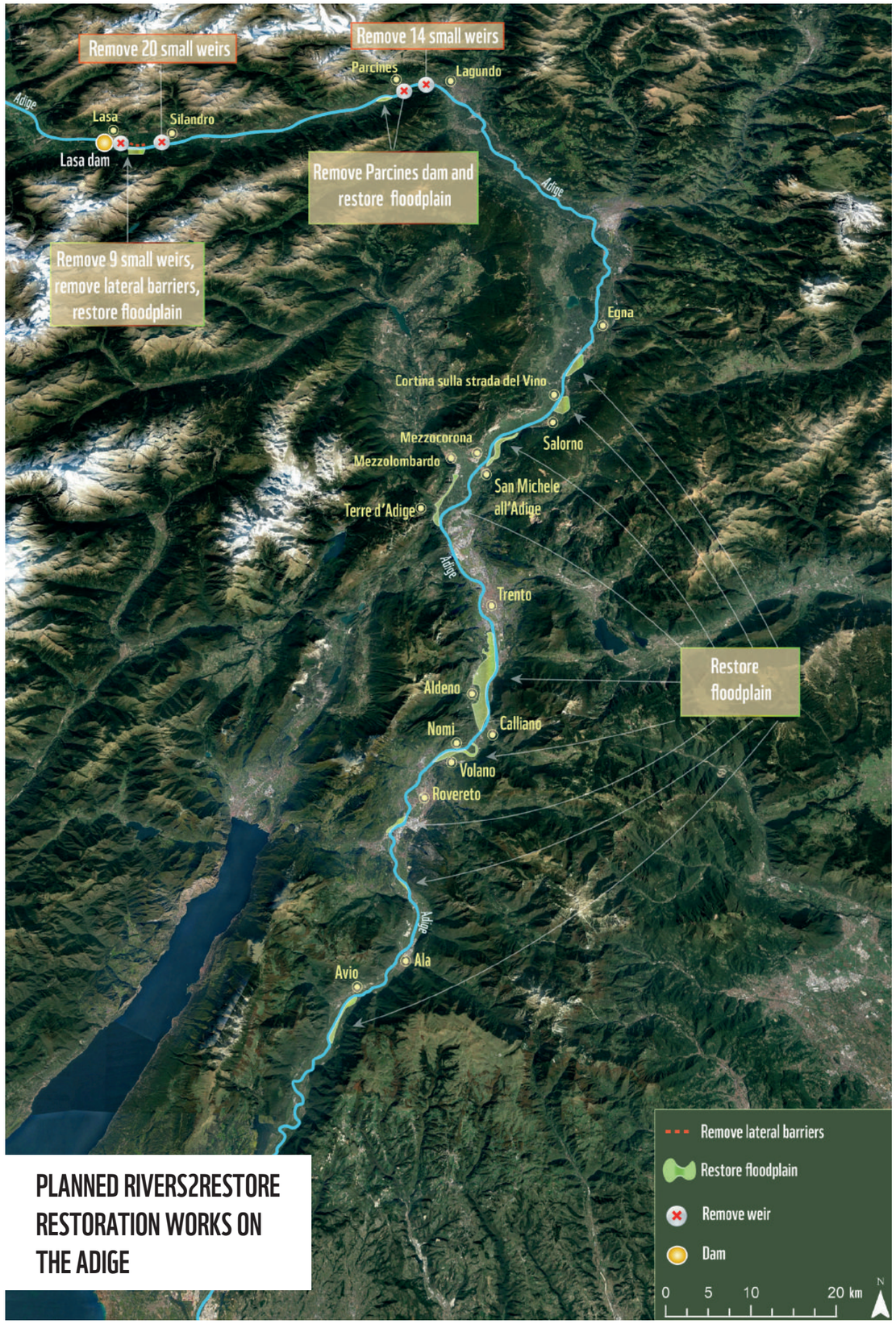
Name of river:
Adige

Length of the river:
about 410 km

Average discharge:
about 253 m^3/s

Protected areas in the section to restore:
Natura 2000 sites La Rupe (IT3120054), Foci dell'Avisio (IT3120053), Servis (IT3120086), Monte Ghello (IT3120149), Taio di Nomi (IT3120082), Adige (IT3120156)

High river levels in summer due to snow melt near a rare green alder forest
© Michielverbeek Wikimedia commons



PLANNED RIVERS2RESTORE RESTORATION WORKS ON THE ADIGE

AN ALPINE RIVER DEGRADED BY REGULATION AND ABSTRACTION

The Adige is one of the main rivers in northern Italy. Originating among the peaks of the Italian Alps in the Trentino-Alto Adige region of today; in ancient Rome, it was known as the "Athesis" and it used to mark the northern border of the Roman Empire. The river flows through a variety of landscapes in the Veneto region. In its upper reaches, it is surrounded by mountains and narrow valleys. Further south, it crosses alluvial plains and hills. Its shape and course have been influenced by erosion, sedimentation, and geological events along the way.

Over the centuries, the Adige has been subjected to straightening, widening and diverting (one famous case is the near removal of the river from the Trento city with a radical straightening of a meander) to prevent flooding and facilitate navigation. It is still used for irrigation, hydropower and transporting freight. These works contributed to the economic development of the region, but they have deeply degraded the ecology of the river: flow regulation almost completely prevents the transport of material (gravel, pebbles, silt) essential for the benthic life of the river. The riparian vegetation is managed almost exclusively from a hydrological point of view with widespread cutting back even during bird nesting periods, perpetuating an outdated and distorted view of the otherwise multifunctional role the river could play.

As an example of its ecological importance, the Adige is home to the marble trout (*Salmo marmoratus*), but there are far fewer fish populations than in the past.

DID YOU KNOW THAT...

The marble trout (*Salmo marmoratus*), which is only found in a handful of rivers in the Adriatic basin, may reach a size of over 1 metre and weigh up to 20 kg?

It is critically endangered in Italy and endangered in Europe, partly because it no longer has enough spawning areas.

Marble trout © Wikimedia_Commons

The river through Trento © Life Franca

HEAVY HUMAN INTERVENTION

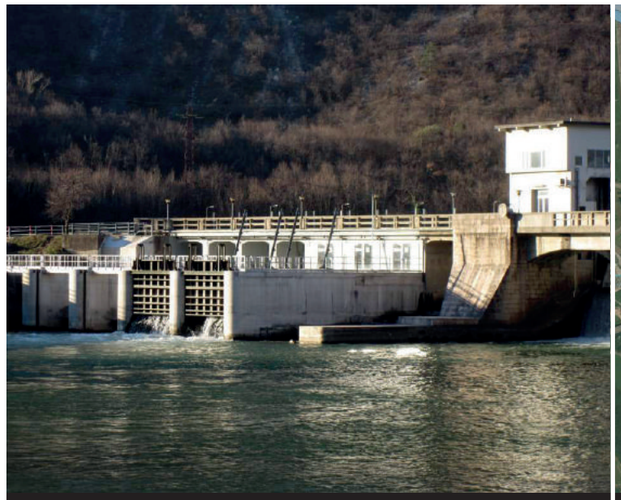
The course of the Adige has been modified many times to improve navigation and reduce flooding. This involved digging deep rectification channels, constructing embankments and managing the flow of water and sediment with dams, significantly impacting river morphology and the surrounding ecosystem, and leading to environmental and sustainability issues.

The repeated works on the riverbed have also massively destroyed the riparian vegetation. Natural floodplains and riparian forests function as natural buffers to flooding where timber accumulates and slowly decomposes. But, their destruction means that wood mass often builds up on artificial river barriers such as bridge piers, which clog the river in high flow times and may worsen floods.

In addition, the catchment has suffered from massive water withdrawals for agricultural purposes, particularly on the tributary rivers of the Adige. In Trentino alone, more than 15,000 derivations through direct collection from river flow are currently active, which put a strain on the natural recharge of aquifers, particularly in 2021-2022. Although the Adige is in good ecological status, many of its tributary rivers are not, partly due to the failure to apply minimum ecological flows which are a national requirement.

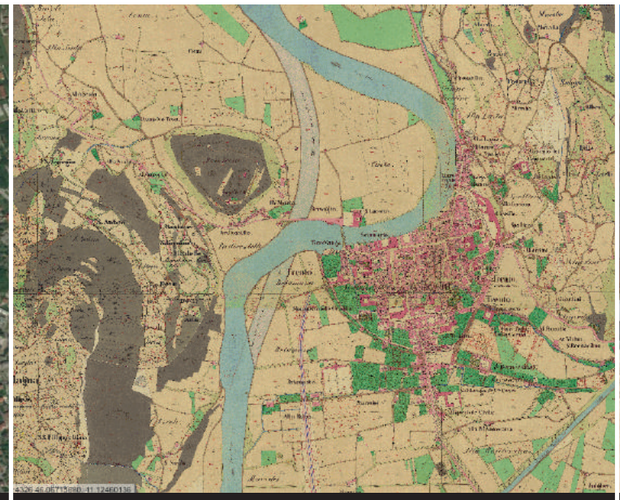
The Adige River experiences water scarcity during early spring and late summer[51]. This is caused by a mixture of factors such as decreased snowmelt or snow formation, less precipitation, and increased water demand for agriculture and industry. Groundwater aquifers in the region, which play an important role in hydrological and socioeconomic droughts, are primarily recharged by the Adige River[52].

51. Shrestha, S., Zaramella, M., Bertoldi, G., Borga, M., Terzi, S., and Massimiliano, P.: Water scarcity and climate change impacts in the Eastern Italian Alps: A case study of the Adige river basin, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-13266, https://doi.org/10.5194/egusphere-egu23-13266, 2023.
52. Castagna M, Bellin A, Chiogna G. Uncertainty Estimation and Evaluation of Shallow Aquifers' Exploitability: The Case Study of the Adige Valley Aquifer (Italy). Water. 2015; 7(7):3367-3395. https://doi.org/10.3390/w7073367



A close-up of the hydropower dam © www.adige.it.

How the river "should" look today without straightening
© ETSCH 2000 Project



The same old course of the river as seen from an historical Austrian map
© Autonomous Province of Trento

Artificial embankments cut the river off from its floodplain © Aaron Lemma

MAKING OVER 100 KM OF THE ADIGE FREE-FLOWING AGAIN

By removing over 38 km of lateral barriers on each side of the river, one dam in Parcines and 43 small weirs, ecological connectivity will recover along a 114 kilometre-stretch of the Adige River.

The weirs were initially constructed for irrigation and riverbed stabilisation. They alter the river flow, reduce the ecosystem services provided and slow down efforts to address social challenges such as drought, pollution and biodiversity reduction. The removal of barriers will allow fish to move freely in full compliance with their ecological characteristics and help improve the resilience of the area against climate change impacts.

In addition, up to 1830 hectares of floodplains will be restored in Parcines, Volano, Rovereto, Ala and Avio. When the river is once again free-flowing, the river landscape will change as its ecological restoration will encourage the growth of diverse plant life along the riverbanks and in the floodplains, adding to the scenic value.

RESTORED ECOSYSTEMS AND HIGH WATER QUALITY

The restoration efforts will lead to improved water quality, as the restored floodplains act as natural water filters, and free-flowing rivers are more effective at filtering pollutants than altered waterways. River restoration will also help stop the river from running dry during times of low rainfall. This should help secure good ecological status in the Adige, which will benefit both the ecosystem and human populations which rely on the river.

The restoration of the river will contribute to the reestablishment of the natural vegetation previously removed by the construction of artificial structures along the riverbanks, such as the alluvial forests. The restoration of stretches of the river is expected to replenish the health of spawning and breeding grounds for the native Marble Trout. The restoration of floodplain habitats will also be positive for a number of protected species such as the Yellow-bellied toad (*Bombina variegata*), Italian tree frog (*Hyla intermedia*), and the large copper butterfly (*Lycaena dispar*), while the restored floodplains can also help in carbon sequestration, contributing to climate change mitigation.

43 small weirs and one dam removed

114 km of free-flowing Adige will contribute 0.45% of the EU's objective of restoring 25,000 km of free-flowing rivers in Europe.

In addition, restoration is likely to have economic benefits. Ecotourism in the region provides jobs and contibutes to the area's economy[53]. It is expected that the restored river will attract more visitors and further boost ecotourism, as the river will look more beautiful in a more natural state, and the restored floodplains and riverbanks will undergo natural seasonal changes, offering a dynamic and ever-changing landscape for visitors to enjoy throughout the year. The restored river can serve as an outdoor educational space where visitors and locals can learn about river ecosystems, conservation efforts, and sustainable practices. Increased tourism can lead to the development of local businesses, such as eco-lodges, guided tour services, and local artisan shops. This influx of tourists can create jobs and stimulate the local economy, with an obvious alliance with local fishers: by removing these barriers, the river will regain part of its natural flow, which is crucial for the survival of many aquatic species leading to a probable increase in fish populations and other aquatic life.

River restoration is also expected to strengthen the resilience of the region to floods. In the past, flood protection levees have required a lot of maintenance and have sometimes failed in the case of big floods, for instance in the Veneto region in 2010[54]. Removing structures and allowing water to stay in the river's floodplains will reduce damage costs and provide natural buffers against floods. By reestablishing meanders and restoring adjacent wetlands, the water storage capacity of the land will be enhanced, which will contribute to reducing flood risks. The removal of the barriers will guarantee the continuity of sediment transport downstream, improving the balance of the morphological condition of the watercourse. These activities will ultimately reduce the risk of flooding for a significant number of people and nearby towns.

Finally, the restoration of river connectivity can contribute to mitigating the impacts of drought by recharging aquifers and preventing the riverbed from drying out.

WHERE WE ARE AT AND NEXT STEPS

Locally, WWF has been campaigning for years on the protection of water resources, attempting to introduce a more ecosystem-based approach to river management together with local associations and committees (in particular after the founding in 1996 of the "Comitato per la difesa delle acque del Trentino"). It has become clear throughout the years that Italy will experience more and more extreme climatic conditions, oscillating between periods of extreme and long drought and intense rainfall with consequent flooding. This makes nature restoration an even more effective solution, but the benefits of river restoration need to become more widely known.

UP TO
1830
HECTARES OF FLOODPLAINS WILL BE RESTORED

53. Negra, O. 2021. (Re) Connecting MUSEUM to WATER. Heritage Research, Outdoor Education, and SGD for integrated museums. https://www.unive.it/pag/fileadmin/user_upload/centri/ECLT/documenti/unesco-chair/2_Osvaldo_Negra_Presentation_17Dec.pdf
54. For instance, the flood in the Veneto region in 2010 caused 9 levee breaches and a total of 426 million euros in damages due to failures such as overtopping, rapid drawdown, soft-structure transition.

Verona city © AdobeStock

EXPECTED BENEFITS OF RIVER RESTORATION ON THE ADIGE RIVER

SOCIETAL BENEFITS	INDICATORS	ASSESSMENT
Improved water supply	Water quality improvement	Significant potential to help maintain the good status achieved from 2016 onwards.
Improved ecosystem functioning, ecological connectivity, and habitat status	Change in population levels of fish species	Potential for improving the health of spawning and breeding grounds for the native Marble Trout (*Salmo marmoratus*).
	Presence of significant species and/or habitats in the restoration area	Enhanced conservation by maintaining the current level of diversity in the 22 protected habitats (such as the Alpine rivers , rivers with muddy banks, and alluvial forests) and hundreds of protected species that are reported to occur in the site.
	Number of barriers removed	The project will remove 43 weirs, one dam and 38 km of lateral barriers.
	Quality of adjacent land to river restored	1830 hectares of floodplain will be restored, allowing the reestablishment of natural vegetation previously removed by construction of artificial structures along the riverbanks.
	Reconnected length of river	Achieved connectivity will be 114 km, which will contribute 0.45% to EU's objective of 25,000 km of free-flowing rivers.
	Riverine flow status	Restoration of the river could restore the minimum vital flow needed for good ecological and hydrological health.
Improved socio-economic benefits	Full-time jobs created	Potential to increase the current 240 jobs generated by ecotourism in the region.
	Additional revenue generated by tourism	Potential to increase the €50 million of revenue from ecotourism in the region.
Climate adaptation	Flood mitigation	Reestablishing meanders and enhancing natural water storage capacity can contribute to reducing flood risk.
	Drought mitigation	Restoration of the river can recharge aquifers which contributes to mitigating the impacts of drought occurrence in the region.

LATVIA:
THE DIENVIDSUSĒJA

A FRAGMENTED RIVER THAT CAN BE RECONNECTED ONCE MORE

Dienvidsusēja is a lowland river which rises just outside the quaint, little town of Subate, and flows along the Latvian-Lithuanian border, through forested and agricultural lands, until it reaches the river Mēmele.

Close to its source, the river crosses rapids and slow-flowing stretches, while closer to Mēmele, the river becomes wider and slower. On the right side of the river, the Baltmuiža marsh is a unique ecosystem, with several islands which host dense linden and pine forests, popular for nesting birds. The marsh is a Natura 2000 site and hosts many protected bird species such as the Black Stork (*Ciconia nigra*), the Red-breasted Flycatcher (*Ficedula parva*) and the Osprey (*Pandion haliaetus*). The bog is also a hotspot for locals who pick berries and mushrooms, and it was an important peat extraction point for more than fifty years.

DID YOU KNOW THAT...

the islands in the Baltmuiža marsh, due to their isolation from the surrounding environment, also host plants that cannot be found anywhere else in the swamp? For instance, the round-leaved sundew.

Round leaved sundew © Chris Parker

ID CARD

Name of river:
Dienvidsusēja (also referred to as Susēja, Lielā Susēja or just Suseja)

Length of the river:
about 114 km

Average discharge:
about 8 m^3/s

Tributary to the Mēmele, which is itself a tributary to Lielupe (one of the 4 main river basins in Latvia)

Protected area:
Baltmuiža marsh Natura 2000 site (LV0504300)

The Dienvidsusēja river from birds eye view © Latvijas Televizija

The Dienvidsusēja has a rich historical value. Gārsene Castle, known as the pearl of Selia, can be found on the left bank, and close to its source, the town of Subate used to be a thriving, multicultural town, but today it is better known for its tranquillity, chicory and barley cafes, old manors and as a departure point for berry and mushroom picking hikes in the marsh. In 2004, the site became part of the Natura 2000 network of protected areas for its unique nature, such as active raised bogs, but several hydropower plants have degraded the quality of its water.

HYDROPOWER BLOCKS THE RIVER

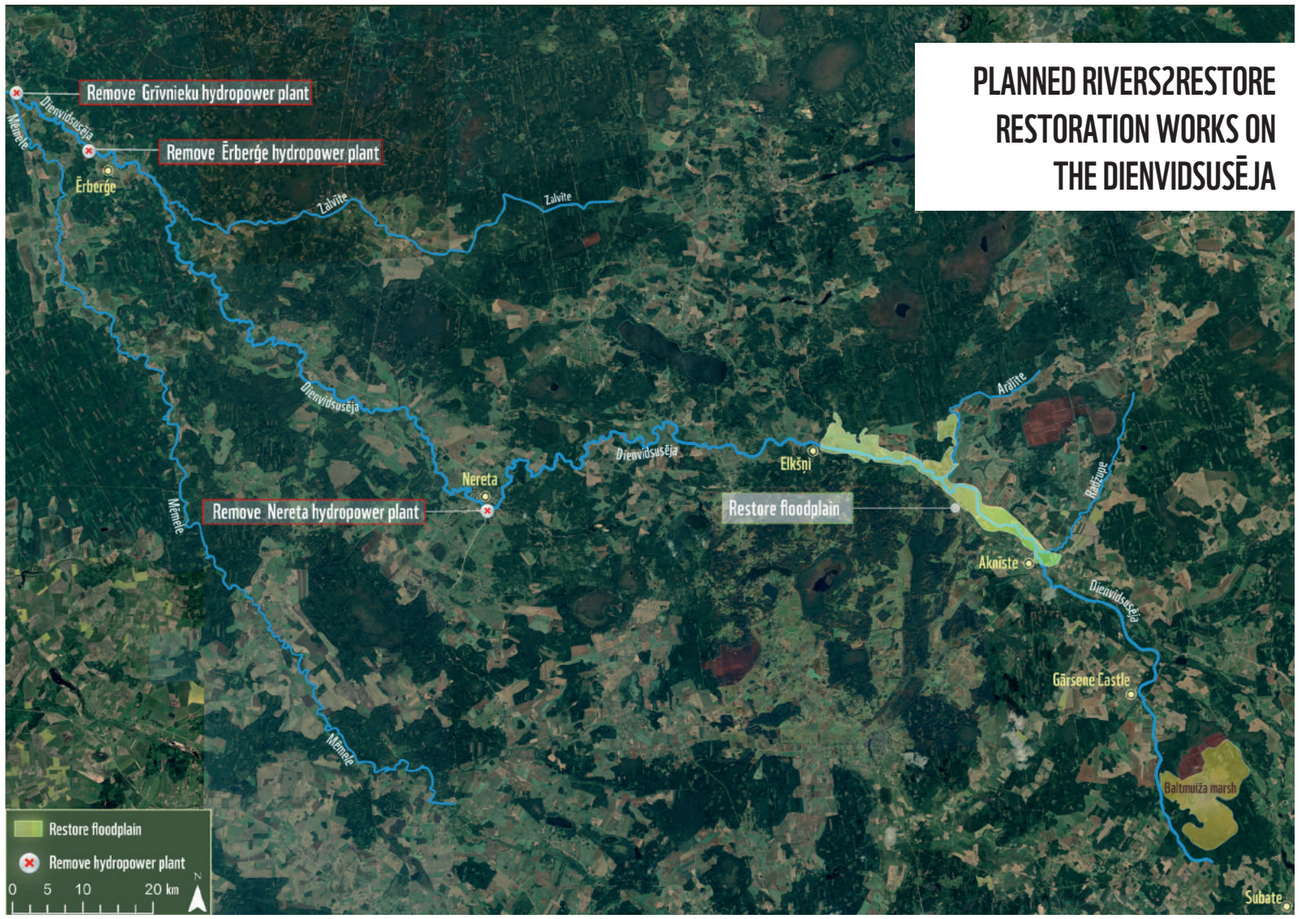
Between 1939 and 1942, 30km of the river, near the town of Aknīste, was dredged for navigation. However, downstream from there, the river remains natural and is meandering. There are three small hydropower stations on the river, with a capacity below 1 MW, which are still operational. Two of the small hydropower stations are around 7 metres tall, and the third one is around 4 metres tall. Two of them are near where the Dienvidsusēja meets the Mēmele (the Grīvnieku and Ērberģes plants) and they impact the river significantly. They both are on a list of 70 barriers in Latvia which are harmful for the environment and potentially eligible for removal, with funding from the European Maritime, Fisheries and Aquaculture Fund specifically earmarked for removing those barriers[55]. The last small hydropower plant is in the town of Nereta.

Kayaking has been impacted by the hydropower stations as the kayakers have to carry the boats out of the water to pass the stations, and the scenery has also changed around the stations as the reservoirs behind the hydropower dams have significantly altered the landscape.

The hydropower stations also restrict the river's natural ecological flow to just a minimal flow. In the warmer seasons, the flow is not sufficient to ensure good environmental conditions for all the species which rely on stable water quantities and temperatures.

The water quality in Dienvidsusēja is moderate – like most water bodies in the Zemgale region. However, the ecological quality of its three main tributaries (Arālīte, Radžupe, and Zalvīte) is good.

The Dienvidsusēja is a flood risk territory according to national flood risk maps. The river has one of the most intense runoffs in the Lielupe basin, which is between 220-245mm annually. The latest flooding in Dienvidsusēja happened in September of 2017. This event flooded agricultural lands and ruined harvests. While exact damage costs to infrastructure is unavailable, farmers in the region were paid a total of €17.7 million in damages while the calculated damage to the agriculture sector alone was over €20 million.




The "Grīvnieku" hydropower plant © Magda Jentgena

THE DIENVIDSUSĒJA CAN BE ENTIRELY FREE-FLOWING ONCE MORE


A natural part of the river above the Ērberģe hydropower plant
© Magda Jentgena

The Dienvidsusēja is a relatively natural river apart from the three hydropower stations blocking its course. By removing the three hydropower stations, river connectivity can be entirely recovered. The hydropower stations were built at a time when locally and nationally produced energy was a priority for the government, and any locally produced energy was subsidised. However, in today's world, where significantly more efficient and better renewable energy options exist, these small hydropower stations are no longer justifiable. The energy produced is minimal, yet the impact is enormous – especially in a river basin which is hugely impacted by agricultural runoff, and has good connectivity potential to the sea. Removing the hydropower could see fish including river lamprey, vimba and salmon, return. It could also have positive impacts on non-migratory fish like Schneider (*Alburnoides bipunctatus*), Spined loach (*Cobitis taenia*), European bullhead (*Cottus gobio*), Brook lamprey (*Lampetra planeri*), and European bitterling (*Rhodeus amarus*).

In addition, natural floodplains should be restored, mainly between the region of "Elkšņi" and "Aknīste"where the flood risk is the highest. Considering that the region is not densely populated, but is surrounded by agricultural, forested and swampy territories, it has strong potential for floodplain restoration. With the effects of climate change becoming stronger every year, we need to restore our floodplains, and give back space for nature. We are experiencing more frequent floods during the colder season and droughts during the summer – and farmers in the region are the first to suffer. By restoring the natural sponge function of these areas, we can minimise the effects of climate change, and protect these important agricultural areas.

55. https://bior.lv/lv/par-mums/jaunumi/izstradata-zivju-migracijas-iespeju-atjaunosanas-datu-baze

IMPROVED WATER QUALITY AND MORE RESILIENCE TO FLOODS

The removal of the small hydropower plants would open up the whole river and its tributaries to migrating fish species such as lampreys, trout, and vimba which are found in the Lielupe river basin.

3 hydropower barriers removed.

Significant potential to reach 'good' ecological status.

114 km of free-flowing Dienvidsusēja will contribute 0.45% of the EU's objective of restoring 25,000 km of free-flowing rivers in Europe.

The restoration of the floodplains would also facilitate the transport of sediments. As a lowland river, it is important that sediment does not get trapped behind the dams, and can be carried down to the sea. Trapped sediment causes two major issues. The first is the eutrophication of the water reservoir behind the dam, as the sediment increases the amount of nutrients available for algae to grow, depleting the water of oxygen. In a region which is already saturated with excess nutrients from agricultural runoff, this makes the problem significantly worse. Additionally, trapping the sediment behind the dam creates issues downstream – depleting the ecosystem of sediments in the rest of the river.

Since the Dienvidsusēja river is part of the Lielupe basin, which is heavily impacted by agricultural activities and run-off, its restoration could also help reduce the eutrophication of the river, and improve its ecological status.

A rowing boat near the Ērberģe hydropower plant © Magda Jentgena

The Zemgale region is already popular for tourism and wishes to increase sustainable tourism. The restoration of the river's connectivity could make the river more attractive for visitors. It is also expected that kayaking, which is very popular in Latvia and already popular on the Dienvidsusēja river today, is likely to increase as the hydropower dams would be removed and new areas of the river could be opened up to kayaking.

The removal of the three hydropower stations will contribute to stabilising the river's banks and regulating its flow. It is therefore expected to improve protection against floods, and to decrease costs associated with crop loss during flooding events. By releasing large amounts of water from the water reservoir behind the dam rapidly through the turbines (known as hydropeaking), hydropower plants destroy the river banks downstream which need to be restored afterwards, resulting in additional costs. Furthermore, because small hydropower in Latvia no longer receives subsidies from the government, but instead sells the energy produced at market value, hydropeaking has become more frequent. Small hydropower stations are inclined to produce energy when the prices are the highest, and stop water flow when the prices are low. By removing the hydropower stations, we can return the natural river flow, end the erosion of the riverbanks, and reduce the risk of flooding.

WHERE WE ARE AT AND NEXT STEPS

- Preliminary work on assessing the species in the river and water quality has been done by national authorities[56].
- Two out of the three barriers will be eligible for funding for their removal within the next 6 months.
- WWF has begun work on engaging different stakeholders and assessing the possibilities for removal and restoration.
- Next steps will include reaching out to specific landowners, local inhabitants, and municipalities regarding the removals and restoration.

56. The Institute of Food Safety, Animal Health and Environment (https://bior.lv/en) and the Latvian Centre For Environment, Geology And Meteorology (https://videscentrs.lvgmc.lv/)

EXPECTED BENEFITS OF RIVER RESTORATION IN THE DIENVIDSUSĒJA RIVER

SOCIETAL BENEFITS	INDICATORS	ASSESSMENT
Improved water supply	Water quality improvement	Significant potential to reach 'good' ecological status.
Improved ecosystem functioning, ecological connectivity, and habitat status	Presence of significant species and/or habitats in the restoration area	Enhanced conservation by maintaining the current level of diversity. 8 protected habitats and 13 protected species are reported to occur in the Natura 2000 site of the Baltmuiža marsh.
	Number of barriers removed	The project will remove 3 hydropower barriers.
	Reconnected length of river	Achieved connectivity will be 114 km, which will contribute 0.45% to EU's objective of 25,000 km of free-flowing rivers.
	Quality of adjacent land to river restored	The Dienvidsusēja passes through diverse land types (agricultural, wooded, swampland, and protected forest). Restoring floodplains is expected to help maintain different associated ecosystem types.
Improved socio-economic benefits	Full-time jobs created	An investment of €1 million in Latvia has the potential to generate 48.4 jobs in the bioeconomy sector, although this factor cannot be directly applied to river restoration[57].
	Additional revenue generated by tourism	Popularity of kayaking and river in general indicates substantial potential for boosting tourism.
Climate adaptation	Damage costs incurred	Damage created by the 2017 flood to the agriculture sector alone was over €20 million. River restoration could contribute to decreasing such costs associated with crop loss.
	Flood mitigation	River restoration can contribute to bank stabilisation and regulated flow, and help mitigate flood risk in the affected territories.
	Drought mitigation	The lack of extreme droughts in the region indicates that river restoration can at least sustain the no-drought conditions going forward.

57. Fuentes-Saguar PD, Mainar-Causapé AJ, Ferrari E. The Role of Bioeconomy Sectors and Natural Resources in EU Economies: A Social Accounting Matrix-Based Analysis Approach. *Sustainability*. 2017; 9(12):2383. https://doi.org/10.3390/su9122383

NETHERLANDS:
THE GEUL

ID CARD

Name of river:
Geul

Length of the river:
about 53 km

Average discharge:
about 4m³/s

Tributary to the Maas river

Protected area:
Natura 2000 site Geuldal (NL9801041)

A FAST-FLOWING STREAM PRONE TO FLASH FLOODING

The Geul is a small rain fed river in the hilly landscape of South Limburg. The valley it runs through is distinguished by a thick loess floodplain formed in mediaeval times. The river has a gradient of 250 metres and flows relatively fast for this area. It rises near Aachen in Germany and follows through Belgium to the Netherlands. It is fed by many small streams such as the Gulp, and the Geul itself feeds into the River Meuse near Bunden. It meanders through the landscape much like it did one hundred years ago. The Geul harbours special species such as the black stork and beavers. It is an important stream for fish species like the common minnow (*elrits phoxinus phoxinus*), the river trout (*salmo trutta fario*), and even some migratory species like the critically endangered European eel, the Atlantic salmon and the grayling. It also is the home of some unique plant species, such as the mountain pansy (*viola lutea calaminaria*). The Geul has an important role in the landscape and is one of the main recreational and tourist attractions of the region. While the Geul itself still runs relatively naturally, its surrounding land has been heavily modified for intensive agriculture and urbanisation impacting its ability to absorb water and limit flood damage.

Although the Geul is a relatively small river, restoring it makes sense because it offers an opportunity to include the whole catchment area in the restoration activities.

The Geul © Maarten Bruns, WWF

DID YOU KNOW THAT...

after a long absence, the black stork might be returning to the Netherlands? It has already been spotted near the border. The river Geul provides it with the river habitat it needs. It can become a hub for the species to recolonise the Netherlands.

Black stork (Ciconia nigra) © Adobe Stock

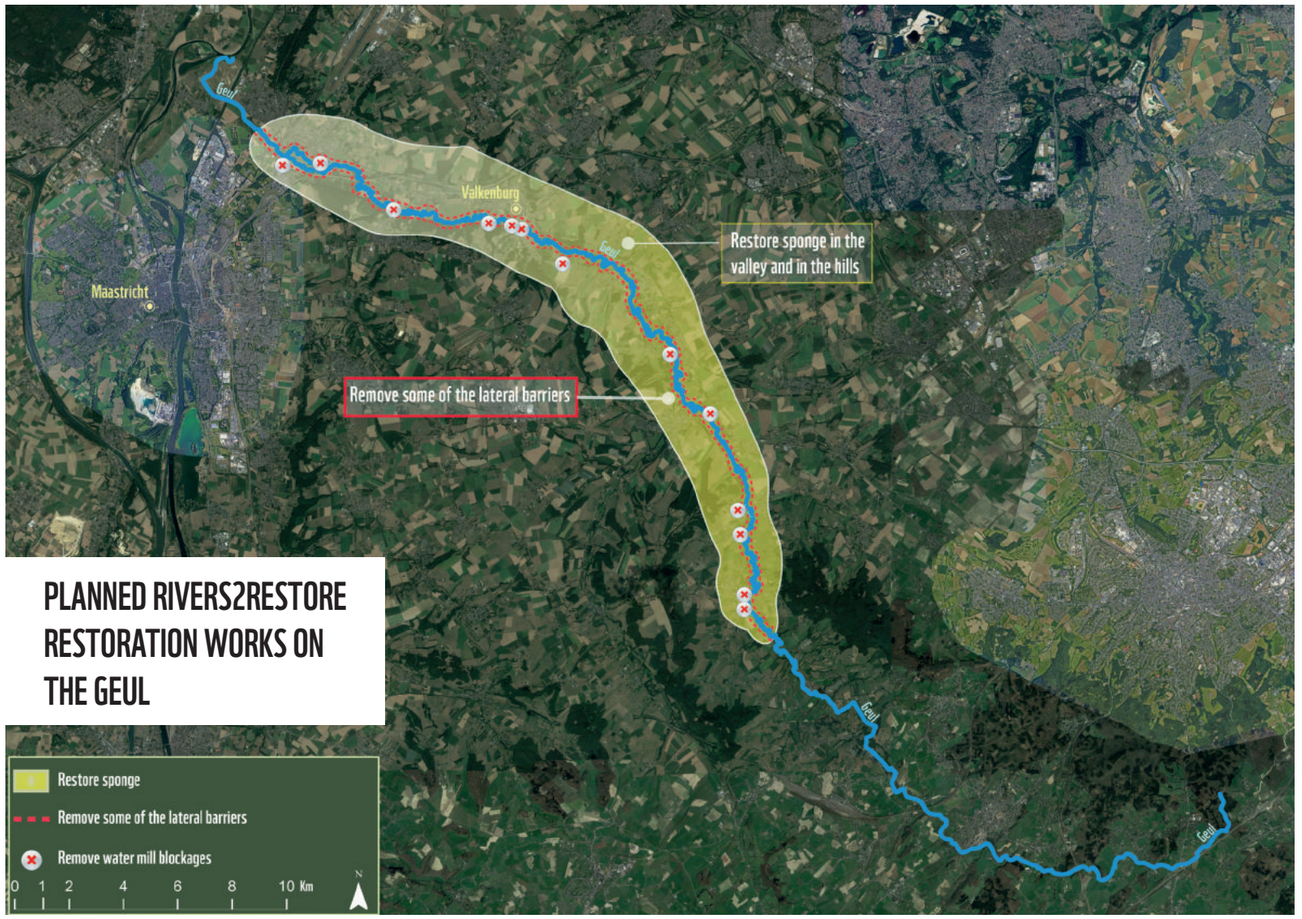
A STEP BACK IN TIME

In the early 20th century, plans were made to use the Geul for the production of electricity. These plans were stopped after heavy opposition by nature organisations. Although the Geul can still run naturally for most of its course, it is prone to flash flooding after heavy rainfall, causing damage to people and nature. During the 2021 European floods, the banks of the river flooded, including in some of the major population centres such as Valkenburg aan de Geul, where flood waters reached up to 1.25 metres in the city centre. The flood event is estimated to have caused approximately €600 million in economic damage[58] proving that we cannot rely on dykes and other technical solutions alone. These will only hold if enough water is being slowed down by the landscape.

Many former canalisations often built for water mills have been undone in recent years, but lateral connectivity has been negatively affected by intensive farming on the river banks, constructions on the floodplains, and the multiplication of hard surfaces in the urban areas.

While the Geul has a good ecological status, it still suffers from disconnectivity and from episodic pollution. A severe manure leakage from a silo in Belgium in 2018 caused widespread environmental damage to the area, and caused stocks of some fish species, such as brown trout and grayling to disappear. No recent data is available to analyse if the fish have since returned. The recent trend of increasing sediment loads in the river due to surrounding intensive agricultural practices have also reduced the suitability of fish spawning grounds[59].

58. Deltares (2021) Analyse overstroming Valkenburg. Available at: https://www.waterschaplimburg.nl/publish/pages/7013/analyse_overstroming_valkenburg.pdf
59. Rijkswaterstaat en Waterschap Limburg (2020) Vier jaar telemetrisch onderzoek in de Geul Migratiegedrag en -patronen van een rheofiele visgemeenschap in de periode 2015-2018



PLANNED RIVERS2RESTORE RESTORATION WORKS ON THE GEUL

A RESTORED LANDSCAPE ACTS LIKE A SPONGE

With nature-based solutions, the restored Geul and its floodplain can be turned into a buffer for future floods, providing opportunities for recreation. Restoring the floodplains along the Geul can reduce the dramatic episodic flooding of small streams caused by heavy rains.

After heavy rainfall, water needs to be slowed down and more water should be allowed to infiltrate into the landscape near the Geul. This means that hard surfaces close to the river need to be removed in order to let the water infiltrate in the ground. On agricultural land, drainage systems will be removed, and measures will be taken to slow down water, such as planting 'graften'(horizontal shrub rows on hilly agricultural lands). Hard agricultural surfaces (such as maize crops) will be replaced with infiltration areas, for example by switching to agroforestry. Small natural ponds and marshes will be (re)created to lower flood peaks. Shrubs, and forests will be replanted in floodplains in order to slow down the water after heavy rainfall. The soil also needs to be decompacted to improve infiltration. In total, about 250 hectares of floodplains are already planned to be restored. This restoration work is compatible with agroforestry, which enables the storage of water and enhances the soil's water retention capacity. Additionally, in the few places where the Geul was straightened, old meanders will be recreated.

In cities, roads and sealed surfaces also need to be replaced with vegetation. Projects involving citizens need to be conducted to create urban sponge areas, for example green spaces with plants and shrubs, where water can infiltrate.

In addition, 13 water mill blockages could be either removed, or bypassed. These are mainly old water mills, some of them now used for producing small amounts of electricity.

A sponge landscape © Maarten Bruns/WWF

Landschap Geul © Maarten Bruns/WWF

REDUCED RISKS OF FLOODING, AND A THRIVING RIVER ECOSYSTEM

A restored, free-flowing Geul with a natural floodplain will reduce flood risks to people in times of extreme rainfall. The restoration is likely to contribute to reduced stormwater loads into the river through the removal of drainage systems in agricultural lands along the river, and through floodplain restoration[60].

Significant potential to reduce flood risks.

The recreation of natural dynamics between the Geul and its floodplain can be expected to improve the ecological status to 'high'.

Significant potential to reach 'high' ecological status.

It is expected that this will greatly improve the habitat of most local species, as well as associated ecosystems and the quality of their services such as increased water retention, reduced soil erosion, and improved habitats.

The removal of lateral barriers is also foreseen to help stabilise sediment dynamics in the river through expanding the floodplain's surface area. The improvement in sediment dynamics is projected to enhance the quality of fish spawning grounds, benefiting the main fish species in the area.

53 km of free-flowing Geul will contribute 0.21% of the EU's objective of restoring 25,000 km of free-flowing rivers.

WHERE WE ARE AT AND NEXT STEPS

- Since the 1990s, WWF and partners have removed drainage, transformed agricultural lands into forest and removed small waterways in the catchment area.
- The government is already investing in the Geul/Gulp to prevent future flood disasters, but mostly using conventional flood protection while nature-based solutions are overlooked. We need more investment in nature based solutions to protect the area from flood damage.
- Preliminary funding was obtained from Natuurkracht (€2 million). This was just the funding to buy seeds. For the next stage and the entire restoration described above, the financial needs are estimated to be €4 million.

60. Deltares (2021) Analyse overstroming Valkenburg. Available at: https://www.waterschaplimburg.nl/publish/pages/7013/analyse_overstroming_valkenburg.pdf

EXPECTED BENEFITS OF RIVER RESTORATION ON THE GEUL

SOCIETAL BENEFITS	INDICATORS	ASSESSMENT
Improved water supply	Water quality improvement	Potential to reach 'high' ecological status.
Improved ecosystem functioning, ecological connectivity, and habitat status	Change in population levels of fish species	Potential for stabilising at risk populations of fish species, including the critically endangered European eel.
	Presence of significant species and/or habitats in the restoration area	Enhanced conservation by maintaining the current level of diversity. 14 protected habitats and 10 protected species are reported in the Natura 2000 site.
	Number of barriers removed	13 water mill blockages need to be removed or bypassed.
	Quality of adjacent land to river restored	Floodplain restoration and the removal of sealed areas likely to enhance sediment dynamics and reduction of stormwater load.
	Reconnected length of river	Achieved connectivity will be 53 km[61], which will contribute 0.21% to EU's objective of 25,000 km of free-flowing rivers.
Climate adaptation	Flood mitigation	Floodplain restoration and the removal of sealed areas likely to enhance flood mitigation. Precise estimates of impact not available.

61. 70 km if the Gulp, a tributary to the Geul, is also counted.

PORTUGAL: THE VASCÃO

ID CARD

Name of river:
Vascão

Length of the river:
about 60 km

Average discharge:
about 3.2 m^3/s (varying between 0 and 641 m^3/s)

Tributary to the Guadiana

Protected area:
Natura 2000 site Guadiana (PTCON0036)

A FRAGMENTED RIVER IN ONE OF EUROPE'S MOST ARID AREAS.

The Vascão river is at the heart of the Serra do Caldeirão, a chain of foothills on the west of the southern Iberian mountain range, the Sierra Morena. Separating the Alentejo lowlands from the eastern Algarve coastal areas, it is located in the Guadiana basin, which is shared between Portugal and Spain. The Guadiana basin is one of the most drought prone basins in Europe[62], and is home to critically endangered species such as the Iberian Lynx. The Vascão has slowly cut into the hard bedrock, creating a deep narrow valley. This unique landscape is home to several endangered fish species, such as the Spanish minnow carp, which is endemic to the Iberian peninsula and mainly found in the Guadiana basin, but classified as endangered because of habitat loss. The Guadiana Natura 2000 site (PTCON0036) was created in order to protect this rich site.

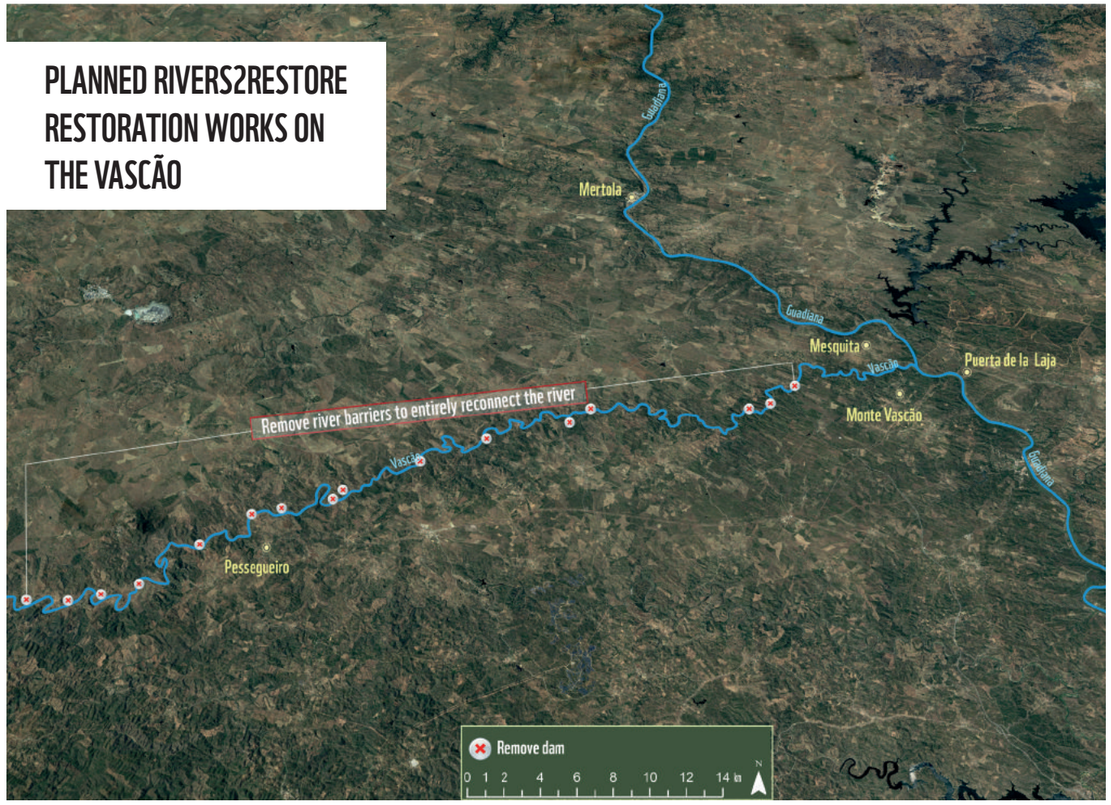
DID YOU KNOW THAT...

the Spanish minnow carp (*Anaecypris hispanica*) can only live in rivers which are shallow, highly oxygenated, dry out in the summer and have a water temperature of no more than 25 °C ?

© ICNF

62. Ranking among the highest rainfall variability in Europe (Do Ó, 2013); 7 dry years over the last 12; drought events up to 4 years long (e.g. 1991-95).

The Vascão winds through the Serra do Caldeirão © Afonso do Ó



A STEP BACK IN TIME

In the mid-20th century many of the river slopes and hilly areas were occupied by livestock, with all fertile ground (mainly riverside sedimentary deposits) turned over to farmland. Water-powered mills sprang up along the river and weirs were built to create reservoirs for irrigation, channel the river for the flour mills or create river passages for vehicles. Grazing, farming, and fishing caused a reduction in biodiversity and fish stocks, worsened by an increasingly disjointed river.

From the 1950s onward, population and economic activity started declining, and land, villages, watermills and farms were progressively abandoned. This resulted in an ecological recovery of the river and its surroundings, with the exception of some local environmental issues including poaching, illegal hunting and fishing. Some small-scale, subsistence farming remained where the valley broadens, as did small grazing areas on some slopes (mainly sheep or goat). Today, small-scale tourism is on the rise, mainly hiking.

While the river is one of the few surface water bodies in the basin with both good ecological and good chemical status, it still suffers from disconnectivity. Abandoned weirs and barely-used road passages remain in place. In addition, increasingly warm temperatures have caused a significant reduction in average flows in the past thirty years.

THE VASCÃO CAN BE ENTIRELY FREE-FLOWING ONCE MORE

By removing 17 river barriers along the Vascão, river connectivity can be entirely recovered, allowing most freshwater species to circulate freely from the mouth of the Guadiana river mouth (which empties into the Golfo de Cadiz) to the upstream areas of the Vascão (about 100 km in total).


One of the Vascão's obsolete barriers © ICNF


Natural embankments protect the banks from erosion and allow plants to grow (2009) © Afonso do O·

All 17 river barriers are now obsolete except for a few road crossings. 10 barriers, ranging from 0.1 to 4.4m in height, can be totally removed and an additional seven – ancient fords still used for car passage – can be replaced by bridges which do not block river connectivity. In addition, the riparian vegetation that was partly removed (for farming or access mainly) or deteriorated (due to climate change and river depletion) should also be restored, and livestock access to the river should be managed to restrict access to the riverbanks.

Significant potential to reach 'high' ecological status.

It is expected that this will greatly improve the ecological status of the river and most local species, as well as associated ecosystems and the quality of its services – mainly through increased water retention, reduced soil erosion, and improved habitats.

RESTORED ECOSYSTEMS AND HIGH WATER QUALITY

With 60km of free-flowing river, the Vascão is very likely to achieve "high" ecological status meaning its waters will be in very good health. Populations of the eight different fish species in the area, 88% of which are in decline and 63% of which are either endangered or vulnerable today, will stabilise.

17 barriers removed.

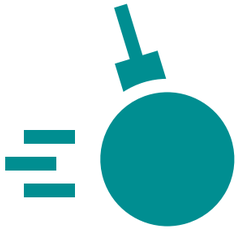
Barrier removal will also improve the conservation of the six different types of habitat and 11 significant species, such as the Iberian Barbel fish, the Eurasian otter and the Greater Mouse-Eared bat, present in the Vascão basin today.

60 km of free-flowing Vascão will contribute 0.24% of the EU's objective of restoring 25,000 km of free-flowing rivers in Europe.

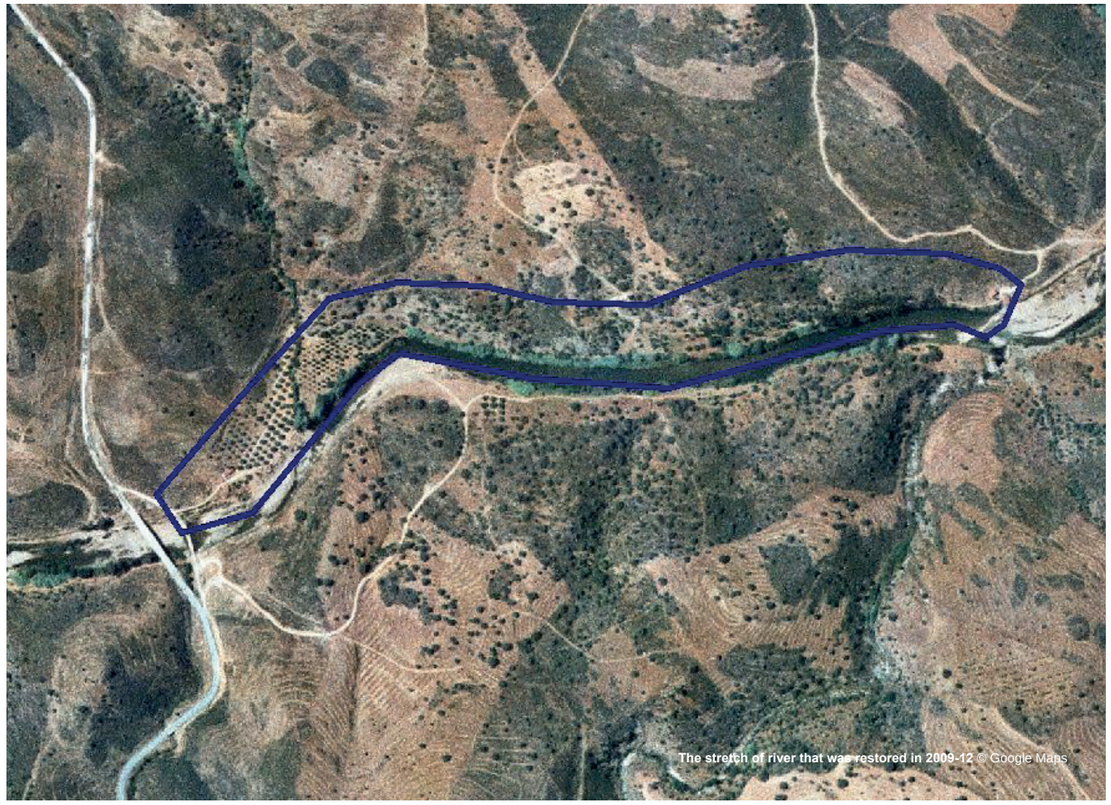
Restoration work and the following maintenance will create at least two to three full-time jobs in the area, while a restored river will also boost local tourism. The consequences of extreme weather events, such as excessive rainfall and drought, could also be reduced by restoring the river and achieving a more steady flow in the Guadiana river downstream.

WHERE WE ARE AT AND NEXT STEPS

- Preliminary work done by WWF since 2007 in the catchment – transboundary restoration projects funded by Coca-Cola and implemented with WWF Spain in 2007-12, Plantar Água projects conducted since 2018.
- Good collaboration with key regional stakeholders (Nature Conservation Authority ICNF, Environmental Agency APA, Municipalities, Landowners Associations).
- We would like barrier removal work to start in 2024, and our vision is that by 2030 all 17 will be removed and/or bridges built.
- A great expansion potential (including with Spain): most neighbouring rivers have lots of obsolete barriers and are strongly harmed by them. Cross-border cooperation with WWF-Spain has been active and delivering results for the Guadiana over the past few years.



BY REMOVING 17 RIVER BARRIERS ALONG THE VASCÃO, RIVER CONNECTIVITY CAN BE ENTIRELY RECOVERED, ALLOWING MOST FRESHWATER SPECIES TO CIRCULATE FREELY



The stretch of river that was restored in 2009-12 © Google Maps

EXPECTED BENEFITS OF RIVER RESTORATION ON THE VASCÃO

SOCIETAL BENEFITS	INDICATORS	ASSESSMENT
Improved water supply	Water quality improvement	Significant potential to reach 'high' ecological status.
Improved ecosystem functioning, ecological connectivity, and habitat status	Change in population levels of fish species	Potential for stabilising at risk populations of fish species. 8 species are reported in the site, 88% of which have a declining population trend and 63% are classified as either 'endangered' or 'vulnerable' status.
	Presence of significant species and/or habitats in the restoration area	Enhanced conservation by maintaining the current level of diversity. 6 different habitats and 11 significant species are reported to occur in this site.
	Number of barriers removed	The project will remove 17 barriers or 0.1% of all barriers in Portugal.
	Reconnected length of river	Achieved connectivity will be 60 km, which will contribute 0.24% to EU's objective of 25,000 km of free-flowing rivers.
Improved socio-economic benefits	Full-time jobs created	On average 2.3 jobs will be generated by the restoration project across the different phases of pre-restoration, implementation, and ongoing maintenance post-implementation.
	Additional revenue generated by tourism	Growing trend in visitors indicates substantial potential.
Climate adaptation	Drought mitigation	Improvements in the Vascão ecosystem are limited, but potential to sustain flow in the Guadiana river downstream.

ROMANIA:
THE DANUBE DELTA

ID CARD

Name of river:
Danube (Fluviul Dunărea in Romanian)

Length of the river:
2,857 km, of which 1075 km in Romania and on the border. The Danube Delta stretches over 4340 km² in Romania

Average discharge:
6500 m³/s

The Danube flows into the Black Sea through the Danube Delta

Protected area:
The Danube Delta has been designated a UNESCO World Heritage Site, a Ramsar Wetland of International Importance, and contains several Natura N2000 sites, Delta Dunării (ROSCI0065, ROSCI0066 and ROSPA0031).

DANUBE DELTA: EUROPE'S LARGEST REMAINING NATURAL DELTA

Located in the easternmost part of the European Union, the Danube Delta is Europe's largest natural delta and one of the most important in the world. It is a sanctuary for extraordinary, delta-specific biodiversity and a provider of critical ecosystem services. The delta is unique as it is the sole delta of a river entirely nestled within an UNESCO biosphere reserve while also being a UNESCO World Heritage site, a Ramsar site, and part of the Natura 2000 network.

The Danube Delta is a vast, well preserved wetland zone located where the Danube River flows into the Black Sea in Romania and Ukraine. Before reaching the sea, the Danube River splits into three major arms (Sfântu Gheorghe, Sulina, and Chilia) creating the Danube delta which is home to 30 types of ecosystem, more than 470 lakes connected by 3500 km of channels, semi natural wetlands and lagoons, inland marshes and natural grasslands, sand dunes, beaches, and broadleaved forests.

Being a biodiversity hotspot, the Danube Delta hosts hundreds of species including over 300 species of bird, such as the endangered pygmy cormorant, dalmatian pelican, and black-tailed godwit; 139 fish species, including many migratory fish like sturgeon, and diverse terrestrial and aquatic plants. It is also an important stopover for migratory birds.

Aquatic vegetation on the Danube. Danube Delta, Romania © Michel Gunther / WWF

DID YOU KNOW THAT...

The Danube Delta hosts over half of the world's white pelicans and more than 60% of the global pygmy cormorant population, making it a crucial hub for avian biodiversity? Also, almost all of the world's red-breasted geese winter in this region.

White pelicans at the Danube Delta © Wild Wonders of Europe / Manuel Presti / WWF

The Danube Delta's diverse ecosystems provide a great variety of benefits to people such as fish, clean water, fodder, reed, wood and honey, as well as protection from extreme weather like floods and droughts, nutrient cycling, pollination, carbon sequestration, and as a place of cultural and spiritual importance.

The significance of the Danube Delta extends beyond its ecological marvels. It is intricately tied to the livelihoods of approximately 10,000 residents. Notably, these communities stand out for their rich ethno-cultural diversity, including Romanians, Russian Lipovans, Ukrainians, Roma, Greeks, Turks, Bulgarians, etc. The historical roots of these settlements run deep, contributing to a unique tapestry of traditions and lifestyles. Despite the vibrant mix of cultures, the Delta region maintains a sparse population density of only three inhabitants per square kilometre—30 times below the national and European averages. This is primarily due to the prevalence of limited non-floodable areas in the region. The residents are engaged in traditional occupations, with fishing being a focal point closely tied to the abundant fishery resources. Connectivity between settlements and commuting to workplaces are predominantly facilitated by water routes, utilising the main branches of the Danube, channels, and lakes. The region's economic development has witnessed a delicate interplay of traditional and modern livelihoods, adding depth to the social fabric of the Danube Delta.

CLIMATE CHANGE, RIVER MODIFICATION AND DRAINAGE THREATS

The Danube Delta's fragile ecosystems are highly susceptible to both natural and anthropogenic pressures. Climate change, for example, is modifying the Danube's hydrological regimen, increasing the occurrence and intensity of floods, periods of extreme low river discharge and the subsidence of the delta area. Sediment compaction and rising sea levels further compound these challenges. Furthermore, the Delta faces vulnerabilities from pollution associated with excessive industrialisation and non-ecological agricultural practices. Deforestation and various hydro engineering activities along the river, mostly dikes, river rectification and channelisation, contribute significantly to the precarious state of these fragile deltaic ecosystems.

Historical land-use practices during the communist regime led to substantial changes in the Danube Delta. Large areas of naturally flooded land were dammed, drained and converted into farmland, which currently covers 12.9% of the Delta's surface area.

THE ECOLOGICAL STATUS OF THE DANUBE DELTA WAS 'POOR' FROM 2016 TO 2021

The dynamic geomorphology of the Danube Delta is shaped by its three major river arms: Sfantu Gheorghe (120 km), Sulina (64 km), and Chilia (112 km). This intricate dance between water and land, coupled with low altitudes and the influence of the sea, gives rise to a mosaic-like landscape with canals, shallow lakes, wetlands, floodplains, alluvial forests, reed beds, lagoons, and coastal areas. Notably, reed covers an expansive 2400 km², representing one of the largest compact reed areas globally, and the Letea and Caraorman forests mark the northern limit for rare oak species.

Avian residents include vital colonies of pelicans (*Pelecanus onocrolaturs and P. crispus*), cormorants (*Phalacrocorax carbo sinensis and P. pygmeus*), egrets (*Egretta alba and E. garzetta*), spoonbills, big owls, and white-tailed eagles.

The richness of fish species is important both economically and ecologically. It includes species specific to the Delta such as starlet (*Acipenser ruthenus*), bleak (*Alburnus alburnus*), rapacious carp (*Aspius aspius, Elymus pycnattum deltaicus* etc.). Anadromous species such as beluga (*Huso huso*), sturgeon (*Acipenser gueldenstaedtii*), sevruga (*A. stellatus*), and Danube mackerel, along with marsh species like carp (*Cyprinus carpio*), pike (*Esox lucius*), crucian (*Carassius auratus gibelio*), and tench (*Tinca tinca*), further contribute to biodiversity. Notably, 26 of these species are protected by the Bern Convention.

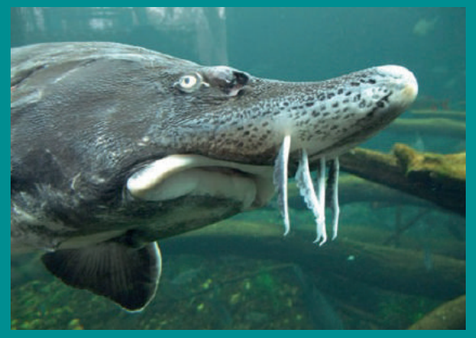
The delta's fauna also includes 3272 invertebrate species, 10 amphibian species, 11 reptile species, and 41 mammal species. The flora encompasses 955 species and 64 subspecies, constituting a third of Romania's known flora. Notably, 34 habitat types listed on the Habitat Directive's annexe can be found here, seven of which are of EU priority. Endangered mammals in the Danube Delta include the otter (*Lutra lutra*), European mink (*Mustela lutreola*) and the ermine (*Mustela erminea*).

Flooded forest in the Danube Delta Biosphere Reserve © Michel Gunther / WWF

The conversion of wetlands into farmlands has impacted biodiversity and led to habitat loss for numerous species, including migratory birds and fish. Water quality has also suffered from agricultural runoff, industrial discharges, and navigation activities, leading to eutrophication and habitat degradation, and a decline in species richness. As a result, the ecological status of the Danube Delta was reported as 'poor' in several areas from 2016 to 2021. Moreover this change has altered the traditional livelihoods of local communities who have experienced a decline in catches and had to adapt their daily practices to the new agricultural landscape.

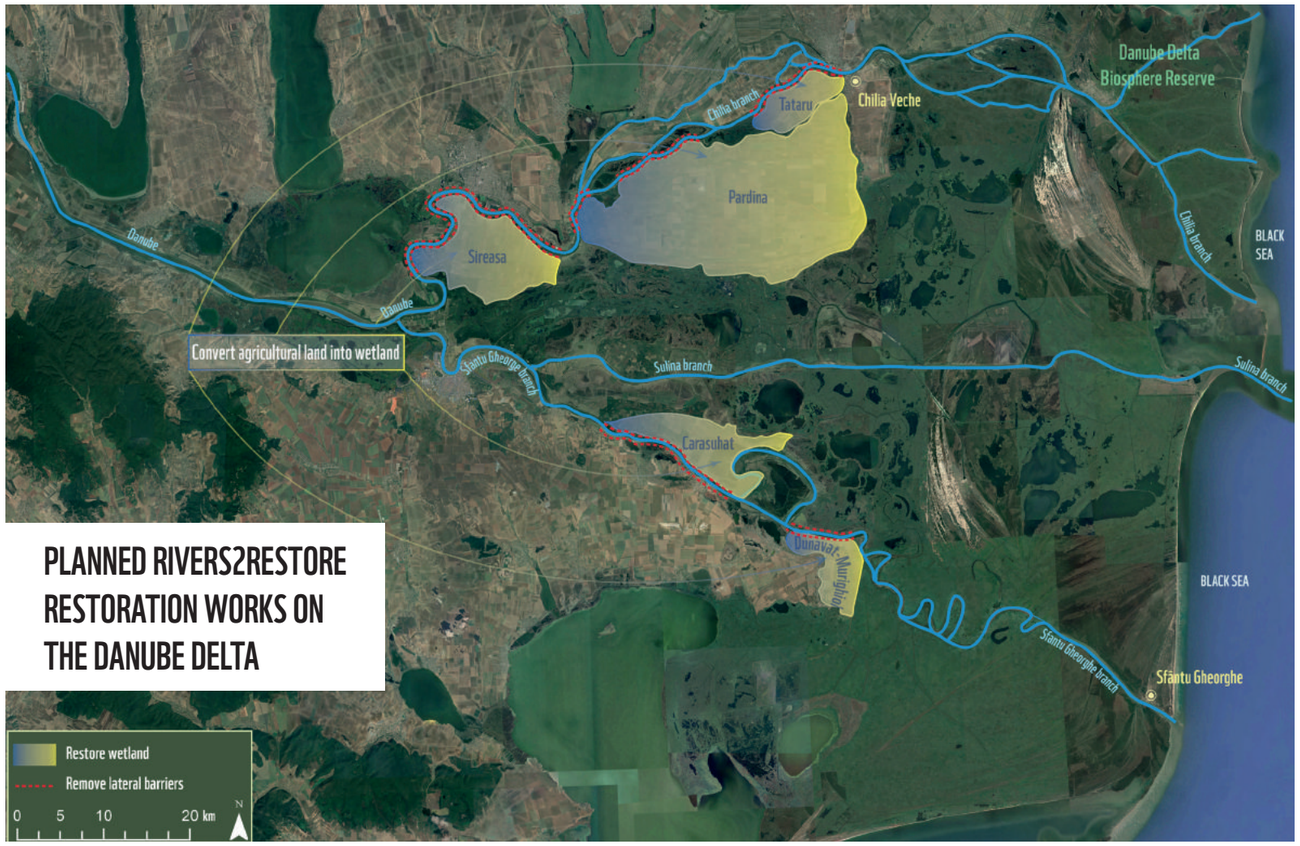
DID YOU KNOW THAT...

Sturgeons have roamed the waters of the Danube for millions of years, making them living fossils? The Danube River hosts six different species. The beluga (*Huso huso*) is the most famous, not only for its significant role in the caviar trade but also for its impressive size, reaching up to six metres! As the largest freshwater fish in the world, these majestic creatures contribute not only to the ecological richness of the Danube Delta but also play a vital role in the region's cultural and economic heritage.



Huso huso © Phyllis Rachler/WWF CEE

97 km of free-flowing Danube in the Danube Delta will contribute 0.39% of the EU's objective of restoring 25,000 km of free-flowing rivers in Europe.



PLANNED RIVERS2RESTORE RESTORATION WORKS ON THE DANUBE DELTA

RESTORING THE NATURAL HYDROLOGICAL RHYTHM OF THE DANUBE DELTA

Restoring the natural hydrological rhythm of the Danube Delta by converting nearly 40,000 hectares of agricultural land back into wetlands is crucial for ensuring the long-term social-ecological resilience of this unique landscape. The project will see the removal of approximately 91.5 km of lateral barriers, mostly dikes. These barriers currently separate the watercourse from the agricultural areas, with Sireasa, Pardina and Tataru located along the Chilia branch, and Carasuhat and Dunavat are situated on the Sfântu Gheorghe branch.

To revive the Delta's intricate network of waterways and promote habitat diversity, it is essential to reconnect the isolated or altered channels to the river. This approach enhances water circulation, sediment transport, and nutrient distribution, fostering the revival of diverse aquatic and terrestrial habitats and species, thereby boosting overall ecosystem health.

Given the numerous natural and manmade channels in the Danube Delta, particularly for irrigation, and the complexity of the hydrological system with its three main branches (estimated at more than 3500 km in total length), our focus leans towards prioritising the connectivity of the Danube branches over individual channels.

RESTORED ECOSYSTEMS, IMPROVED WATER QUALITY AND ECONOMIC BENEFITS

Making the Danube delta free-flowing is a pivotal step towards reinstating the natural hydrological and ecological processes that sustain the delta's diverse habitats. The restoration efforts will lead to the recovery of habitats, the resurgence of native flora and fauna, and the promotion of thriving ecosystems by 2030.

A primary focus of the restoration initiative is the enhancement of water quality within the Delta's aquatic ecosystems. This entails a targeted reduction of pollution levels, improved water clarity, and the restoration of natural nutrient cycling, fostering a healthier aquatic environment. Given the Delta's vulnerability to climate change impacts, the restoration actions also aim to fortify its resilience to rising sea levels, extreme weather events, and changes in precipitation patterns.

Potential to improve the ecological status of the delta which is currently 'poor' in several areas.

Beyond environmental gains, the restoration project envisions a resurgence of community engagement and sustainable livelihoods for local residents. This includes sustainable fishing practices and eco-tourism. Official data on the number of visitors to the Danube Delta shows a decline post-2020, with 2022 recording a 36% decline compared to 2019 (106,000 visitors in 2022 and 166,000 visitors in 2019). The disruptions caused by Covid-19 are likely responsible for the reduced visitor numbers observed. Nevertheless, restoring the site can help bring back the visitor numbers seen in previous years.

The restoration project is also likely to become a catalyst for employment opportunities that directly benefit the local community. Surveys conducted by WWF-Romania revealed a high level of local support with 83% to more than 97% of respondents in favour of restoring former wetlands over agricultural polders in different areas. Respondents said that restoration initiatives yield substantial benefits for themselves, their families, and the broader community.

WHERE WE ARE AT AND NEXT STEPS

Between 2012 and 2016, a collaborative effort between WWF-Romania, Mahmudia City Hall, and the Danube Delta Biosphere Reserve Administration saw the implementation of a transformative project funded by the EU. The goal was to convert 924 hectares of agricultural land within the Carasuhat agricultural precinct into a thriving wetland. Extensive monitoring activities and studies following the works uncovered a flourishing ecosystem within the restored area, attracting diverse wildlife. Five years after the project's completion, a comprehensive socio-economic study led by WWF showcased tangible economic benefits for local fishers and tourism operators resulting from the restored wetland. Key advantages included a 50% reduction in the distance to prime fishing and birdwatching sites, leading to decreased fuel consumption. The area's appeal to tourists also experienced a notable upswing in the following years, before the pandemic.

In 2023, a survey revealed overwhelming support from the people in Mahmudia. Over 97% of respondents said they support the wetland restoration, citing substantial benefits for themselves, their families, and the community at large. Moreover, the study underscored strong local support for potential wetland restoration in other sections of the Carasuhat agricultural area.

Building on this success, the Carasuhat model has the potential to be replicated in other parts of the Delta, specifically in the five agricultural precincts – Pardina, Sireasa, Tataru, Murighiol-Dunavat – and the remaining farmland area in Carasuhat. This not only emphasizes the project's scalability but also sets the stage for further nature restoration efforts in different regions of the Delta.

Pelicans and cormorants using the restored wetland area of Carasuhat, Mahmudia as a feeding site. © Bogdan Lungu / WWF-Romania

EXPECTED BENEFITS OF RIVER RESTORATION IN THE DANUBE DELTA

SOCIETAL BENEFITS	INDICATORS	ASSESSMENT
Improved water supply	Water quality improvement	Potential for improving the ecological status (currently 'poor' in several areas) by establishing lateral connectivity.
Improved ecosystem functioning, ecological connectivity, and habitat status	Sediment carried by the river	Potential for increasing sediment transport – but requires additional monitoring.
	Change in population levels of fish species	The decline in fish populations serves as a compelling catalyst, urging efforts towards habitat restoration, and the preservation of crucial wetlands ecosystems within the Danube Delta.
	Presence of significant species and/ or habitats in the restoration area	Enhanced conservation by maintaining or widening the current level of diversity. More than 5000 species and 29 community interest habitats are reported on the Danube Delta.
	The reconnected length of river	Maximum potential for achieved connectivity will be 91,5 km, contributing 0.37% of the EU's objective of restoring 25,000 km of free-flowing rivers.
	Riverine flow status	Rewetting the delta can bring important benefits such as replenishing water tables, sedimentation, and restoration of ecological flow[63].
Improved socio-economic benefits	Full-time jobs created	On average 11.2 jobs will be generated by the restoration project across the different phases of pre-restoration, implementation, and ongoing maintenance post-implementation.
	Additional revenue generated by tourism	Restoration of the site can contribute to restoring the visitor numbers to pre-covid levels.

63. The river's flow speed is 0.83 – 4.11 m sec-1 in the delta. Active channel width is noted as maximum 50 m with a maximum depth of 18 m.

SLOVAKIA: THE BELÁ

ONE OF THE LAST WILD RIVERS IN CENTRAL EUROPE IS INCREASINGLY FRAGMENTED

The Belá River is the largest mountain braiding river in Slovakia, a scenic Alpine river flowing from the Tatras mountains into the Váh River. It has a unique, meandering shape and biodiversity, and is home to the nearly threatened Eurasian otter, as well as to the German tamarisk (*Myricaria germanica*) flower. Its multi-thread river pattern and gravel-bed are typical of a near-natural braided and wandering river system. The channel of the Belá River is constantly moving, filled in by new sediments of pebbles and gravel coming from the mountain, and the character of the floodplain is also changing. This riverbed movement is important for the preservation of unique habitats, such as alluvial forests. A large stretch of the Belá River and its floodplain is part of the Natura 2000 network, and it is one of the four priority river basins in Slovakia which are part of the LIFE "Living rivers" project started in the beginning of 2023.

ID CARD

Name of river:
Belá

Length of the river:
about 23.6 km

Average discharge:
6.8 m^3/s

Tributary to the Váh River (the longest river in Slovakia)

Protected area:
The Belá flows through both the Bela (SKUEV0141) and Tatry (SKCHVU030) Natura 2000 sites

DID YOU KNOW THAT...

The tamarisk (*Myricaria germanica*) flower, which lives in gravel in braided rivers, is mentioned in two books of the Iliad?

Blooming German tamarisk. © Miroslav Očadlík

Over the past 150 years, human alterations of rivers have caused its dramatic decline in Europe. The Belá River has a permanently preserved dynamic regime of the channel, which creates exposed gravel benches on which tamarisk can grow.

Source: https://www.sciencedirect.com/science/article/abs/pii/S143383192100041X

Sunlight dances on the Bela © Miroslav Ocadlik WWF-Slovakia

DRAINING AND CONSTRUCTING ON THE RIVER

At the end of the 19th century, works started to drain the river for flood control and to allow building on the floodplain. From then on, the Belá River suffered various interventions which altered the direction of the main channel, disrupted the river flow, and accelerated erosion of the river bed and banks – mainly for flood protection.

The most recent large floods, caused by melting snow in the High Tatras, occurred in 1997 and 2018. Following those events, flood protection barriers were built on the Belá even in places where they were not necessary. This resulted in the loss of side-channels and precious habitats. In addition, from 1950 to 2000, more or less 140,000 m^3 of gravel was extracted as a flood protection measure for the two towns of Liptovský Hrádok and Dovalov, and to protect road and railway bridges.

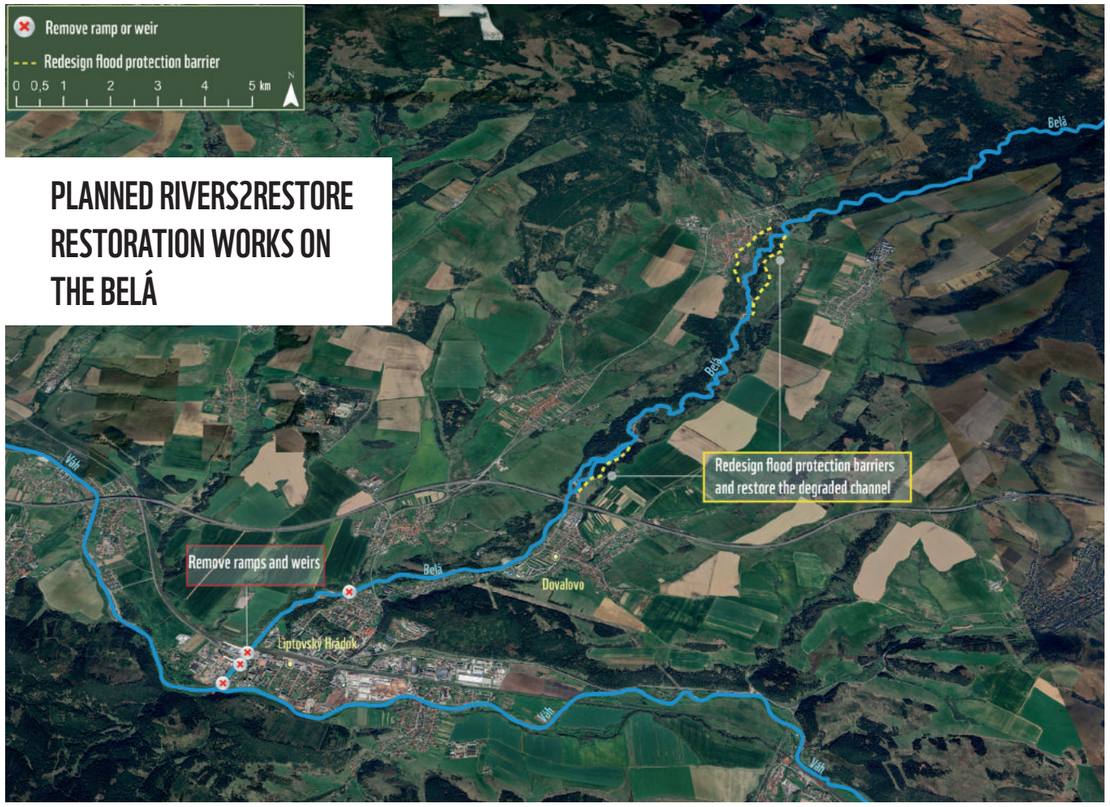
Furthermore, the upper part of the river was cut off from its lower stretches by the construction of four small hydropower plants on abandoned side channels. One plant is in Vavrišovo, and four are in Pribylina – they are still operational today. The main river channel was disconnected from its river banks and its adjacent floodplain by the construction of ramps, dikes and bypass channels. This disrupted the homogeneity of the river, and the transport of sediment was reduced. The local fish populations, in particular grayling and trout, were also affected by those barriers, which worsened their ability to migrate, especially upstream.

Further downstream, the channel is regulated at the point where four bridges cross the Belá River. It is also regulated at the river mouth into the Váh River along a 4 km stretch where the channel is diverted into the inter-dike area to protect the urban areas of Liptovský Hrádok and Dovalovo. This part of the river that runs near to buildings is regulated by five stone ramps which create a barrier to fish and sediment.

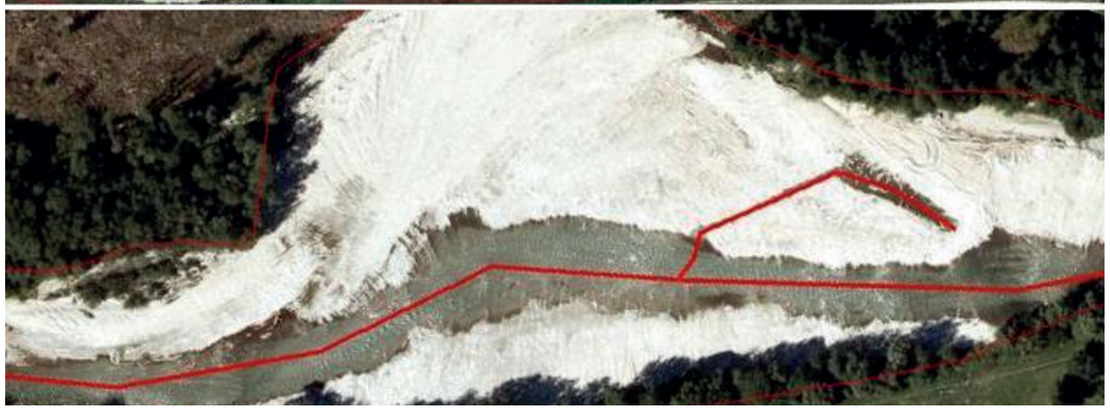
The Belá River is also affected by pollution from poorly operated sewage treatment plants. Given that the water in the Belá River is low in nutrients (oligotrophic), pollution from sewage plants has a significant impact on biological communities by overcharging them with nutrients and affecting sensitive aquatic species (the nutrient content reduces the oxygen level in the water, especially in summer periods).

Although all water bodies in the Belá River basin reach at least good ecological status or potential, the hydromorphological interventions carried out in 2018 for flood protection have most-likely worsened the status. For this reason, the ecological status is being reassessed as part of the measures planned under the LIFE Living Rivers project.

A 1.5m-high ramp upstream of the confluence with Váh river. By modifying this object it is possible to improve the migration from the river Váh. © M. Očadlík



Channel modification and habitat loss in one section after flood mitigation measures between 2015 and 2018. The unification of the channel has led to the loss of valuable habitats, deterioration of the water regime of the surrounding floodplain and erosion of the river bed. Credit: Anna Kidová © EUROSENS



RESTORING THE NATURAL COURSE OF AN ALPINE JEWEL

By removing four barriers, at least 23.5 km of waters will be allowed to flow freely once more in the Belá River and its tributaries. The four barriers to be removed are 0.5-1.5-high ramps and weirs, built for flood protection. Two of them should be removed in the framework of the LIFE Living Rivers project, and WWF recommends the removal of two others.

In addition, the restoration should entail the development of a management plan for the protected area, the restoration of habitats that are home to specific fauna and flora, the redesign of the flood protection plan, and the modification of the degraded channel through the restoration of the banks at critical sites hundreds of metres long.

RESTORED ECOSYSTEMS AND HIGH WATER QUALITY

With 23.5 km of free-flowing river, the Bela's ecological status is expected to increase from moderate[64] to good, in particular due to the improvement in the abundance of fish populations.

4 barriers removed.

The Belá river is used for rafting, sport fishing and also hosts a nature trail. The restoration of the river is expected to boost these activities. Meanwhile, restoring the migratory channels will improve the natural protection against floods, as the river will be able to expand during times of heavy rain. The improvement of habitats protected under the Habitats directive, such as the Alpine river and the subalpine and alpine spruce forests is also expected.

The restoration of 23.5 km of free-flowing river will be an example of good practice given the iconic nature of the Belá river.

WHERE WE ARE AT AND NEXT STEPS

Within the LIFE Living Rivers project, WWF is working with stakeholders and project partners to map the full potential for river revitalisation. Measures to be completed by 2030 will be proposed by the end of 2025. With the local water authority, WWF wants to develop a new and ecological maintenance plan for the stream in the open country outside settlements.

64. Latest data from 2016-2018 indicate a good ecological status, but a revision of the status is expected in the coming months and WWF assumes the status is likely to decrease to "moderate".

EXPECTED BENEFITS OF RIVER RESTORATION IN THE BELÁ RIVER

SOCIETAL BENEFITS	INDICATORS	ASSESSMENT
Improved water supply	Water quality improvement	Significant potential to reach 'high' ecological status.
Improved ecosystem functioning, ecological connectivity, and habitat status	Presence of significant species and/ or habitats in the restoration area	Enhanced conservation by supporting the current level of diversity. 7 different habitats and 2 significant species protected under the Habitats directive are reported on this site.
	Number of barriers removed	The project will remove 4 ramps.
	Reconnected length of river	Achieved connectivity will be 23.5 km, which will contribute less than 0.1% to EU's objective of 25,000 km of free-flowing rivers.

BY REMOVING FOUR BARRIERS, AT LEAST

23.5 KM

OF RIVERS WILL BE ALLOWED TO FLOW FREELY ONCE MORE

SPAIN:
THE GUADALQUIVIR

OBSOLETE DAMS HAVE CUT OFF THE RIVER FROM ITS ESTUARY

The Guadalquivir is one of the longest Southern rivers in the EU. It originates in the Sierra Nevada, and then flows South West towards the cities of Córdoba and Sevilla, until it reaches the marshlands of Las Marismas and ultimately its mouth in the Gulf of Cádiz. The lower part of the river was once so big (its name comes from the Arabic meaning "big river") that it created an inland delta hosting rich wildlife – such as sturgeons which were present until the 1970s – that also includes the area of the present world-renowned Doñana national park. In its lower reaches, the river was once a transition zone from freshwater habitats to saltwater habitats, supporting key areas for many fish, animal and plant species. This zone supported a very rich biological community, occupying a vast area of marshlands. However, the lower river channel is now dredged and modified to allow inland navigation, while marshlands are drained and dried to allow the expansion of agriculture. Furthermore, the Alcalá del río and Cantillana dams that were constructed to regulate the natural flow and produce electricity, have deeply modified the natural functioning of the river. As a result, the freshwater flow is no longer strong enough to balance the tidal influx of saltwater, and the ecological status of the estuary and its biodiversity are in decline.

Although the Guadalquivir has some water bodies in good ecological status, many of its species are now suffering from the loss of their habitats and biodiversity, such as the vulnerable Iberian roach (*squalius alburnoides*). The lower section of the Guadalquivir, which is classified as heavily modified according to the EU Water Framework Directive, has serious water quality issues, and since 2015 has suffered from regular drought.

ID CARD

Name of river:
Guadalquivir

Length of the river:
about 657 km - the R2R site includes the last 200 km before the estuary

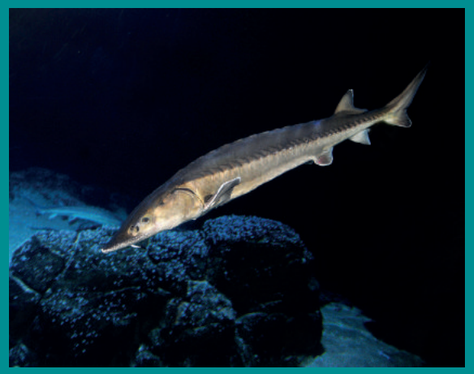
Average discharge:
on average 121 m^3/s at the restoration site

Protected area:
Bajo Guadalquivir Natura 2000 site (ES6150019)

Flamingoes wade in the marshlands or "Marismas" adjacent to the current Guadalquivir river channel in the background, dredged and modified for inland navigation © ONER / WWF-Spain

DID YOU KNOW THAT...

The Alcala del río and Cantillana dams contributed to the extinction of the European sea sturgeon (*Acipenser sturio*) in the lower Guadalquivir?



© Diergaarde Blijdorp / WWF-Netherlands

A STEP BACK IN TIME

In 1930, two large[65] dams were constructed upstream of Sevilla, in Alcala del río and Cantillana, to produce electricity and provide water for irrigation. As a result, the Guadalquivir was cut off from its estuary and the natural freshwater inflow into the estuary was significantly reduced. A large quantity of river sediments is now trapped upstream behind the dams and no longer flows into the estuary. This, along with the reduction of freshwater flowing to the lower part of the river, allows tidal waves from the Atlantic to travel up to the Alcalá del río dam, bringing salt water and disruptions to sediments in the estuary. This severely impacts water quality, habitats and biodiversity present in the lower part of the river today. The works leading to the construction of the dams and the dredging of the estuary in recent decades have also widened and deepened the river, eliminating its natural meanders and islands and ending the former variations in flow. As a result, some habitats on the original marshlands of the Guadalquivir have been reduced significantly. It has also destroyed or cut off access to spawning grounds for some fish species that used to migrate from the estuary, such as the sturgeon, sea bass and eels.

65. Approximately 20 metres-high each and 200 metres-wide.

FREE-FLOWING ONCE MORE

By removing the Alcala del Río and Cantillana dams, a 90 km section of the Guadalquivir can be made free-flowing again. Both dams are too small to be able to store large amounts of water, therefore their electricity production is inconsequential and mostly dependent on often low river flows.

While they are both operational, their permits are close to expiring and the hydropower generation capacity is much lower than the potential of other sources of energy like wind and solar. WWF therefore recommends not renewing these permits and opening their gates instead to let the river flow and rebalance the slope and sediment transport. This solution would avoid maintenance costs and deliver benefits for society and nature. The structure of the dam could be kept as a bridge as it has been declared as a "cultural heritage site of importance" under regional law. This would not impact the functioning of the river, as the open gates would allow water to flow freely up and down the structure.

WWF advises against the alternative proposal to build a massive fish ladder. On top of being very costly due to both the construction and the reclamation of some private land around the dam, it would be far less effective in allowing fish to pass up and downstream. It would not allow the recovery of the population of threatened fish species like the sturgeon, as this must be accompanied by the restoration of the riverine habitat and spawning areas in the Guadalquivir river. Nor would it allow the recovery of sediment and water flows.

The Alcala del río dam crosses the entire width of the Guadalquivir blocking the natural flow of the river, trapping sediments and making it impossible for fish to pass and access riverine habitats upstream. © Rafa Seiz / WWF Spain

IMPROVED RIVER ECOLOGY AND IMPROVED RESILIENCE TO DROUGHT AND SEA LEVEL RISE

Removing the two dams will create a 90 kilometre completely free-flowing stretch upstream of the dam, and will reconnect the lower Guadalquivir with its estuary[66].

90 km of free-flowing Guadalquivir, between the Alcalá del río and Cantillana dams and the next dam upstream (Peñaflor) will contribute 0.36% of the EU's objective of restoring 25,000 km of free-flowing rivers in Europe.

We believe that bringing back the natural functioning of the river will help riverine habitats in this part of the basin recover. Although the natural river flows will not fully recover (since there are other dams and barriers upstream), we expect that the free-flowing river section will naturally recreate small islands, some meandering of the channel, alternate rapids and ponds, and carry sediments of different sizes.

It is expected that the improved habitats and biodiversity, the increased sediment transport and flow variation during the different times of the year, and the reduction in turbidity and salinity in the estuary will greatly improve the ecological status of the river and most local species. This can also improve water quality, the status of associated ecosystems and the quality of their services. For instance, the estuary and the lower part of the Guadalquivir are very close to the Doñana wetland, so they are important for the biodiversity and the ecological processes that happen around it (including the potential freshwater inlet in the Marisma in the northeast of Doñana).

With this restoration, the lower part of the Guadalquivir river will partially recover its functioning as an estuary, helping to mitigate the impacts of sea level rise and higher tidal waves in the current channel. It will also impact the conditions of part of the river, helping biodiversity to adapt and be more resilient to the more challenging conditions due to the impact of climate change in the area.

66. The section downstream the Alcala del Río dam is not considered as free-flowing as the river crosses the city of Sevilla, where lateral connectivity is not ensured and is considered as heavily modified according to the standards from the EU Water Framework Directive.

WHERE WE ARE AT AND NEXT STEPS

- In the short term, there is an opportunity since a specific measure in the Programme of Measures of the Guadalquivir River Basin Management Plan includes action to recover the lower part of the river, and the authorities are discussing the different possibilities. We hope that these discussions result in the restoration of the condition of the river and its habitats.
- In the medium term, we would advocate for the return of a more natural ecological flow, which depends right now on how the water is managed in the basin upstream. WWF will ask for a revision of the flows as a complement to the restoration actions.
- In the long-term, WWF envisions having a good basis (proper habitat restored and good ecological flow conditions) to promote the reintroduction and allow the recovery of sturgeons, given that species such as eels and other riverine biodiversity will also benefit from all of these actions.

REMOVING 2 DAMS WILL CREATE A

90 KM

STRETCH OF FREE-FLOWING RIVER

The Guadalquivir river channel (left) near its mouth in the Atlantic ocean (background), with remaining marshland areas nearby and former marshlands now drained for agriculture (right). © ONER / WWF Spain

A former fishing boat which was dedicated in the past to fishing glass eel in the river, but now anchored near the shore during low tide on the Guadalquivir estuary, near Trebujena municipality © Rafa Seiz / WWF

EXPECTED BENEFITS OF RIVER RESTORATION IN THE LOWER GUADALQUIVIR RIVER

SOCIETAL BENEFITS	INDICATORS	ASSESSMENT
Improved water supply	Water quality improvement	Significant potential to reach 'high' ecological potential.
Improved ecosystem functioning, ecological connectivity, and habitat status	Sediment carried by the river	Barrier removal projected to stabilise sediment loads in the medium-long term.
	Change in population levels of fish species	Barrier removal is aimed to positively impact critically endangered sturgeon and other fish populations in the long term.
	Presence of significant species and/ or habitats in the restoration area	The restoration is likely to positively influence the array of habitats and species present in the area. 8 protected habitats and 70 protected species are reported in the Natura 2000 site.
	Number of barriers removed	The project will remove 2 large dams.
	Reconnected length of river	90 km of free-flowing rivers will be created, which will contribute 0.36% to the EU's objective of 25,000 km of free-flowing rivers.
Climate adaptation	Drought mitigation	The restoration is expected to help biodiversity to adapt and be more resilient to the warmer and dryer conditions due to climate change.

CONCLUSIONS

Bogdan Lungu © WWF-Ro

Rivers2Restore sites are only a snapshot of the scale of river restoration needed in Europe. They are meant to provide inspiration and demonstrate the benefits of river restoration for nature and society.

Free-flowing rivers offer a multitude of benefits to both the environment and communities. Restoring them will contribute to addressing the twin issues of building Europe's resilience to climate change impacts and fighting freshwater biodiversity loss. Free-flowing rivers help mitigate the risk of flooding by allowing rivers to absorb excess water during heavy rains, and they help prevent drought by allowing water to be stored in the soil. Bringing back the natural flow and ecosystem of rivers improves water quality, which, in turn, supports greater biodiversity.

Restored free-flowing rivers provide substantial economic benefits. Reviving and preserving healthy river ecosystems can boost the tourism and recreation industries, attracting people interested in activities like fishing, boating, and hiking. These activities generate revenue for local businesses, create jobs and increase property values. Moreover, by reducing the risk of flooding and associated damages, river restoration projects save substantial costs in disaster recovery and insurance pay-outs. Improved water quality and quantity resulting from restoration can also support sectors like agriculture and navigation.

Overall, river restoration projects not only enhance environmental sustainability but also boost the economic vitality of the surrounding areas. Furthermore, these projects often reconnect people with their natural heritage, fostering a sense of stewardship and appreciation for the environment. Ultimately, river restoration contributes to more resilient ecosystems, safer communities, and enhanced quality of life. In the annex, an overview of the ecological, economic, and social benefits of river restoration is outlined.

› We call on national governments in the EU to include Rivers2Restore projects in National Restoration Plans and work towards their implementation by 2030.

We are looking forward to collaborating with governments in the coming years to work together towards this goal. We call on governments to ensure that the necessary permits and authorisations for the restoration works are delivered, that funding is secured, and that governments engage more broadly in planning and delivering river restoration beyond Rivers2Restore projects in order to achieve the objectives of the EU Nature Restoration Law and the Water Framework Directive.

› We call on the European Commission to support and encourage national governments to include Rivers2Restore sites in National Restoration Plans.

We also call on the European Commission when assessing those plans in 2026-2027, to flag any insufficient ambition on river restoration.

ANNEX - METHODOLOGY:
RIVERS2RESTORE INDICATORS

Rivers2Restore worked with 12 indicators identified to show the ecological, socio-economic and climate benefits of river and floodplain restoration:

- Improved water supply
- Sediment carried by the river
- Change in population levels of fish species
- Presence of significant species and habitats in the restoration area
- Number of barriers removed
- Quality of adjacent land to river restored
- Reconnected length of river
- Riverine flow status
- Full-time jobs created
- Additional revenue generated by tourism
- Damage costs incurred from floods
- Flood mitigation
- Drought mitigation

Within the categories of ecological, socio-economic and climate benefits, indicators were scoped based on their applicability to a series of criteria, namely:

- Alignment to societal challenges addressed by river restoration, based on the IUCN global standard for nature-based solutions.
- Broad applicability to most Rivers2Restore site projects.
- Grounded in EU reporting regimes, such as the Nature Directives and Water Framework Directive. Using the data flowing from these legislation, indicators could be assessed relatively easily.

INDICATOR	RATIONALE	METRICS AND DATA COLLECTION	APPLICATION
Improved water supply			
Water quality improvement	Restoration improves nutrient/ sediment transport and hydrological dynamics. The resulting improvement in water quality benefits the environment, the supply of drinking water, and recreational activities.	Ecological status under the Water Framework Directive (Good; Moderate; Poor; Bad; Unknown status) before and after restoration. Data available through national water agencies and the EU WISE portal.	Compare the observed water quality status before and after restoration, to infer change of status and whether the water can be used for various purposes (fishing, bathing, drinking).
Improved ecosystem functioning, ecological connectivity, and habitat status			
Sediment carried by the river	Restoration, in particular barrier removal, can impact the sediment load carried by rivers, by providing uninterrupted flow through stretches of rivers. Sediments help maintain riverbanks and shorelines (which can prevent erosion and mitigate the exposure to flooding), and increase soil fertility in floodplains and deltas.	Depth of transparency (m) measured within 0.5 km downstream of the barrier using the 'Secchi disc' method.	Compare the obtained measurements before and after restoration. Decreased transparency of water flow implies increased turbidity and sediment load, thus implying more natural river flow conditions (i.e., sediment no longer trapped by a barrier).
Change in population levels of fish species	Restoration, in particular barrier removal, is likely to improve population numbers of migratory species through allowing undisturbed passage to breeding areas. In addition, restoring connectivity is expected to improve aquatic habitat conditions in the river.	Fish count (per species), before and after restoration, collected on a monthly basis from historical regional/local fish surveys or biodiversity monitoring for national reporting.	To understand the potential benefit, examine the percentage of reported species with declining trend at site by referencing the IUCN red list of endangered and critically endangered species at the site. Compare the data obtained for the period before and after restoration to identify trends.
Presence of significant species and habitats in the restoration area	A healthy ecosystem is one capable of supporting significant biodiverse habitats and species of ecological, cultural, and economic value. Restoration activities can strengthen ecosystems' resilience (water availability, soil stabilisation), thus supporting the health of these already existing diverse habitats and species.	The presence of EU protected species and the presence of EU protected habitats gleaned from the EU Natura 2000 viewer. https://natura2000.eea.europa.eu/	Record a total number of protected species and/ or habitats present in the restoration site.

Number of barriers removed	Barrier (lateral, longitudinal) removal allows rivers to return to their natural state and function, supporting healthy ecosystems and enhancing the well-being of nature and people.	The number and type of barriers to be removed, based on restoration project documentation. Follow AMBER nomenclature for type of barriers (dam, weir, sluice, ramp, ford, culvert, other).	Record a total number of barriers to be removed. For a wider view, this number can be compared to the total number of barriers existing in the country, using AMBER atlas, to scope the overall impact (% of barriers to be removed in a country).
Quality of adjacent land to river restored	Floodplain restoration can have a significant positive impact on the quality of land adjacent to a river by enhancing soil fertility (reintroducing nutrient-rich sediments), reducing erosion through stabilisation of riverbanks, and increasing land resilience by creating natural buffers against flooding.	Inundation area within 0.5 km downstream of the restoration site, before restoration (average area inundated, seasonally, from the past 5 years- km^2) and following restoration (average area inundated, seasonally- km^2). For first approximation, Google Maps and GIS mapping tools can be used.	Describe in qualitative terms the inundation area (vegetation coverage, flow dynamics) before and after restoration. Use expert judgement to recognise changes and assign them as positive or negative (e.g., increased vegetation cover in inundation area increases water retention capacity, decreases downstream flooding).
Reconnected length of river	Free-flowing rivers underpin the health of ecosystems, economies, and communities. The EU Biodiversity Strategy aims to reconnect 25,000 km of free-flowing rivers by 2030 in an effort to restore rivers.	Absence of longitudinal, lateral, vertical and temporal barriers in a stretch of river - https://environment.ec.europa.eu/publications/guidance-barrier-removal-river-restoration_en. Consult AMBER atlas to identify barriers, in addition to any in-field data collection. https://amber.international/european-barrier-atlas/	Determine the total length of free-flowing river to be achieved by measuring the distance (km) from the barrier removal site to the next barrier upstream and downstream (even if the occurrence of the barrier is cross border), and adding these lengths.
Riverine flow status	Water velocity and dynamics can be expected to revert to natural flows under restoration. This creates benefits such as biological purification processes which contribute to cleaner water, carriage of sediment downstream supporting natural erosion and redeposition.	Velocity of river flow (m/s) recorded seasonally, up to 5 years prior to restoration, as recorded by relevant monitoring institutions. Active channel width (m), before and following lateral restoration (within 0.5 km upstream and downstream of restoration). Active channel depth (m), before and following longitudinal restoration (at the barrier prior to removal).	Compare the measured values before and after restoration, to note trends in change. Using expert judgement, evaluate the benefit of change taking into consideration contextual data, such as the current (natural) meandering of the river (which could impact the flow dynamics of the river).

Improved socio-economic benefits			
Full-time jobs created	Restoration works are likely to provide some employment benefits to the local economy. For example the removal of barriers will likely require specialist demolition teams, the restoration of floodplains will likely require a dedicated team of planners and monitoring personnel.	Number of full-time equivalent (FTE) jobs directly involved in the restoration work, (1 FTE=40 hr work week; 0.5 FTE=20 hr work week) across: i) pre-restoration (design, establishing monitoring needs), ii) implementation (conducting restoration works), and iii) ongoing (monitoring and maintenance - may be projections). Collect data from all parties involved in the restoration project.	Determine the total number of FTEs created by the restoration project. The assessment considers only the jobs created directly for the purpose of a restoration project. Indirect employment effects, such as jobs potentially lost or gained due to restoration (e.g., tourism and hospitality, protected area management) are not considered as this requires a detailed socio-economic analysis.
Additional revenue generated by tourism	Tourism brings business opportunities for small communities, promotes the creation of jobs and can contribute to the development of the local economy. When a portion of proceeds are invested towards river upkeep, it also creates added value for restoration projects.	Average number of visitors to restoration site/month, prior to restoration (previous 5-10 years, depending on data availability) and after restoration. Average spending per tourist visit (this can be national/regional/local data). Collect data from relevant tourism or statistical offices. Supplement with surveys to project future impacts of restoration.	Analyse trends in visitors and spending before and after restoration projects as a simple comparison of before / after, noting any increase as a beneficial consequence of restoration.
Climate adaptation			
Damage cost incurred	Natural disasters (flooding, landslides, droughts) cause disturbances to normal life and can threaten the safety of the living by causing destruction to property, infrastructure, habitats etc. A restored free-flowing river, by having its natural flow dynamics and good ecosystem functioning restored, can be expected, in the long-term, to buffer damages associated with adverse effects of disasters.	Damage costs (€) incurred in the local area (within 5 km of the restoration site) from previous natural disasters, recorded as direct costs (damages due to direct physical contact with the disaster) or business interruption costs. Collect data from relevant insurance and/or national databases on disasters.	Care is required in data collection on where damage occurred in proximity to restoration, and attribution of restoration to reduced damage. Future projections will largely be qualitative, taking inspiration from previous EU examples of restoration impacts on damage costs.

Flood mitigation	Restoration activities, in particular floodplain restoration, can result in greater water retention capacities of rivers, which in turn can reduce the frequency and/or severity of flooding events further downstream. Reduction in uncontrolled flooding and extent of areas under flooding result in safer living spaces for communities, and in greater predictability of crop success.	Number of flooding events, within the same river as the restoration project, within 5 km of the site in the previous 25 years. Historical data from official reports, e.g., meteorological data from environment or water agencies or meteorological offices.	Compare the obtained data before and after restoration, to determine trends of change. Decrease in the number of flooding events after restoration compared to the same time period before the restoration, all else being equal, should imply a beneficial outcome of the restoration project.
Drought mitigation	Restoration activities through, inter alia, their impact on the water retention capabilities of floodplains and improved percolation to groundwater bodies can reduce the impacts of droughts. These impacts can be seen in stable river water levels, and groundwater levels, and reduced stress on soil and vegetated areas during drought events.	Number of drought events, within the same river as the restoration project, within 5 km of the site in the previous 25 years. Historical data from official reports, e.g., meteorological data from environment or water agencies or meteorological offices.	Compare the obtained data before and after restoration, to determine trends of change. Decrease in the number of drought events after restoration compared to the same time period before the restoration, all else being equal, should imply a beneficial outcome of the restoration project.

LIMITATIONS OF THE STUDY

- Not all indicators fit all contexts, therefore a high number of benefits listed for a given Rivers2Restore site does not automatically reflect higher net benefits than other sites with fewer benefits listed. For example, the indicator "quality of adjacent land to be restored" was designed to infer the benefits of lateral barrier removal on floodplains. However, in Alpine areas, lateral barrier removal would have minimal impacts on this indicator due to the steepness of such rivers and their adjacent banks.
- Data availability made quantitative assessment not always possible. Therefore in the majority of instances, quantitative assessment had to be substituted by qualitative assessment.

The developed indicators present a range of potential opportunities for future use. We recommend the entities implementing the Rivers2Restore projects to continue monitoring these indicators, during and after the restoration takes place. Directly comparable 'before' and 'after' data would assist in clearly outlining the tangible benefits of the restoration. Furthermore, the rich data flow which would result from this process, would greatly improve the knowledge base of river restoration activities, potentially improving the likelihood of future projects.

OUR MISSION IS TO STOP THE DEGRADATION OF THE PLANET'S NATURAL ENVIRONMENT AND TO BUILD A FUTURE IN WHICH PEOPLE LIVE IN HARMONY WITH NATURE.

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