



SZIGETKÖZ

Reconnecting a Danube Floodplain

The story of a large-scale floodplain rehabilitation in Hungary

Danube Region Water Lighthouse Action | Grant Agreement No. 101094070

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IN MEMORIAM: JÓZSEF KERTÉSZ

József Kertész, former district engineer of Szigetköz at the North Transdanubian Water Directorate, generously shared his deep local knowledge and many stories from the periods covered in this book. His insights helped shape the story presented here, and he also provided many of the photographs used throughout the book. Sadly, he passed away while the book was being finalized and could not see it through to completion. We will remember his contribution to the understanding and preservation of Szigetköz with gratitude.

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Szigetköz in DALIA: A Long-Term Rehabilitation Story

Szigetköz is one of the Danube's most distinctive floodplain landscapes and Demonstration Pilot Site 1 of the Horizon Europe DALIA – Danube Region Water Lighthouse Action project.

Over more than a century, river regulation, flood protection, navigation, hydropower development, and changing land use progressively transformed the relationship between the Danube and its floodplain. Today's landscape reflects a long sequence of natural processes and human interventions rather than a single period of change.

Early water-management measures addressed navigation, flood safety, and drainage, while later interventions increasingly responded to declining river levels, weakened connections between channels, and ecological degradation. The diversion of the Danube in 1992, implemented as part of

the start-up of the Gabčíkovo Hydropower Plant, intensified many of these problems and led to major new efforts to return water to the active and historical floodplains.

This publication tells the story of these long-term rehabilitation efforts: how different interventions were planned, implemented, tested, adjusted, and extended as conditions and priorities changed in response to both natural processes and emerging challenges. Particular attention is given to the interaction between technical solutions, ecological objectives, and the needs of people living and working in the region. Within DALIA, the Szigetköz experience provides a long-term case study of large-scale floodplain rehabilitation in a heavily modified and transboundary river system, while recognizing that approaches developed here can be adapted to the specific conditions of other rivers.

The lesson learned is that rehabilitation is not just about fixing rivers; it is about reconnecting people and processes. Success requires collaboration, technical expertise, local stakeholder involvement, and long-term commitment.



Figure 1: DALIA meeting in Szigetköz, autumn 2023.

Why this story matters

A rehabilitated floodplain is not a return to the past, but an attempt to restore important ecosystem functions and services under changed conditions.

The story of Szigetköz spans centuries of river transformation, from a shifting multi-channel floodplain through successive phases of river regulation, flood protection, drainage, and hydropower development. The 1992 diversion – 34 years ago was decisive because it rapidly intensified problems that had been developing for decades. Many branches lost their water supply, groundwater levels declined, wetlands and forests were affected, and the connection between the Danube and its floodplain weakened. The response had to address both an immediate water shortage and the longer-term consequences of an already heavily modified river system.

This booklet follows four central questions: **What changed in Szigetköz and why? Why did large parts of the floodplain lose water? How does the replenishment system work?**

What has improved, what remains unresolved, and what can other river rehabilitation projects learn from the experience?

The wider story unfolds through 34 short tales. You can read the booklet from cover to cover to see the whole picture or begin with any account and follow the numbered links between related topics. Story numbers such as #21 allow readers to trace themes and connections through the booklet.

Szigetköz matters beyond its region because it shows how rehabilitation can proceed when a return to former natural conditions is no longer possible. Its experience demonstrates the need to combine hydraulic engineering, ecological knowledge, monitoring, stakeholder cooperation, and adaptive management over decades. The individual structures are specific to Szigetköz, but the wider approach, understanding causes, working within constraints, testing solutions, monitoring results, and adjusting management, can inform rehabilitation elsewhere.



Figure 2: Active floodplain branch after rehabilitation

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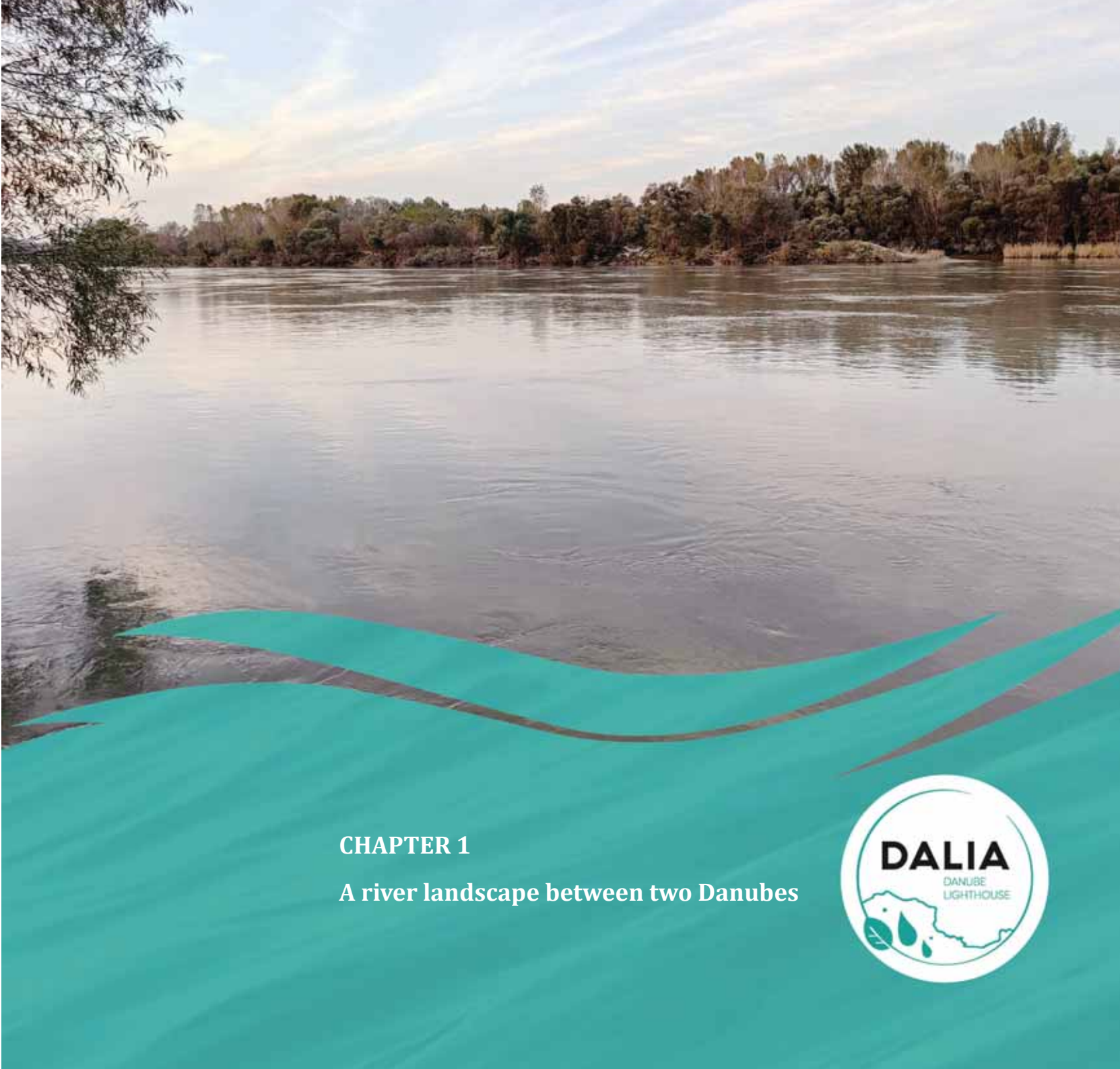
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CHAPTER 1

A river landscape between two Danubes



#1 The land between the Danube and Mosoni-Danube

Szigetköz developed where the Danube slowed, deposited gravel, and divided into a changing network of branches.

Downstream of Bratislava, the Danube leaves the confined Alpine–Carpathian corridor and enters the flatter Danubian Lowland. As the river’s gradient decreases, its capacity to carry coarse sediment also declines. Over thousands of years, gravel and sand accumulated in a broad alluvial fan. The river repeatedly divided, rejoined, shifted sideways, and built islands between its branches.

Szigetköz lies between the Old Danube, which now forms much of the border between Hungary and Slovakia, and the Mosoni-Danube, the southernmost major branch.

With a land area of approximately 375 square kilometers, Szigetköz is generally described as Hungary’s largest river island. Across the Old Danube, the larger Csallóköz or Žitný Ostrov forms part of the same transboundary alluvial and hydrological system (Jakus et al., 2024).

The term inland delta describes the wider multi-channel landscape. It is not a coastal delta, but it behaves similarly: water and sediment are distributed among many channels, creating a mosaic of flowing reaches, backwaters, wetlands, islands, and floodplain forests (#2).

Flood-protection levees (#7) divide Szigetköz into two main zones. The active floodplain lies between the levees and remains directly exposed to high Danube flows. In contrast, the historical floodplain lies behind the levees and no longer receives regular direct flooding from the river.

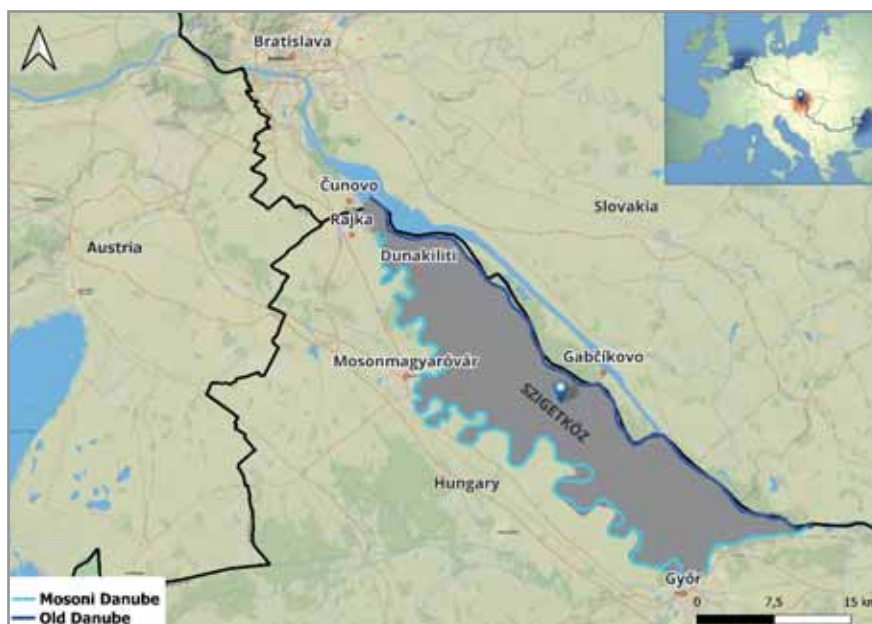


Figure 3: Location of Szigetköz along the Danube and within the Rhine–Main–Danube Waterway

#2 A landscape built by water

Surface water, groundwater, soil, and vegetation are closely connected in Szigetköz.

Water shaped Szigetköz both above and below the surface. The Danube once supplied a dense network of flowing branches, shallow channels, wetlands, and seasonally inundated areas. At the same time, water moved through the thick layers of gravel and sand beneath the floodplain, linking river levels with groundwater conditions across the landscape (#12).

These different water pathways created a varied mosaic of habitats. Frequently inundated areas supported wetland vegetation and softwood floodplain forests, while higher and less frequently flooded surfaces developed different plant communities and land uses. Local conditions depended on land elevation, gravel depth, the character of the overlying soil, and the strength of the connection to nearby channels.

River regulation gradually reduced this natural variability. Some branches became less connected to the Danube, seasonal inundation became less frequent, and water levels declined in parts of the floodplain. After the 1992 diversion (#10), these changes intensified: several channels lost most of their flow, wet habitats contracted, and vegetation increasingly reflected drier and more stable conditions. The later rehabilitation focused on bringing water back (#20) into the branch system and restoring a more varied pattern of flowing, standing, wet, and periodically inundated habitats (Guti, 2020).

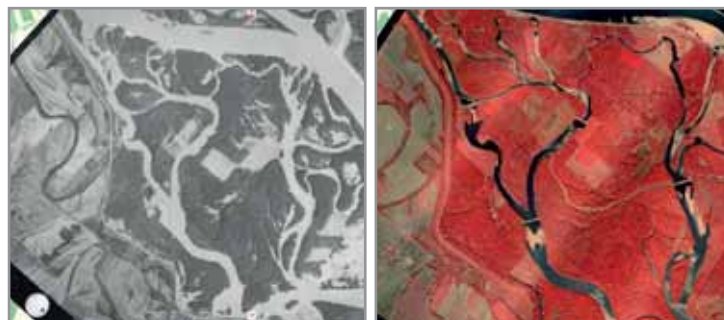


Figure 4: Floodplain near Ásványráró in 1965 and 1993 (fentrol.hu)

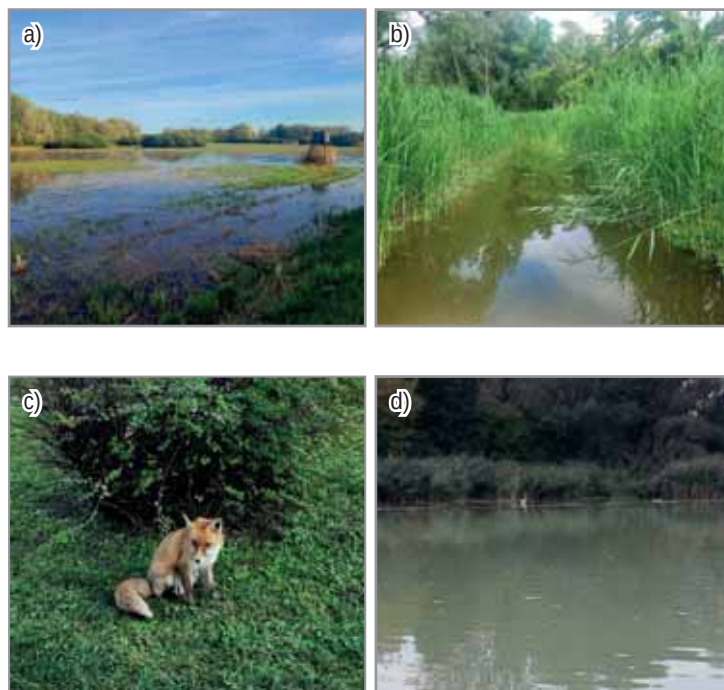


Figure 5: Flora and fauna of Szigetköz: a) wet meadow; b) floodplain branch with reeds and forest; c) fox in floodplain vegetation; d) great egret in the active floodplain branch system

#3 Life centered around water

Nature conservation, farming, forestry, settlements, and recreation share one connected floodplain.

Szigetköz is neither untouched wilderness nor simply an engineered countryside. Behind the levees, arable fields occupy much of the landscape, but meadows, pastures, forest strips, canals, oxbows, marshes, reedbeds, and open water remain woven through the cultivated areas. Between the levees, the active floodplain contains river branches, natural floodplain forests, and managed poplar stands.

Water also shaped the cultural landscape. Pumping stations, sluices, embankments, settlement patterns, traditional livelihoods, and local customs reflect generations of living with the Danube. The rehabilitation of Szigetköz influenced more than habitats. It affected a landscape in which nature, infrastructure, land use, and community history remain closely connected.

The Szigetköz Landscape Protection Area was established in 1987, and much of the wider floodplain later became part of the Natura 2000 network. Legal protection, however, could not preserve these habitats on its own. Their condition continued to depend on water levels (#29), water quality (#30), connections between channels (#31), seasonal inundation (#28), and surrounding land use (Fertő–Hanság National Park Directorate, n.d.).

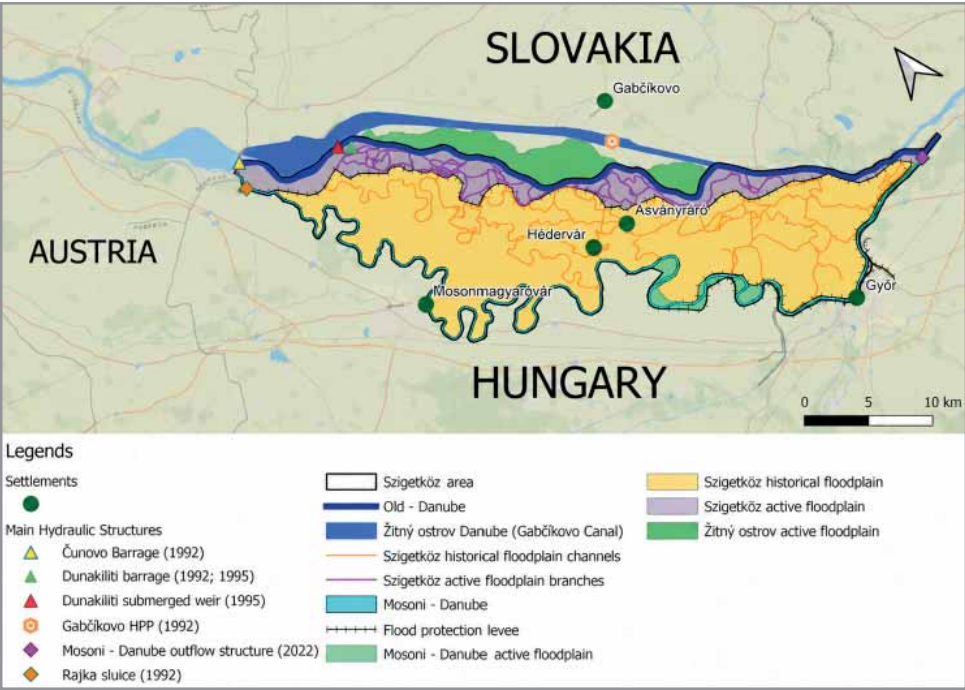


Figure 6: An overview map of the Szigetköz area

#4 A floodplain that supports people

The same water system sustains ecosystems, settlements, farming, tourism, and regional identity.

Water in Szigetköz has always shaped both the landscape and the lives built around it. The river and its branches supplied drinking water, supported farming, forestry, and fishing, and created places for recreation and tourism. Wetlands, forests, fields, settlements, and waterways formed parts of the same changing landscape and became closely linked to the region's identity.

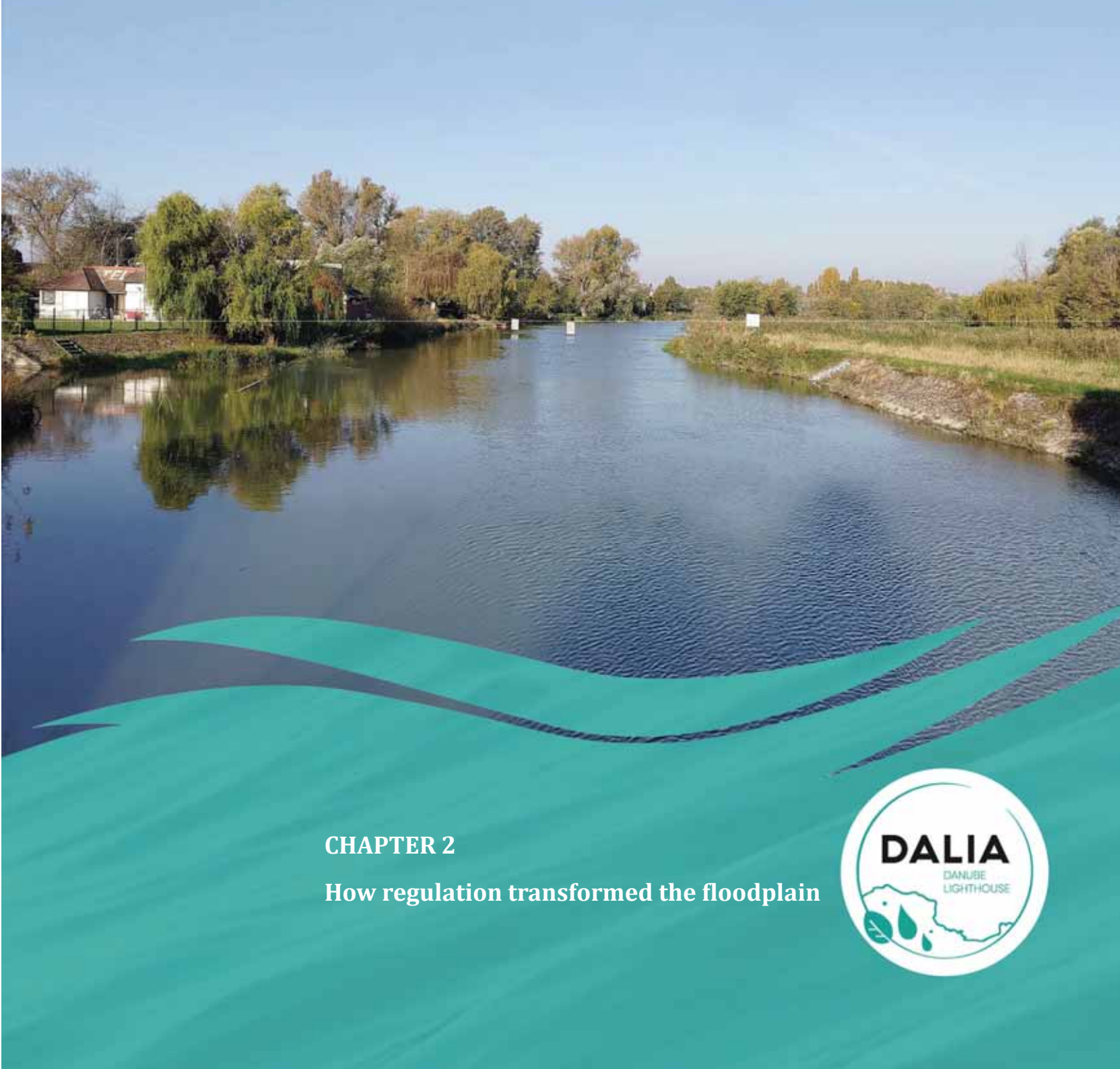
These activities did not always demand the same water conditions. Seasonal inundation supported wetlands and floodplain forests, while settlements and infrastructure relied on effective flood protection.

Agriculture benefited from sufficient soil moisture but could be damaged by prolonged waterlogging. Fish depended on connected habitats and changing water levels, while recreation often favored safer and more predictable conditions.

As the river became increasingly regulated, these differences became more visible. Decisions about where to retain water, where to drain it (#23), and how quickly water levels should change affected both the floodplain and the people who used it. The rehabilitation of Szigetköz developed through repeated efforts to balance ecological needs with the everyday requirements of settlements, land users, and local communities (#15) (Chappon et al., 2024b; Tatai and Pap, 2023).



Figure 7: Examples of land use and water-related recreation in Szigetköz



CHAPTER 2

How regulation transformed the floodplain



#5 History of transformations

The development of Szigetköz can be divided into five main phases:

1. A dynamic river landscape — before 1800

Before large-scale regulation, the Danube flowed through a shifting network of branches, islands, and floodplain channels (#6). Early navigation works, including towpaths built during the seventeenth and eighteenth centuries, adapted to a river whose branches frequently changed after floods.

2. Regulation, levees, and drainage — 1800–1959

During the nineteenth century, river engineering increasingly concentrated flow into a principal channel, reshaping and stabilizing what is now known as the Old Danube. Navigation works, branch closures, and flood-protection levees progressively reduced the area directly influenced by the river. During the early twentieth century, levees, drainage canals, pumping stations, and the Rajka control structure further changed how water moved through the active and historical floodplains (#7).

3. Declining water connections — 1960–1992

From the 1960s onward, closures of active floodplain branches, dredging, reduced gravel supply from the upper Danube, and continued riverbed incision increasingly weakened water flow between the Danube and its floodplain branches. As the riverbed deepened, water levels in the Old Danube declined, and progressively higher Danube discharges were required for water to enter the branch system (#8).

4. The 1992 diversion

The Gabčíkovo–Nagymaros project (#9) culminated in the implementation of Variant C in 1992. Approximately 80% of the Danube’s flow was diverted into the power canal (#10).

Water levels in the Old Danube fell sharply, many branches in Upper Szigetköz dried out (#11), and groundwater, forests, wetlands, agriculture, and fisheries were affected (#12).

5. Emergency action and long-term rehabilitation — 1992 to the present

Emergency measures began soon after the diversion (#13).

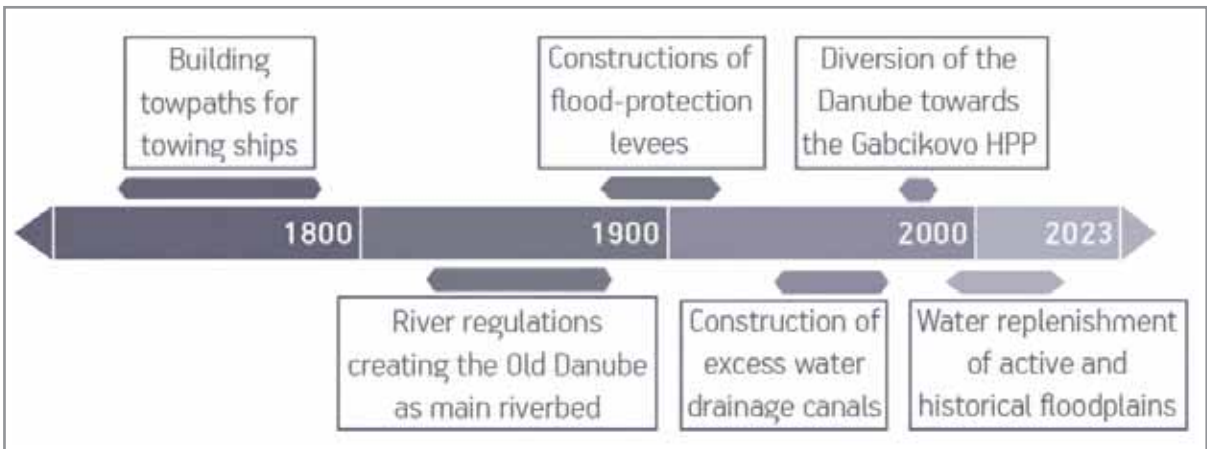


Figure 8: Timeline of the most significant anthropogenic alterations in the Szigetköz floodplain, 1700–2023. (Chappon et al., 2024b)

In the historical floodplain, water returned to parts of the Upper Szigetköz branch system by spring 1993, producing rapid, visible improvement. Emergency measures in the active floodplain had more variable results: temporary pumping and localized interventions provided short-term relief but could not maintain stable water levels. The 1995 Hungarian–Slovak agreement (#19) subsequently enabled regulated water supply, test operation, and joint monitoring. Over the following decades, rehabilitation expanded through control structures, fish passages, permanent operating rules (#26), controlled floodplain inundation (#28), and later projects in the Lower Szigetköz (#32) and in the Mosoni-Danube (#33). The Szigetköz Operating Committee (#27) oversees system operations.

#6 Before large-scale regulation

The pre-regulation Danube was a moving network of branches rather than a single fixed riverbed.

The Danube in Szigetköz did not follow a single, stable channel. It moved through a wide network of branches that changed after floods. Channels widened, narrowed, divided, or gradually filled with sediment, while islands and gravel bars formed and disappeared. Eighteenth-century records describe a river landscape shaped by frequent flooding and continuous change.

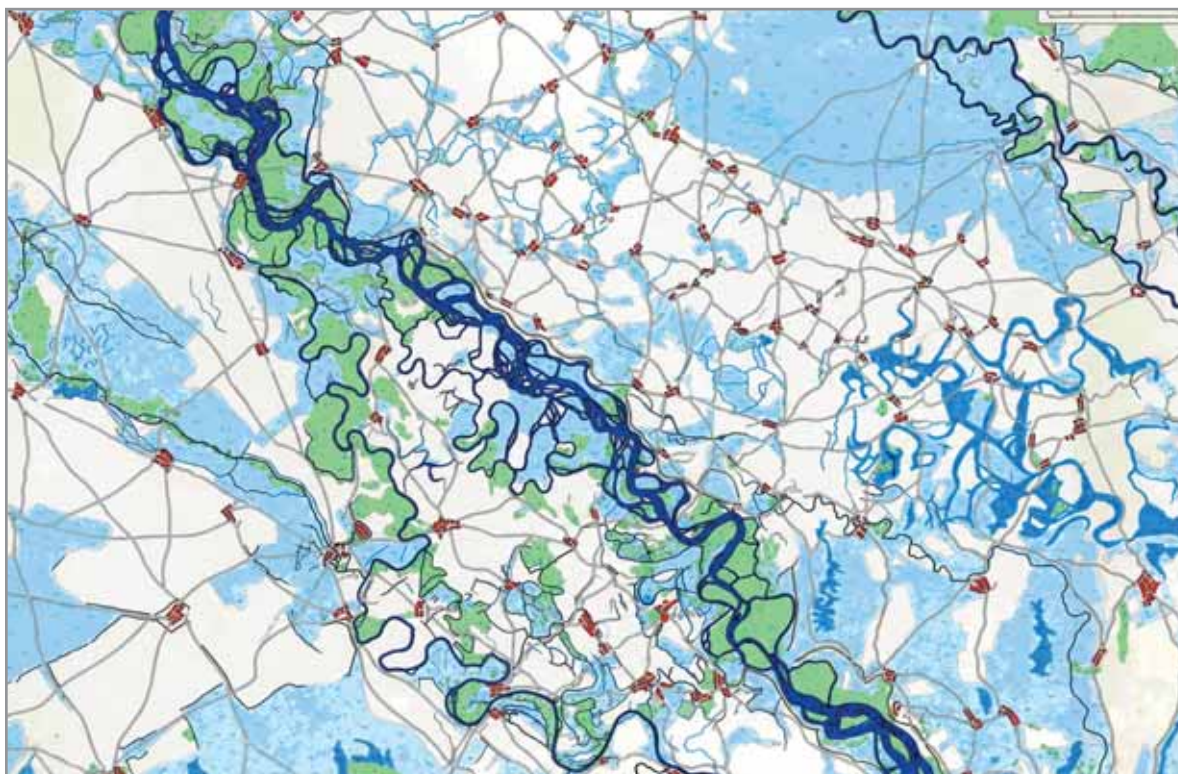


Figure 9: Extent of regularly flooded areas along the Szigetköz reach before large-scale river regulation, reconstructed from the First Military Survey conducted between 1763 and 1785. Source: Feasibility Study: The Rehabilitation of the Szigetköz Reach of the Danube (2010), based on material from the collection of the Danube Museum

The earliest engineering works did not yet attempt to control the entire river system. Local dykes provided limited flood protection, while towpaths were built to support navigation. Because the river's course could shift after major floods, these routes and structures had to be repeatedly adjusted to changing conditions.

During the nineteenth century, the purpose of river engineering began to change. Instead of continually adapting navigation to a moving river, regulation increasingly aimed to concentrate flow and stabilize the Danube as the main channel (#7). Levees and channel works gradually reduced the area regularly reached by floods and began to separate the active floodplain from the land behind the flood-protection system (#1). The shift marked the beginning of a more fixed river corridor and prepared the ground for later transformations (SEA, 2010).

#7 A main channel, levees, and drainage

Nineteenth- and twentieth-century works improved navigation and flood safety but reduced lateral connectivity.

Nineteenth- and twentieth-century works improved navigation and flood safety, but they also changed how water moved across the floodplain.

As regulation progressed, the Danube became the principal channel and many side branches were closed, narrowed, or only intermittently connected. Flood-protection levees then divided the former floodplain into two distinct zones: the active floodplain between the embankments and the historical floodplain behind them.

The levees reduced direct flooding of settlements and farmland (#4) but did not eliminate seepage, high groundwater, or excess inland water behind them. During the twentieth century, drainage canals and pumping stations were built across the historical floodplain (#23) to remove excess inland water. Parts of this network incorporated former oxbows and inactive river branches, and water was generally conveyed south-eastward toward the Mosoni-Danube.

In July 1954, a major Danube flood caused severe flooding and exposed failures in the existing flood-defense system, demonstrating the need for stronger and more consistent protection. Subsequent works raised and reinforced the levees, improved sections affected by seepage, and introduced a more systematic approach to flood-defense planning (SEA, 2010; Jakus et al., 2024).



Figure 10: Flood event on the Danube in Szigetköz, in September 2024

#8 Sediment imbalance and riverbed incision

Upstream barrages and dredging reduced the gravel supply reaching Szigetköz.

The Danube naturally transports gravel and other sediment downstream. During the twentieth century, barrages in Germany and Austria trapped much of the coarse material. Estimated bedload supply at Rajka, where the Danube enters the Szigetköz reach, fell from about 650,000 cubic meters per year in the 1960s to about 200,000 cubic meters per year around 1990 (Rákóczi, 1989).

A river that still has enough energy to move sediment but receives less material often begins to erode its own bed. Industrial gravel extraction intensified this imbalance. As the Danube deepened, water levels during low and average flows declined (#16). The beds of floodplain branches did not lower, so water entered them less frequently and only at increasingly high river discharges.

At the same time, fine suspended sediment continued to settle in low-velocity floodplain areas during floods. As a result, the system experienced two contrasting processes: incision in the main channel and sediment accumulation in side branches. Together, the two processes weakened hydraulic connectivity between the Danube and the floodplain branches even before the diversion of the Danube in 1992 (#10) (Rákóczi, 1989).

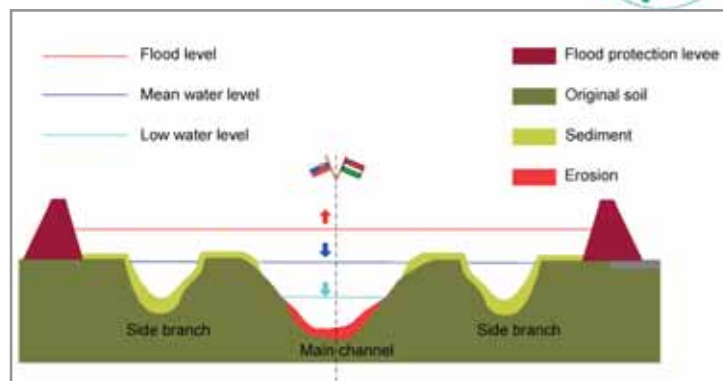


Figure 11: Water level and morphological changes after the 1950-s



Figure 12: Old Danube in Szigetköz during low flow conditions



CHAPTER 3

The 1992 diversion and its consequences



#9 The Gabčíkovo–Nagymaros project

Hydropower, navigation, flood safety, and floodplain water supply were planned as one international system.

In 1977, Hungary and Czechoslovakia signed a treaty to construct and operate the Gabčíkovo–Nagymaros system of locks. The project envisioned a barrage at Dunakiliti, the Gabčíkovo Hydropower Plant, and a downstream barrage and power station at Nagymaros. Water would be diverted through an artificial canal for hydropower generation and navigation (Hungarian People's Republic and Czechoslovak Socialist Republic, 1977).

The original concept also included water supply to the Szigetköz floodplain. A reservoir upstream of Dunakiliti would have created the water levels needed to feed the side-branch network. The planned arrangement was never completed as designed.

During the 1980s, environmental concerns and political opposition grew in Hungary. Work at Nagymaros was suspended in 1989. Czechoslovakia then developed Variant C (#10), an alternative configuration that allowed the upstream part of the project to operate without the Hungarian Dunakiliti and Nagymaros structures (International Court of Justice, 1997).



Figure 13: Design Concepts and Plans: Photograph of a 3-dimensional raised relief map of the impacted area of the Gabčíkovo–Nagymaros Barrage Project (a). Axonometric computer drawing of Gabčíkovo HPP (b). Artistic representation of the Nagymaros Barrage (c)

#10 The 1992 diversion

Variant C redirected most of the Danube's flow into the power canal.

In October 1992, Czechoslovakia implemented Variant C, an alternative configuration developed to operate the Gabčíkovo Hydropower Plant without the originally planned Hungarian structures at Dunakiliti and Nagymaros. Instead of using the planned Dunakiliti Barrage to control and divert the river, the Danube was diverted at Čunovo, on Czechoslovak territory, upstream of Szigetköz.

Approximately 80% of the Danube's flow was diverted into the artificial canal serving the Gabčíkovo Hydropower Plant. The natural channel downstream of Čunovo—the Old Danube—received only a fraction of its former discharge (International Court of Justice, 1997; Jakus et al., 2024).

The change was immediate. Near Rajka, at the upstream end of the Hungarian section of Szigetköz, mean annual discharge fell from roughly 2,000 cubic meters per second to about 200–400 cubic meters per second. Water levels in the Old Danube declined by approximately three meters on average. The floodplain water-supply system originally associated with the international project was incomplete (#9), so the branch network (#11) and the whole water system (#12) could not safely adjust to the new regime (Jakus et al., 2024).

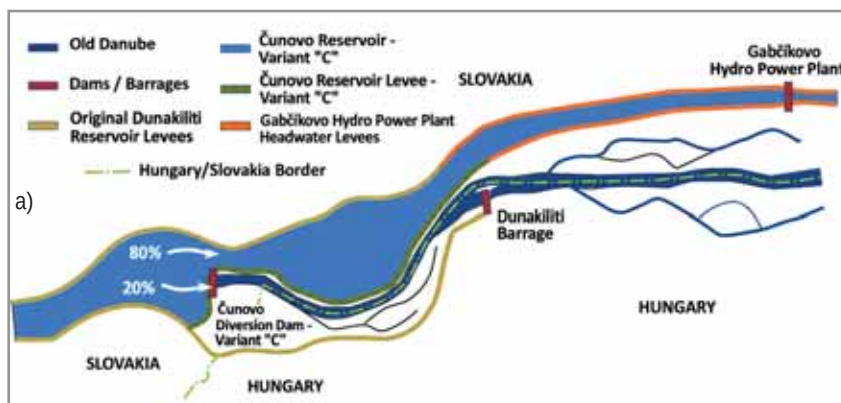


Figure 14: a) Layout of Variant "C" and its principal structures. b) The Čunovo Barrage was built to take the place c) of the Dunakiliti Barrage in diverting water from the Old Danube towards d) the Gabčíkovo Hydropower Plant

Czechoslovakia dissolved at the end of 1992, and Slovakia became the successor state involved in the dispute. Hungary and Slovakia jointly submitted the case to the International Court of Justice in 1993. The Court's 1997 judgment required both states to negotiate in good faith but did not prescribe the river's detailed hydraulic operation (#19) (International Court of Justice, 1997).

#11 When the branches dried

The upper floodplain experienced the most rapid and visible damage.

After the diversion of the Danube (#10), many branches in Upper Szigetköz lost their surface-water supply. Because the planned water-replenishment system had not been completed, branches in both the active and historical floodplains

dried out, and some aquatic habitats were lost entirely. The decline in river levels also reduced groundwater levels and affected agriculture, forestry, and water-dependent habitats (#4) (KvVM, 1996; Guti, 2020).

Lower Szigetköz was initially less affected. Its condition deteriorated more in the following decades, as riverbed incision (#8) lowered water levels in the Danube downstream of Gabčíkovo and reduced the amount of water entering the downstream branch systems. These changes later required further rehabilitation in Lower Szigetköz (#32) (Kertész, 2017).

The Mosoni-Danube, which forms the southern boundary of Szigetköz, experienced a different immediate change. Before 1992, its water supply had sometimes been insufficient during low-flow periods. Under the modified operating regime, it received a continuous discharge of approximately 20 cubic

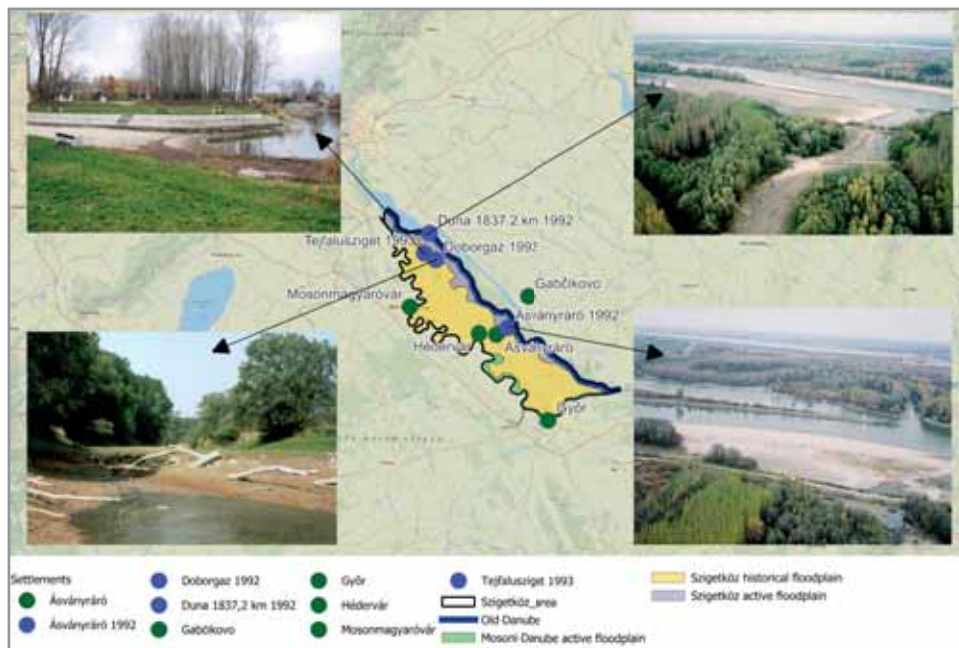


Figure 15: Hydrological impact of the Danube diversion in the Szigetköz between 1992 and 1993

meters per second from Čunovo, providing a more reliable basic water supply (#22). This more reliable supply was one benefit within a wider pattern of severe hydrological decline across Szigetköz (Jakus et al., 2024).

#12 Beyond the dry channels

The fall in the Old Danube changed water conditions across the floodplain, both in the channels and below the surface.

The drying of the branch network was the most visible effect of the 1992 diversion (#10), but it was not the only one. Before the diversion, groundwater levels across much of Szigetköz broadly followed the Danube's seasonal rise and fall. Water moved through the thick gravel deposits beneath the floodplain, connecting the river with surrounding soils and water bodies.

When water levels in the Old Danube fell by approximately three meters, this relationship changed. Monitoring recorded groundwater declines of about 30–150 centimeters in many areas, with the strongest effects close to the Old Danube.

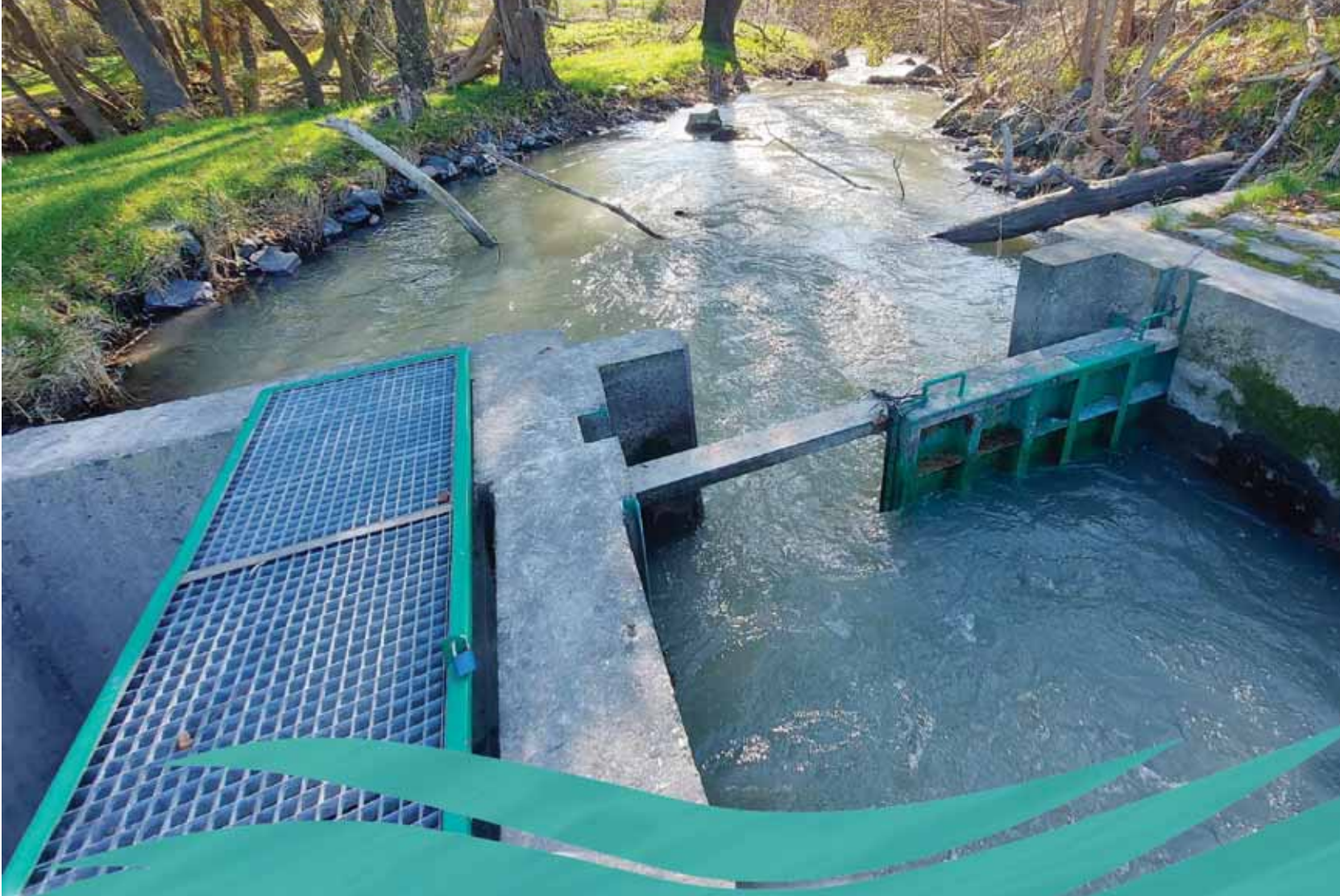
In some locations, the lower river stage altered or locally reversed the former direction of groundwater flow, drawing water toward the river rather than supplying the surrounding floodplain. Seasonal groundwater fluctuations also became smaller (Bárdossy and Molnár, 2004; KvVM, 1996).

The consequences varied across Szigetköz. They affected water-dependent habitats, floodplain forests, and agricultural areas. However, the scale of the change depended on distance from the Old Danube, local channel connections, and soil and geological conditions (#29). The loss of surface water and the decline in groundwater were not separate problems. They were connected effects of the same change in the river system.

The most urgent damage was visible in the dry branches, where aquatic habitats had been severely reduced or lost in some reaches. The first interventions (#13) concentrated on returning water to these channels. The emergency response became the starting point for the larger replenishment system (#20), (#34) (KvVM, 1996; Dunai, 1995).



Figure 16: Dry active floodplain branches following the diversion of the Danube—source: Fertő–Hanság National Park Directorate



CHAPTER 4

From emergency action to shared objectives



#13 Emergency actions

The first goal was simple: return water to channels that had dried only months earlier.

The immediate response had to work with the existing infrastructure. Water released from Čunovo toward the Mosoni-Danube passed through a supply channel and a toe-drain system (#22). Local water managers proposed connecting this route to the historical floodplain branch network (#23).

The plan was approved as an emergency measure. A side spillway and a short feeder channel allowed 2-5 cubic meters per second to enter the Zátonyi-Danube—an upper historical-floodplain branch—and nearby channels. About six months after the diversion, water had returned to sections of the Upper Szigetköz historical floodplain (Dunai, 1995).

Emergency measures in the active floodplain included diesel-powered pumping and localized distribution works. These actions provided short-term relief but were too costly and unreliable for continuous operation. The experience established a central design principle for the permanent system: use gravity wherever possible (#21) and avoid dependence on continuous pumping (Dunai, 1995).



Figure 17: Dry conditions in the Zátonyi-Danube near Doborgazsziget in November 1992 (a) and after the return of water in May 1993 (b)

#14 Open planning and trust

Visible improvement created space for negotiation about the floodplain's long-term future.

The return of water to historical floodplain channels (#13) showed residents that practical damage mitigation was possible. It also increased confidence in the water-management authorities at a time when the barrage project's history had weakened public trust. Public trust, differing perceptions, internal conflicts, and stakeholder compromise remained important challenges throughout the following phases (Chappon et al., 2024b).

The county government office initiated an open planning process and carried it out under the supervision of the North-Transdanubian Water Directorate (ÉDUVIZIG). Local governments, regional economic actors, environmental organizations, and community groups were invited to define their needs. A neutral expert team facilitated the discussions, helped manage conflicts, and ensured that technical experts participated as impartial advisers (Janák et al., 2014).

Expectations differed sharply. Some environmental organizations initially favored extensive renaturalization, including removing hydraulic structures and even flood-protection levees (#6). At the same time, farmers and foresters emphasized protecting cultivated land and suitable groundwater conditions. The competing proposals were compared through a structured value-analysis process (#15) (SAVE International, 2015). Flood protection emerged as a non-negotiable priority: all groups accepted that the levees had to remain in place. Once that boundary was established, attention could focus on ecological rehabilitation and other water-use interests (Janák et al., 2014; Chappon et al., 2024b).



Figure 18: Stakeholder meeting during the planning of the rehabilitation system

#15 Value analysis: making conflicts visible

Functions were defined before solutions were selected.

Value analysis organized the needs of nature conservation, environmental protection, forestry, hunting, agriculture, fishing, tourism, and water management (#3). Rather than starting with individual structures, stakeholders (#14) first identified the functions the system needed to provide. The main functions were then ranked using a pairwise comparison matrix, allowing competing priorities to be compared systematically and incorporated into the evaluation process (SAVE International, 2015; ÉDUVIZIG 2000a).

Function trees were prepared to connect broad objectives with the practical tasks and measures required to achieve them. Read from objectives toward measures, the function tree answered, "How can this goal be achieved?"

Read in the opposite direction, it answered, “Why is this intervention needed?” The function-based approach also helped reveal where objectives supported one another and where conflicts had to be managed by separating functions in space, time, or operation (Dunai, 1995; Janák et al., 2014).

In the historical floodplain, for example, water retention and drainage could not both be maximized at the same time. Adjustable structures, residence-time limits, seasonal operation, and designated storage zones allowed the two functions to coexist within one network (#23) (Tatai and Pap, 2023).

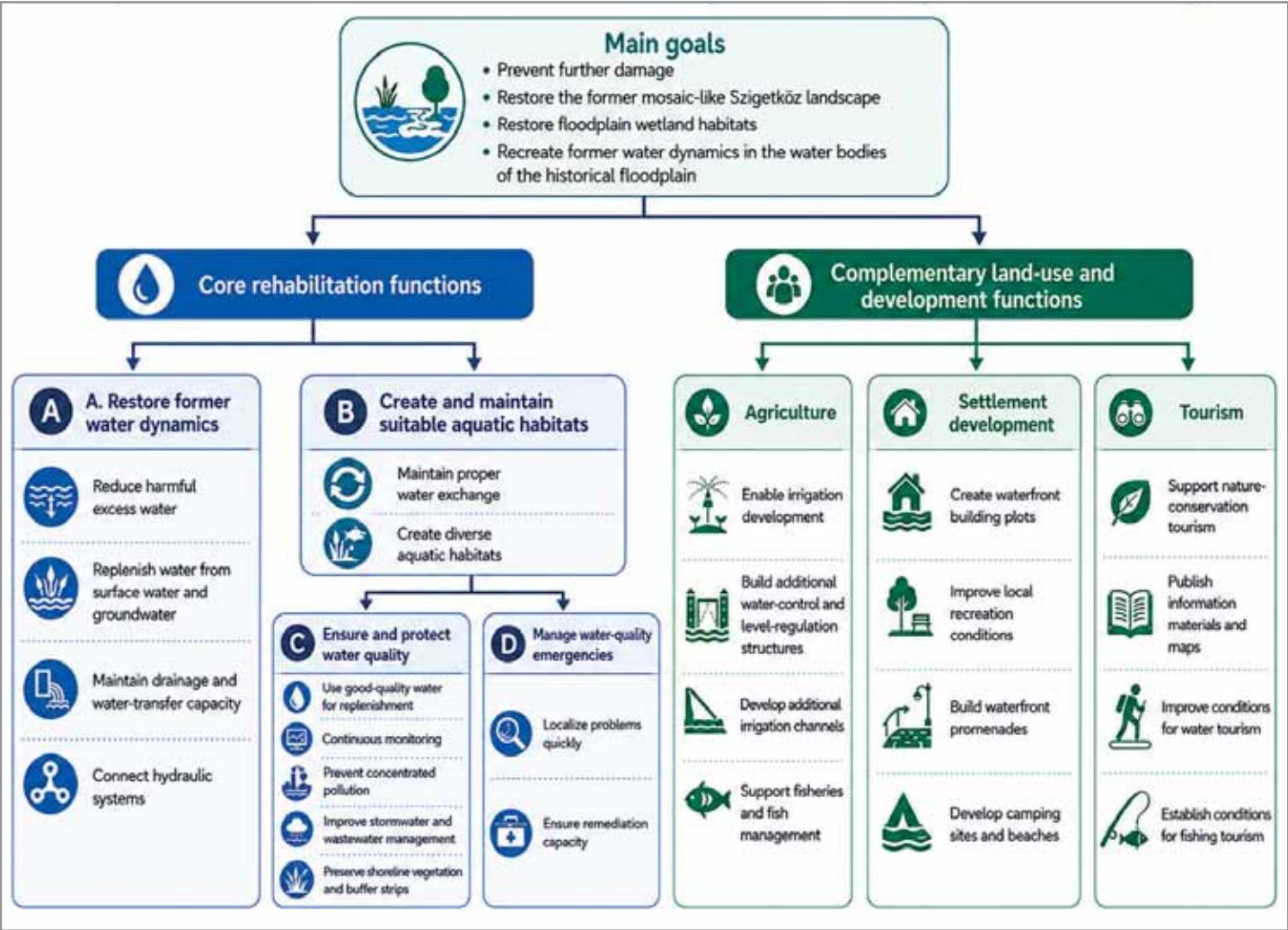


Figure 19: Function tree for the historical floodplain

#16 Looking to a functioning past

Once the objectives were agreed, planners needed a realistic picture of the water conditions they wanted to achieve.

Continuous hydrological records from Dunaremete, a Danube gauge in central Szigetköz on the channel now known as the Old Danube, have been available since 1901. Planners compared these records with Danube discharge data from Bratislava (Dévény), historical information, ecological knowledge, and the experience of older residents. The 1950s emerged as a useful reference period, when the active floodplain still maintained a strong connection with the Danube and water levels varied more dynamically than in later decades.

The choice did not mean that the 1950s represented an untouched or pristine floodplain (#6). Flood-protection levees and earlier river regulation were already in place (#7). The period was selected because it was well documented and because the relationship between the Danube and its floodplain branches was still functioning in a way that stakeholders considered favorable.

The reference period provided a realistic direction rather than a historical state to be recreated exactly. Rehabilitation could aim to recover important characteristics of the 1950–1959 water regime—particularly water levels, flow relationships, and variability (#18)—while recognizing that the river landscape had already changed (#17) (Pannonhalmi, 1999).

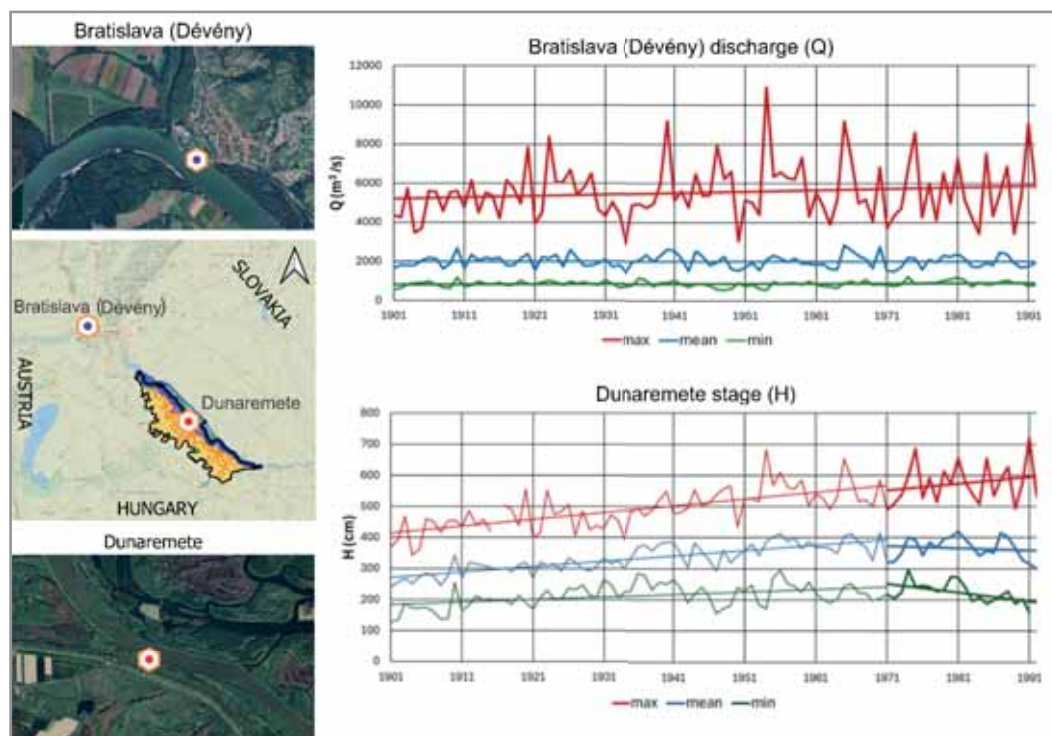


Figure 20: Long-term water level at Dunaremete and Danube discharge at Bratislava (Dévény)

#17 The river had changed

Historical flows could not simply be copied because the Danube no longer produced the same water levels.

Comparing historical records revealed an important complication. The relationship between Danube discharge at Bratislava (Dévény) and water level at Dunaremete had changed considerably between the 1950s (#16) and the years immediately before the 1992 diversion (#10). Rating curves—graphs showing the relationship between river discharge and the corresponding water level—made this change visible (Pannonhalmi, 1999).

At lower Danube discharges, water levels at Dunaremete were lower in 1989–1992 than in the 1950s. At higher discharges, however, they could be higher. Riverbed incision (#8) had lowered low-water stages, while changes in the regulated river corridor and floodplain (#7) influenced water levels during larger flows (SEA, 2010).

Because the relationship between Danube discharge and water level had changed, the same Danube discharge no longer produced the same water level at Dunaremete as it had during the reference period. The river and floodplain had physically changed. Rehabilitation had to combine an appropriate water supply with structures capable of raising, retaining, and distributing water through the branch network (Janák et al., 2014).

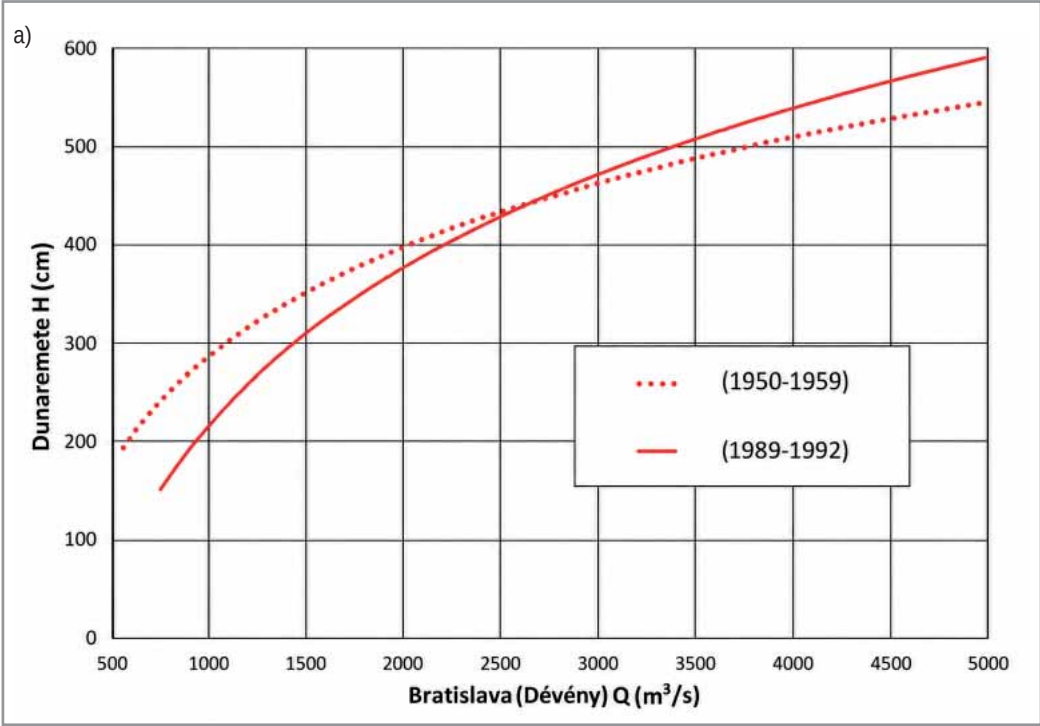


Figure 21: Relationship between Danube discharge (Q) at Bratislava (Dévény) and water level (H) at Dunaremete during 1950–1959 and 1989–1992 period (a) Dunaremete gauge (b)

#18 Turning ecological needs into water targets

The goal was not one fixed water level, but a varied and changing floodplain.

Historical records showed that water levels in the 1950s changed frequently, often by one to two meters. These fluctuations influenced shallow habitats, connections between branches, and water movement through the floodplain. The rehabilitation system was intended to create changing conditions (#31) rather than maintain one permanent water level (Pannonhalmi, 1999).

How quickly water moved through the branches was also important. Earlier hydrobiological assessments indicated that the risk of eutrophication increased when water remained in the branch system for more than about four days (#30). In the main branches, an average flow velocity of at least 0.3 meters per second was used as a practical target to reduce fine-sediment deposition and bed clogging (Pannonhalmi, 1999).

Hydrodynamic modeling indicated that approximately 20–50 cubic meters per second was needed to support these basic low-flow conditions in the active floodplain, while around 60–150 cubic meters per second was required to approach average water levels from the reference period. The objective, however, was not to create the same conditions everywhere. The desired floodplain was a mosaic of flowing channels, slower branches, backwaters, and partly isolated water bodies (#2). The planning process translated the broader rehabilitation objectives into practical water-level, flow, and ecological targets. With these targets defined, the next challenge was to secure enough water (#19) and develop a system capable of distributing it across Szigetköz (#20).

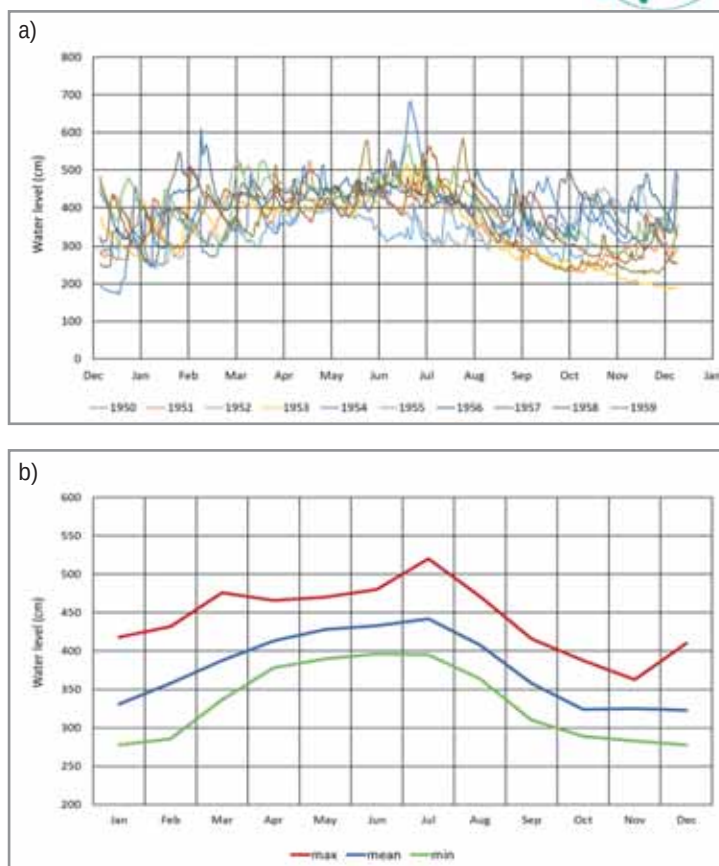


Figure 22: a) Daily water-level variation and b) monthly minimum, mean, and maximum water levels at Dunaremete during 1950–1959.



Figure 23: From left to right: Active floodplain branch –Fish Passage and the Old Danube



CHAPTER 5

Bringing water back



#19 The 1995 water-sharing agreement

International cooperation provided the water needed to begin regulated operation.

After the 1992 diversion (#10), the discharge remaining in the Old Danube was too low to maintain both the main river channel and the intended water levels in the Szigetköz active floodplain. A long-term solution depended not only on new hydraulic structures, but also on agreement between Hungary and Slovakia over how much Danube water would remain in the Old Danube and how much could be supplied to the Hungarian floodplain.

In April 1995, the two governments signed an interim agreement establishing seasonal discharge ranges for the Old Danube. During winter, 250–400 cubic meters per second was to remain in the river, increasing to 400–600 cubic meters per second during summer.

Up to 150 cubic meters per second could be directed into the Hungarian floodplain systems. The agreement also increased the supply to the Mosoni-Danube and toe-drain system to 43 cubic meters per second (Agreement, 1995).

The agreement also enabled construction of a submerged weir near Dunakiliti (#21). By raising the upstream water level in the Old Danube, the weir created the water-level difference needed to supply the active floodplain branches by gravity. Together with the Dunakiliti Barrage, it made it possible to regulate water levels and divide the available flow between the Old Danube and the floodplain system.

Joint Hungarian–Slovak environmental monitoring was also established, providing shared measurements and data (#24) to evaluate the new water regime and support later operational decisions (#26). Although the interim agreement did not resolve the wider legal dispute, it created the water-sharing and hydraulic framework that made regulated operation of the Szigetköz Water Replenishment System possible.

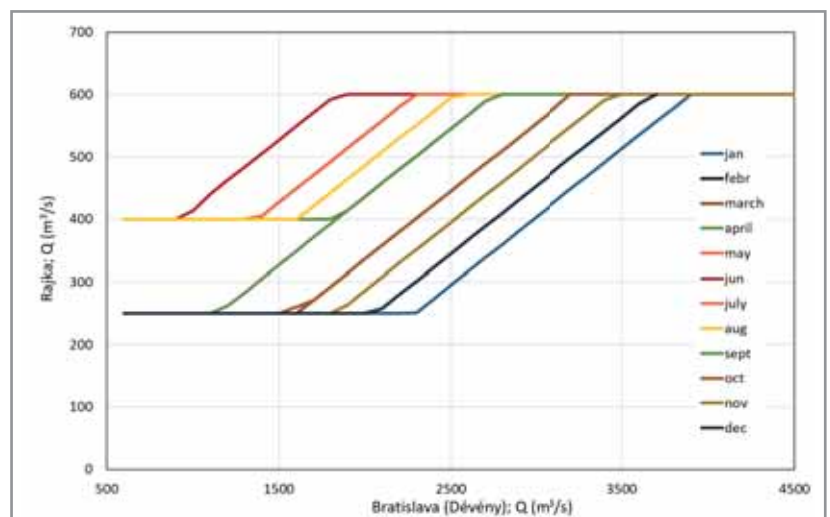


Figure 24: Relationship between Danube discharge at Bratislava (Dévény) and the flow entering the Szigetköz reach at Rajka (ÉDUVIZIG, 2001). More water was made available during the biologically active summer period, while actual releases continued to respond to changing Danube discharge at Bratislava (Dévény)

#20 How the replenishment system works

Water is raised, divided, retained, redistributed, and, when necessary, drained.

The Szigetköz Water Replenishment System is not a single channel or structure. It is an interconnected network linking the Old Danube, the active floodplain branches, the historical floodplain channel system, and the Mosoni-Danube. Water moves through this network using a combination of gravity and adjustable control structures (Dunai, 1995; ÉDUVIZIG, 2000a).

In the Old Danube, the submerged weir near Dunakiliti (#21) raises the water level sufficiently for water to enter the active floodplain branch system by gravity.

The Dunakiliti Barrage and a series of weirs, sluices, culverts, and branch-end structures then help distribute and retain water within the network.

Behind the flood-protection levees, the historical floodplain works differently. Former riverbeds and drainage canals, originally used mainly to remove excess water, were adapted to supply and retain water as well. The same network can serve two opposite purposes: bringing water into the landscape during dry periods and draining it when excess water threatens land or settlements (#23).

The Mosoni-Danube receives water through a separate supply channel and toe-drain system from Čunovo (#22). Together, these three parts of the system allow water to be distributed according to the different needs of the active floodplain, the historical floodplain, and the Mosoni-Danube.



Figure 25: a) Dynamic control of the active floodplain; b) overflow weirs to supply the active floodplain, c) submerged weir, and Dunakiliti Barrage

#21 Raising and retaining water in the active floodplain

The system uses gravity and adjustable structures to bring water into the branches and keep it there.

The Dunakiliti submerged weir raises the water level in the Old Danube by about four meters relative to the local riverbed, creating the conditions needed for water to enter the active floodplain branches by gravity. Built mainly from stone, gabions, and gravel rather than conventional reinforced concrete, the structure creates a backwater upstream without forming a large reservoir (Dunai, 1995).

The Dunakiliti Barrage works together with the submerged weir to regulate the upstream water level and divide the available flow between the Old Danube and the floodplain. Its gates and navigation lock allow operators to fine-tune water levels (#26) while maintaining flow along the main river channel.

Getting water into the branches is only part of the task. In several reaches, water levels in the replenished branch system are maintained one to three meters above the adjacent Old Danube (#17). Without branch-end closures and other control structures, much of this water would quickly drain back into the main channel. These structures retain and redistribute water while still allowing controlled flow through the branch network.

The aim is not to create the same conditions everywhere. Main branches maintain flowing water, while other parts of the floodplain include slower branches, backwaters, and temporarily connected water bodies.

Where control structures would otherwise interrupt aquatic movement, fish passages help maintain connections be-



Figure 26: The submerged weir: a) after construction and b) in 2025.

tween the floodplain branches and the Old Danube (#32). The long, gentle downstream slope of the submerged weir also dissipates energy and limits erosion, while its coarse surface can permit fish movement under suitable flow conditions (Kertész, 2017; Jakus et al., 2024).



Figure 27: Examples of complex hydraulic structures used to distribute and retain water within the active floodplain: a) “Szent Kristóf” Bridge and water level control structure; b) “Denkpál” branch-end closure and fish passage

#22 Keeping the Mosoni-Danube supplied

The southern branch receives regulated water through the supply channel and toe-drain system.

The Mosoni-Danube had received controlled water through the Rajka structures since the early twentieth century. As the bed of the Danube gradually deepened, however, its water levels fell, and gravity-fed intake at Rajka became increasingly difficult. By the late 1980s, the supply could cease altogether during prolonged low-water periods (Jakus et al., 2024).

After the 1992 diversion, water released from the Čunovo reservoir was conveyed toward the Mosoni-Danube through the supply channel and toe-drain system. The 1995 agreement (#19) increased the available discharge and allowed water to be divided between the Mosoni-Danube, the Zátónyi-Danube route supplying the historical floodplain (#13), and, under certain conditions, the active floodplain (Agreement, 1995).

This regulated supply provided the upper Mosoni-Danube with a more reliable basic flow, particularly during prolonged low-water periods. Together with the active-floodplain and historical-floodplain systems (#23), it became the third main component of the wider Szigetköz water-replenishment network.



Figure 28: (a) Rajka Sluice Gate in 1991; (b) Mosonmagyaróvár Barrage in 2025; (c) Mosoni-Danube supply channel at the Čunovo reservoir; and (d) flow in the supply channel and toe-drain system near the Rajka Sluice Gate.

#23 A two-way network behind the levees

The historical floodplain must retain water during dry periods and remove it during wet periods.

Behind the flood-protection levees, the historical floodplain no longer receives regular direct flooding from the Danube (#7). During the twentieth century, many former river channels were incorporated into a drainage network designed mainly to remove excess inland water toward the Mosoni-Danube. After the 1992 diversion, this existing network also offered a practical way to bring water back into the landscape (#13) (Dunai, 1995; Tatai and Pap, 2023).

Using the same network for both replenishment and drainage created a new challenge. Water needs to be retained to support wetlands, fisheries, wet meadows, and other water-dependent landscape functions. During periods of intense rainfall, or when floods cause seepage beneath the levees and high groundwater levels, excess water must instead be drained to protect agricultural land and settlements.

These needs can place conflicting demands on the system, making the construction of numerous control structures that allow flexible operation particularly important.

Adjustable structures built during different phases of rehabilitation (#32) allow the direction and purpose of water management to change with conditions. Water can be supplied and retained in suitable low-lying areas when it is needed, while the drainage function remains available when conditions become too wet. The historical floodplain network operates in two directions: it can bring water into the landscape and, when necessary, carry excess water away (Dunai, 1995; Tatai and Pap, 2023). The replenishment system did not become fully developed in a single step. As structures were introduced and operation expanded, their performance was tested, monitored (#24), and adjusted under real river conditions (#25).



Figure 29: A channel used for both water replenishment and drainage in the historical floodplain in Upper Szigetköz (a) and Lower Szigetköz (b)



CHAPTER 6

Learning through operation



#24 Testing the system in practice

Between 1995 and 2000, the system was operated, monitored, and adjusted as experience accumulated.

Before permanent operating rules (#26) were adopted, the replenishment system operated under a test regime for several years. During this period, water levels and discharges were measured alongside groundwater, soil moisture, water quality, forest condition, aquatic vegetation, fish, macroinvertebrates, and other biological indicators. Hungary and Slovakia also exchanged monitoring data and prepared annual joint reports (Agreement, 1995; Mucha and Lisický, 2006).

Monitoring was part of the test operation itself. Measurements showed how the floodplain actually responded to different water levels and flows and where this differed from the original design assumptions (#18).

Looking at hydrological, chemical, and biological conditions together was important: a branch could have acceptable chemical water quality but still provide poor ecological conditions (#31) if flow was too slow or too fast, connections were weak, or fine sediment accumulated (Pannonhalmi, 2005; Ördög and Koltai, 2008).

During the test period, measurements were used to compare planned and observed conditions, identify local problems, and determine where further adjustment was needed. Monitoring therefore became not simply a record of environmental change, but a necessary tool for testing and managing the replenishment system (#27) (ÉDUVIZIG, 2000a; Jakus et al., 2024).

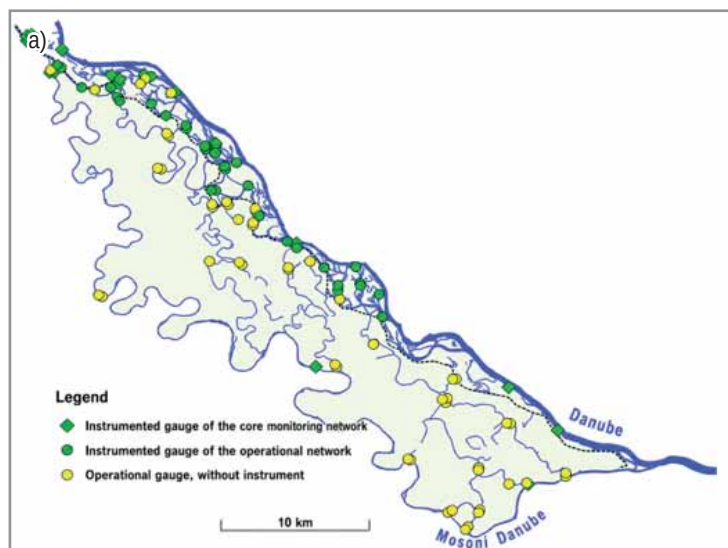


Figure 30: Locations of surface-water level gauging stations in Szigetköz. a) Gauging stations are monitoring points where river or channel water levels are measured regularly or continuously to track changes over time (Szűcs, 2018); b) Old Danube gauge at Doborgaz

#25 Lessons learned from test operation

Operating experience led to seasonal settings, smoother day-to-day adjustments, technical corrections, and more targeted water distribution across the branch network.

Operating experience revealed important seasonal differences. Infiltration and evaporation were greater during warmer months, so more inflow was needed in summer to maintain the same target water level. Rapid day-to-day changes in discharge also caused erosion near some structures. These findings led to separate seasonal settings and the use of the two-day mean Danube discharge in later operating rules.

Field measurements showed that the branch network did not respond uniformly (#29). Channel geometry, vegetation, sediment, closures, and local hydraulic resistance meant that the same inflow could produce different water levels and velocities in different parts of the system.



Figure 31: Oxbow lake in the historical floodplain

A hydrodynamic model helped explain these differences and test how water was distributed through the connected branches.

The analysis indicated that low-water conditions generally required about 20–50 cubic meters per second, while average water levels required approximately 60–150 cubic meters per second. The existing structures allowed a maximum operational replenishment flow of about 250 cubic meters per second (#28), yet even at that discharge, some branches remained below the intended high-water targets (ÉDUVIZIG, 2000a).

One of the most important lessons was that simply adding more water was not always the best solution. In some locations, redistributing the available flow, modifying control structures, or improving connections between branches produced greater benefits than increasing the total inflow.

The test period changed the way the system was managed. Field observations and modeling were used together to identify where local intervention was needed and to refine the rules for distributing water through the network. These lessons later became part of the permanent operating system (#26), linking Danube discharge, monitored conditions, and day-to-day water allocation (ÉDUVIZIG, 2000a).

#26 From test operation to permanent rules

The operating permit converted experience, constraints, and stakeholder priorities into a formal management framework.

After several years of test operation, the Szigetköz Water Replenishment System needed permanent rules. Monitoring and modeling showed what the system could achieve (#25), but available water remained limited, and different users did not always need the same conditions (#15).

Stakeholders were involved again in defining the system's long-term operation. Water management, nature conservation, agriculture, forestry, fisheries, local interests, and other users brought different requirements for water levels, flows, and timing.

These needs were compared with the amount of water available and with the technical limits revealed during test operation (#24). Where objectives conflicted, priorities and practical compromises had to be agreed.



Figure 32: Developing the permanent operating rules: stakeholders identified their needs and balanced them against the available water and the system's technical limits before the rules were finalized

The resulting operating rules defined how water should be distributed among the Old Danube, the active floodplain, the historical floodplain, and the Mosoni-Danube under normal, flood, special, and emergency conditions. Normal operation responds to Danube discharge at Bratislava (Dévény) (#19) and seasonal conditions, while separate procedures apply to maintenance, controlled inundation (#28), pollution (#30), ice, structural problems, and other exceptional situations (ÉDUVIZIG, 2000a; Tatai and Pap, 2023).

The operating permit did more than formalize technical procedures. It translated experience from test operation and competing stakeholder needs into an agreed framework for sharing the available water.



Figure 33: a) Mosoni-Danube outflow structure operation control; b) daily water-level control at Dunakiliti

#27 A forum for continued adaptation

The Szigetköz Operating Committee keeps stakeholder participation active as part of the system's long-term operation.

Stakeholder involvement (#14) continued after the first phase of the water-replenishment system was completed in 1995. Following several years of test operation, stakeholders met again in 1999 to discuss long-term management. After the operating-permit process, the Szigetköz Operating Committee was formally established in 2001, creating a permanent forum for cooperation among water management, disaster management, nature conservation, forestry, agriculture, local government, fishing, and tourism (#4) (Janák et al., 2014).

The Committee meets at least once a year to review the previous year's operation, monitoring results, maintenance needs, and change requests. The North-Transdanubian Water Directorate (ÉDUVIZIG) evaluates these proposals and develops possible technical responses, allowing different sectoral needs to be considered within the same decision-making process (Tatai and Pap, 2023).

Operational adjustments that remain within the existing permit can be incorporated into the operating instructions, while larger changes require a separate permitting procedure (#32, #33). The Committee provides a continuing link between monitoring, stakeholder needs, and adaptive operation, keeping participation active long after construction was completed.



Figure 34: a) Meeting of the Szigetköz Operating Committee in 2025; b) Process leading to the establishment of the Szigetköz Operating Committee

#28 Controlled floodplain inundation

Routine replenishment supplies water continuously; controlled inundation temporarily restores part of the spring flood pulse.

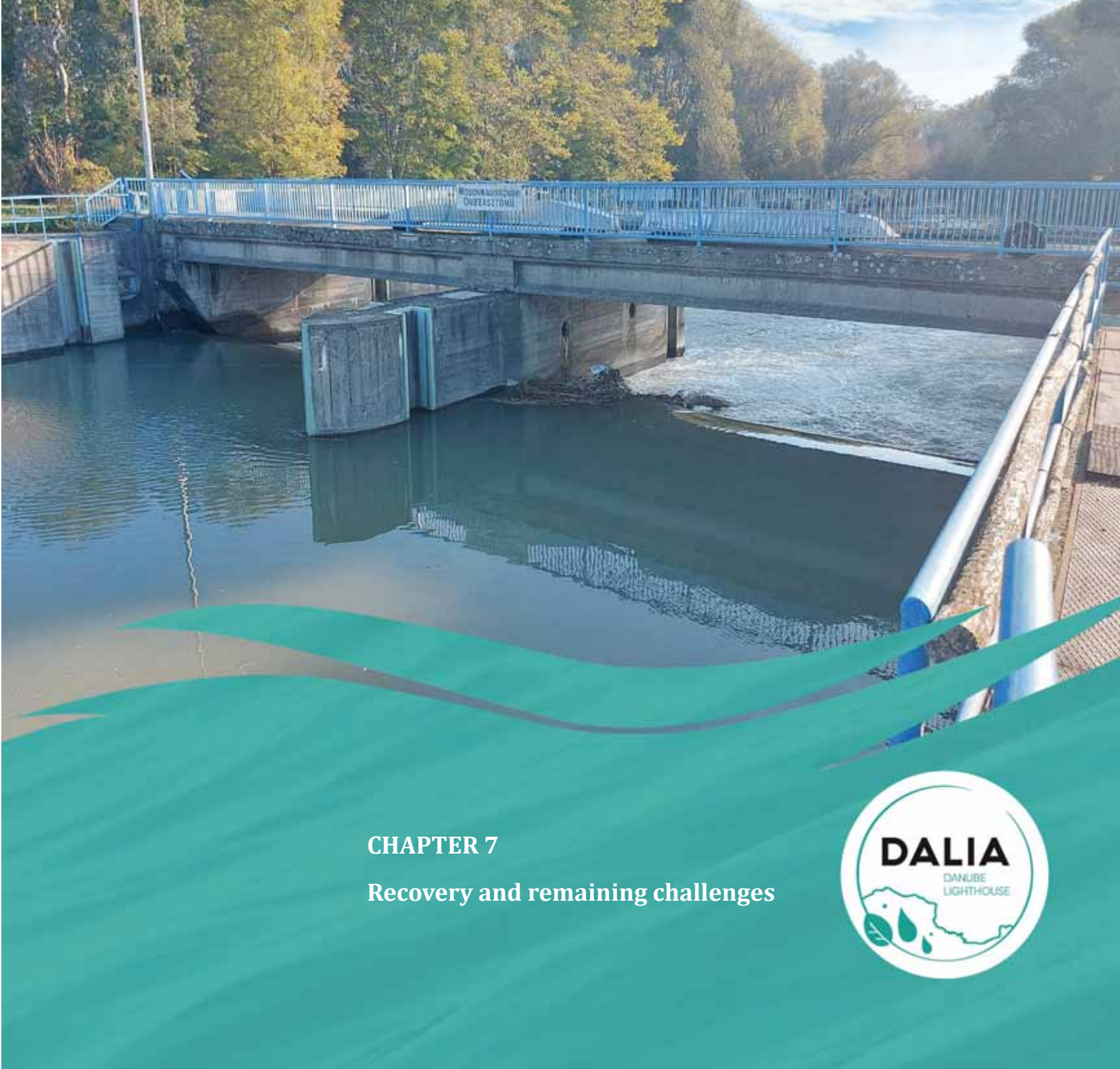
Routine replenishment (#21) cannot reproduce the temporary rise in water levels that once accompanied spring floods (#16). To restore part of this seasonal dynamic, controlled floodplain inundation has been carried out in selected years since 2004. During April and May, when Danube flow forecasts, water temperatures, and operating conditions are suitable, releases to the Old Danube can be increased and approximately 200–250 cubic meters per second can be directed into the active floodplain for about two weeks (Kertész, 2017; Tatai and Pap, 2023).

The temporary rise in water levels allows water to spread across a larger part of the floodplain. It can provide access to spawning and nursery habitats, support groundwater recharge, and supply floodplain forests and wetlands during an ecologically important part of the year (#31) (Tatai and Pap, 2023).

Controlled inundation does not recreate a natural flood. Its timing, discharge, duration, and extent are regulated, and the operation must remain compatible with flood protection and the safe operation of hydraulic structures. Where possible, discharge is reduced gradually at the end of the event so that water levels fall more slowly and the risk of stranding fish and juvenile fish is reduced. In this way, controlled inundation restores part of the seasonal variability that routine replenishment alone cannot provide (ÉDUVIZIG, 2000b; Tatai and Pap, 2023).



Figure 35: Controlled floodplain inundation in the Szigetköz active floodplain



CHAPTER 7

Recovery and remaining challenges



#29 Recovery was substantial but uneven

Replenishment refilled many channels, but it did not recreate the former natural water regime.

Surface-water conditions improved visibly in large parts of the active and historical floodplains. Previously dry channels (#11) refilled, and water levels stabilized in many directly supplied branches and water bodies. The greatest improvements generally occurred close to channels receiving replenishment water, while the effect weakened farther from the supplied network (Jakus et al., 2024).

Groundwater (#12) followed a more complex pattern. The persistently low water level of the Old Danube continued to influence nearby areas, particularly in Upper Szigetköz, while locations closer to replenished branches experienced greater stabilization. Long-term analysis shows that spring and summer groundwater levels increased by approximately 20–30 cm in parts of central Szigetköz, offsetting much of the earlier decline (Chappon et al., 2024a).

Recovery was also seasonal. While growing-season groundwater conditions improved in several areas, winter groundwater levels continued to decline in some upstream locations. The results show substantial but spatially and seasonally uneven recovery rather than a return to pre-diversion conditions (Chappon et al., 2024a).



Figure 36: Surface water in an active floodplain branch a) before the diversion (1988); b) after the diversion (1993); c) following water replenishment (1995)

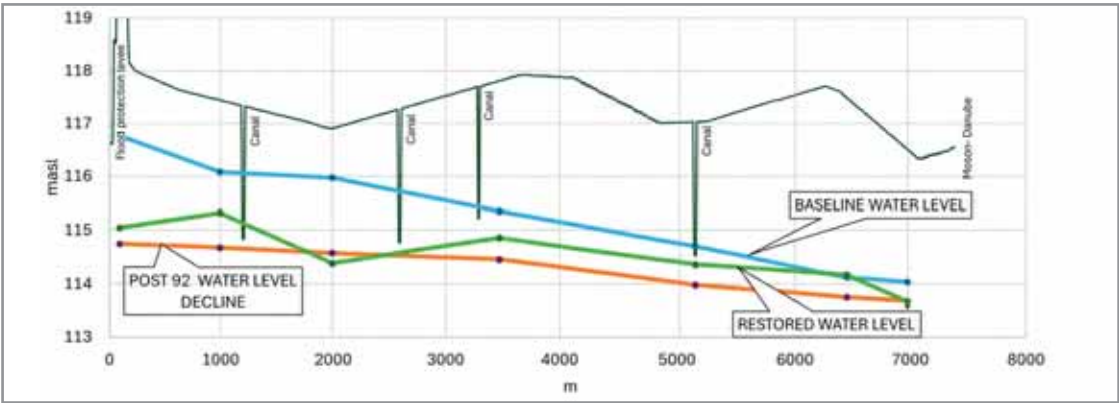


Figure 37: Groundwater response after water replenishment, showing the replenishment network, investigated sections, and groundwater potential patterns across Szigetköz (Chappon et al., 2024a)

#30 Water quality and local ecological risks

Bringing water back was only part of the recovery: its quality and movement through the floodplain also shaped ecological conditions.

The recovery of surface water and groundwater improved conditions across much of Szigetköz (#29), but the ecological response depended on more than water levels alone. The quality of the incoming Danube water, together with how quickly it moved through the branch network and how long it remained there, also influenced the condition of aquatic habitats (#18).

Long-term monitoring (#24) in Lower Szigetköz shows substantial declines in several forms of organic, nutrient, and bacterial pollution compared with the more polluted conditions of earlier decades. Improved wastewater treatment in upstream urban areas and changes in industrial activity contributed to this trend (Pannonhalmi and Varga, 2021; Mucha and Lisický, 2006).

Consequently, water entering the replenishment system had better chemical quality than during the 1960s–1980s. Conditions within the network, however, were also influenced by tributary inflows, local pollution sources, floods, and local flow conditions. Slow flow, long residence time, fine-sediment accumulation, and high biological productivity could promote algal growth and large daily variations in dissolved oxygen (Pannonhalmi, 2007; Ördög and Koltai, 2008).

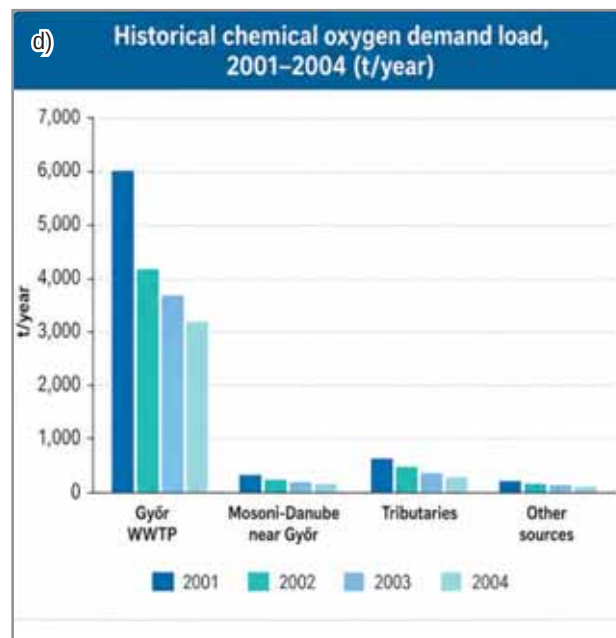


Figure 38: Main factors influencing water quality in the Mosoni-Danube: a) incoming Danube water and tributary inflows; b) diffuse pollution and accidental events; c) floods and local flow conditions; and d) wastewater discharges. Together, these factors influence water quality in the river and connected branch systems (Pannonhalmi, 2005)

Monitoring in 2006 and 2007 showed that equally favorable biological responses did not always match favorable chemical conditions. Slow-flowing or weakly connected branches showed the greatest spatial and seasonal variability, confirming that ecological water quality depended not only on the water entering the system, but also on how it moved through the floodplain (Pannonhalmi, 2007; Ördög and Koltai, 2008).

#31 Biological recovery and ecological limits

Rewatered habitats support more aquatic life, but the floodplain remains regulated and fragmented.

The return of water (#21) allowed many aquatic and wetland habitats to recover. Fish returned to rewatered branches, amphibians and waterfowl again used floodplain wetlands for breeding and feeding, and aquatic vegetation developed in oxbows and slower-flowing channels. Improved soil moisture also supported floodplain forests close to supplied water bodies (ÉDUVIZIG, 2004; Jakus et al., 2024).

Recovery, however, differed among habitats. Flowing channels, slow-flowing branches, oxbows, and temporarily connected water bodies responded differently, and ecological conditions remained strongly dependent on local water exchange and connectivity. Some poorly connected or slow-flowing waters were more vulnerable to algal growth and other signs of eutrophication (Pannonhalmi, 2006, 2007; Ördög and Koltai, 2008).

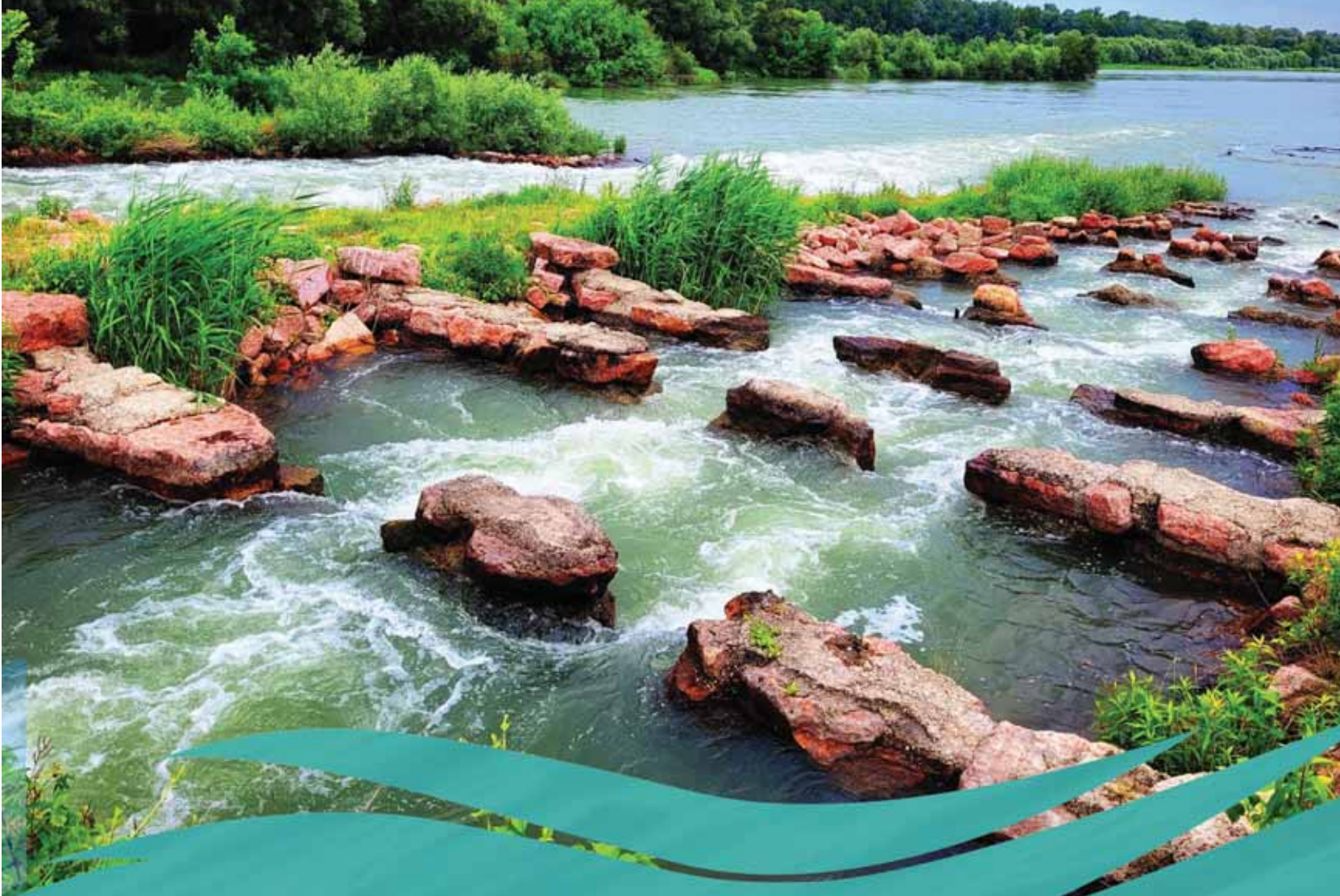
Important characteristics of the former floodplain regime have not been fully restored. Natural flood pulses remain weaker, seasonal water-level variation is reduced, and ecological connections between the main river and many floodplain habitats remain limited. Some historically characteristic species are still absent, while invasive species have expanded in modified habitats (Guti, 2020; Jakus et al., 2024).

The result is a substantial but incomplete ecological recovery: many floodplain functions and habitats have returned, but the present landscape remains a managed system rather than a recreation of pre-diversion conditions (#2).

These limitations, particularly in Lower Szigetköz and along the Mosoni-Danube, led to a new phase of rehabilitation (#32, #33).



Figure 39: a) Lipót Oxbow Lake (Lipóti-morotva-tó) in the historical floodplain; b) Öntési Lake, representing a slow-flowing or standing-water habitat within the active floodplain mosaic



CHAPTER 8

Extending the rehabilitation



#32 Extending replenishment through Lower Szigetköz

The main challenge was retaining and redistributing existing water farther downstream.

Before 2015, regular active floodplain replenishment ended near the upper Ásványi branch system. Several downstream branch systems periodically dried or lost their aquatic character as low water levels in the Old Danube declined, and floodplain branches gradually silted up (#8). Rather than increasing total inflow, the project focused on retaining and redistributing water already available within the system (#25).

Water that had previously returned to the Old Danube was retained and directed through a downstream sequence of branches. Submerged outlet weirs, dredged feeder channels, modified closures, and fish passages created a connected route through the lower active floodplain (Kertész, 2017).

Three siphon-based intakes also expanded water supply to the adjoining historical floodplain channels (#23). Because siphons carry water beneath the levee but do not provide migration routes for larger aquatic organisms, ecological connectivity depends on fish passages at downstream water-level-control structures near the Mosoni-Danube (#33), together with suitable operating rules (Dunai, 2006; Kertész, 2017).



Figure 40: (a) Replenished river branch in Ásványráró; (b,c) Béka-ér Siphon in Ásványráró supplying water from the (b) active floodplain to the (c) historical floodplain



Figure 41: Extension of water replenishment through the lower Ásványi, Bagaméri, and Patkányosi branch systems with photos of fish passages. Base map: ÉDUVIZIG

#33 Rehabilitation of the Mosoni-Danube

Later projects treated the river corridor as an ecological, urban, recreational, and flood-protection system.

The Mosoni-Danube, the southern branch of the Szigetköz river system (#1), flows through Mosonmagyaróvár and Győr and connects floodplain, urban, and tributary environments. Its rehabilitation was implemented in two main phases, reflecting different local problems along the river corridor that remained after the first phase of rehabilitation (#22).

The upstream phase, completed in 2015, focused on the reach upstream of Győr. It included urban river sections, oxbows, wetlands, island branches, and the lower Lajta River, an important tributary of the Mosoni-Danube. Water-level-control structures were reconstructed, while fish passages and boating facilities improved longitudinal connectivity and public use (Dunai, 2024).

The downstream phase addressed the lower reach near Győr, where persistently low water levels had weakened the hydraulic connection between the Mosoni-Danube, the Rába, adjoining side branches, and the urban waterfront. The Mosoni-Danube Outflow Structure, completed in the second phase, was designed to raise and regulate upstream surface water and groundwater levels while also supporting flood protection and navigation objectives.

Taken together, the two phases extended rehabilitation from individual structures to the wider river corridor. Upstream and downstream works responded to different local conditions. However, both were coordinated around the same broader aims: improved water levels, better ecological connectivity, flood management, navigation, and a stronger relationship between the river and surrounding settlements (Dunai, 2024).

These later projects showed that rehabilitation in Szigetköz was not a single completed intervention (#34), but an evolving regional process that continued as new problems and opportunities emerged.



Figure 42: Rehabilitation of the Mosoni-Danube: a) Historical floodplain branch connection to the Mosoni-Danube upstream of Győr; b) River landscape in Győr; c) small boat downstream from Győr; d) the Mosoni-Danube Outflow Structure

#34 A rehabilitation that continues

The water-replenishment system substantially improved conditions across a heavily modified floodplain, but its operation and development remain ongoing.

Water has returned to many branches that dried after the 1992 diversion (#11). Controlled water distribution, fish passages, and later extensions of the replenishment system have improved hydraulic and ecological connections while maintaining flood protection and supporting settlements, land use, and other human activities (#3).

The floodplain, however, has not returned to its former natural state (#6). The Old Danube still receives only a fraction of its former discharge, and its water levels remain low. In the active floodplain, seasonal fluctuations are smaller than they once were, and large-scale regulation still influences groundwater conditions. Some ecological connections and flood-pulse processes remain only partly restored, and the benefits of replenishment are uneven across the landscape (#29) (Chappon et al., 2024a; Gutí, 2020).

At the same time, more than three decades of work (#5) transformed emergency measures into a system of adaptive management. Initial measures were followed by construction, test operation, monitoring, technical adjustments, formal operating rules, and the establishment of the Szigetköz Operating Committee (#27). Together, these efforts created a replenishment system that supports both ecological functions and human uses. Rehabilitation has continued in Lower Szigetköz (#32), along the Mosoni-Danube (#33), and through controlled inundation on the active (#28) and historical floodplains.

It is perhaps best to view the story of Szigetköz not as a completed rehabilitation project, but as an ongoing relationship between the Danube, the floodplain, its infrastructure, and the institutions and communities responsible for its operation.



Figure 43: Rehabilitation in Szigetköz: a) historical floodplain; b) fish passage between the active floodplain and the Old Danube (Ásványráró)

What can other river projects learn?

Szigetköz offers a method for working with constraints, not a universal technical blueprint.

The project's principal achievement is not the recreation of an undisturbed floodplain. It is the development of an adaptable system that brings water back to a heavily modified landscape while maintaining ecological functions, flood safety, and multiple social uses (Dunai, 1995; ÉDUVIZIG, 2000a; Tatai and Pap, 2023).

Some conditions are specific to Szigetköz: it is a transboundary inland delta, overlies a crucial gravel aquifer, lies on a major European navigation corridor, and must be managed under significant flood risk.



Figure 44: Present-day Szigetköz floodplain landscape

These conditions make the site distinctive and mean that its structures should not be copied as a universal technical blueprint (Bárdossy and Molnár, 2004; Jakus et al., 2024).

What transfers is the method: identify the problem and historical causes, recognize conflicts, involve affected groups, translate ecological goals into design criteria, implement in phases, operate adaptively, monitor results, and evaluate long-term sustainability. Technical lessons include gravity-based distribution, dynamic control, and fish-passage design; institutional lessons include conflict resolution and a permanent operating committee (Dunai, 1995; Pannonhalmi, 1999; Janák et al., 2014; Tatai and Pap, 2023).

Within DALIA, these lessons are being exchanged with replication sites linked to LIFE4LAMPREY in Portugal, WATER-GUIDE in Bosnia and Herzegovina, and SMARR in Israel. The aim is not to duplicate Szigetköz structures, but to adapt monitoring, stakeholder participation, decision-making, and nature-based design principles to local conditions.

Rehabilitation is not only about fixing rivers; it is about reconnecting people and processes (Water Resources Research Group, 2025).

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Image credits

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