Beyond Room for the River: Towards a Multifunctional, Climate-Robust, and Resilient Management Strategy in the Netherlands

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ABSTRACT

The Room for the River programme (2007–2018) transformed the Dutch river landscape by increasing flood safety while improving spatial quality, ecology, and landscape value. In a low-lying and densely populated country such as the Netherlands, however, river management is a continuous task rather than a one-off effort. Ongoing investments are required to maintain embankments, floodplains, and navigation channels, while adapting to long-term challenges including climate change, population growth, and land-use change. For this reason, river management is not considered complete, and the follow-up programme Room for the River 2.0 (RftR 2.0) has been initiated.

Compared to its predecessor, RftR 2.0 addresses both persistent and emerging challenges. Flood safety and spatial quality remain central, but increasing riverbed erosion, freshwater scarcity, and tensions between navigation, nature development, and climate adaptation have become more prominent. These challenges are intensified by the bifurcating layout of the Rhine, where water and sediment are distributed across multiple branches during both low and high discharges.

This paper examines how these growing and sometimes competing demands can be addressed from a long-term, system-level perspective. Focusing on the Rhine and its branches, we explore pathways towards a multifunctional river system that supports navigation, freshwater supply, and nature development while remaining safe under climate change towards 2100. Also, potential spatial reservations for future river widening are identified.

Recent studies indicate that historical interventions—such as channel straightening, embankment reconstruction, and flow regulation—have pushed the river system out of morphological and hydraulic balance. The delayed system response, combined with climate-driven shifts towards higher winter discharges and prolonged summer low flows, increases risks of floodplain desiccation, freshwater shortages, and navigation problems. Against this background, measures such as side channels and more natural floodplains are explored as promising strategies to restore system balance, enhance ecosystem services, and strengthen climate robustness.

KEYWORDS: flood risk management, climate resilience, river morphology, multifunctional river systems

1 INTRODUCTION

1.1 From High-Water Events to Room for the River

In December 1993 and January 1995, exceptionally high discharges occurred in both the Rhine and Meuse rivers, resulting in some of the highest water levels recorded in the Netherlands in the twentieth century. Although no major dike breaches occurred, these events brought the river system close to its physical limits and exposed the vulnerability of a densely populated, low-lying country that relies heavily on flood protection infrastructure.

The high-water events caused major social disruption. As a precautionary measure, approximately 250,000 people were evacuated from riverine areas along the Rhine and Meuse. The evacuations, extensive media attention, and visible stress on embankments acted as a national wake-up call. They demonstrated that the prevailing strategy of continually raising dikes to accommodate higher design discharges was reaching its societal, spatial, and technical limits.

In the immediate aftermath, emergency reinforcement measures were implemented to restore confidence in the flood protection system. More importantly, however, the events triggered a fundamental rethinking of Dutch river management. Rather than continuing a strategy focused solely on dike reinforcement, a new approach emerged that aimed to increase the discharge capacity of the river system itself. This marked the conceptual starting point of the Room for the River programme.

The core idea of Room for the River was to reduce flood levels by giving rivers more space instead of further confining them. Measures such as floodplain lowering, dike relocation, side-channel construction, and the removal of hydraulic obstacles were combined to increase conveyance capacity during high flows. At the same time, the programme explicitly introduced spatial quality as an objective, aiming to enhance landscape values, ecological conditions, and the integration of river areas with their surroundings. This approach was often described as reconnecting with the river's 'DNA'.

Parallel to the implementation of Room for the River (2007–2018), Dutch flood risk management evolved towards a more risk-based approach, influenced by international events such as Hurricane Katrina. This shift placed greater emphasis on consequences, system robustness, and societal resilience. The process culminated in the Dutch Delta Programme, which provides a long-term framework to keep the Netherlands safe and liveable towards 2050 and beyond.

From the outset, Room for the River was not intended as a final endpoint. Long-term visions already acknowledged that ongoing climate change and increasing spatial claims—such as for nature development, navigation, recreation, cultural heritage, and urban growth—would eventually exhaust the available space within the river system. This insight necessitated an integrated, system-level analysis of future river management.

This analysis was elaborated within the Integrated River Management programme (Ministry of Infrastructure and Water Management, 2025).

1.2 New challenges ahead

Spatial pressure in river areas has increased rapidly over recent decades. Whereas development around 1900 was limited, many former floodplains have since been transformed into residential areas, business parks, and infrastructure corridors. Large investments in roads, railways, and bridges have locally narrowed the winter bed, creating hydraulic bottlenecks at various locations.

In the future, housing, economic activity, and mobility demands in river areas are expected to continue to grow, particularly around large and medium-sized cities. These urban centres are also the locations where major infrastructure corridors intersect the river system. Together, these developments intensify land use and reduce the space available for river widening or other system improvements. Bottlenecks that limit the safe conveyance of high discharges are already apparent near urban areas. In historic city centres and villages, further dike raising will often be infeasible without major impacts on existing buildings. Cultural-historical values, such as characteristic riverfronts, visual relationships between inner and outer dikes, and flood defences as landscape elements—further constrain adaptation options. Three developments negatively affect the functioning of the river system:

1. More frequent occurrence of high discharges;
2. More frequent occurrence of low discharges;
3. Continued erosion of the main channel bed, largely resulting from interventions carried out up to 150 years ago.

(1): The increasing frequency of high water levels intensifies the challenge of safely conveying river discharges to the sea. Higher and more frequent floods also affect the river system itself: hydraulic bottlenecks cause additional backwater effects and increased flow velocities, which can locally accelerate erosion. This increases the demands on flood risk management and may generate new challenges beyond the current Flood Protection Programme (HWBP, Web-1). Measures to accommodate higher discharges invariably require additional space, which is becoming increasingly scarce.

(2): Projections indicate that low-flow periods may occur more frequently and become more extreme, leading to increased problems related to low groundwater tables. It also leads to an increased disconnection between main channel and floodplains, which reduces the inundation of the floodplains. This is necessary for a natural dynamical situation, with creating opportunities for nature and a rich biodiversity. Economic losses in agriculture and inland navigation during low-flow periods are substantial.

(3): Riverbed erosion in free-flowing rivers is a growing concern because of its wide-ranging impacts on river functions and ecological values (Ylla Arbos et al. 2020). The effects are most severe during droughts, affecting not only the river and its floodplains but also surrounding regions far beyond the river corridor (figure 1). Inland navigation becomes problematic during low flow conditions, due to limited navigational depth. The fact that at certain locations there are non-erodible (man-made or natural) sections in the riverbed exacerbates the problems for navigation, as these protrude with respect to the erodible river bed and become an obstacle for ships.

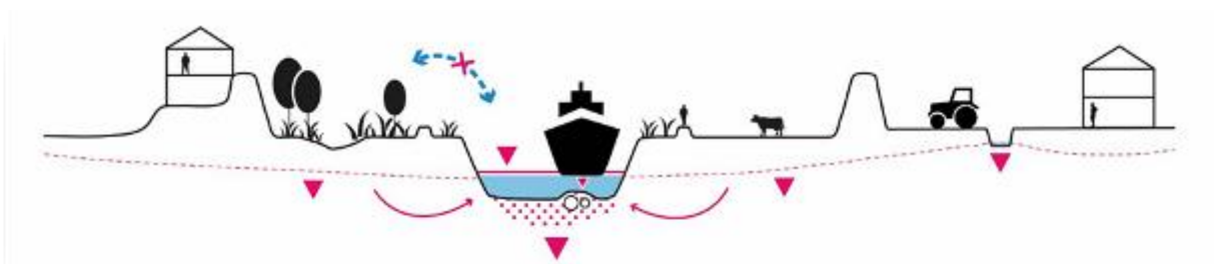

Figure 1: Schematic of the river's main channel and flood plains. In red, the challenges are denoted: river bed erosion, disconnection of main channel and flood plains, and lowering ground water tables.

In addition, the partitioning of river discharges across the Netherlands plays a crucial role under both high- and low-flow conditions (Chowdhury et al., 2023). Ongoing erosion in the Waal branch gradually alters this distribution: at low discharges, an increasing share of water remains in the Waal, reducing flows towards Lake IJssel, the Netherlands' primary freshwater reservoir. During extreme high discharges, changes in the distribution increase hydraulic loads on some river branches at the expense of others. Restoring a balanced discharge distribution therefore requires careful consideration of costs and benefits at the national scale.

In section 2, we describe the ambition and working method of Room for the River 2.0 (Web-2), the follow-up of Room for the River. Section 3 presents the underlying concepts and solution directions, while Section 4 discusses the first results and their implications and we conclude in section 5.

2 AMBITION AND WORKING METHOD OF ROOM FOR THE RIVER 2.0 (RFTR2.0)

The ambition of RftR 2.0 is "a future-proof river system that functions well as an integrated system and can be used in multiple ways." This refers to a river system that, as far as possible, is self-regulating through natural processes and possesses the system characteristics required to support its various functions effectively. RftR 2.0 focuses on the following five river functions:

1. Water conveyance (flood protection);
2. Freshwater availability and drinking water supply;
3. Nature and ecological water quality;
4. Navigability;
5. Regional economic development and spatial quality, including agriculture, recreation, and mineral extraction.

In a preliminary study (Ministry of Infrastructure and Water Management, April 2025), two overarching policy goals were formulated for the river area. Within the RftR 2.0 programme, these goals are elaborated into policy choices along two main lines, one on the riverbed, and one the discharge capacity and room for the river.

Riverbed and sediment management: A sufficiently stable and manageable summer-bed level that contributes to the restoration of natural river dynamics and ensures good navigability and an adequate distribution of water across the Netherlands during low discharges.

Discharge capacity and room for the river: Sufficient capacity to safely accommodate the higher river discharges expected over the course of this century, while also enabling spatial developments, nature development, subsurface considerations, and other societal tasks.

The challenges associated with the different river functions cannot be addressed in isolation. The river area is therefore approached as a coherent system, and the tasks related to the various functions are addressed in conjunction. The two policy choices act as the main system controls for designing a river system that optimally supports all five river functions (figure 2).

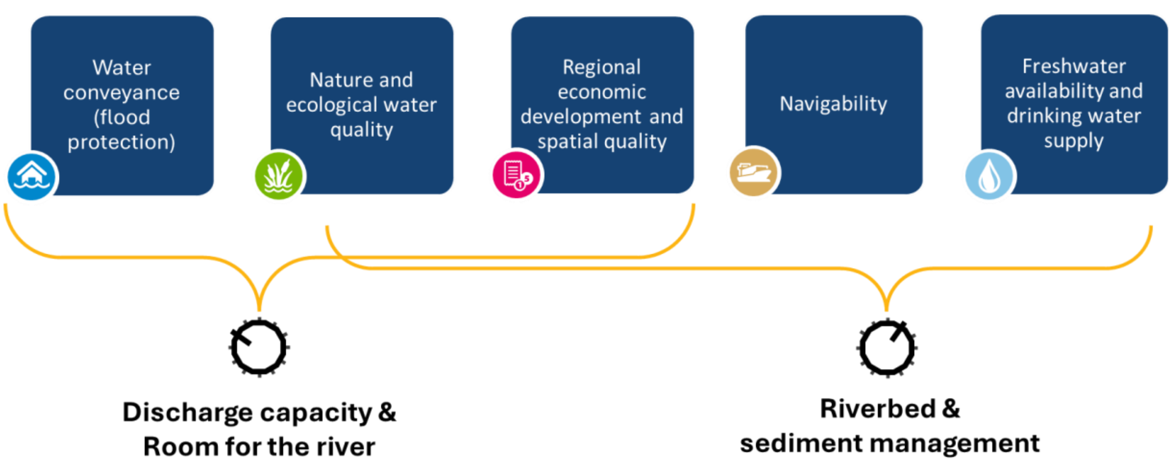

Figure 2: The two policy choices in relation to the five river functions

To keep this integrated approach manageable, RftR 2.0 adopts a clear division of roles with other programmes. Parties work within RftR 2.0 on system-level design questions, while sectoral objectives—such as freshwater supply, nature restoration, navigation, and flood protection—remain the responsibility of dedicated sectoral programmes. There is no transfer of tasks or decision-making powers.

Decisions on sectoral objectives are taken within the administrative platforms of the relevant programmes, while impacts on other river functions are explicitly considered by addressing these interactions early in the RftR 2.0 context. Where necessary, RftR 2.0 may place on the agenda the need to reconsider sectoral objectives if they prove mutually incompatible or cannot be achieved in a timely manner.

3 UNDERLYING CONCEPTS AND SOLUTIONS

3.1 Coherence of policy choices in the main water system of the Netherlands

The policy choices prepared within RftR 2.0 also affect other, interrelated choices in the main water system of the Netherlands. Coherence among these decisions is achieved through the process leading to a national Delta Decision on Large Rivers and Deltas which will be taken in the context of the national Delta Programme.

The Delta Decision addresses strategic choices for the design of the major rivers and deltas in the Rhine–Meuse system, including the Meuse, the Rhine branches, Lake IJssel, the lower river area up to the river mouths at sea, and the Southwest Delta. The Decision is periodically reassessed based on updated climate and Delta Scenarios, drawing on input from multiple national and regional programmes.

Increasing system degradation and the accumulation of water-related challenges mean that tasks in different regions are becoming more interdependent. This requires coherent decision-making.

Four sequential steps structure the preparation of the Delta Decision:

1. **Towards a low-water-resilient delta**
   Preparing the main water system for periods of low and insufficient water availability, in parallel with initial adaptations in land use.

2. **More space for water in a busy delta**
   Creating additional room in and along rivers in a timely manner to anticipate higher water levels in rivers and tributaries.

3. **Sea in sight!**
   Aligning the design of the main water system and land use with the long-term impacts of sea level rise.

4. **Leap in scale along the chosen pathway**
   Implementing further measures that build on and scale up previously made strategic choices

Each step consists of interrelated components that must be addressed jointly.

3.2 Sequence of policy choices

Chapter 2 describes how RftR 2.0 relates to the five river functions and how the two policy choices **'Riverbed and sediment management'** and **'Discharge capacity and room for the river'**—act as two key system controls for designing a river system that optimally supports these functions. These two choices are strongly interrelated, and their effects influence one another.

It is therefore essential to consider alternatives and measures for both policy choices in conjunction, while at the same time keeping the process manageable. To avoid an excessive number of combinations—many of which would be neither logical nor relevant—the **RftR 2.0** programme applies a deliberate sequencing of policy choices to reduce complexity. This sequencing also reflects the urgency of the underlying problems and the alignment with the recalibration of the Delta Decision on Large Rivers and Deltas.

The RftR 2.0 programme follows the sequence below:

1. **Discharge distribution at low flows**, which is essential for elaborating riverbed solutions (see points 2).

2. **Stabilisation and, where feasible, elevation of the riverbed** to a level that effectively addresses existing problems.
3. **Discharge distribution at high flows**, which informs the elaboration of branch-specific solutions (see point 4).
4. **Dimensions of the floodplains (discharge capacity)**, including the combination of functions and the preferred order of measures.

This order is crucial, as the choices made in steps 1 to 3 largely determine the scope and scale of the task in step 4, concerning discharge capacity.

In practical terms, this means that the policy choice **'Riverbed and sediment management'** (steps 1 and 2) is guiding for the policy choice **'Discharge capacity and room for the river'** (steps 3 and 4). Interactions and synergies between both solution pathways are explicitly taken into account when substantiating the overall solution strategies.

3.3 Policy choice Riverbed

To prevent continued erosion of the summer bed, the balance between sediment supply and sediment removal must be restored. When sediment input and output are in equilibrium, the riverbed remains stable and there is no net aggradation or degradation.

Two principal solution directions have therefore been explored to restore this balance:

1. **Sediment nourishment**
   Increasing sediment supply by adding sediment to the river system, with the aim of annually compensating for the volume lost through erosion.
2. **Widening**
   Addressing the root cause of riverbed erosion by widening the riverbed. Increased cross-sectional width reduces flow velocities, thereby decreasing sediment transport capacity and limiting erosion.

3.4 Policy choice Discharge capacity and room for the river

To ensure that measures for safe discharge remain feasible in the long term, additional space must be reserved along rivers, both between the main embankments and at the land-side of the embankments. These spatial reservations provide planning certainty and contribute to a safe and robust river system under future conditions. At the same time, they create opportunities to restore natural river dynamics. A river system with sufficient space and connectivity is essential for resilient and climate-adaptive riverine ecosystems.

Within RftR 2.0, the areas required at the land-side of the embankments to guarantee long-term flood risk management have been identified. This assessment is complex, as future discharge projections span a wide range due to uncertainties in climate change trajectories and spatial developments in upstream river basins. Furthermore, strategic choices regarding discharge distribution across the Rhine branches and the selection of an open or closed delta system to address sea level rise also influence outcomes.

To account for these uncertainties, both a high and a moderate climate scenario were considered, in combination with two alternative discharge distributions across the Rhine branches. For each scenario, bottlenecks were identified where flood safety cannot be ensured through dike reinforcement or river widening outside the dikes alone. For these locations, scenario-specific packages of measures were developed, comprising combinations of dike reinforcement and river widening both between the embankments and at the land-side of then embankments. The concept of river widening is explored through the implementation of a system of multiple side channels located within the floodplains, combined with a narrowing of the main channel. The side channels are equipped with a weir, leading to increased water levels during low discharges. During high discharges, the side channels increase the discharge capacity, leading not only to lower flood water levels, but also to less erosion of the main channel.

For each package, impacts and indicative costs were assessed, allowing for comparison across scenarios. Potential synergies with nature development and other spatial objectives were also examined. On this basis, the implications of different discharge distribution choices across the Rhine branches were mapped.

At this stage, the administrative choices prepared within RftR 2.0 are limited to spatial reservations at the land-side of the embankments for potential future river widening. These choices are informed by considerations such as the time horizon for which flood safety must be guaranteed, the degree of uncertainty to be accommodated, and the distribution of impacts across regions.

4 FIRST RESULTS

The overall picture emerging from the studies confirms earlier conclusions: by the end of this century, opportunities to further increase the resilience of the river system will be limited, although negative climate impacts can still be mitigated. It will no longer be possible to fully accommodate all river functions simultaneously, making difficult trade-offs unavoidable. These trade-offs concern both the degree to which future climate developments are anticipated and the extent to which hydraulic, morphological, and ecological bottlenecks—including the declining possibilities for dike reinforcement—are addressed.

Not all of these choices fall within the scope of the RftR 2.0 programme. Responsibilities for freshwater availability, navigation, and nature (restoration) remain with the relevant sectoral programmes. Within this framework, RftR 2.0 focuses on assessing how adaptations to the geometry and layout of the Meuse and Rhine branches can continue to support sectoral objectives. The analyses show that under continued climate change, freshwater availability limits will be exceeded: in all scenarios, water demand cannot always be met. Similar constraints apply to navigability. Measures to counteract riverbed erosion cannot fully resolve these issues but can substantially reduce their severity.

After 2050, the current strategy of meeting flood protection standards mainly through dike reinforcement reaches its limits in terms of both discharge capacity and space. River widening outside the dikes will therefore be required in all scenarios to compensate for limited dike-raising options and existing bottlenecks, ensuring safe conveyance of river discharges to the sea.

Under a high climate scenario towards 2100, river widening inside the dikes also becomes unavoidable. Part of this task results from the assumption that Germany will likewise reinforce its dikes. Selecting a multi-channel system on the Waal as a riverbed erosion measure would also significantly increase discharge capacity there and relieve pressure on the IJssel.

For nature development, two minimum conditions were applied: system conditions must not deteriorate, and remaining statutory obligations under existing nature restoration programmes must be met. In addition, opportunities to contribute to UN and EU Biodiversity Strategy ambitions were explored, focusing not only on increasing natural areas but particularly on enhancing hydro-morphodynamics and floodplain connectivity.

The results show that many measures aimed at increasing discharge capacity can simultaneously contribute to nature objectives, revealing substantial synergy potential outside the dikes. Similar opportunities exist inside the dikes, where it was assumed that at least 25% of river widening would be nature-based.

Finally, solutions to riverbed erosion are partly determined by their ability to reduce navigation bottlenecks and improve low-flow water distribution, supporting freshwater availability and limiting salinisation. For the Waal, sediment replenishment and a multi-channel system were assessed. While both can halt further erosion, only the multi-channel system contributes to improving freshwater distribution and reducing navigation bottlenecks. Even so, it cannot fully eliminate these challenges.

Overall, the analyses confirm that under continued climate change, structural limits will be reached: freshwater demand and navigability cannot always be guaranteed. System-level interventions can mitigate these impacts, but they cannot remove them entirely.

5 CONCLUSION

The analyses presented in this paper show that Dutch river management is entering a phase in which structural limits become increasingly apparent. Under continued climate change, not all river functions can be fully accommodated simultaneously, making explicit and timely trade-offs unavoidable. The Room for the River 2.0 (RftR 2.0) programme provides a system-level framework to address these trade-offs by linking riverbed management and discharge capacity to multiple societal and ecological functions. Results indicate that river widening outside the dikes is unavoidable after mid-century, while widening inside the dikes becomes necessary under high climate scenarios. Measures targeting riverbed erosion, particularly multi-channel systems, can substantially reduce impacts on freshwater availability and navigation, although they cannot fully eliminate constraints. Importantly, many safety-driven measures offer strong synergies with nature development, especially through enhanced hydro-morphodynamics and floodplain connectivity. Overall, RftR 2.0 demonstrates that a coherent, long-term, and multifunctional system approach is essential to maintain a safe, resilient, and usable river system under future climate conditions.

REFERENCES

Chowdhury, M.K., Blom, A., Ylla Arbós, C., Verbeek, M.C., Schropp, M.H.I., and Schielen, R.M.J. (2023) Semicentennial Response of a Bifurcation Region in an Engineered River to Peak Flows and Human Interventions, Water Resources Research 59 (4), https://doi.org/10.1029/2022WR032741

Ministry of Infrastructure and Water Management (2025). Towards a future-proof river zone, Integrated River Management Programme, Start of the Programme, Room for the River 2.0, retrieved from https://www.platformparticipatie.nl/irm/documenten-programma-irm/handlerdownloadfiles.ashx?idnv=3032216

Ylla Arbós, C., Blom, A., Viparelli, E., Reneerkens, M., Frings, R.M. and Schielen, R.M.J. (2020), River Response to Anthropogenic Modification: Channel Steepening and Gravel Front Fading in an Incising River, Geoph. Res. Letters 48 (4), https://doi.org/10.1029/2020GL091338

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Web-1: https://www.hwbp.nl/
Web-2: https://www.ruimtevoorderivier.nl/