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Flood resilient landscapes: application of a design approach for future-proof landscapes

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ABSTRACT

Society faces a wide range of societal and climatic challenges that impact various sectors, including agriculture, energy, and ecosystem restoring. Additionally, these complex challenges are highly interdependent with the need to develop housing, industry, and infrastructure. Meanwhile, the Netherlands is starting to experience the effects of climate change-induced weather extremes, calling for renewed strategies for flood risk management and freshwater supply. At first sight, societal development and response to climate change seem conflicting as implementation of water measures requires space. How to make the right decisions in spatial planning which will not be regretted in 100 years?

At ICFM9, we presented a new approach that offers the prospect of keeping the Netherlands safe beyond 2100 at a socially acceptable cost and with public support (De Leeuw et al., 2024). This paper presents a further elaborated version of this approach including how it has been applied to Zwolle region, the Netherlands, and lessons learned. The six-step approach comprises of: 1) preparation: setting process rules, mutual agreement on process rules and a shared understanding of the system; 2) area analysis with a focus on values and historical developments; 3) exploration of the future for various themes and the water system; 4) exploration of possible futures using narratives and visuals, including the development of a value framework; 5) alternative landscapes and building blocks; and 6) transformation pathways that reason backwards using tipping-points and building blocks. For the Zwolle case, the approach resulted in illustrative products that allow stakeholders to experience different futures, as well as a qualitative comparison of a "business as usual development" with three value-oriented, but very different future perspectives. In future projects, we aim to test the approach with more stakeholders, in other areas and to extend the scope to water resilience in general.

KEYWORDS: Flood resilience, design methodology; landscape planning; cross-sectoral collaboration; governance.

1 INTRODUCTION

The Netherlands, a low-lying and densely populated country, is situated at the delta of rivers Rhine, Meuse and Scheldt. To protect residential and rural areas from flooding, an extensive flood defence system has been implemented over the last decades (de Leeuw et al., 2024 and Tromp et al., 2022). This system requires regular maintenance, e.g., due to increasing river discharges and expected sea level rise. Dealing with this challenge, the Dutch Flood Protection Programme (DFPP) primarily focuses on effectiveness (production rate) and efficiency (reduction of cost per kilometre) (de Leeuw et al., 2024). The DFPP is an alliance of the Ministry of Infrastructure and Water management and regional water authorities, and is responsible for keeping the flood defence system up to date, while considering societal developments and new insights (Jorissen et al., 2016). However, the challenge associated with achieving set flood defence

targets is especially wicked due to a high level of complexity, uncertainty and conflicting interests (Tromp et al, 2022). Flood risk issues are for example highly interdependent with other societal and spatial challenges related to agriculture, housing or energy, which all require the involvement of diverse stakeholders. Furthermore, governance of Dutch flood risk management is institutionally fragmented: Coastal and fluvial floods are managed by a national agency and regional water authorities, while the responsibility for managing pluvial flood issues is delegated to municipalities. Responsibility for spatial planning lies with national government, provinces and municipalities – the water authorities only have an advisory role.

Meanwhile, consequences of climate change are becoming increasingly evident in water management in the Netherlands, and urbanisation further increases pressure on available space. Consequently, its margins to cope with extreme weather—such as heavy rainfall and drought—are narrow, calling for more integrated flood risk management approaches. To preserve perspective for future generations, long-term climate risks must be considered in short-term spatial projects and decisions (Pot et al. 2022), which requires diversification of flood risk management strategies (Hegger et al. 2016). However, integrating water management with other spatial challenges appears to be challenging. New residential areas are still being built in low-lying, flood-prone areas and floodplains, and agriculture and natural areas continue to dry out because economic decisions often ignore soil and water system characteristics. How can we ensure robust spatial choices so that future generations also enjoy a prosperous and attractive future?

To answer this question, this paper presents how the novel '*Flood Resilient Landscapes*' (FRL) approach, which was presented at ICFM9 (De Leeuw et al., 2024), can be practically applied. To illustrate this, we use the application in Zwolle region, the Netherlands, as a case. This case was selected given the urgent need to find new ways to achieve socio-economic development and climate resilience in an area where space is limited and also needed for other transitions. In this case, the approach was translated into six steps that guided diverse stakeholders in designing future landscapes that can address both climatic and societal challenges and identifying transformation pathways. After showing how each of the steps were applied in this case, we conclude with lessons learned and an outlook towards the future.

2 APPLICATION OF THE STEP-WISE APPROACH

The FRL approach was developed as context-driven and human-centred design approach (Hekkert and Van Dijk, 2017). Through application in Zwolle region, we were able to further develop and test the approach. In this case, an interdisciplinary team of area partners and experts active in water management and spatial planning followed six steps (see figure 1) to collaboratively design future-oriented perspectives for a landscape where flood resilience goes hand-in-hand with other developments (De Leeuw et al., 2025a and 2025b, www.waterveiligheidslandschappen.nl). Each step involved at least one workshop. The steps are elaborated below.

2.1 Preparation

Implementation of design-based approaches like the FRL approach demands collaboration between diverse actors. In the case of Zwolle, we paid specific attention to developing a shared understanding of the area and making process rules and values explicit. In developing a shared understanding of the area, we prepared a comprehensive systems analysis and also organized a field trip. We learned that approaches like this necessitate flexibility and a different mindset, regarding existing information and its application. Hence, we really invited participants to take time and space for internalising and reinterpreting existing data collaboratively.

As previous research into integrative approaches (Warbroek et al., 2023; Bakhanova et al. 2025) shows that collaboration between diverse sectors benefits from designing process rules that can guide cross-sectoral collaboration, we paid explicit attention to drafting process rules. Inspired by the rules as presented in the Institutional Analysis and Development framework of Elinor Ostrom (2011), we made specific agreements about scope, participation, positions, information, expectations of way of involvement, decision-making and results.

Another key element of the preparation phase was making professional values explicit. Using value cards that were developed as part of a research project, we asked experts to identify and reflect on values that guide their work. This exercise showed that professional values of experts in water management differ significantly from experts in spatial planning (De Vries et al., under review). In later steps, we built on these insights to develop an integrated value framework.

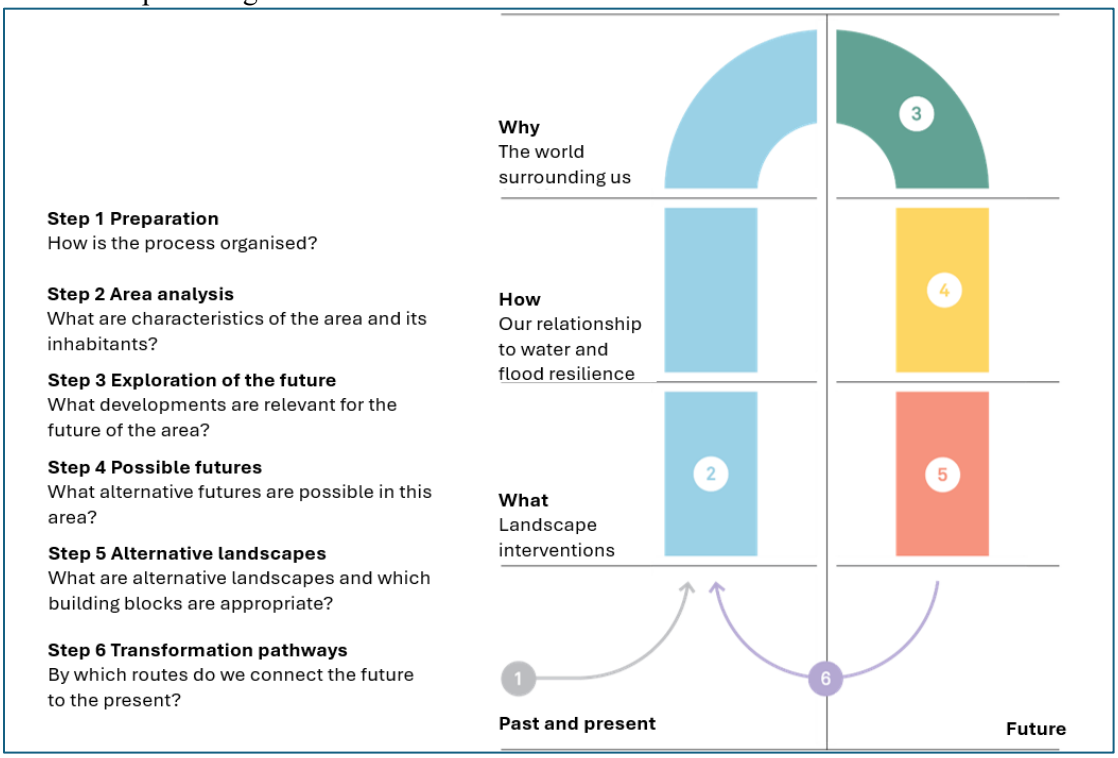

Figure 1: Central approach to the Joint exploration of flood resilient landscapes

2.2 Area analysis

Central in the second step is the analysis of the study area, with a focus on developing an in-depth, shared understanding of the region and its historical development. The analysis addresses not only the physical evolution of the area, but also the extent to which human decisions have influenced that evolution. By jointly engaging in this process, stakeholders gain insight into the values that are important to the local population and how these values have shaped the current spatial configuration. Such an analysis gives insight into how, in the study area, tipping points lead to changing views or strategies. To support the area analysis and apply different perspectives, the framework of narratives for flood resilient landscapes (Reframing Studio & Deltares, 2022, de Leeuw et al., 2024) inspires a holistic analysis. This framework distinguishes future oriented narratives along three perspectives and was used to construct a historic timeline to analyse developments at three interrelated levels: the physical water and spatial system (matterscape), institutional arrangements and power relations (powerscape), and societal values and practices (mindscape) (De Leeuw et al, 2025a and 2025b). By jointly reconstructing these developments in the Zwolle case, participants built a shared understanding of how past choices have shaped the current landscape and water management practices.

2.3 Exploration of futures

The analysis of the past is followed by a forward-looking exploration that systematically examines future trends and changes within the area. In the Zwolle case, we considered a broad set of themes: demography, social developments, spatial developments and developments in technology, economy, culture, and (geo)political situation. Additionally, we conducted an in-depth analysis of the capacity of

the current water system to cope with climate change impacts, including flood management in response to increasing precipitation and sea level rise, as well as drought management.

During the process, it appeared essential to spatially represent the urgency of emerging challenges. In the case of Zwolle, we therefore performed a stress-test that was inspired by cloud bursts that occurred in 2021 in the Eiffel and caused flooding in Germany, Belgium and the south of the Netherlands (figure 2). This stress-testing exercise provided critical insight into the necessity of making informed strategic choices. Additionally, there appeared to be a need to visually represent consequences of continuation of the traditional Dutch spatial development and water and flood management practices; this led to a "Business as usual" exploration of spatial development and served as reference scenario for comparing alternative futures in step 5.

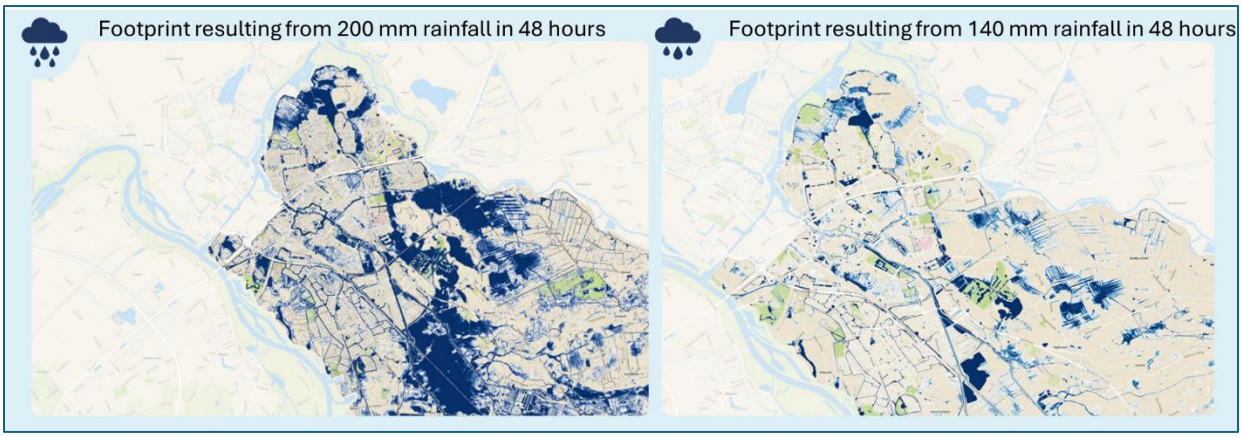

Figure 2: Stress-tests to generate a joint sense of urgency

2.4 Possible futures

Conventional approaches to regional development processes tend to reason from current challenges. The FRL approach differs in this regard; it reasons from societal values associated with diverse future user groups and their relationship to managing flood risks. Following up on the exploration of the past in step 2, the exploration of possible futures is inspired by the national framework of narratives for flood resilient landscapes (Reframing Studio & Deltares, 2022; de Leeuw et al., 2024). This framework distinguishes future-oriented narratives along three perspectives (mattercape, powerscape and mindscape) which articulate alternative ways of understanding and organizing the relationship between society, water and space. The narratives are used as a design and dialogue tool to move beyond current problem definitions and to explore fundamentally different long-term approaches to deal with water-related challenges. Since it is important to *temporarily* let go of current (organizational) challenges and objectives, this step starts with a role play in which participants are asked to step into the role of a future inhabitant of the area. Through dialogic engagement, supported by narratives and visualizations, multiple future perspectives are collectively explored and prioritized. Prioritized perspectives are elaborated in suitable and plausible future narratives informed by the local context. To refine the narratives that were generated and making them immersive, visuals were created. Table 1 gives an overview of three future perspectives of the Zwolle case.

Table 1: Future perspectives for the Zwolle case

Selected and applied narrative	Description	Example of visual	Agriculture visual
Protectionistic	*Business as usual* The story of continuing traditional spatial planning, creating housing, and technology-driven water management (protection by levees)	Not available	Not available

Collectivist and protectionstic	*New Neighborship* The story of traditional view on flood risk management, protecting cultural heritage, traditions and sense of community, e.g. through neighbourhoods.		
Ecocentric and amphibious	*Big Marshes* The story of adaptation to nature and a society that puts ecosystem thinking central.		
Ecomodern and global	*Hanze Deltalab* The story of a strong belief in technology as means to cope with global challenges. Functions are separated leading to strong contrast between urban and nature areas.		

In parallel to creating future visions, a shared value framework was established, enabling joint decision-making and bridging the identified gap between the water management and spatial planning domains (see step 1, De Vries et al., under review). In mixed groups, participants were able to develop an integrated, and shared value framework. The framework that was developed for comparing long-term landscape variants (100 years) contains the following values:

- **Ecological sustainability**: The landscape variant contributes to biodiversity, improved water and soil quality, and an ecologically sustainable design that supports climate resilience;
- **Economic sustainability**: The landscape variant creates opportunities for the economy and ensures the continuous functioning of the landscape without pursuing economic depletion;
- **Socio-cultural sustainability**: The landscape variant leverages cultural heritage, strengthens social cohesion, and avoids passing burdens onto future generations;
- **Adaptivity**: The landscape variant is adjustable, flexible, and capable of responding to changing conditions;
- **Safety**: The landscape variant guarantees safety and health for residents.

2.5 Alternative landscapes

In the fifth step, future perspectives are elaborated and concretised. In the Zwolle case, this was done through the development of three landscape variants, following the narratives of step 4, which were called: New Neighborship, Big Marches and Hanze Deltalab. Spatial representations make these future perspectives tangible and reveal spatial interconnections. For each future perspective, a set of building blocks is selected and further defined in terms of spatial scale, and level of integration. Building blocks refer to interventions in the water system, spatial design, legislation and regulation, as well as education and knowledge development, all of which are necessary to realize a future perspective. Therefore, these building blocks often serve multiple functions. Figure 3 shows the results of the Zwolle case, with a focus on water and spatial design at a system scale and a local scale.

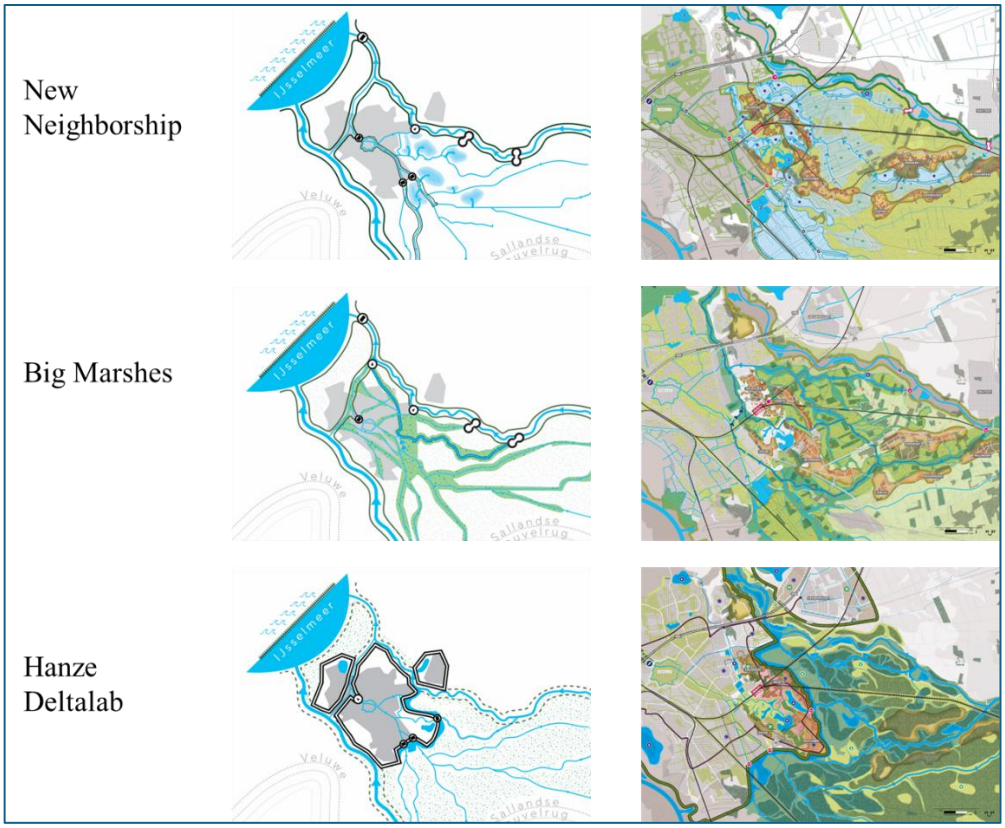

Figure 3: Landscape variants of Zwolle case

2.6 Transformation pathways

The final step in the FRL approach is to develop transformation pathways using a back-casting procedure for each future perspective. In this process, future tipping points (derived from step 3, Exploration of the future) play a key role since building blocks should be implemented before reaching a tipping point. In the Zwolle case, we emphasized that implementation requires not only construction activities but also preparation: e.g., securing funding, acquiring societal support in participation processes and setting up legal and governmental settings. Drafting timelines created urgency, as implementing building blocks in a few decades often requires preparation in the immediate future. In estimating the potential societal transitions required, attention is given to conditions across social, technical, spatial, economic, legal, ecological, and knowledge domains.

3 REFLECTIONS & CONCLUSIONS

When we started application of the FRL approach to Zwolle, many experts involved and participants were not or only familiar with part of the approach. Given the openness of the process and the need to learn we decided to adopt a 'reflection-in-action' methodology (c.f. Hartmann et al., 2023) throughout the process. This method has been developed for large construction projects but was used here to support continuous reflection, keeping track of lessons learned and, where possible, apply them directly in the project. At different points in time, we organized reflection and learning moments (three in total). Each moment was organized as follows. First, participants individually completed a questionnaire, which addressed the process and content of the organized activities, as well as the relevance of the project and the insights gained for the national programme that funded the project, water authorities, provinces, and municipalities. After processing the individual responses, we collectively reflected on them and drew conclusions. Some of the key insights that emerged from these reflections are:

- By exploring different values of spatial planners, designers and flood risk managers followed by discussing the results, mutual understanding, a shared vision, and a common narrative were fostered.
- The approach facilitates meaningful discussions about what matters for the area's development and which qualities should be preserved or enhanced. By confronting future transition challenges, the approach generates insights into smart combinations.
- A shared understanding of the area's history is essential for exploring an uncertain future together.
- Eight national narratives (Reframing Studio & Deltares, 2022) provided a strong foundation for discussing future storylines.
- The design-based research approach and intermediate reflections led to the integration of useful tools like timelines, a serious game based on role-playing, and transformation path-building tools.
- Stress tests and extrapolations of the current discourse ("business as usual") help identify problematic future choices.
- More, integrative and multi-use building blocks are desired.
- The Zwolle case showed that current practices are not fostering resilience in the long term. Each of the future perspectives reacted in its own character to enhance the robustness and flexibility of the water system, to enable it to cope with the effects of climate change. To the municipality, the case was another sign that future water management issues needed to be addressed in their new spatial perspective on housing and other transitions, which was adopted by the Council on July 7, 2025.

In the Zwolle case, the approach was applied in a rather 'informal' setting, giving space to participants to share opinions and views without the fear of being compromised for their views and opinion. Inhabitants or interest groups were not included. Also, decisions were not an intended outcome. As such, participants could freely explore the diversity of possible futures for an area. Future steps include supporting the implementation of area-specific choices in the short and medium term, while also considering long-term scenarios. This includes calculating the effectiveness of measures and socio-economic welfare impacts across timeframes, and providing governance advice for realizing attractive, future-proof, productive, water-robust landscapes. In this next phase, the project team advances on the main project insights, moving away from the term 'flood resilience', as water issues are not only bound to flood risks, but also to droughts and water quality.

An important reason for selecting Zwolle region as a case was that many issues are at play. Each (economic) sector tends to look for space from its own objectives, whereas from a water system point of view, the robustness and flexibility are too low to be able to cope with future challenges in which different sectors take space, and where climate change stresses the system. We expect that the case is quite representative for the Dutch institutional context, which is characterised by the tradition of creating a man-made environment optimised for economic use. International perspectives on the approach and its underlying cultural assumptions would be needed to evaluate applicability in other international delta areas.

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REFERENCES

Bakhanova, E., Vinke-de Kruijf, J. Wöhler, L, Warbroek, B. Arentsen, M. (2025). Integrative Approaches to Interconnected Environmental Challenges: How Institutional Factors Influence Cross-Sector Integration in Dutch Rural Areas . Environmental Management 75:1308–1321. https://doi.org/10.1007/s00267-025-02140-2

De Leeuw, A.M., Tromp, E. and de Boer, F: Flood resilient landscapes: area-based solutions combine added value for society with flood risk management, Proc. IAHS, 386, 173–179, https://doi.org/10.5194/piahs-386-173-2024, 2024.

De Leeuw, A.M., de Boer, F.M., Koppel, S, Mateman, E., Vinke de Kruif, J. (2025a): Aanpak waterveiligheidslandschappen: Een methodiek om in zes stappen te komen tot een toekomstbestendig landschap. https://publications.deltares.nl/WeL3280.pdf.

De Leeuw, A.M., de Boer, De Vries, M.C.J., F.M., Dijkstra, M.J., Köppel, S., Mateman, E, Niesten, M., Oenema, A.J., Rooze, D., van den Berg, F., Vinke de Kruif, J: (2025b): Toekomstbestendig landschap Zwolle : een toepassing van de methodiek Waterveiligheidslandschappen. https://publications.deltares.nl/11209756_000_0005.pdf.

De Vries, M.C.J., Vinke-de Kruijf, J., Volker, L., Augustijn, D.C.M., Mind the gap: the role of values in integrated flood risk management. Under review in Environmental Science and Policy.

Hartmann, A., Vinke-de Kruijf, J., & Van Weesep, R. (2023). Asking the right questions: The role of reflection for learning in and between projects. International Journal of Project Management, 41(5), 102494. https://doi.org/10.1016/j.ijproman.2023.102494

Hegger, D. L. T., P. P. J. Driessen, M. Wiering, H. F. M. W. Van Rijswick, Z. W. Kundzewicz, P. Matczak, A. Crabbé, G. T. Raadgever, M. H. N. Bakker, S. J. Priest, C. Larrue, and K. Ek. 2016. Toward more flood resilience: Is a diversification of flood risk management strategies the way forward? *Ecology and Society* 21(4):52. https://doi.org/10.5751/ES-08854-210452

Hekkert, P. and Dijk, M. van: Vision in design, a guidebook for innovators. ISBN 978-90-6369-371-8, 2nd printing 2017Tromp, E., te Nijenhuis, A. and Knoeff, H.: The Dutch Flood Protection Programma: Taking innovations to the next level, Water 2022, 14(9), 1460; https://doi.org/10.3390/w14091460.

Jorissen, R.; Kraaij, E.; Tromp, E. Dutch flood protection policy and measures based on risk assessment. In Proceedings of the 3rd European Conference on Flood Risk Management (FLOODrisk 2016), Lyon, France, 17–21 October 2016.

Ostrom, E. (2011). Background on the institutional analysis and development framework. Policy Studies Journal, 39(1), 7-27 https://doi.org/10.1111/j.1541-0072.2010.00394.x

Pot, W.D., De Vaan, K., Dewulf, A. (2022), Institutions for long-term problems: the influence of the Dutch Delta Programme on forward-looking climate adaptation responses at the local level, https://doi.org/10.1080/09640568.2022.2153331

Reframing Studio & Deltares (2022) – in Dutch. Toekomstige narratieven rondom waterveiligheid: Als onder deel van het Raamwerk Waterveiligheidslandschappen. https://cms.deltares.nl/assets/common/downloads/221208_WVL2100_Eindrapportage-gecomprimeerd-1.pdf

Tromp, E., te Nijenhuis, A. and Knoeff, H.: The Dutch 50 Flood Protection Programma: Taking innovations to the next level, Water 2022, 14(9), 1460; https://doi.org/10.3390/w14091460

Warbroek, B., Holmatov, B., Vinke-de Kruijf, J., Arentsen, M., Shakeri, M., de Boer, C., Flacke, J., & Dorée, A. (2023). From sectoral to integrative action situations: an institutional perspective on the energy transition implementation in the Netherlands. Sustainability Science, 18, 97-114 https://doi.org/10.1007/s11625-022-01272-2

Web sites:

www.waterveiligheidslandschappen.nl, consulted 30 November 2025