Flood resilient landscapes: area-based solutions combine added value for society with flood risk management

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Abstract. Society faces challenges such as caring for sustainable agriculture, clean energy and restoring biodiversity, whilst developing housing and industries. Climate change meanwhile stresses the Dutch water management system, impacts flood risk management and fresh water supply. To ensure making the right decisions, which we won't regret in 100 years, we developed the concept of flood resilient landscapes. The underlying principle is to create social added value while promoting or at least maintaining flood risk management, given (future) spatial and societal developments. The approach develops typologies for Dutch rivers and coast. The first results are so promising that the Dutch Flood Protection Programme aims to incorporate it. The flood resilient landscapes concept offers the prospect of keeping the Netherlands safe beyond 2100 at socially acceptable costs and with public support now and in the future and paves the way towards implementation throughout international deltas.

1 Introduction

The Netherlands is located at the delta of rivers Rhine, Meuse and Scheldt. Two-third of the country lies below sea-level, and if it were not for an extensive flood defence system, large part would be prone to flooding by hazard of high water at sea, river or lakes (Tromp et al, 2022). In the past, the Dutch responded reactively to floods. This changed after floods of 1953 by setting legal standards to flood defences and setting up a comprehensive flood defence system. In 2008, the second Delta Commission advised to take future uncertainties into account and therefore to anticipate even more rigorously (Delta Committee, 2008). Consequently, the Dutch adopted a risk-based approach (van der Most, 2014). New legal protection standards considering climate change and socio-economic developments are based on economic risk, local individual risk and societal risk. They are translated to statutory standards in terms of signal and lowest acceptable levels of flood (or failure) probability of levees. Every 12 years the regional water authorities assess whether the levees under their mandate are still up to standard. If not, the authorities can apply for funding for improvement at the Dutch Flood Protection Programme (DFPP) (Jorissen et al., 2016). Over 1500 km of levees and over 400 structures will have to be upgraded before 2050. The magnitude of the improvement challenge forces the DFPP to focus on effectiveness (increase of production rate) and on efficiency (reduction of cost per kilometre). However, the challenge that comes with reaching the set target is especially wicked due to high level of complexity, uncertainty, and conflicting interests (Tromp et al, 2022): flood risk issues are entwined with other local problems involving diverse stakeholders, whilst the sector is institutionally fragmented, and resources are distributed in a non-hierarchical way. The ever-increasing complexity is producing new challenges and demands (Tromp et al, 2019). The institutionary flood defence system has been part of the Water Act and emerges to the upcoming Environment Act, justifying the role of flood defences as an integral part of the rural and urban environment. This development entices a movement to scope flood risk management measures as part of a future oriented, sustainable spatial development in which value creation is key.

The complexity of planning sustainably for a future society, the future orientation, and the desire to strive for societal added value brought the following research question: *How can the use of design approaches in flood risk management give a perspective to a manageable approach to face these wicked problems?*

2 Frames and methods

2.1 Flood risk management framing

The Associated Programme on Flood risk management (APFM, 2017) provides comprehensive guidance on how to plan for flood risk management in view of the Sendai Framework for disaster risk reduction (UNDP, 2016). The document states that planning for integrated flood management is an iterative, policy-cyclic process towards risk-based decision-making with a significant role for the involvement of stakeholders (Figure 1).

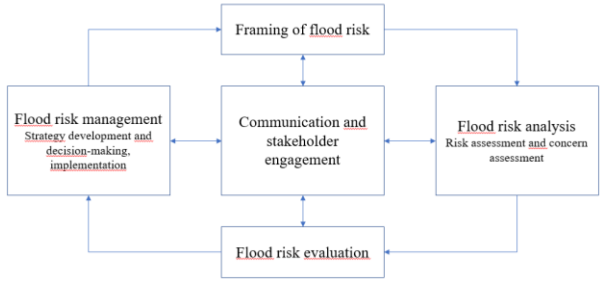

Figure 1: Framework for integrated flood management, APFM 2017

In view of finding sustainable strategies, the flood risk analysis activity in this cycle comprises the definition of future scenarios and an analysis of the response of water and soil system to these scenarios. This analysis results in a definition of the current problem, with a view on future problems because of autonomous change. We will explain more about the Dutch future situation in paragraph 3.1. The challenge that we currently face, is how to perform framing for flood risk management in a more integrative, interactive, and future resilient way. The hypothesis is that design approaches could give (part of) the answer to the wicked problem faced, by anticipating to the future, instead of focusing on today's problems and challenges.

2.2 Vision in Design

Hekkert and Van Dijk (2017) published a guidance to designing, based on a vision. They described a standard approach to define this vision, based on an understanding of the changing patterns of concerns, attitudes, and behaviours in a complex future world. Their context-driven and human-centered approach is depicted in Figure 2. Although the method was originally developed for industrial design, in the past decade the method has proved to help organizations, communities and citizens to understand their changing environment, envision alternative futures and to develop sustainable strategies to navigate from the present into a desired future. It was investigated how this design approach could also be applicable to the societal challenge of future proof flood risk management at landscape scale.

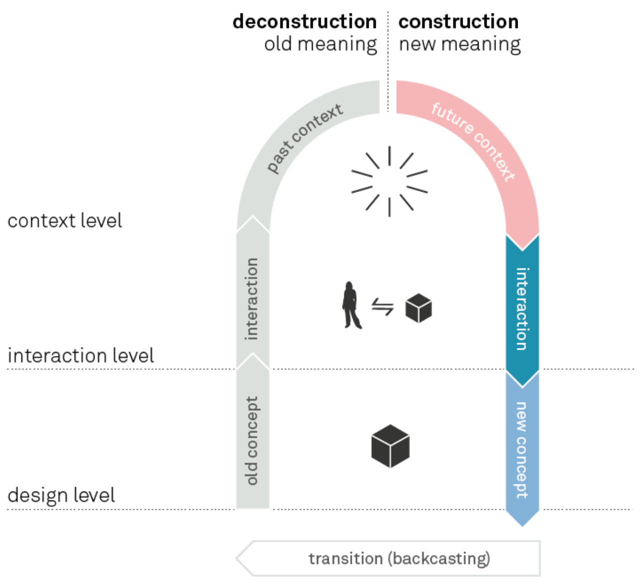

Figure 2: Vision in Design approach

To this end, a desk study with additional interviews was performed to find clear and unclear, or unspoken elements that are part of our current solutions in Dutch flood risk management. A description of the current relation of Dutch society to flood risk management followed. This included a description of dominant narratives of that relation. At context level, a description of conditions and developments that led to the Dutch relation to flood risk management followed. The next level in the analysis is to find probable future narratives. A summary of the collected information can be found in paragraph 3.2.

3 Data and results

3.1 Qualitative description autonomous response of landscapes to climate change in the Netherlands

Following the work of the Dutch Delta program, the following typical Dutch main landscapes were defined, based on water and soil characteristics:

- *Peatlands*: located mainly in the west and north of the Netherlands. Suffering of subsidence due to drainage and oxidation of peat. Land use mainly agricultural area.
- *(High) Sandy soils*: located mainly in the higher east and south of the Netherlands. Well drained for agricultural and urban use. Land use mainly agricultural area, nature and urban. Vulnerable for droughts.
- (Saltating) *Coastal areas and deep polders*: located mainly in the west and north of the Netherlands. Mostly clay soil, which makes it very suitable for agriculture. Vulnerable to floods and salinization through surface and groundwater.
- *Main water system*: main rivers, lakes and sea. Mainly set for fast discharge of water, whereas the lakes are increasingly in use as strategic source for fresh water supply.
- *Urban areas*: mainly located in the west. The drainage system is focussed on fast discharge of precipitation. Intense pavement leads to vulnerability to flooding, drought and heat.

Climate change effects that drive responses of these landscapes are rising temperatures, sea level rise, intensifying precipitation. Currently the Delta program is performing quantitative analyses on the effects of climate change in the Netherlands. This data is not yet available. Therefore, experts on water- and soil management were challenged to specify in an expert elicitation session what emerging problems are to be foreseen for the Netherlands. The experts gave their answers under the condition of "business as usual" for land use functions. For the sake of the scope of this conference paper, only results related to flood risk and pluvial risk are summarized in Figure 3. The results correspond to other studies (Klijn, 2021 and Schra, 2022). When focussing on flood risk, attention is drawn to peat lands, polder areas and the main water system. The situation will set boundary conditions to socio-economic development and gives direction to adaptation measures. If society wishes to maintain a current function under pressure, the function will need to adapt to new circumstances to remain feasible. The alternative is to change the land use function. And if society wishes to construct built environment in peat lands or polder areas, special attention is needed to account for long term effects to create a sustainable design.

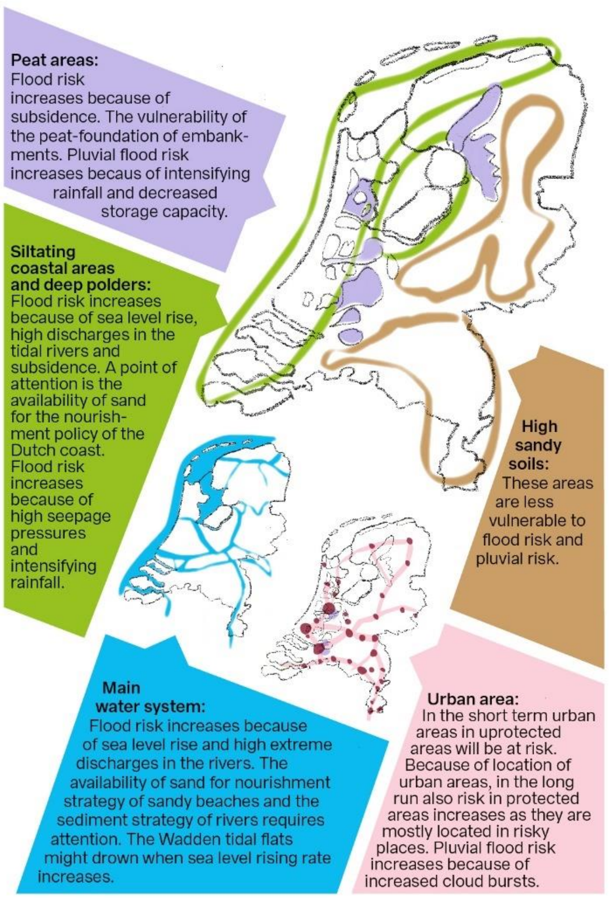

Figure 3: Identified flood and pluvial risk developments, driven by climate change

3.2 Societal context factors

Literature with a wide perspective but related to the attitude of Dutch society to flood risk management was reviewed, with a focus on finding current and future context factors and important themes.

This first step in the Vision in Design approach, the deconstruction phase, is aimed at understanding the *why* behind the world of solutions that are currently used. Based on literature and experts interviews the dominant past and current narratives underlying flood risk management in The Netherlands were explored. An important insight was that there were four repetitive narratives in Dutch society (Jensen, 2020):

1. The technologic narrative tells how the Dutch created the Netherlands with hydraulic ingenuity, adaptive capacity and pioneer mind. It brings management perspective and hope, but the trust in technology also leads to being less prepared for disaster, of even to climate scepticism. This is the dominant narrative in the Netherlands today.
2. The apocalyptic narrative is a story of catastrophizing. The thought that the world will decease leads on one hand to a fatalistic attitude, but on the other hand fear motivates too: We will try hard to prevent a disaster like the floods of 1953 and base our policy on incidents.
3. The ecologic narrative tells us that nature is supreme and must be given the space it needs. We do not battle with water but live with water. To date stories of climate change and loss of biodiversity stimulate this narrative.
4. During past ages, the secular narrative declared floods as a collective punishment of God to the sin of Man. A current variant to this narrative is that man is increasingly aware of the influence of their own behaviour to climate change.

The currently dominant technologic narrative has led to trust in technology: the Dutch landscape, flood risk management and spatial planning are considered manufacturable. This leads to low awareness with the Dutch population on flood risk related to living below sea level: the Dutch are not prepared to respond to floods.

To understand the changing societal context, literature was reviewed to collect social, cultural, economic, technological, and other developments and trends that will impact people's behaviours and attitudes with regards to flood safety. Over 180 factors were found and enriched in eight interviews with leading experts. Verification was performed in a review team.

The research team structured these factors to describe potential future attitudes to flood safety. Three main divides were found:

1) *Matterscape*: the societal attitudes vary from belief in manufacturability to adapting to nature;

2) *Powerscape*: dealing with (climate) change can be organised by concentrating power or by organising decentralised power in smaller communities; and

3) *Mindscape*: in a fast-changing world people can find confidence being rooted in the past, or they trust in innovation and planning for the long term.

Realizing these three divides, eight logical narratives (Figure 4) were constructed to represent future attitudes to flood risk management.

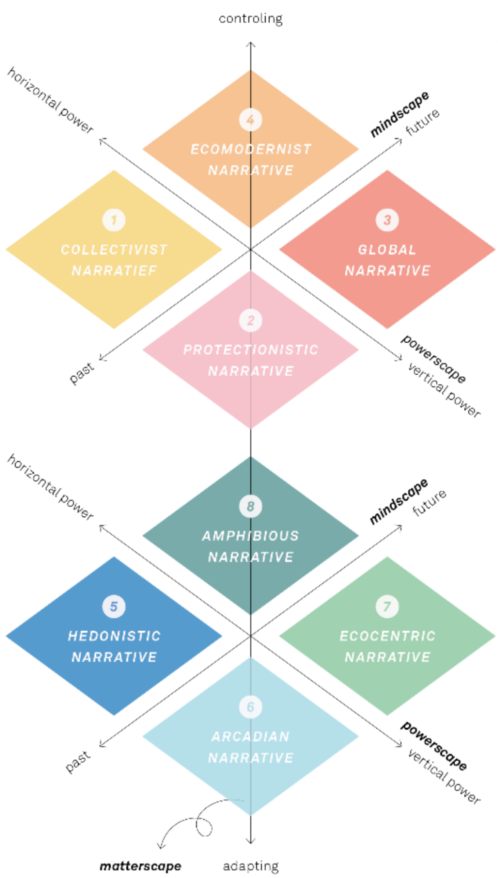

Figure 4: Narratives represent future societal attitudes to flood risk management in the Netherlands

4 Discussion and foresight

The investigation on system boundary conditions, arising from water and soil system and challenges that come with striving for sustainable, future-oriented developments covered not only flood risk and pluvial risk issues but also drought, heat and water quality issues. Integrated water management solutions and integrated spatial developments can leverage each other, e.g. creating space for water in or near urban area will benefit mitigation of urban heat stress. The generated overview can serve as a first start for deeper investigations of potential integrative solutions.

This research revealed four categories of factors, driving change in a landscape: 1) climate change, 2) societal challenges and transitions, 3) societal attitudes and 4) challenges related to maintain a sustainable water and soil system. Until now, our research covered only societal attitudes and challenges for a sustainable water and soil system.

The research brings new perspectives to Dutch flood risk management forward, also to understand how ‘wicked’ the coupling of flood risk management and integrated spatial development is. We see a current strong technologic narrative, whereas in future different narratives might become dominant. This insight sheds new light on the way the scoping of flood risk management planning (figure 1) could be shaped to end up with a *future proof* flood risk management strategy. A strategy that deals with climate change ánd societal attitudes towards flood risk, ánd emerging societal challenges ánd sustainable ecosystem services of the natural system.

This first exploration generated insight and clarity as to what societal attitudes and perspectives towards flood risk management in the Netherlands could emerge. As such, bringing in a designer’s approach already seems promising. In further experimental research the value of taking a designer’s approach will be evaluated in real life pilot areas: will it be possible to set up scoping when starting from a discussion on values in the area, on the effects of the current dominant perspective versus potentially desired narratives? Will we be able to use flood risk management as a leverage to transitions for large societal challenges vice versa, such as the transitions towards sustainable agriculture, the energy transition and housing? Which building blocks are needed to make a transition from the current situation towards a desired situation? Can we design a value-oriented, human-centered perspective and start working towards it? Are we able to define transformative pathways for future proof, integrated flood risk management in the Netherlands? In new research we explore the application of the method further in real pilot areas. The stakeholders of these pilot areas experience the sense of urgency, and together with societal challenges this results in a window of opportunity. The flood resilient landscapes concept offers the prospect of keeping the Netherlands safe beyond 2100 at socially acceptable costs and with public support now and in the future, and paves the way towards implementation throughout international deltas, requiring strong stakeholder commitment and collaborative learning.

6 Acknowledgements

This research was made possible by the Strategic research funding to Deltares by the Ministry of Economic Affairs and Climate Policy and by the research funds of Knowledge for Flood Defences by the Ministry of Infrastructure and Water Management.

7 References

Associated Program on Flood Management (APFM): Selecting measures and designing strategies for integrated flood risk management, A Guidance Document, April 2017

Delta Committee: Working together with water, a living land builds for its future, report, 2008

Hekkert, P. and Dijk, M. van: Vision in design, a guidebook for innovators. ISBN 978-90-6369-371-8, 2nd printing 2017

Jensen, L: (in Dutch): The battle against water in language and picture: Wat stories do we tell? Narrative strategies related to water management and sea level rise, 2020

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.

Deltares, Bosch Slabbers and Sweco (in Dutch): Based on the watersystem: Boundaries to the constructability of our water- and soilsystem, report, July 2021

Most, H.; van der Tánczos, I.; Bruijn, K.M.; de Wagenaar, D.: New Risk-based standards for flood protection in the Netherlands. In Proceedings of the 6th International Conference on Flood Management, Sao Paulo, Brazil, 16–18 September 2014.

Schra, J., Kleinhans, M., Cohen, K., Haasnoot, M. and Middelkoop, H.: (in Dutch) What does the Delta want? Report 31171979, April 2022.

Tromp, 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

Tromp, E. Enhancing Knowledge Transfer and Uptake in the Design Processes of Flood Defences. Ph.D. Thesis, Delft University of Technology, Delft, The Netherlands, 11 November 2019.

UNDP. Sendai Framework for Disaster Risk Reduction (2015 – 2030), September 7, 2016.