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On Sea Level Rise

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While the severity of the climate crisis calls for a discussion on transformative and potentially disruptive change, science, engineering, design, governance and practice are currently too detached to effectively contribute to such discussions.

The spatial manifestation of climate crisis rarely appeals to one's imagination. Yet, when reviewing the range of sea level rise projections and their accelerated rate of change, it is clear that understanding when and why to navigate between mitigation, adaptation and transformation measures is essential for flourishing coastal communities globally.

The Netherlands is one of those and has been characterised by a long history of renowned flood risk and water management as well as spatial planning. Facing the potential extreme scenarios of sea level rise, the country now however struggles to include measures preparing for a shift from incremental to the required transformative strategies.

This research project identifies the criticalities by means of a risk matrix and stress maps as an initial act to introduce the Sea Level Impact Knowledge Collect and its transdisciplinary Research by Design approach to guide the discussion on transformative change and its implementation in living labs.

(a) 6500 BP (b) 5100 BP (c) 3800 BP (d) 2600 BP

(e) 800 CE (f) 1500 CE (g) 2020 CE (h) Delta Plan X

Geomorphological maps the Netherlands

(a-g) Simplified geomorphological maps from the Netherlands (adjusted from Vos et al, 2020).

(h) Delta plan X by ZUS [Zones Urbaines Sensibles]

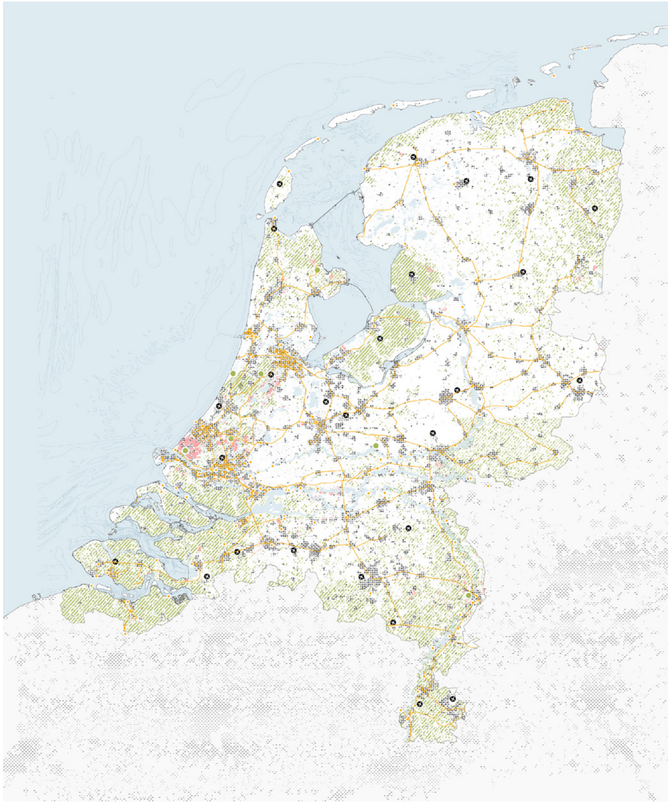
THE DUTCH TRADITION

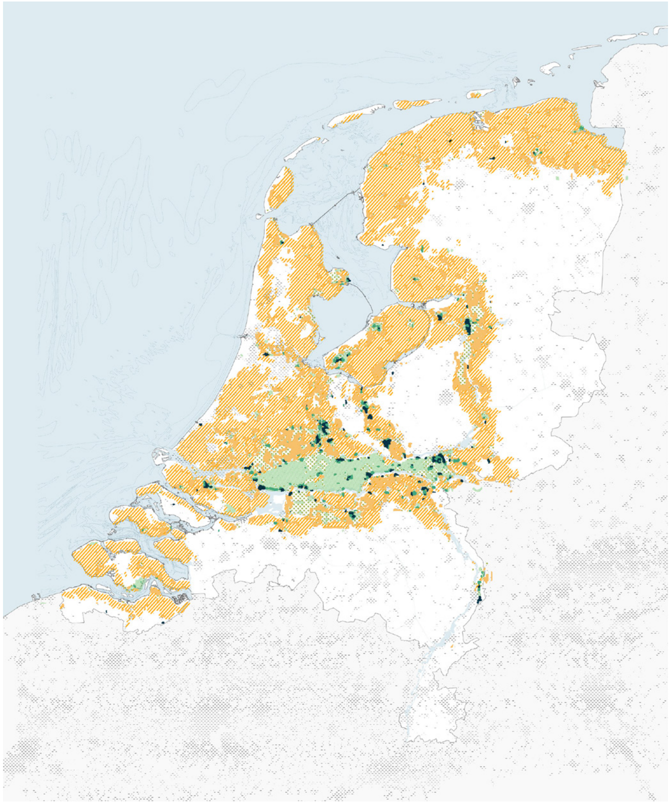
The Netherlands made a name for itself and became water management world market leaders due to the challenges the country faced at early stages of its establishment. The necessity to continuously manage the relationship between land and water systems led to its ground breaking and renowned flood risk management response. Throughout history, there have been radical proposals and actual interventions transforming the Netherlands and its relation to water and flood risk, ranging from the Southern Sea Works (originating from the 19th century) to futuristic proposals of creating an artificial tulip shaped island in front of the coast. However, one of the major faults of these radical endeavors is that they offered little guidance on the spatial, social, economic or political conditions on how the nation would transform or adapt to later climatic issues.

Historically, the Dutch spatial planning system has been lauded to be successful in the quality of urban development and forecasting needs for citizens. Decades after World War II, a series of national spatial planning reports (Ruimtelijke Notas) guided the urban and economic growth of the Netherlands. The Notas offered prescribed national spatial guidelines with set requirements to create a sustainable economy alongside boundary conditions. However, the tradition was lost in 2001 when the issued 5th report was not executed and the 2006 Nota Ruimte was heavily criticized. Currently, the Netherlands lacks an existing national framework for spatial planning and thinking, while facing climate crisis related pressures on the development of the urban and rural environment. The Dutch associations of (landscape) architects and urbanists therefore brought forward an open letter to Dutch policy makers to protect the Netherlands from becoming a sum of sectoral sub-solutions (BNA, BNSP & NVTL, 2019). Their call asks for the creation of space in policy making and development processes to deploy research by design for the shaping of the Netherlands of the future.

PROJECTIONS

Latest IPCC reports have indicated that global mean sea level rise after the year 2100 has a chance of surpassing three meters which will exceed our current coastal defense infrastructure (IPCC, 2019). Models integrating the contributions of the cryosphere present the wide range of sea levels between 0.50 and 15.52 meters in 2300 which also highlights there is little correlation between the contribution of ice melt to sea level rise in the coming century and beyond (DeConto & Pollard, 2016; Kopp et al., 2017). This deep uncertainty is intrinsically tied to rising costs of climate change mitigation measures and expected costs for future investments in infrastructure, health, agriculture, among others.





Land use: Distribution of valuable land uses, urbanised areas and functions

Arable land
Railway
Port
Airport
Glass house
Semi-built area
Greenport
Urbanized area

Land use: Annual expected economic risk calculated from the probability of levee failure and the consequences of flooding (damages and fatalities) if flood defenses fail

< 10 € / ha / y
< 50 € / ha / y
< 100 € / ha / y
< 2500 € / ha / y
< 5000 € / ha / y

Regardless of the eventual sea level rise scenario, sea level rise will affect the physical, social and economic coherency of the Netherlands and many other coastal and floodplain communities. Despite the high level of uncertainty, an understanding is required on how the Netherlands can mitigate, adapt or transform land, urban areas and infrastructures for future scenarios. Looking back at the historical geomorphologic evolution of the land we now call the Netherlands (adapted from Vos et al., 2020), its shifting delta characteristics are evident. Only in the last centuries, the Dutch land reclamation and polder practices have fixated its outline, allowing a quickly decreasing dynamicity of the border between land and water.

Acknowledging that the current outline of the Netherlands has only been set in the last sixty years with the completion of the Delta Works, allows for the reconsideration of its maintenance, anticipating extreme sea level rise scenarios in the debates about long-term strategies. Attempts at creating the required long-term national vision addressing extreme sea level rise scenarios resulted in proposals like LOLA Landscape Architect's Plan B NL 2200 (2018) and ZUS' Delta Plan X (Hendriks, 2019). However radical, these visions are a potential future but the strategies or steps needed to achieve the vision remain absent.

SEA LEVEL IMPACT KNOWLEDGE COLLECTIVE

The Sea Level Impact Knowledge Collective (SLIKC) is a design-led initiative born from collaborative efforts between knowledge institutes, academia, municipalities, NGO's and experts. Framed around the climate crisis, uncertainties tied to extreme sea level rise and a lacking national framework to address those, the research branches out to encompass fields such as urbanism, water management, geology, landscape architecture, policy analysis and social and climate sciences. Its aim is to critically think, design, engineer, assess, visualise and communicate a spatial vision for the future of the Netherlands and its method of establishment with the urgency of the changing climate extremities.

Given the complexity and urgency of future climate change, socio-economic trends and governmental development, the project leverages on a multi-faceted team comprised of several disciplines and expertise. This is vital given that even the new Delta Program does not cover all risks and opportunities for the Netherlands and focuses predominantly on flood protection, freshwater supply and urban flooding.

The SLIKC team positions itself in seeking for alternative measures that would not result in the Netherlands resorting to large scale mass retreat and aims to develop methods and tools for the delivery of transformative change by design by means of:

Critical infrastructure: Energy systems

Gas field
High voltage electrical line
Powerstation
High voltage sub station
Existing wind farm
Productive oil field
Production platform
Oil pipeline

Nature: Landscape infrastructure

Park
Forest
Nature 2000

1. Developing a resilient vision for the Netherlands that can be translated into and can inform current practice.

2. By doing so, developing and implementing a research framework and methodology, allowing for realistic, concrete and feasible Dutch landscape designs and accommodating different contexts, which can be objectively assessed.

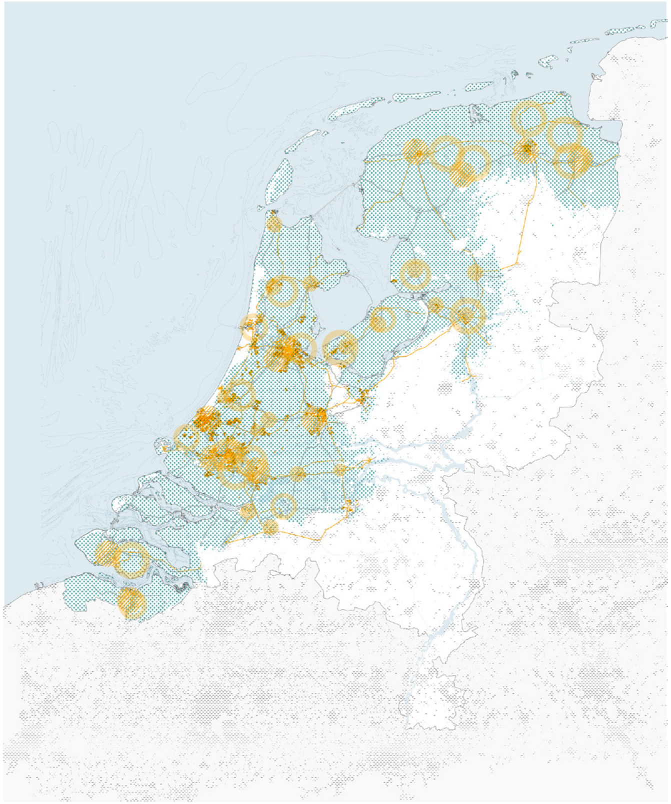
3. Establishing an optimal current engineering and design practice that aligns both the short term (< 2100) and long term (> 2100) future.

4. Creating added value by coupling to other spatial challenges such as water availability, biodiversity conservation, energy transition and agriculture.

RISK MATRIX

As an initial act, in order to identify the criticality of the Dutch context pressured by sea level rise and grasp a more holistic understanding of the multitude of risks and key pressured areas in the Netherlands, a risk matrix and a series of stress maps were developed. The main risks identified, alongside extreme sea level rise (three meters), were drought, river discharge, salinity and subsidence and the matrix aligns each of them with the relevant variables. Using the risk matrix, the stress map for each risk was established by means of a cartographic exploration overlaying these relevant variables including the distribution of population density, growth and GDP projections, land use and the associated value and potential economic loss, critical infrastructure such as energy, drinking water provision and transportation systems and nature in terms of topography, landscape infrastructure, river discharge but also natural trends such as salinisation, subsidence, drought. Each stress map ultimately outlines the key areas in the Netherlands with the highest stresses among all the variables considered.

The majority of the data was obtained from an open-source database from a joint collaborative effort between multiple parties found on the online Klimaat Effect Atlas. Several notable partners that have contributed to the research on the website range from Wageningen University, Deltares, KWR, TNO, the Deltaprogramme, Rijkswaterstraat, HKV and many more. The data is public assessable on the online interface and Esri's Map web database that can connect to ArcGIS Pro.



Sea level rise stress map

Highly urbanized and densely populated area
3m flooded area
High concentration transportation systems
High concentration energy systems
Impacted railway
Impacted motorway

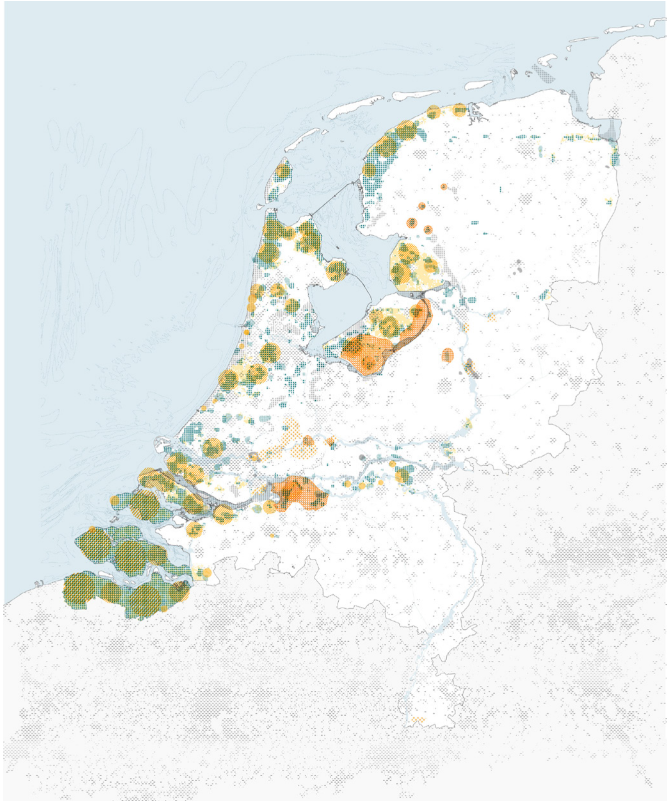
River discharge stress map

Current river discharge (low)
Current river discharge (high)
Future river discharge (high)
Highly urbanized and populated development
High concentration transportation systems
High concentration energy systems

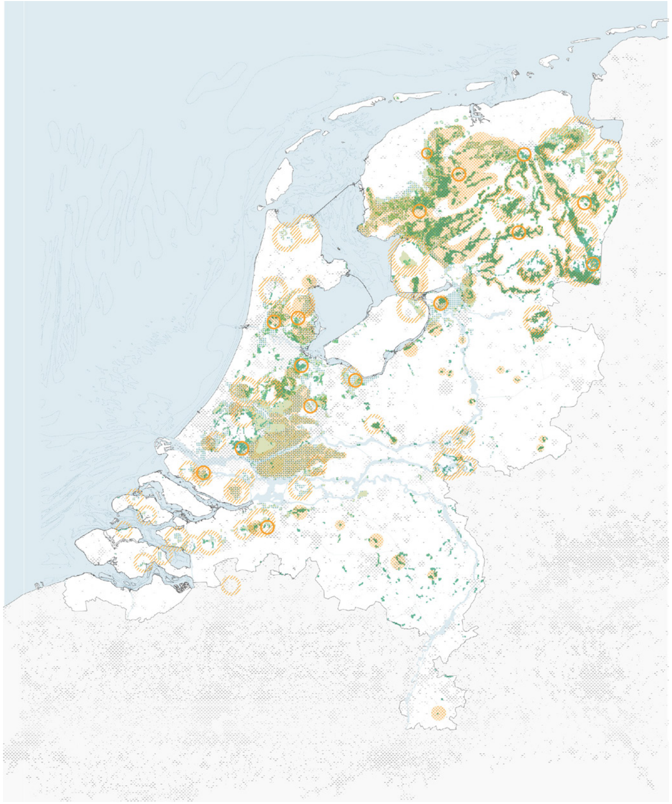
STRESS MAPS

The sea level rise stress map highlights the area below sea level with a general mean sea level rise of three meters. Large parts of the country are already below the current sea level but this future projection casts light on how contemporary developments as population growth and distribution and infrastructure investments in the national transportation and energy systems in the Randstad and secondary Dutch cities coincides with areas where risk will increase. In the south of the Randstad, this observation is additionally highlighted on the river discharge stress map as the area where the rivers responsible for the largest part of the national discharge debouche to the North Sea with discharge volumes subject to more unpredictable fluctuations in the future. This area, together with the center of the Randstad is furthermore one of the two focal areas on the subsidence stress map, increasing stress and risk in the area.

The less urbanised parts of the Netherlands are not free of risks. The other focal point of the subsidence stress map highlights for instance the northern provinces of Friesland and Groningen and the salinisation stress map indicates the coastal arable land facing increasing salt contents, especially in the south-western province Zeeland, the north of Noord Holland and the west of Friesland. As opposed to excessive water, the drought stress map shows more concentrated areas of concern like the system of dunes along the Dutch coast, the Utrechtse Heuvelrug, Veluwe and large parts in the east of Noord Brabant and the north of Limburg. Drought poses a particular threat in these areas due to their protected Natura 2000 status and their role as national or provincial groundwater reserves.



Salinity stress map



Subsidence stress map

A WAY FORWARD

The complexity highlighted in the layered stress maps is an initial act in identifying the criticalities and underlines the impossibility of a single solution and one future map of the Netherlands. It highlights a call for a way to address the challenge and, in our opinion, a call for Research by Design. Design has the capacity to continuously explore and set out both the problem space and the solution space and to define the opportunities which are capable of connecting them. Research by Design allows for a solution to be the development of a transdisciplinary approach and process embracing a radical vision as a way to transition and to accept multiple options simultaneously rather than one solution map.

As innovations and potential high-end sea level rise scenarios unfold, the SLIKC approach aims to guide the discussion on transformative change in the Socio-Technical-Ecological System (STES) of the Dutch Delta and its implementation in scale-free living labs. Where STES is predominantly linked to the governance and management system, the Research by Design approach will take a multi-layer stratified model approach that distinguishes spatial planning in a land-use occupation layer, an infrastructure network layer and a subsurface layer. Transdisciplinary work will be at the intersection between these systems and layers. Being scale-free, the approach seeks to defy multi-system and layer issues through design-based interaction in local, regional, and national living-labs.

To achieve the objectives, the research is climate action oriented, connecting and re-connecting academics and professionals from different institutes and practices with citizens. This is done in a design-oriented fashion, producing a multi-method approach that combines design, engineering, modelling and action research with participative approaches and citizen science for transformative change based on STES. Its products are innovative practices and designs, supporting methods and models, that inform professionals and citizens and active niches for transformative change.

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