Spatial assessment framework for mitigating future flood and land subsidence risk in expanding delta areas

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Abstract

Delta areas are prone to flooding and land subsidence. Flood risk increases because of climate change and land subsidence. Risk can be reduced by strengthening levees. Risk can also be reduced by land use planning, raising buildings and infrastructure, and emergency measures. However, expanding urban areas in delta areas will increase risk.

Based on the precautionary principle, it can be decided to live outside the (known) flood zones with soft soils to avoid flood risk. However, in these places, also other risks are present. Examples are diseases, poor air quality, industrial plants, and longer travel distances to work. Accepting some level of risk is inevitable. The concept of acceptable risk provides a way to balance these factors when building in flood-prone areas with soft soils.

In the Netherlands, the 'Water and Soil is Guiding' initiative incorporates acceptable risk and local flood and land subsidence risk profiles into land use planning. This paper focuses on flood risk and land subsidence and introduces a 'spatial assessment framework' to guide decisions on where and how to build new urban developments.

The framework sets out criteria to mitigate the flood risk and land subsidence in these developments, considering projected flood risk in 2100 taking climate change into account. It divides areas into risk zones based on local flood depth and probability of occurrence, allowing:
1) new urban developments must include flood risk mitigation and land subsidence measures to prevent damage
2) areas where explicit trade-offs between risk reduction measures and acceptance are necessary
3) zones with low risk which is acceptable.

Additionally, the framework provide guidelines for shelter locations to ensure residents are protected during worst-case flood events. In addition to the risk maps, additional zones can be identified where development is prohibited, such as areas needed for future floodwater storage.

Framework

Start:
- Development of new housing areas, industrial areas etc.
- Existing criteria for building codes, and performance of water system and levees based on official (risk based) standards

Ambition:
- Insight in possible future impact
- Avoid decisions which you might regret in de future
- Take the life cycle of (societal) costs into account.
  Avoid easy choices during development (with low costs) and create high cost in the future.

What is new: Additional criteria to take 'water and soil' into account. These criteria are needed because of the low frequency of these events (flooding) and the long-term impact (soil subsidence, fresh water)

Step 1: Rethink the location of new urban development
Step 2: Rethink the design and spatial integration of new development
Step 3: Only if needed and step 1 and 2 are not realistic – redesign of the water system or additional emergency measures
Step 4: Public consultation and regulation

Classes and Data

Flooding (regional rainfall, extreme river discharge, failure of levees): source "National Database of Flood Risk Information https://basisinformatie-overstromingen.nl/
- Local exposure to consequences of a flood using a 'water risk profile
- Opportunities for evacuation or shelter in place (based on worst case flood depth)

Method: primary levees along sea and rivers are considered to be fully independent, regional levees among regional canals fully dependent.

Soil subsidence
- Expected soil subsidence in case of classic development (equal to a mass of 1m additional sand)

Drink water
- Expected shortage based on current permits

Year: 2100
- Climate change based in SSP5-8.5 (KNMI 2023)
- Levees are reinforced to (exactly) the safety standards

Locally additional layers can be added!

	Soil subsidence	Flooding: Exposure	Flooding: Evacuation and Shelter
D: Not allowed	External decision	External decision	External decision
D: No unless	> 90 cm	Flood Depth > 20 cm T > 1/100 py	Flood Depth > 20 cm T > 1/100 py
C: Comply or explain (high risk)	> 60 t/m 90 cm	Flood Depth > 20 cm, T ≤ 1/100 - > 1/1.000 py	Flood Depth > 500 cm
C: Comply or explain (medium risk)	> 30 t/m 60 cm	-	Flood Depth > 250 en ≤ 500 cm
B: Comply or explain (low rsk)	> 5 t/m 30 cm	Flood Depth > 20 cm, T ≤ 1/1.000>1/10.000 py	Flood Depth > 50 en ≤ 250 cm
A: Accept risk	< 5 cm	Flood Depth > 20 cm, T ≤ 1/10.000 py	Flood Depth ≤ 50 cm
0: Building codes sufficient		Flood Depth ≤ 20 cm	Flood Depth ≤ 20 cm
No risk			

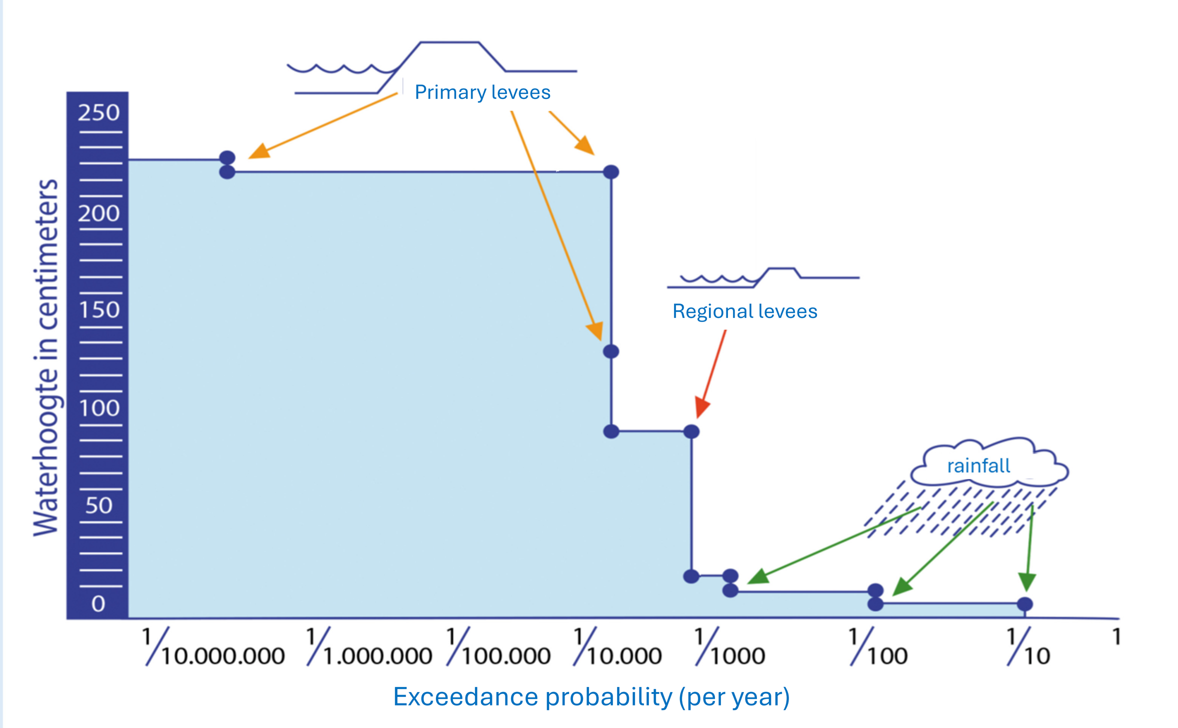
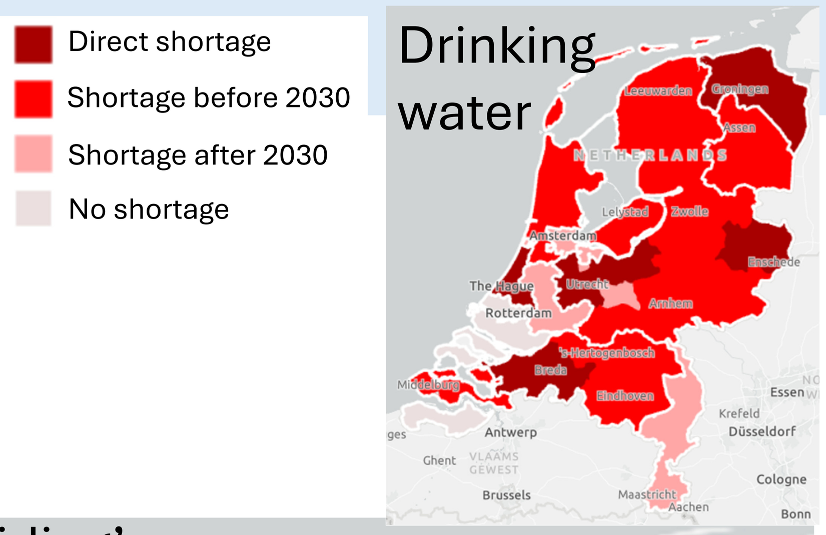
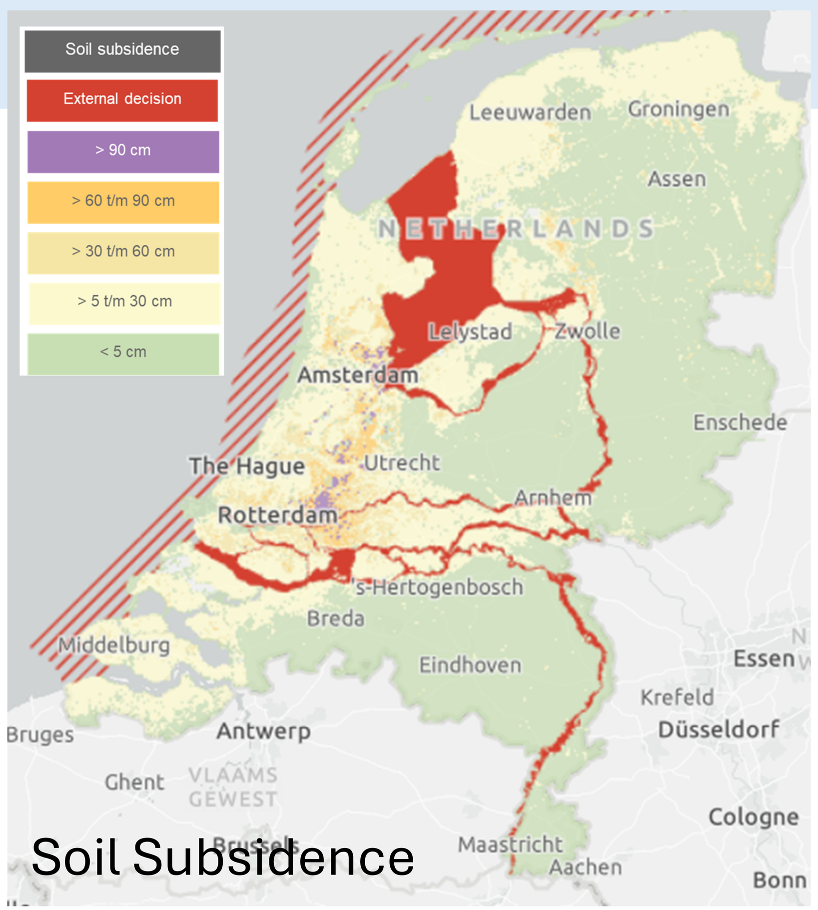


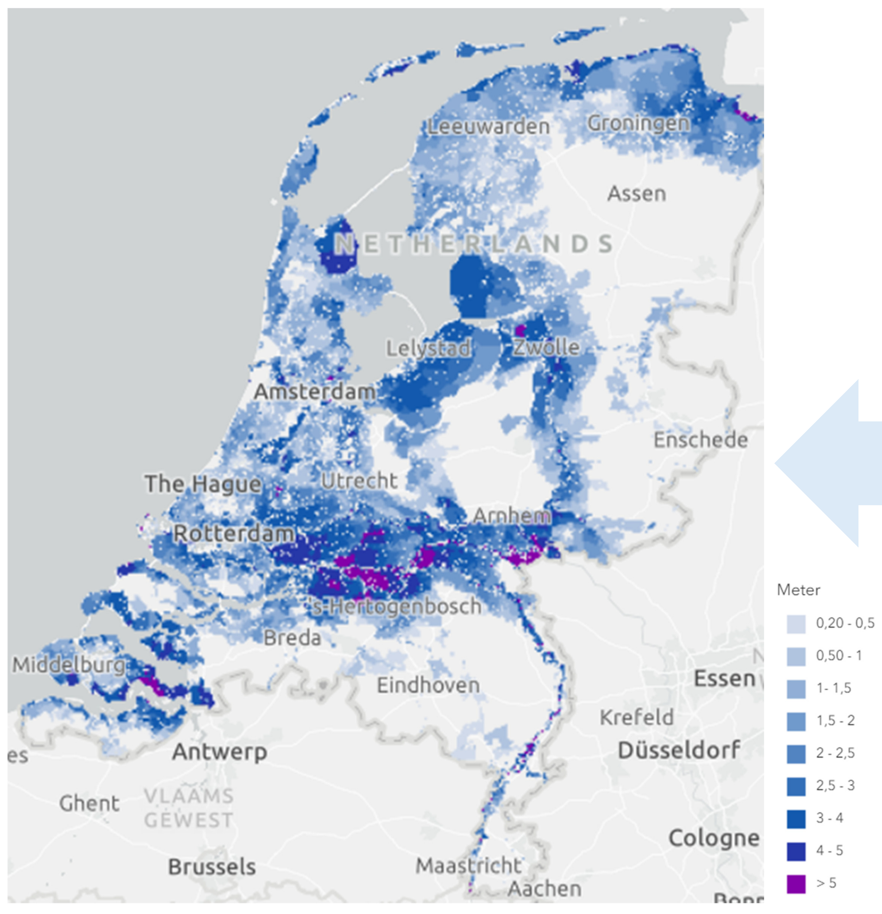
Figure: Water risk profile showing the exceedance probability of flood depth (www.mijnwaterrisicoprofiel.nl)

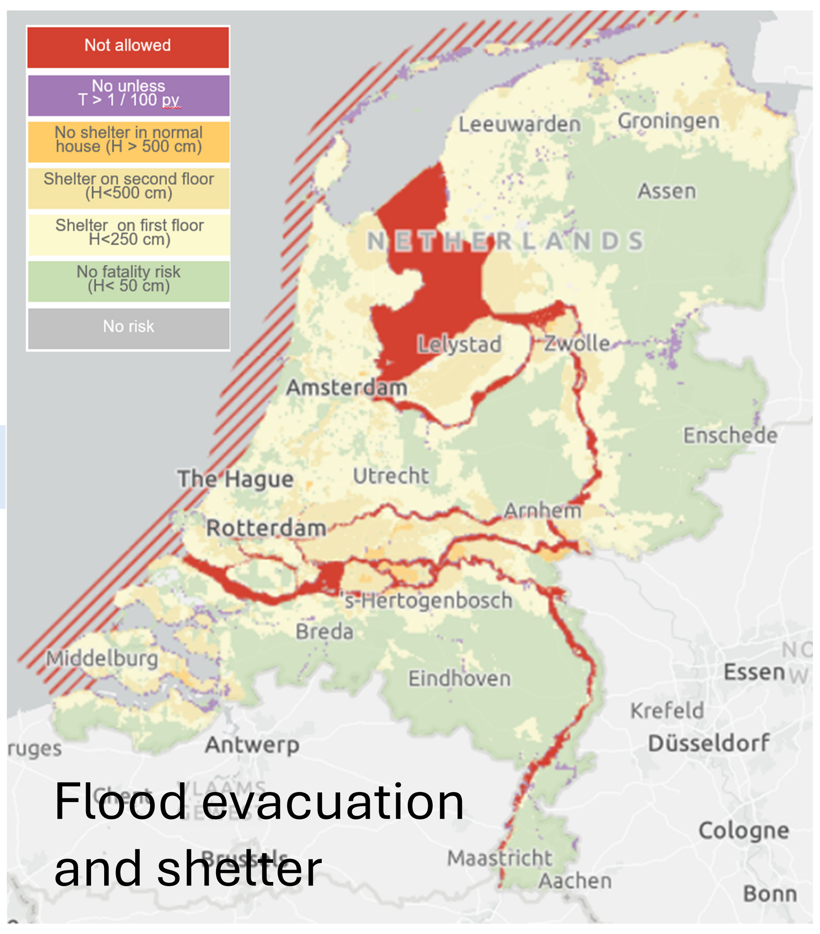


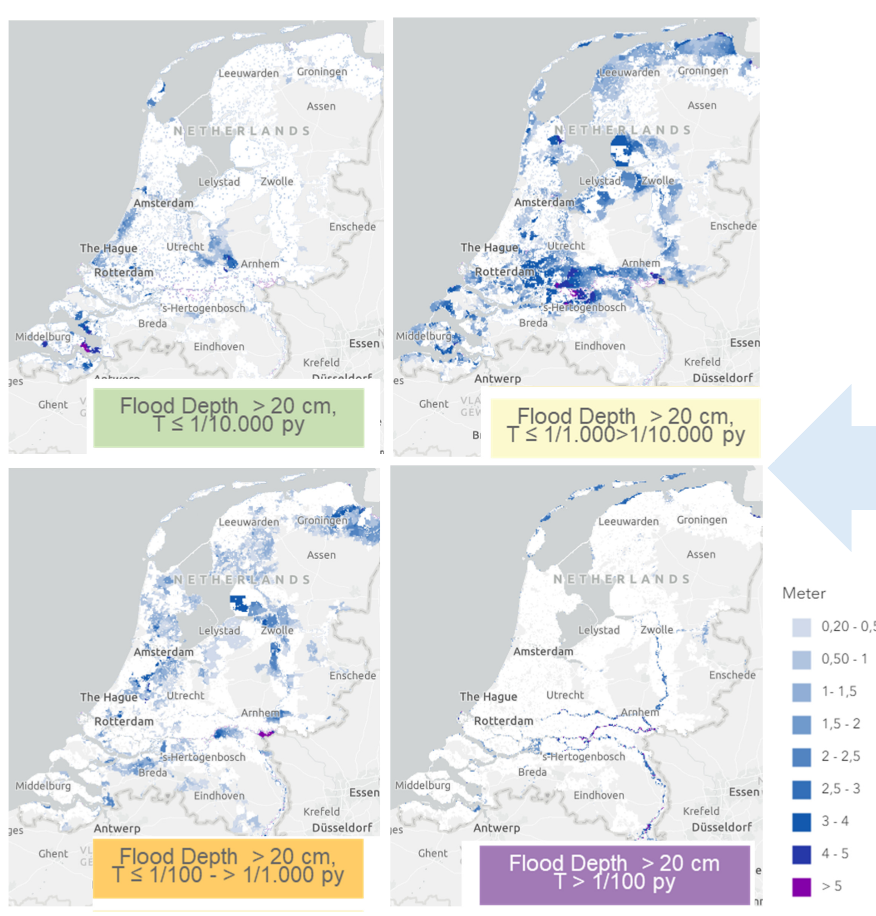
Design maps

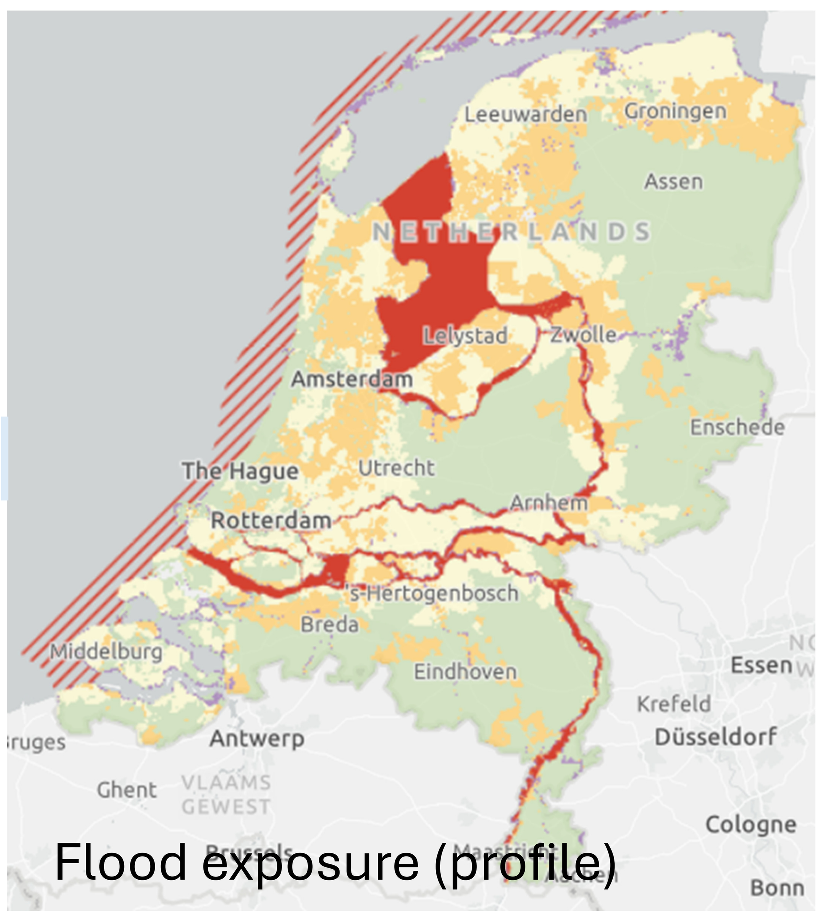
Local design criteria per parameter











Combined steering map

National map 'water en soil guiding'