



How to prepare for the future? Scenarios for future water conditions and sea-level rise adaptation strategies from the Netherlands

European Marine Board

16 January 2025

Renske de Winter

History of Adaptation in the Netherlands



**Culverts
Drainage
ditches**

800 ad



**Dikes and
polders**

After
1000



**1916 flood
Zuiderzee works**

1916-
1932

Anticipate with
adaptive
planning

Dwelling mounds



**Polders and
land
reclamation**



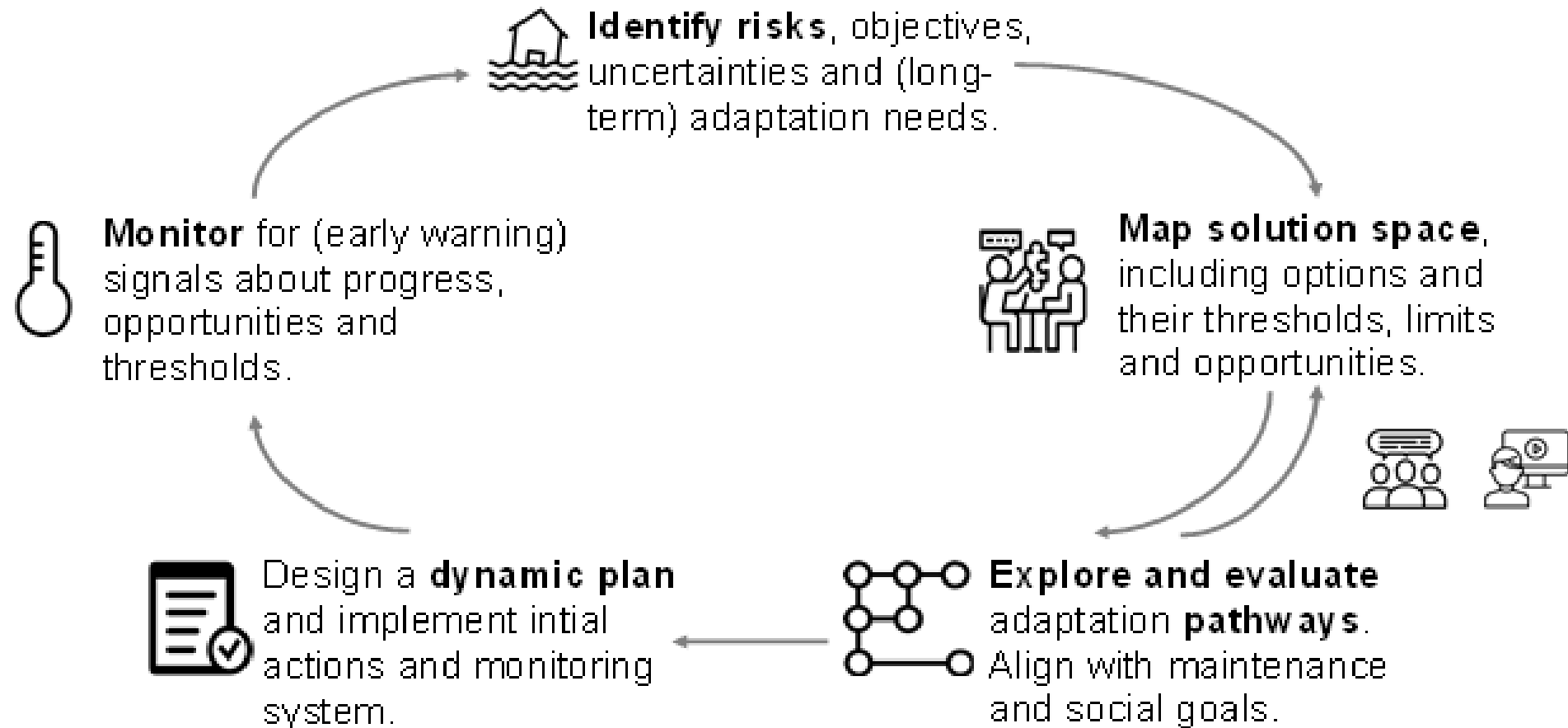
**1953 North Sea
Flood
1st Delta
Committee**



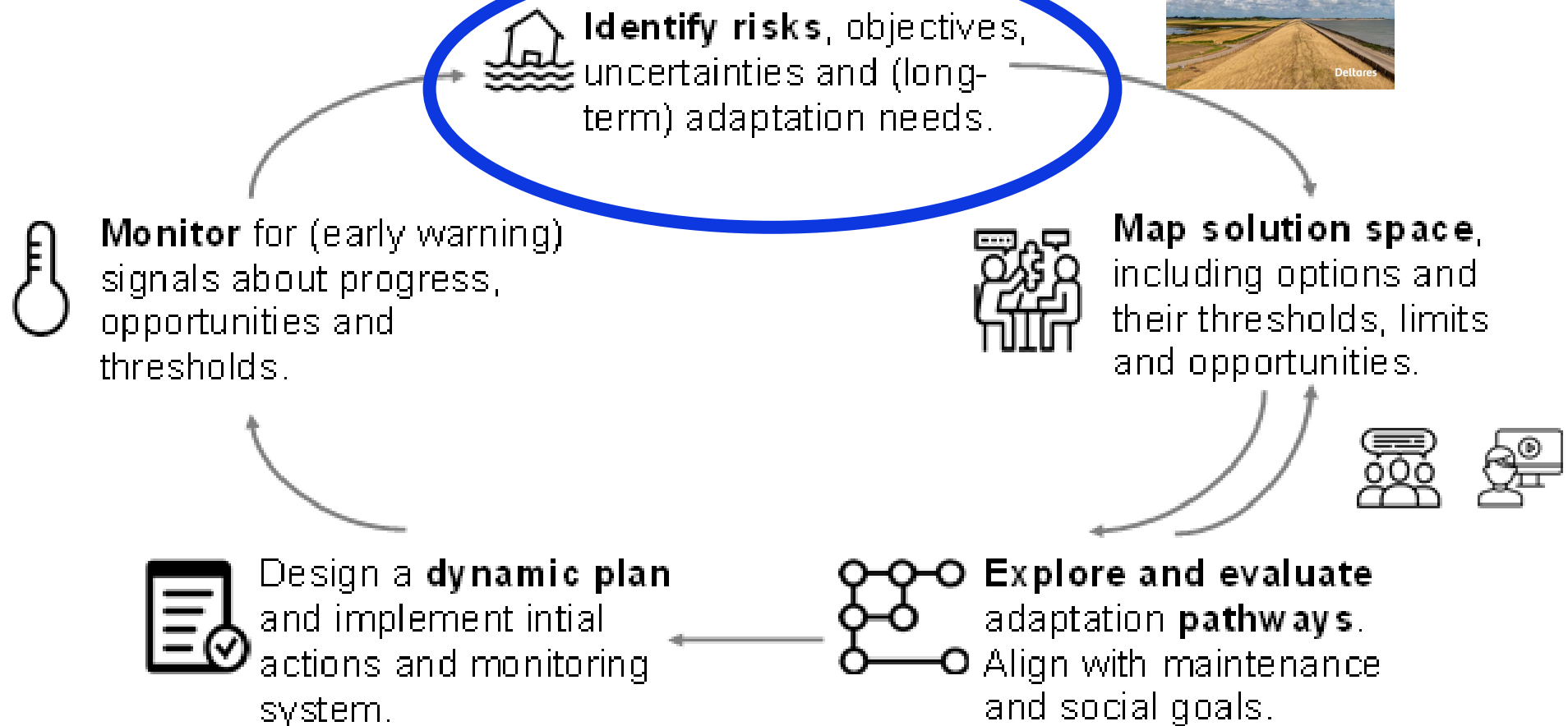
**2nd Delta
Committee**

Delta
Program

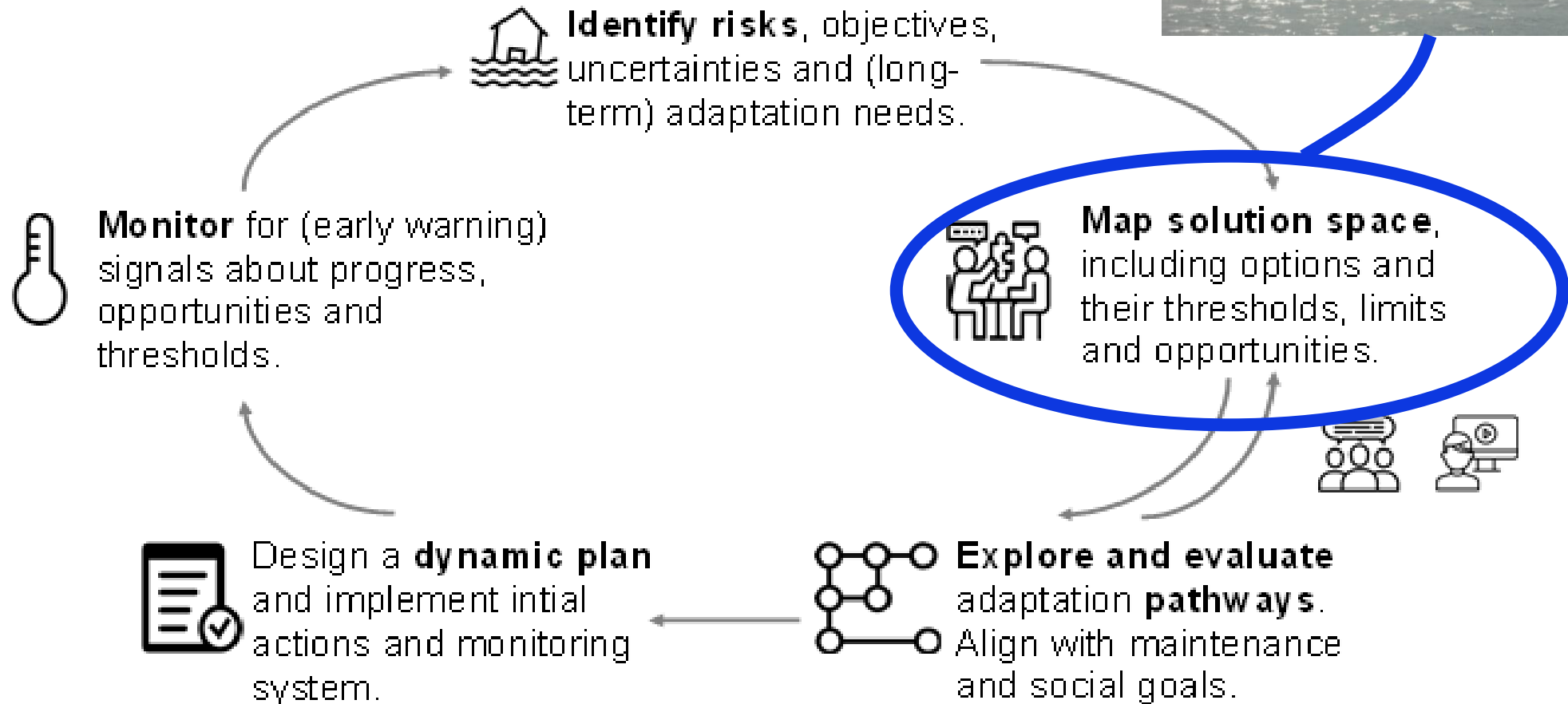
Dynamic Adaptation Pathways



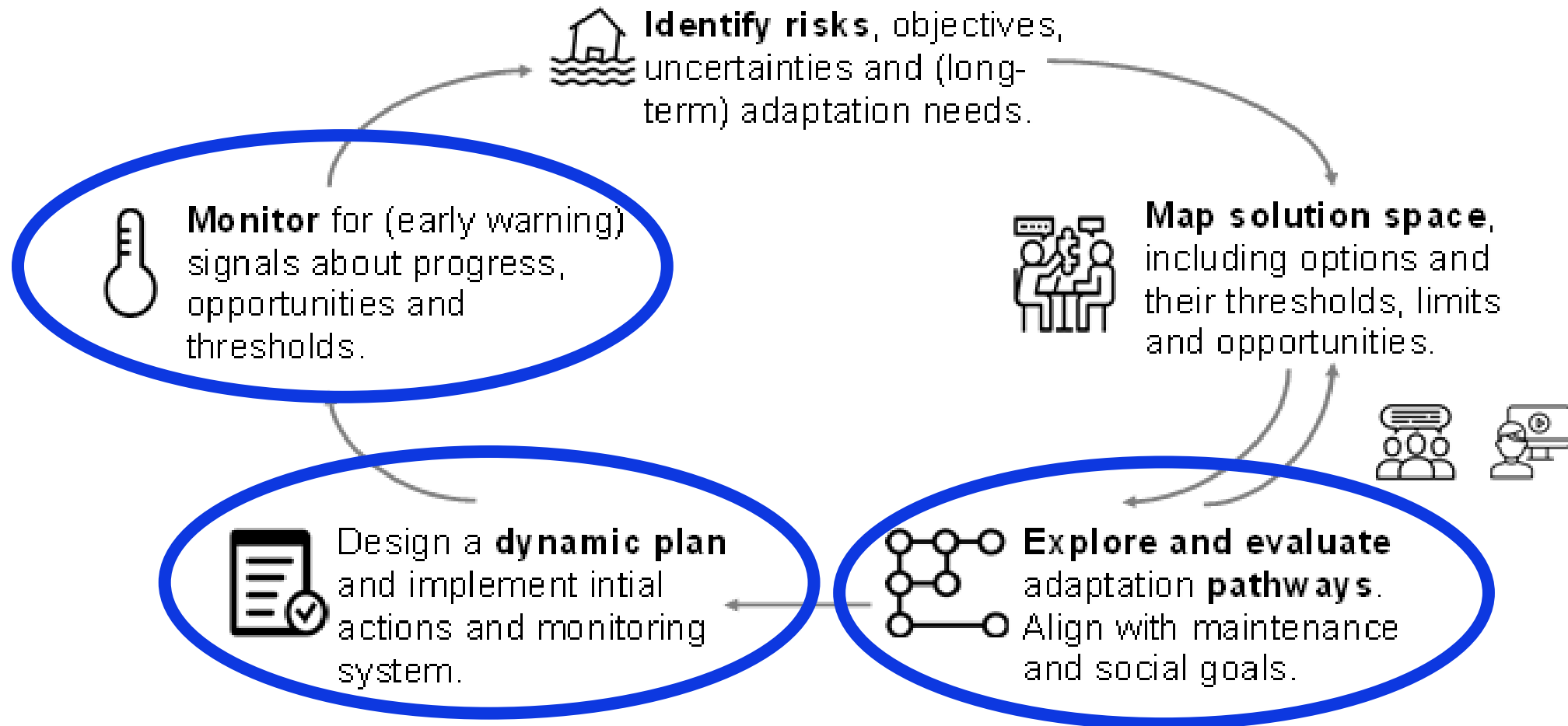
Dynamic Adaptation Pathways



Dynamic Adaptation Pathways

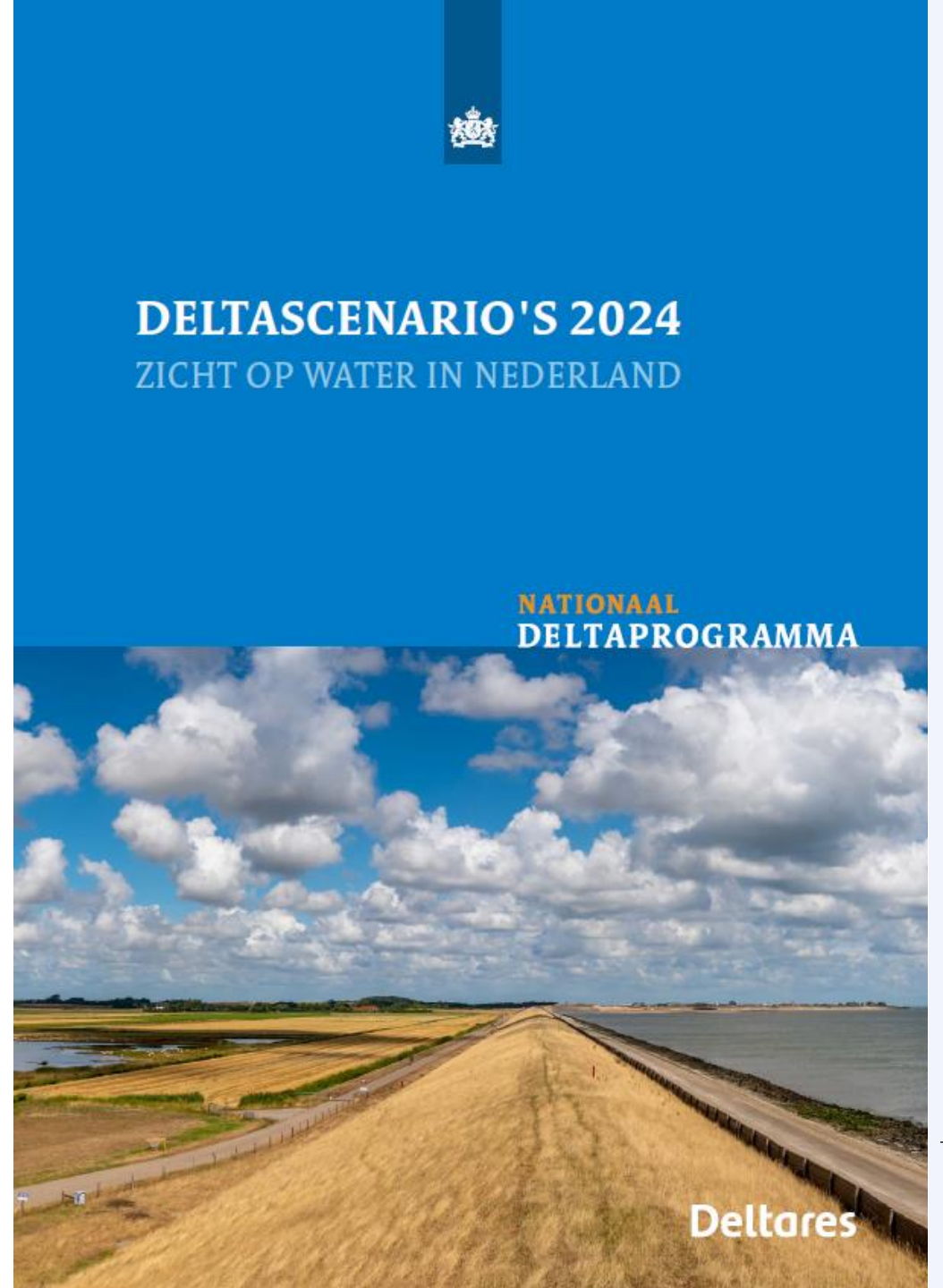


Dynamic Adaptation Pathways



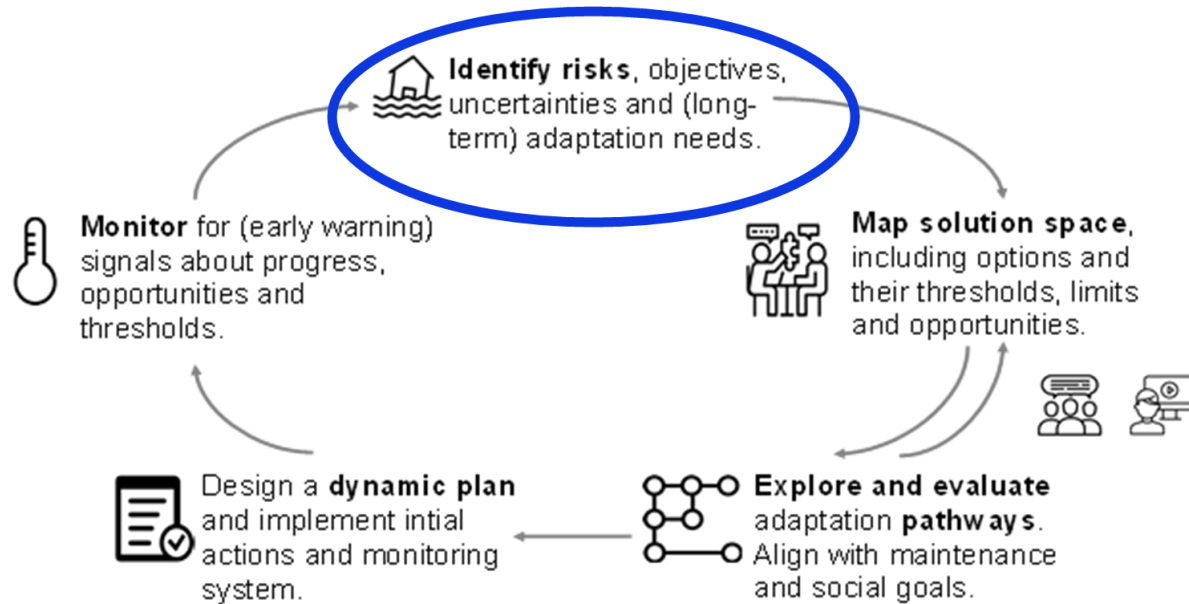
Delta Scenarios 2024

- Needed for reassessment of Dutch water strategies
- Insight in water challenges in 2050 en 2100
- Regular scenarios and “What-if?”-developments



Why Delta Scenarios?

- Insight into future water tasks and bandwidth
- Timely anticipation; enabling robust long-term decisions in the water domain and also in the spatial domain.
- Update 2017 Delta Scenarios, part of the recalibration of the Delta Program



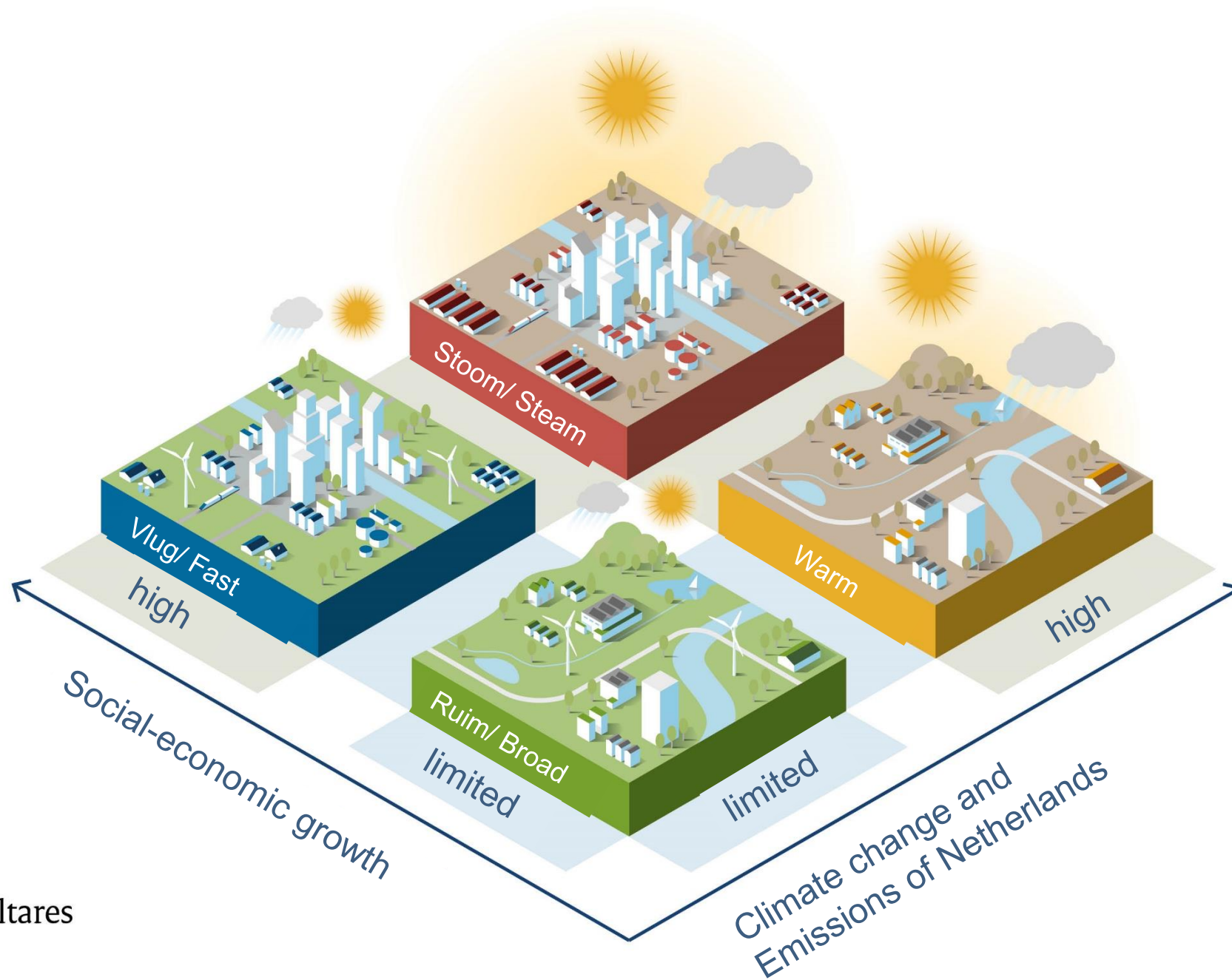
Why and How

Why work with scenario's

- Insight into future water tasks and bandwidth
 - Flooding, fresh water availability, water nuisance
- Timely anticipation; enabling robust long-term decisions in the water domain and also in the spatial domain.
- Part of the recalibration of the Delta Program

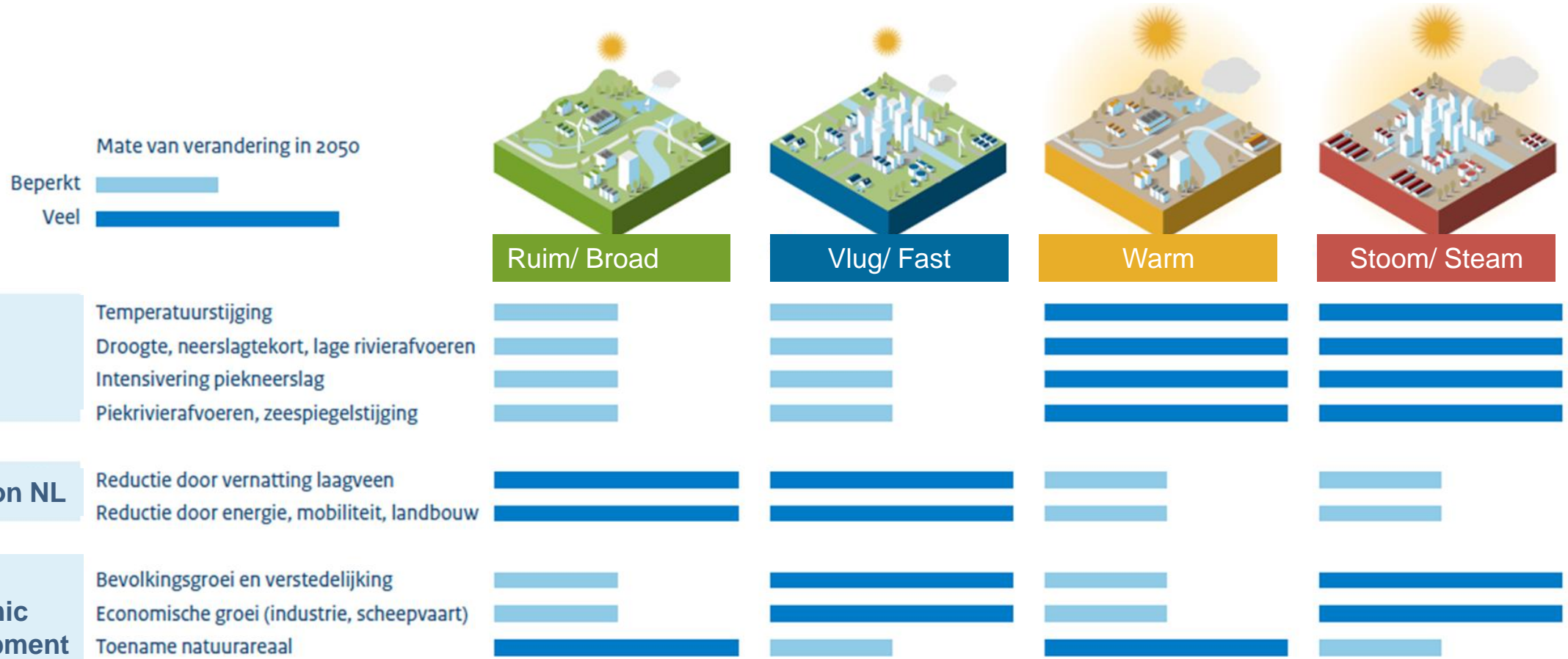
Guiding principles defining Delta Scenarios

- Context scenarios, not normative perspectives for the water sector
- Bandwidth, individual scenarios have no probability
- Projections for 2050, 2100



Bron: Deltares

Contrasts between Scenarios



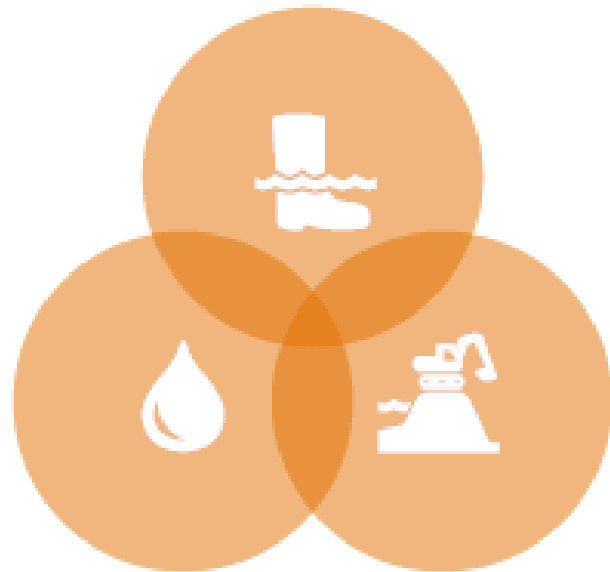
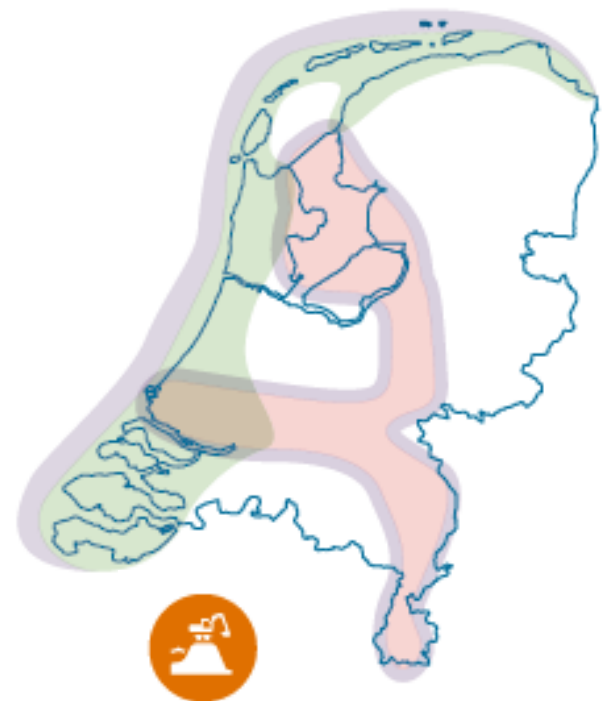
Bron: Deltares



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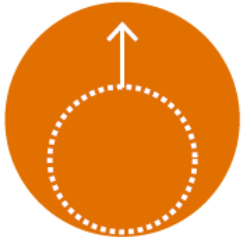


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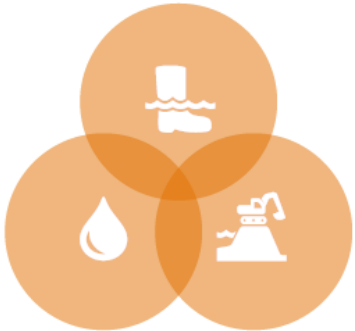


Deltares

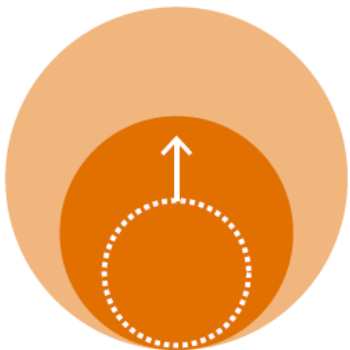
Insights



- Increasing water challenges in all scenarios



- Water challenges are piling up: a water shortage and water nuisance and flooding and other social challenges



- More climate change results in greater water tasks: less time to adapt, larger tasks, increased bandwidth to work with.

“What-if”-development

Large potential impacts, but outside Guiding principles.

- Extra accelerated sea level rise
- Extreme weather
- Changes in upstream land, soil and water use
- Agricultural reforms
- Autonomous adaptation
- Land use in 2100, large transitions



Outreach and Media

April 2024:

Hand-over to minister of Infrastructure and Water works and Delta Commissioner

June 2024: Technical briefing in Parlement



Media



Door Emma van Bergeijk

24 apr 2024 om 18:08 409 reacties Delen

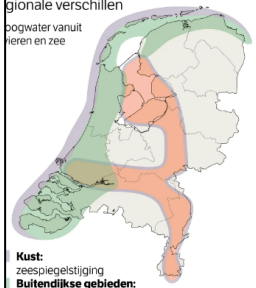
Nederland is een waterland. En toch kunnen we in de toekomst problemen krijgen met water. Er is te veel én te weinig van, concluderen wetenschappers in de nieuwe Deltascenario's. "We moeten het zo inrichten dat we de extremen beter kunnen opvangen."

In de **Deltascenario's** worden de grootste opgaven voor Nederland op het gebied van water eens in de zes jaar op een rij gezet. Wetenschappers van Deltares bestudeerden vier scenario's voor 2050 en 2100, waarbij rekening wordt gehouden met klimaatverandering, klimaatbeleid, bevolkingsgroei en



...stroomt...
...or het...
...rd kan...
...ater kan...
...jaarlijks...
...de

Opgave waterveiligheid* voor 2050
...gionale verschillen
...ogwater vanuit...
...eren en zee



Kust: zeespiegelstijging
Buitendijkse gebieden: vaker onder water
Rivieren: vaker hoge rivierwaterstanden

NRC 250424 / TT / Bron: Deltares



Rivierengebied: vaker lage rivierafvoer
Hoog-Nederland: wateroverslast als beken en rivieren buiten hun oevers treden

Lage rivierstanden

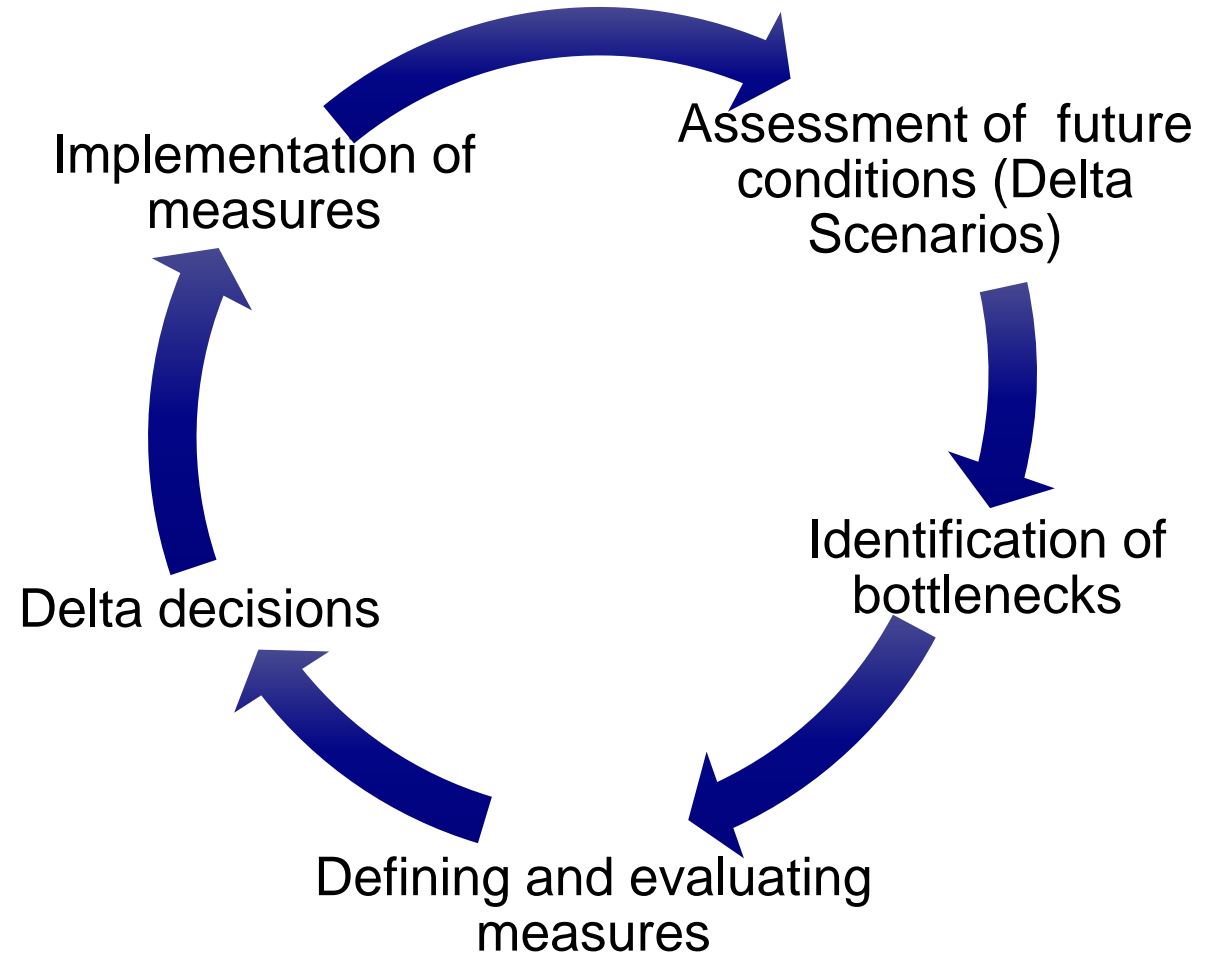
In het nu verschenen rapport werkt Deltares vier mogelijke scenario's uit voor 2050 en 2100. Daarin variëren onder meer de mate van klimaatverandering, de bevolkingsgroei, de verstedelijking en de economische groei.

Zo heeft de scheenvaart in het ene scenario meer last van lage rivierstanden



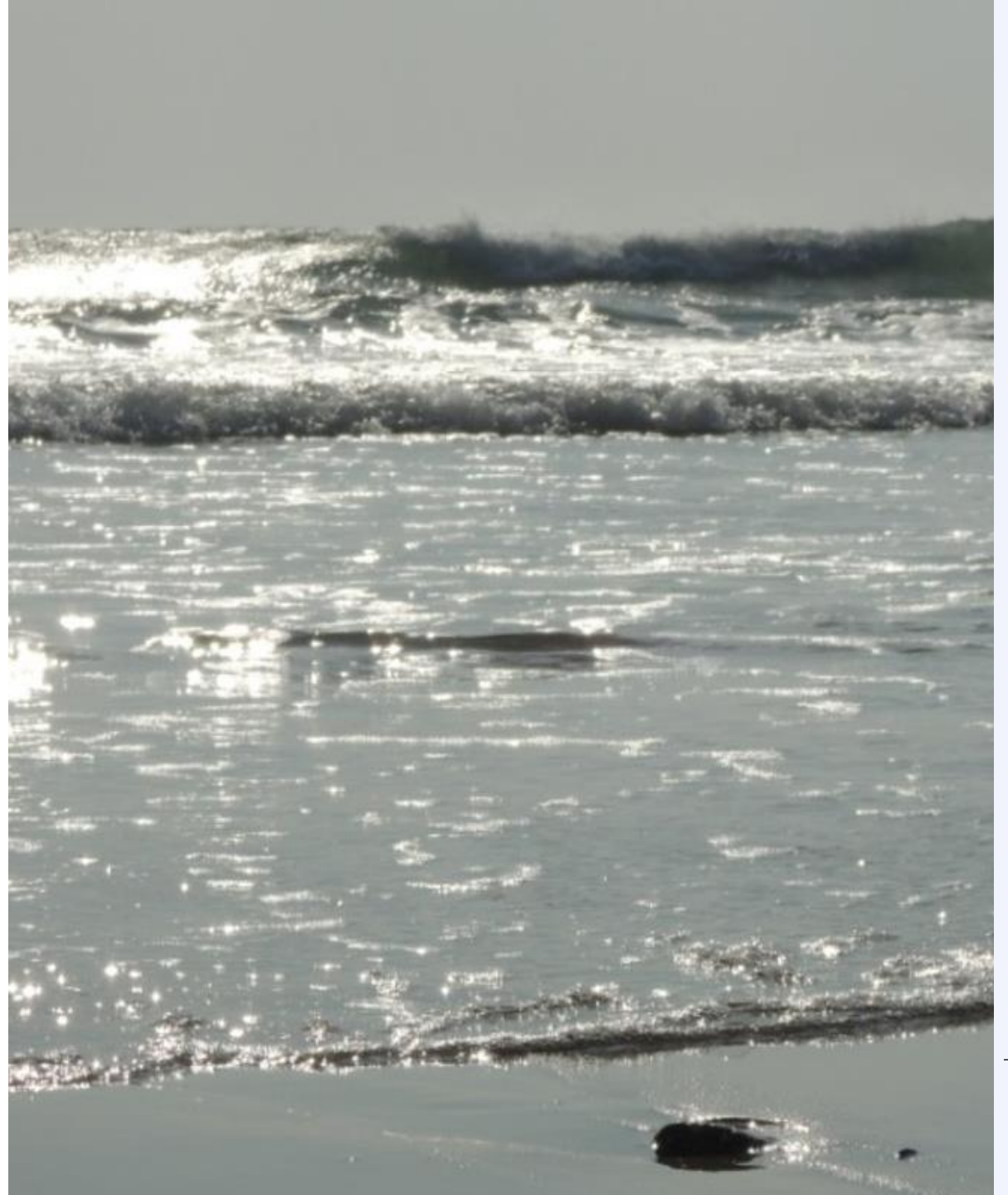
What's next

- Part of 6 yearly assessment of Dutch Water System
- Bottleneck identification ungoing
- Results overall assessment 2026



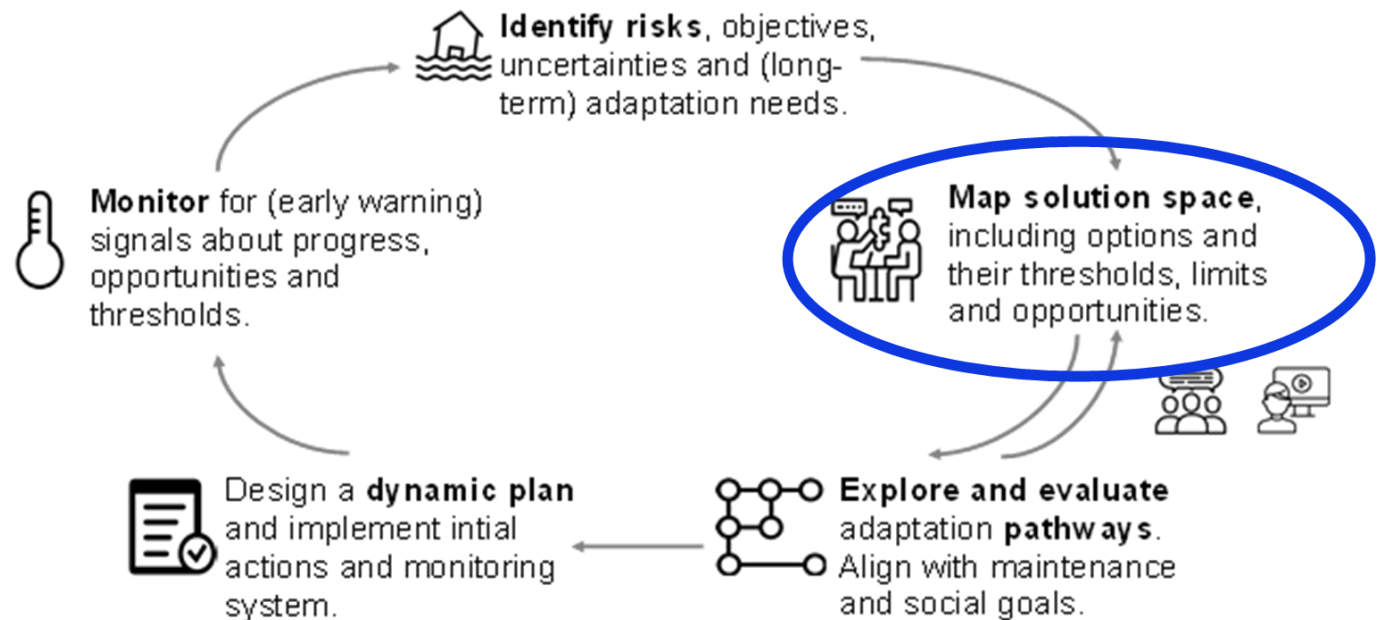
Deep uncertainty and adaptation

Extreme accelerated Sea-level rise and adaptation strategies



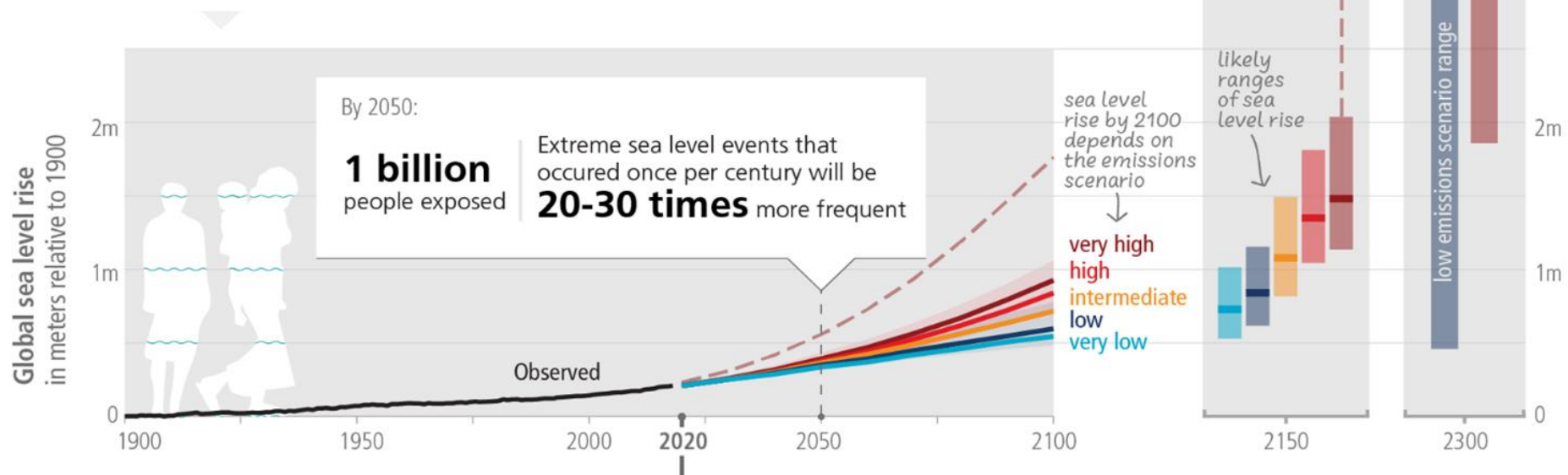
Extreme accelerated Sea-level rise and adaptation strategies

- Far future
- How to deal with deep uncertainty
- Identify limits and thresholds

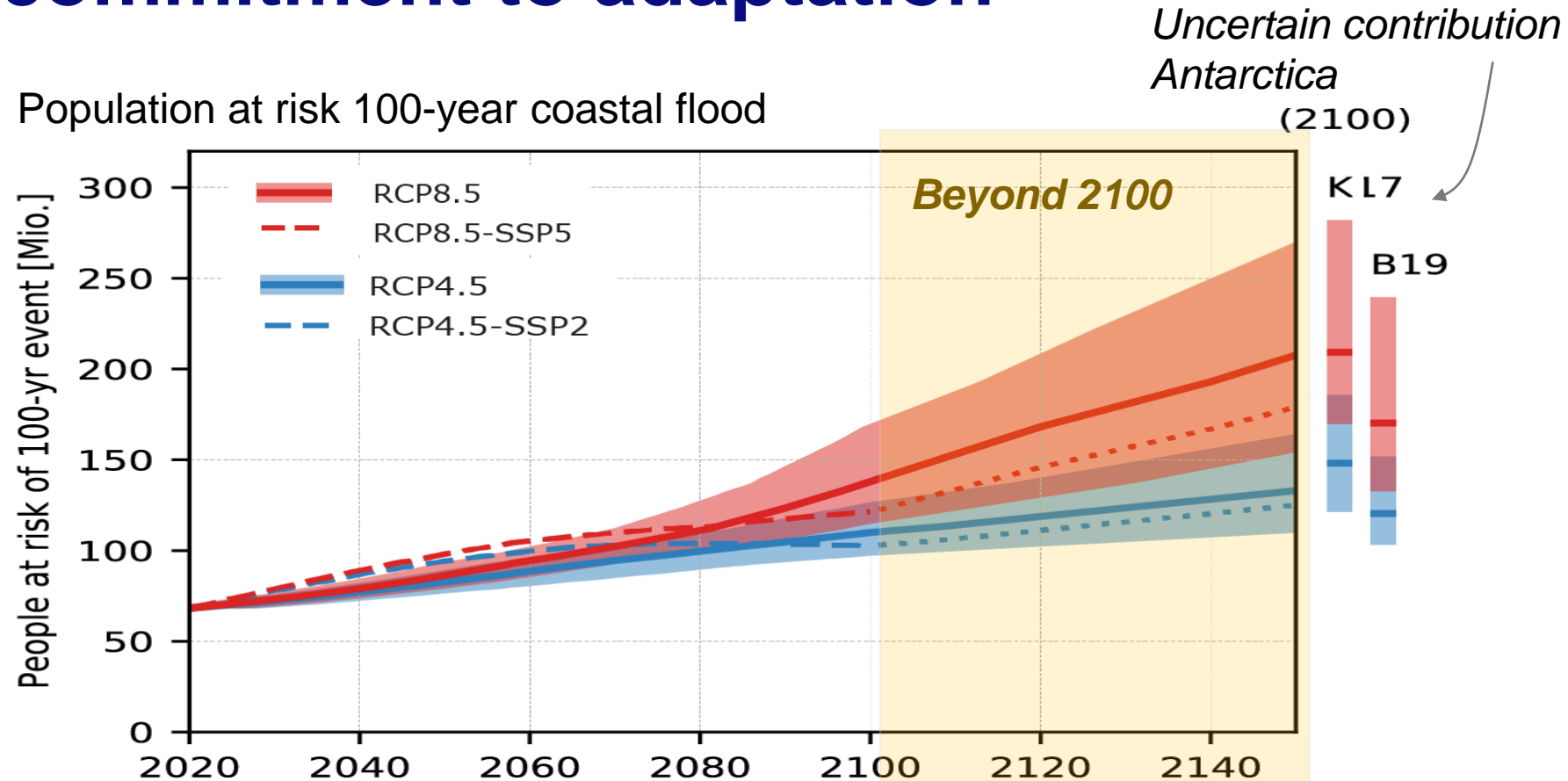


Sea level rise poses a severe and distinctive adaptation challenge

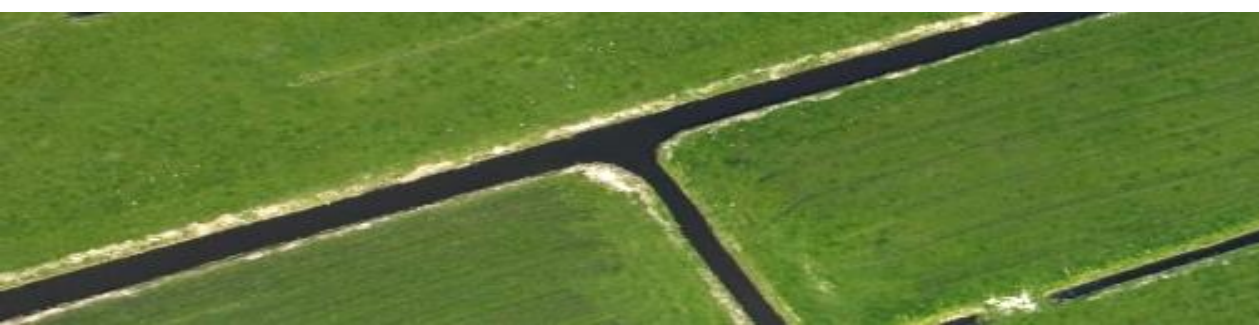
- The amount and rate depends on emissions
- The possibility of very large contributions from icesheets increases with more global warming
- Even if we limit emissions and global warming, sea levels will rise meters on the long-term



Long-term sea level rise necessitates a commitment to adaptation

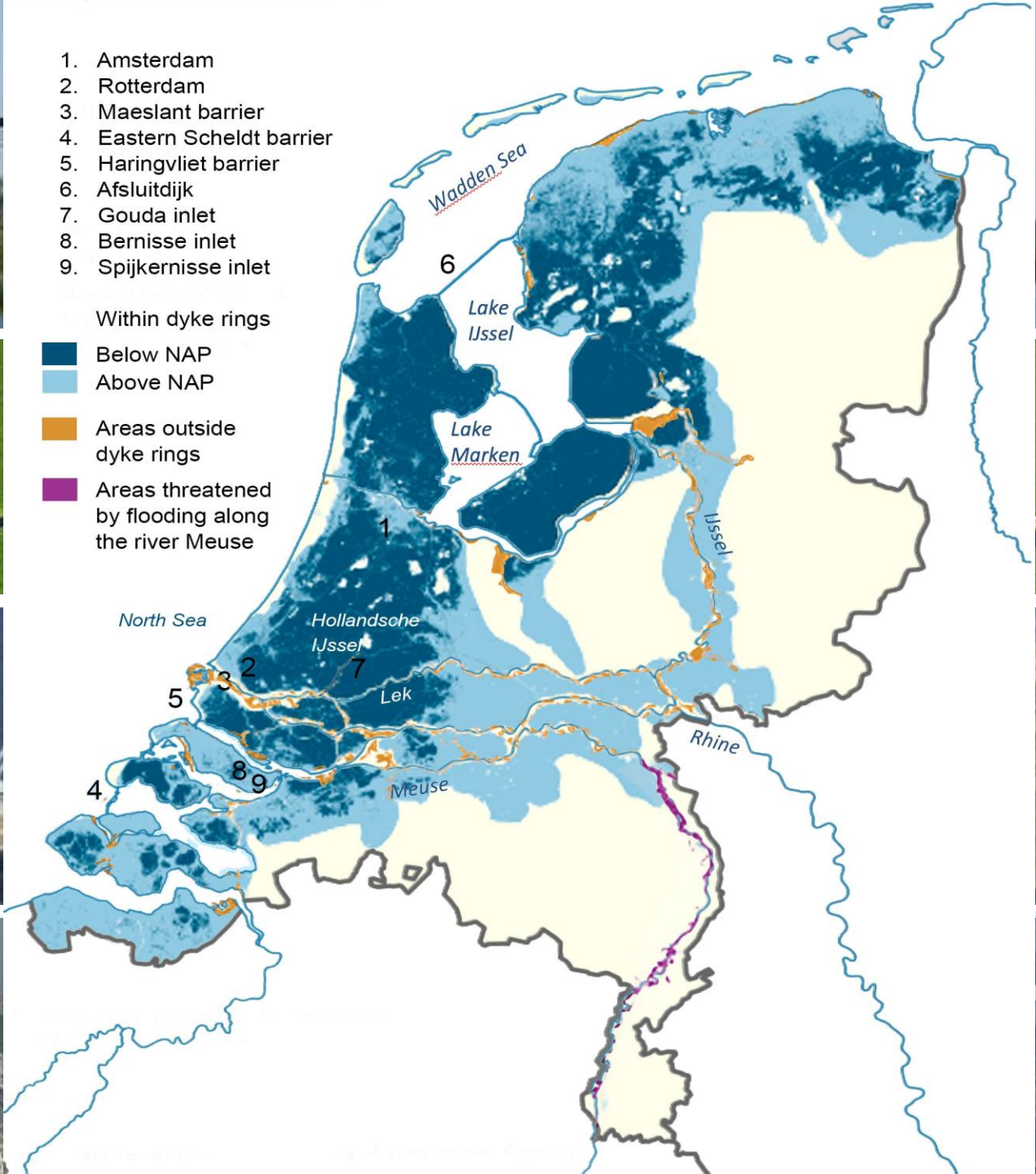


Without adaptation the population at risk to 100-year flood increases with 21% at 0.15m, and doubles at 0.75 m. Large increase in Asia, but also in Africa and Europe



1. Amsterdam
2. Rotterdam
3. Maeslant barrier
4. Eastern Scheldt barrier
5. Haringvliet barrier
6. Afsluitdijk
7. Gouda inlet
8. Bernisse inlet
9. Spijkernisse inlet

- Within dyke rings
- Below NAP
 - Above NAP
- Areas outside dyke rings
- Areas outside dyke rings
 - Areas threatened by flooding along the river Meuse



The Netherlands

- Enable delta life: flood risk and water supply
- Adaptive plan until 1 m sea level rise in 2100:
 - Protect and strengthen levees, barriers and dunes
 - Room for the river
 - Fresh water supply from IJsselmeer and local storage and reduced water use
- Knowledge program: impacts and adaptation options beyond 1 m



2008: 2nd delta committee
2015: adaptive plan



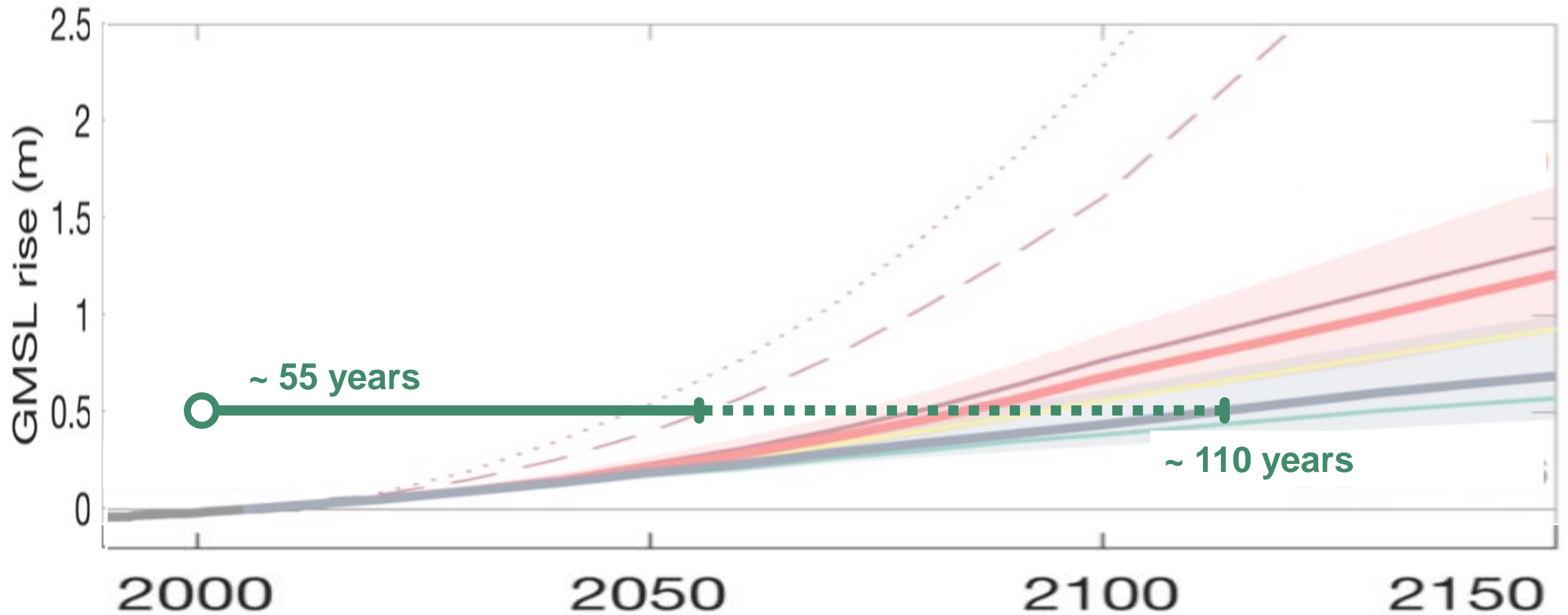
2017: Signal (Deltares, KNMI)
2019: knowledge program sea level rise

What if sea level rises much faster...

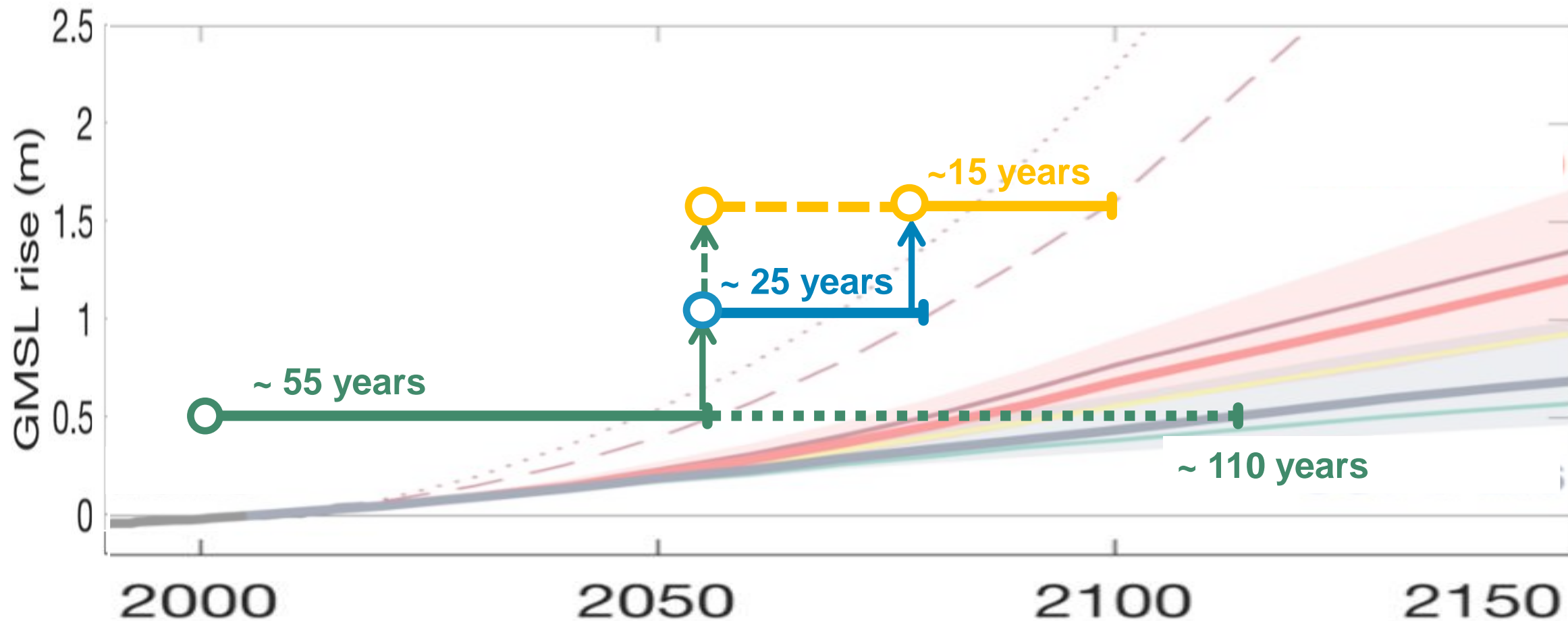


- Increase of sea-level rise continues after 2100
- And, potential acceleration in rate of sea-level rise due to the contribution of Antarctica and the collapse of ocean circulation AMOC

Adapt much faster or to higher amounts of SLR



Adapt much faster or to higher amounts of SLR



POTENTIAL CONSEQUENCES OF ACCELERATED SEA-LEVEL RISE

Uncertainty in timing (*when* instead of *if*)

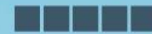
ANTARCTICA

Coast
more sand needed

10 mm/year



14 mm/year



60 mm/year



Drought risk

Increase water demand to lake IJssel



At 1m:
permanent alternative
needed for supply
route via Gouda

Flood risk
pumping capacity
lake IJssel

From 0.65 m
structurally needed



From 1.75 m



Flood risk
Maeslant Barrier

1 m



closed 3
times per year

1,5 m



closed 30
times per year

Flood risk
Eastern Scheldt Barrier

1 m






closed 45
times per year




1.3 m

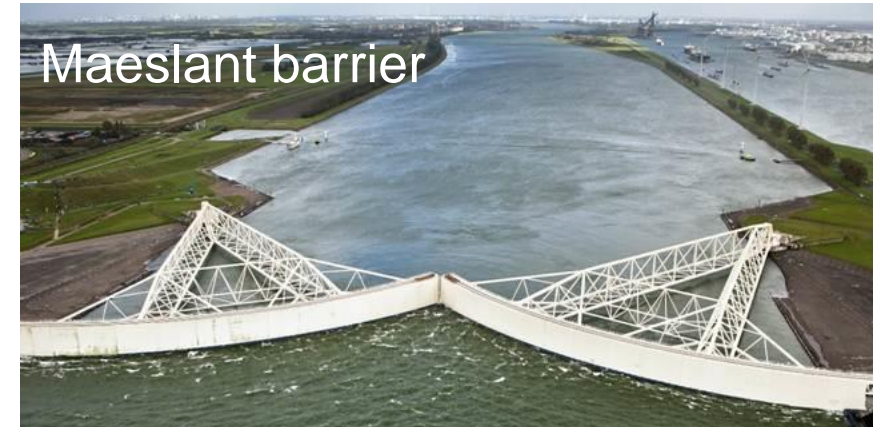


permanent

Flood barriers will close more frequently and eventually overtop

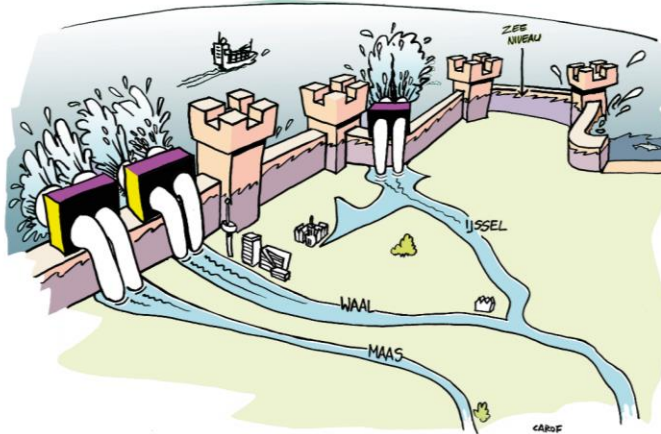
- 1 m  closed 3 times per year
- 1.5 m  closed 30 times per year
- 1.2 m  design levels exceeded 1:10 years

- 1 m  closed 45 times per year
- 1.3 m  closed permanent
- 2.1 m  design levels exceeded 1:10 years

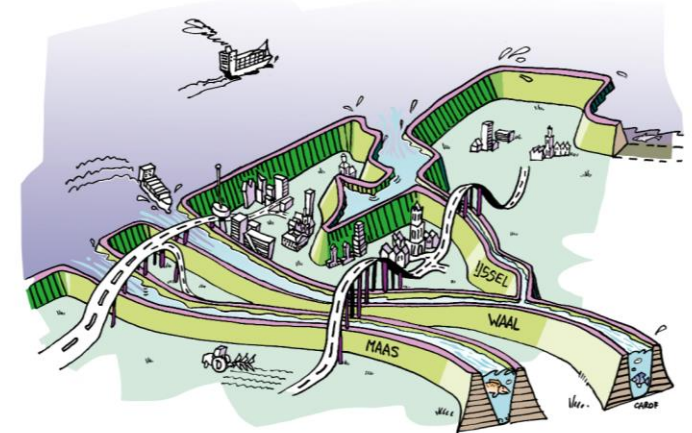


4 types of strategies for adaptation to sea-level rise

Protect-closed



Protect-open



Advance



Accommodate



<http://nladapt.deltares.nl>

Haasnoot et al 2019

Van Alphen 2022

Deltares

Cartoons developed by Carof for Deltares

Deltares

Netherlands: Four alternative long term strategies to adaptation

Protect - closed



1 Rivieren via pompsysteem Nieuwe Waterweg, Haringvliet en evt. Grevelingen



2 Afvoerverdeling aanpassen en pompsysteem Nieuwe Waterweg en/of Haringvliet

Protect - open



1 Open verbinding rivieren



3 Deels gesloten, rivieren omleiden

Seaward

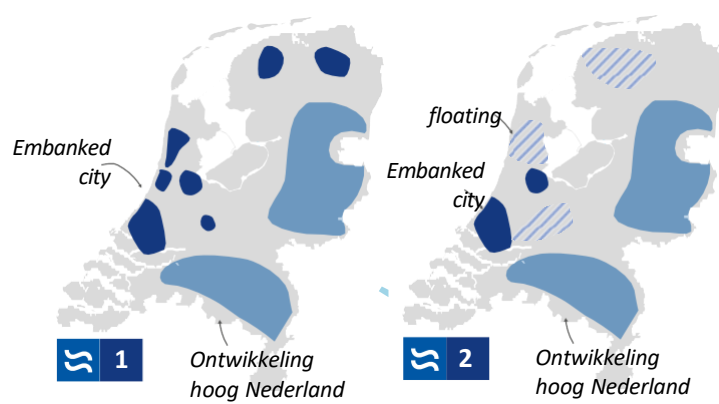


1

2 Verbonden eilanden

3 Zeewaarts uitbreiden

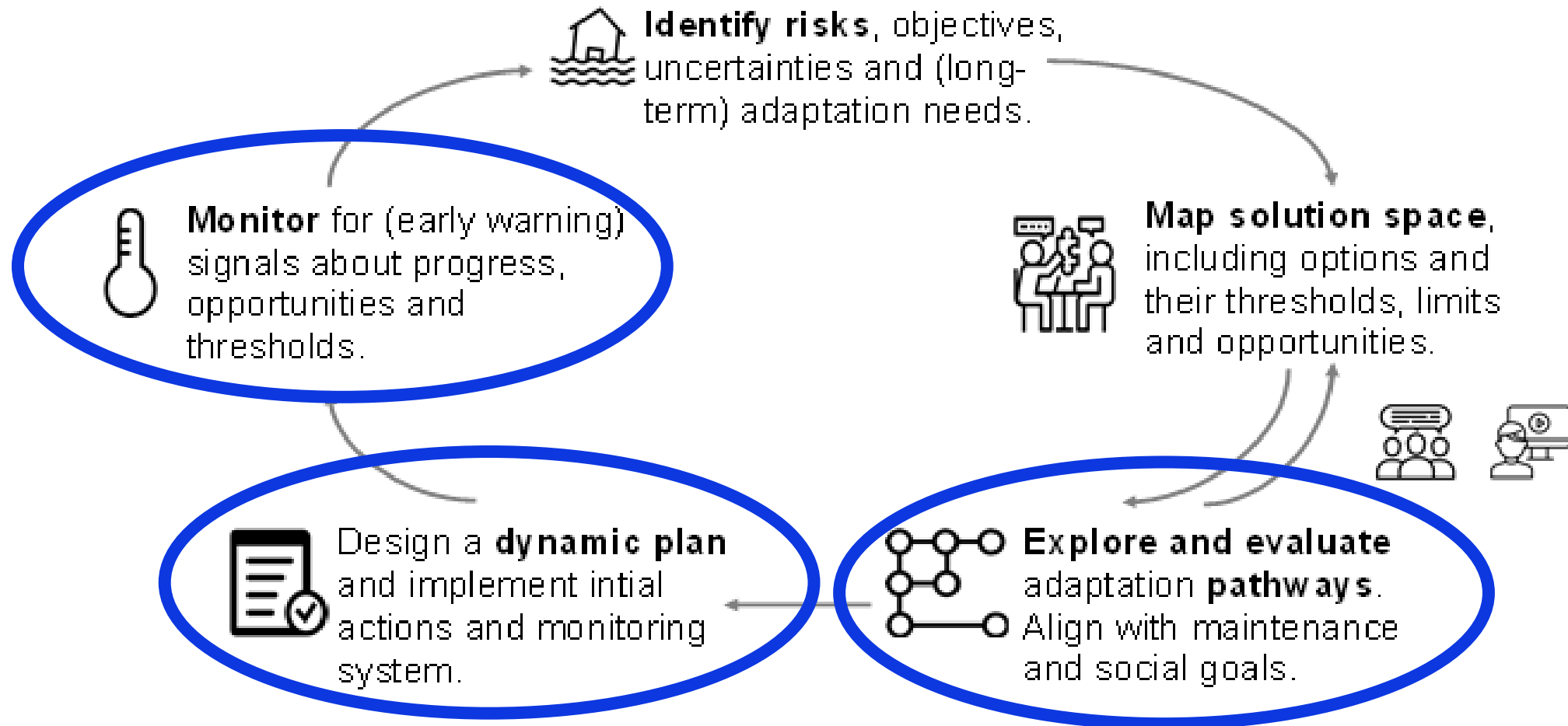
Accommodate&relocate

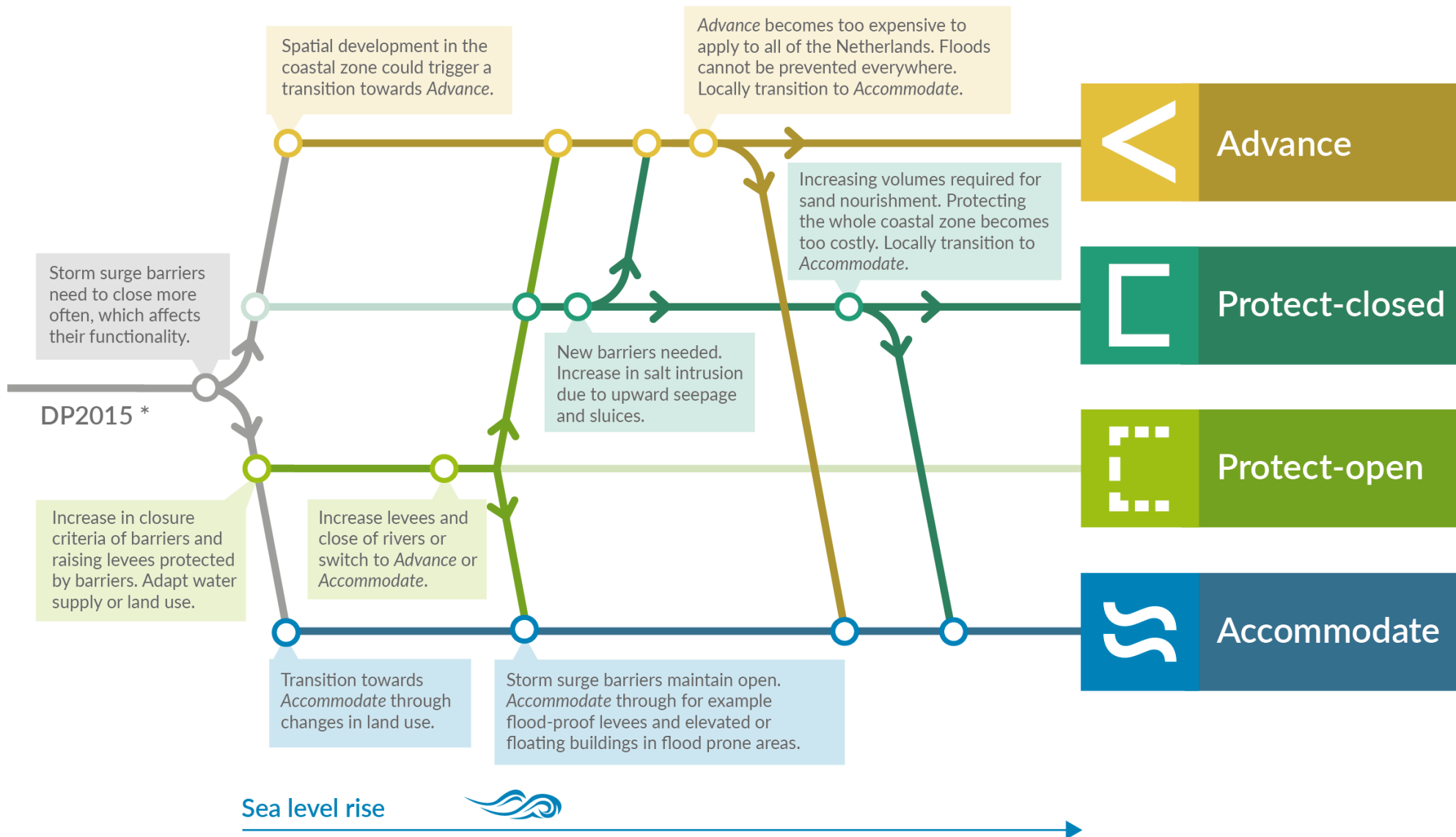


1 Ontwikkeling hoog Nederland

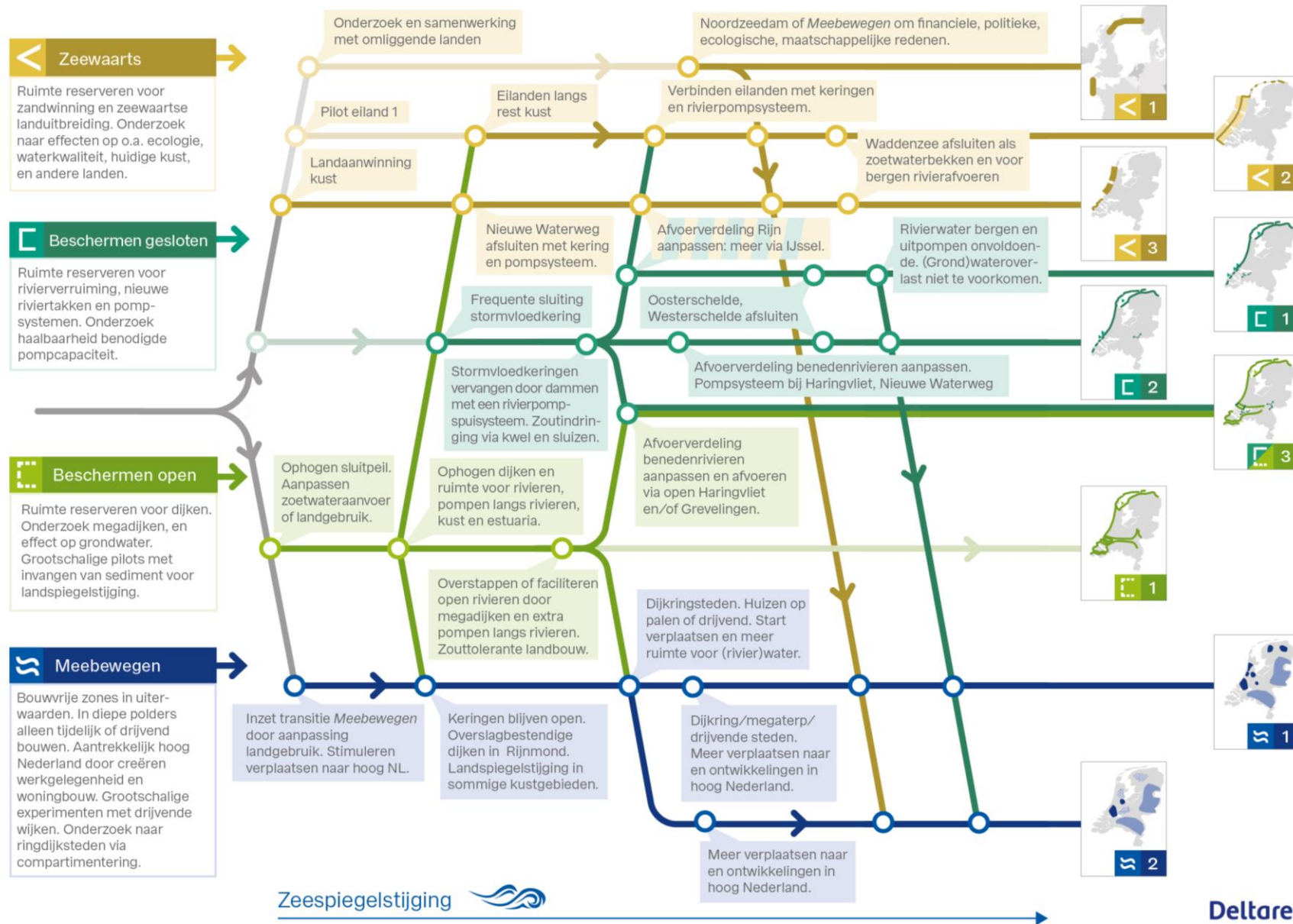
2 Ontwikkeling hoog Nederland

Dynamic Adaptation Pathways





Adaptation pathways, pivotal and low-regret decisions



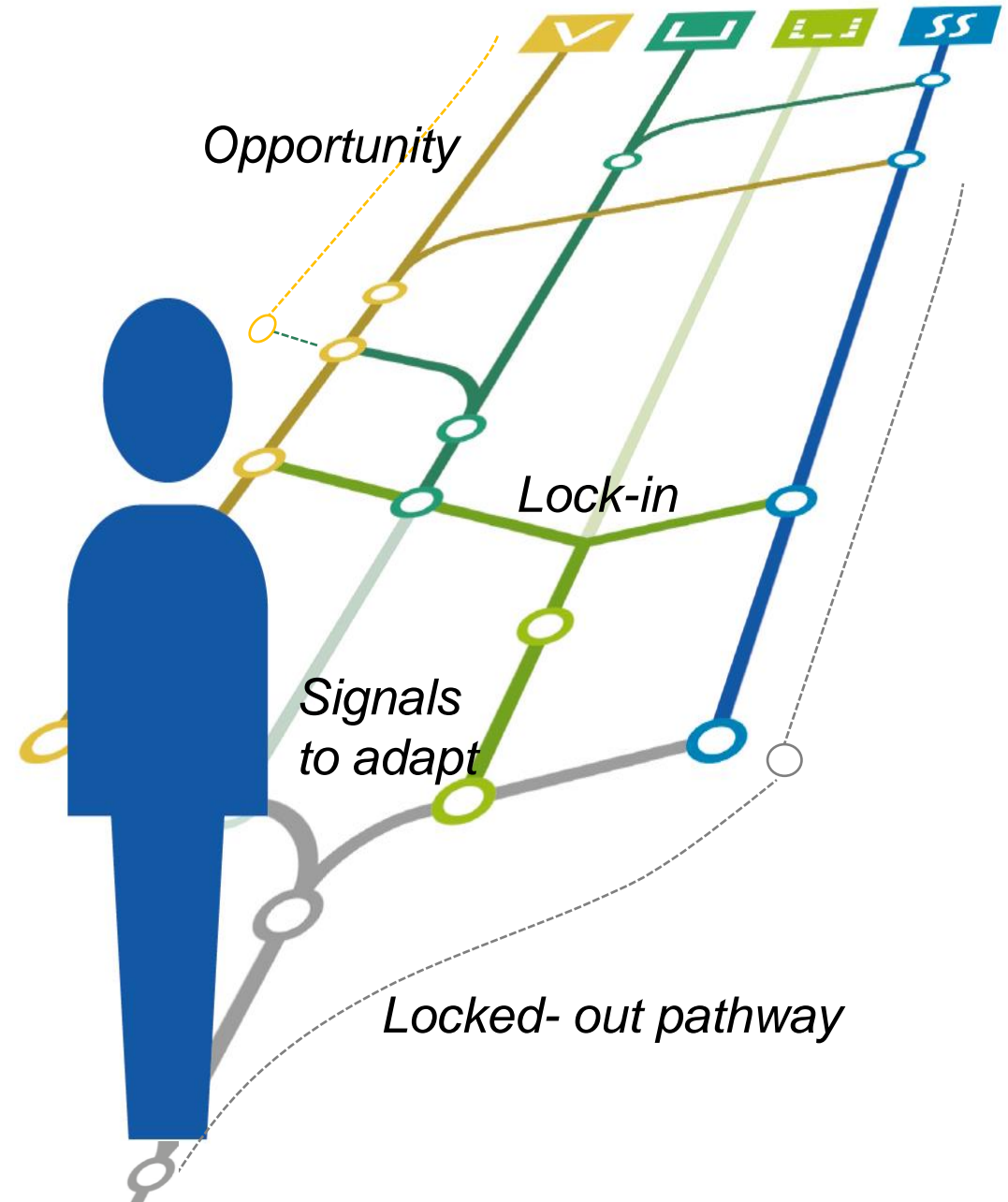
Activities at sea
Pilots for islands

Maeslant Barrier
Rivers

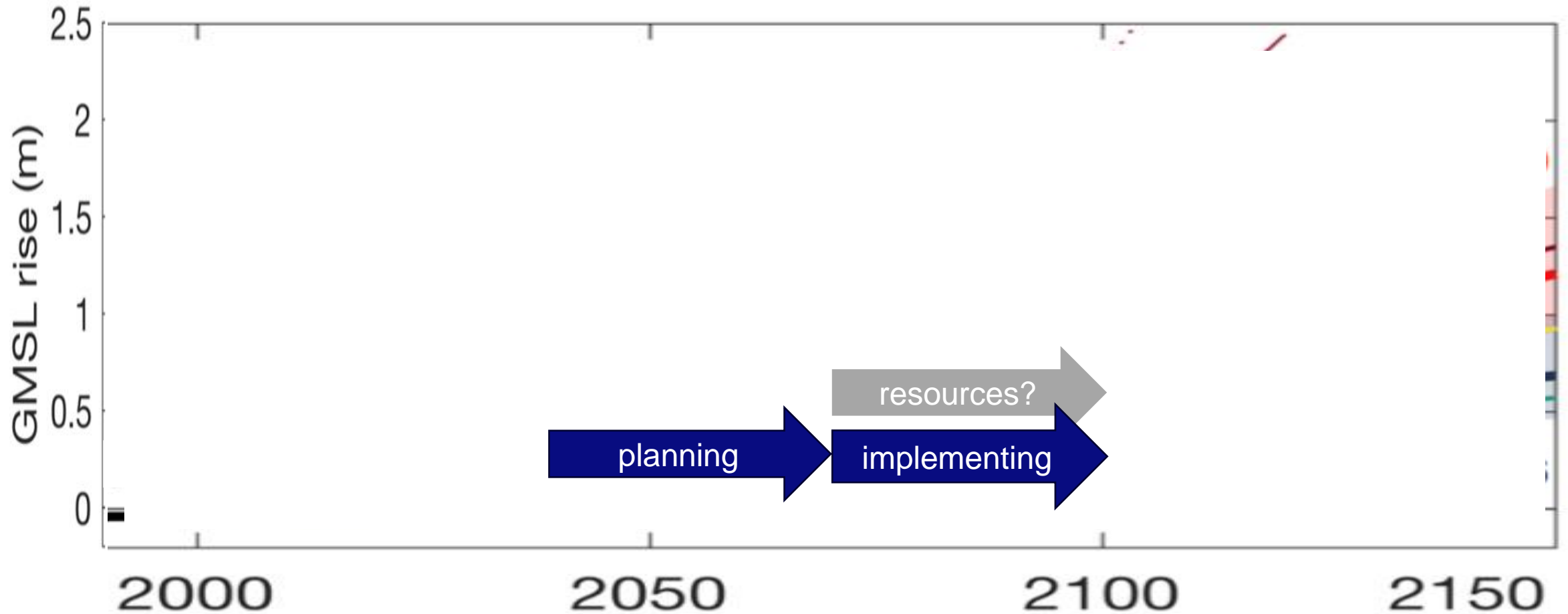
Developments
low-lying parts

Exploring adaptation pathways

- Connect adaptation tipping point to signals
- Conduct research to identify ocean signals for coastal adaptation tipping points

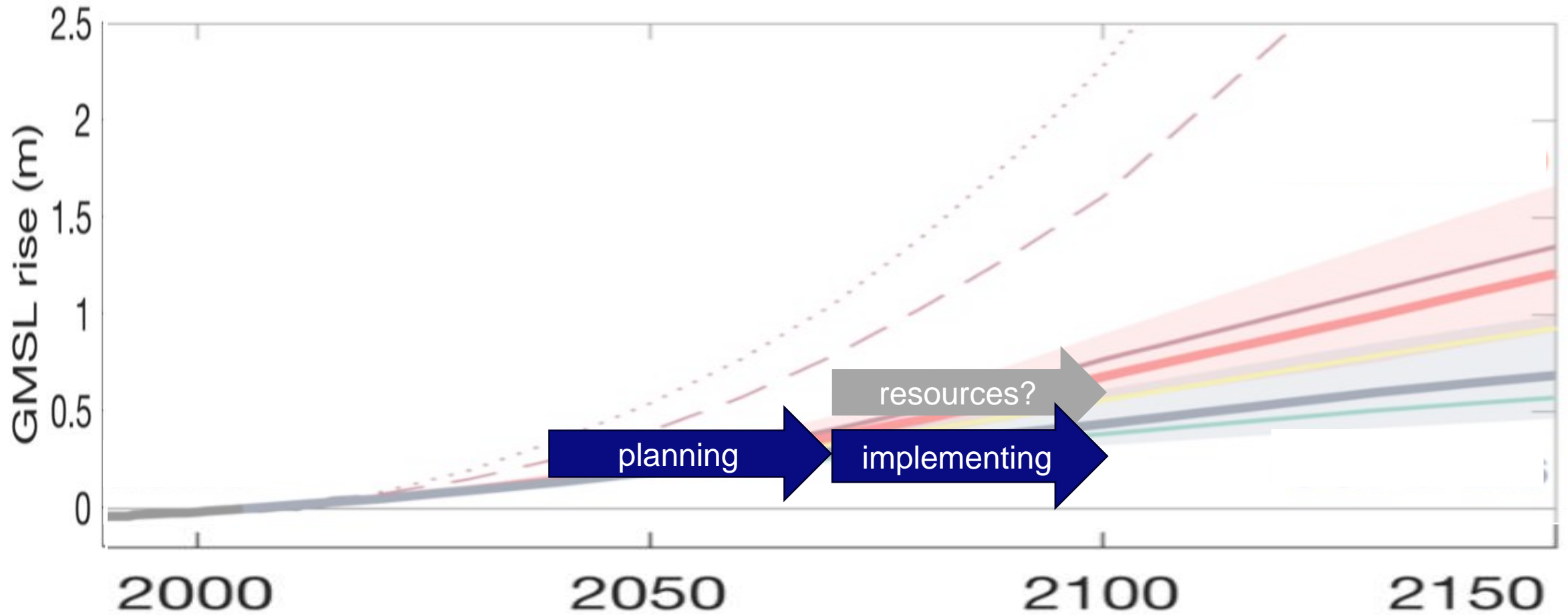


When to start?



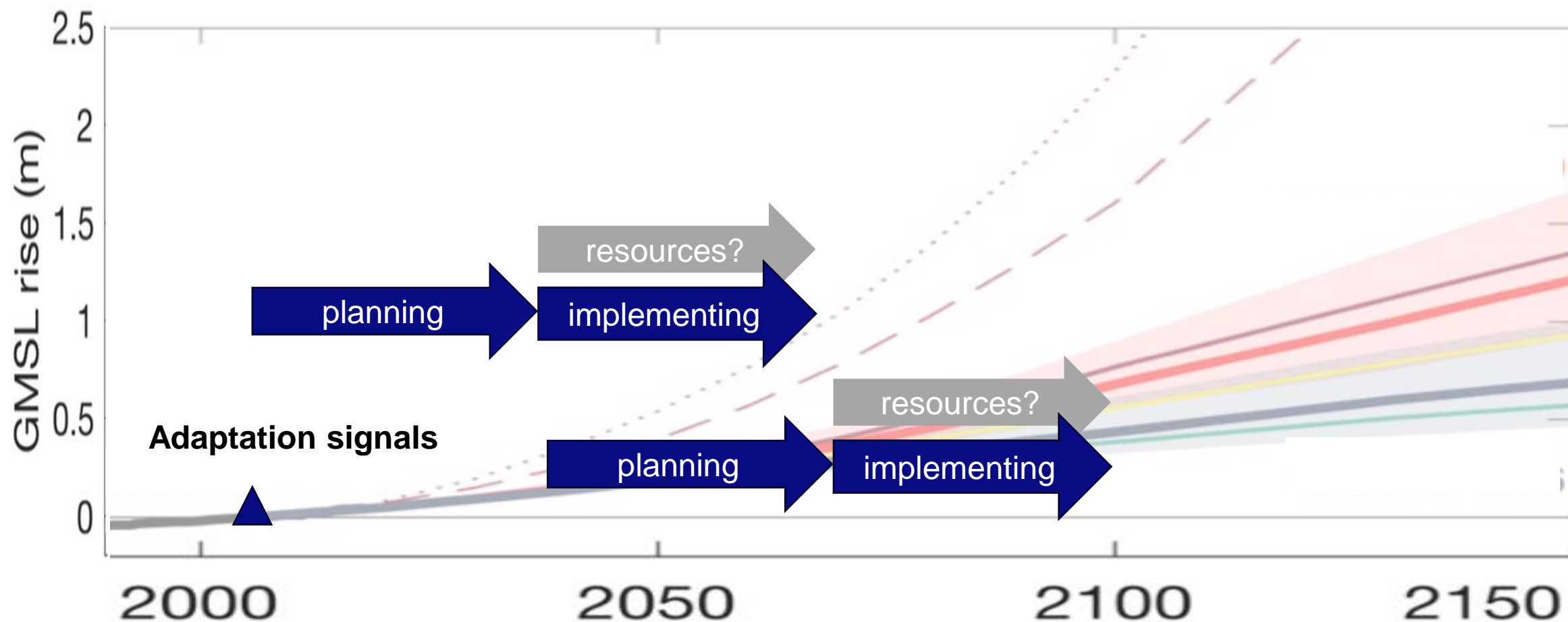
Sea level rise: IPCC WG1 2021; Pathways: Haasnoot et al 2020

When to start?



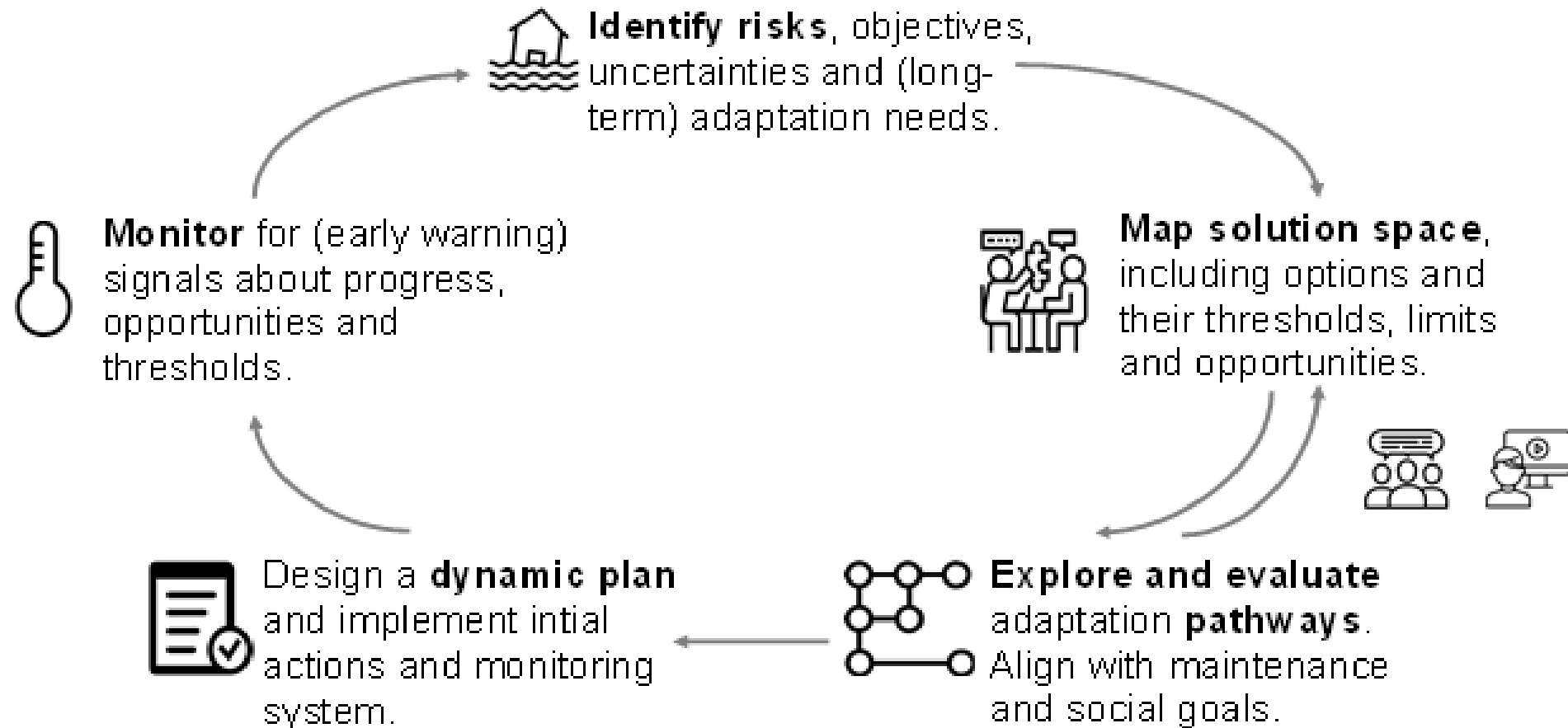
Sea level rise: IPCC WG1 2021; Pathways: Haasnoot et al 2020

When to start?



Sea level rise: IPCC WG1 2021; Pathways: Haasnoot et al 2020

Dynamic Adaptation Pathways



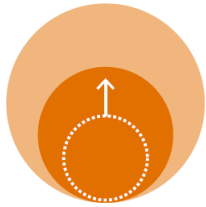
Take home



- Increasing water challenges in all scenarios



- Water challenges are piling up: a water shortage and water nuisance and flooding and other social challenges

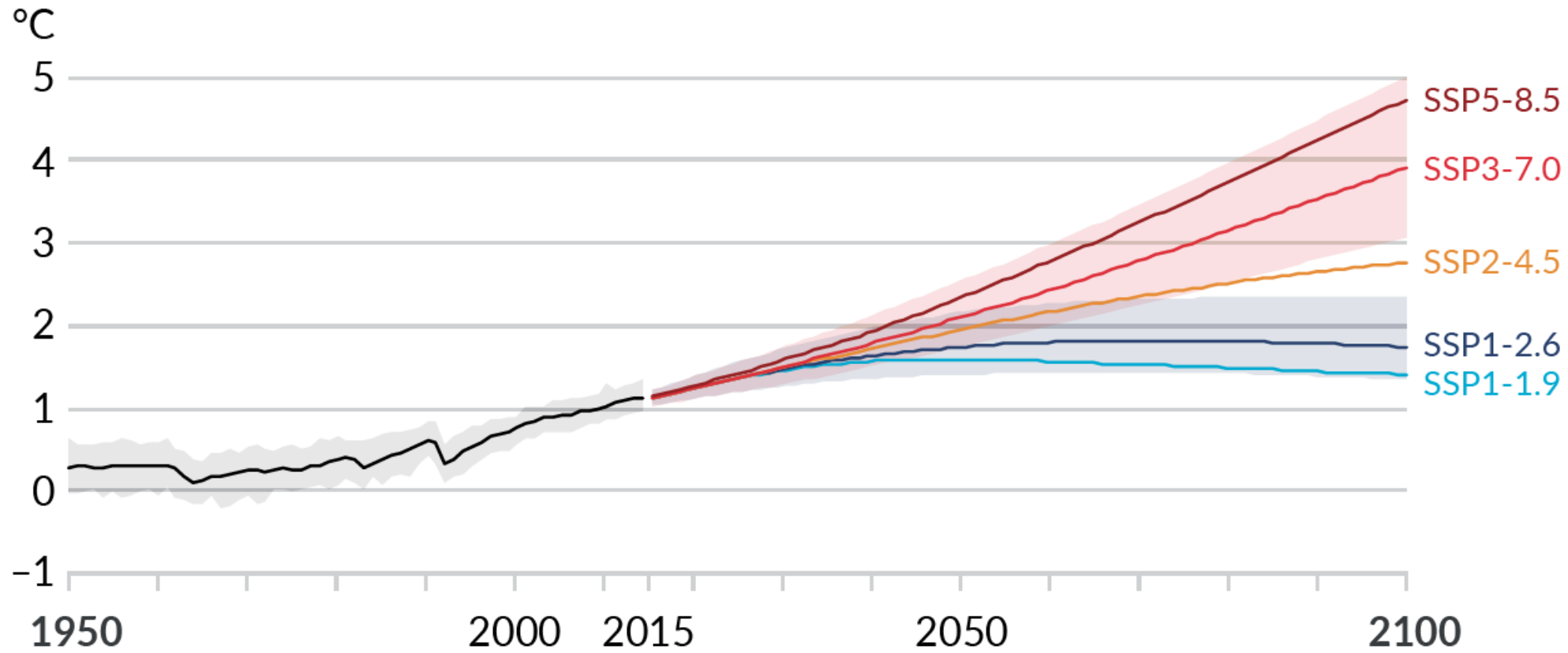


- More climate change results in greater water tasks: less time to adapt, larger tasks, increased bandwidth to work with.



- Large band width of possible climate change and sea-level rise
- Rate of change is important
- Adaptation can alter the deltaic system largely
- Conduct research to identify ocean signals for coastal adaptation tipping points

(a) Global surface temperature change relative to 1850–1900



Sea-level rise

Netherlands

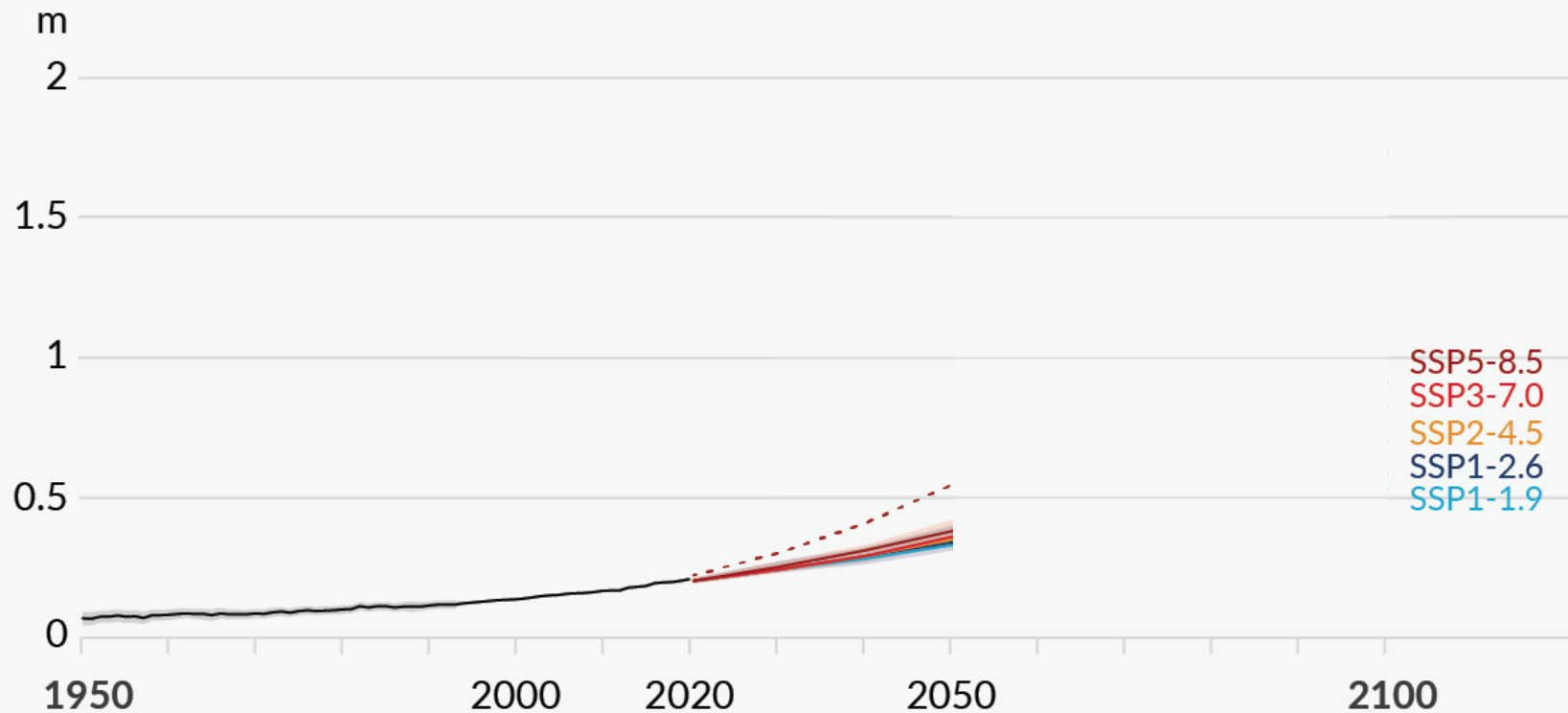
2050

SSP1-2.6: 0,14 - 0,38 m

SSP5-8.5: 0,16 - 0,48 m

- Limited difference between slr-projections in 2050

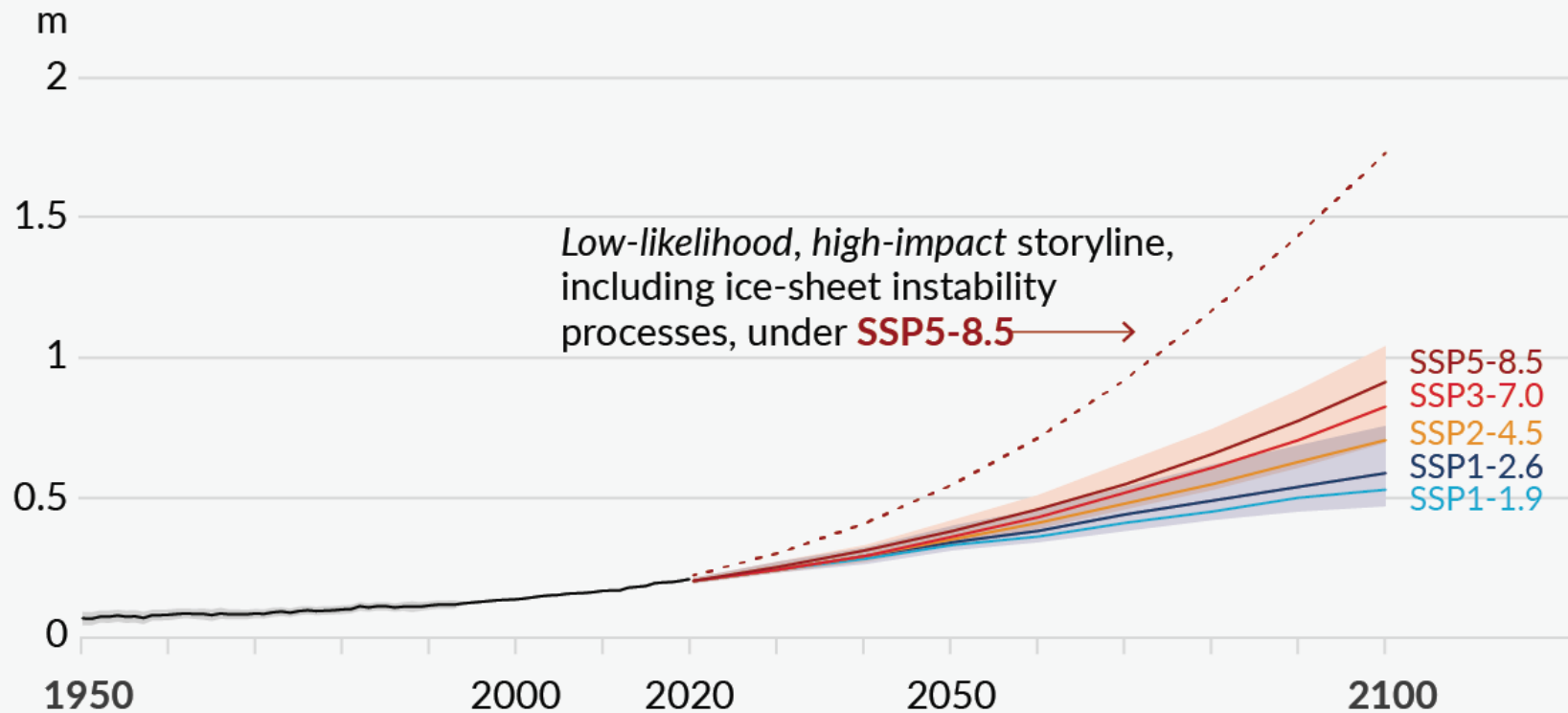
(d) Global mean sea level change relative to 1900



Sea-level rise

The influence of emission increases after 2050

(d) Global mean sea level change relative to 1900



Netherlands

2050

SSP1-2.6: 0,14 - 0,38 m

SSP5-8.5: 0,16 - 0,48 m

2100

SSP1-2.6: 0.30 – 0,81 m

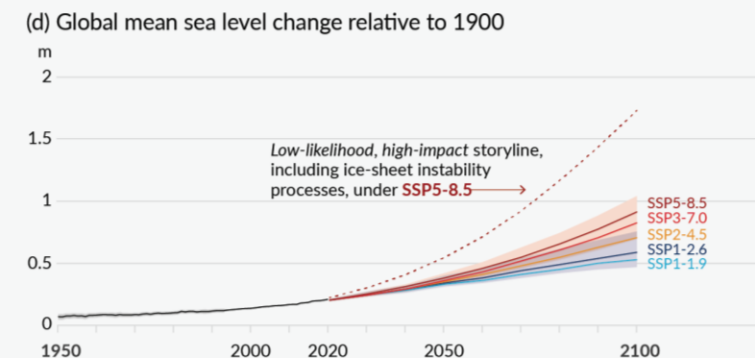
SSP5-8.5: 0,54 – 1,21 m

Sea-level rise

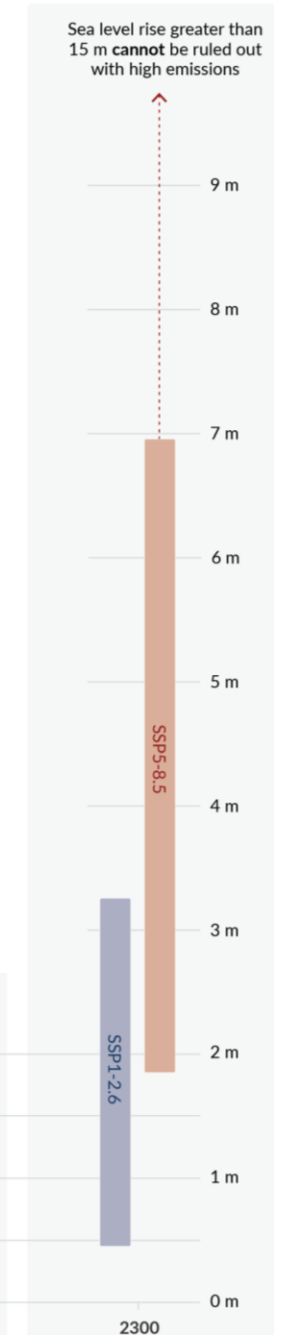
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Deltares

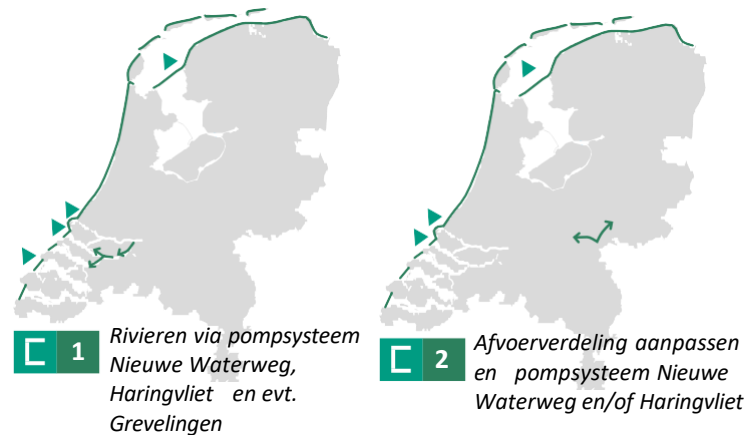


(e) Global mean sea level change in 2300 relative to 1900

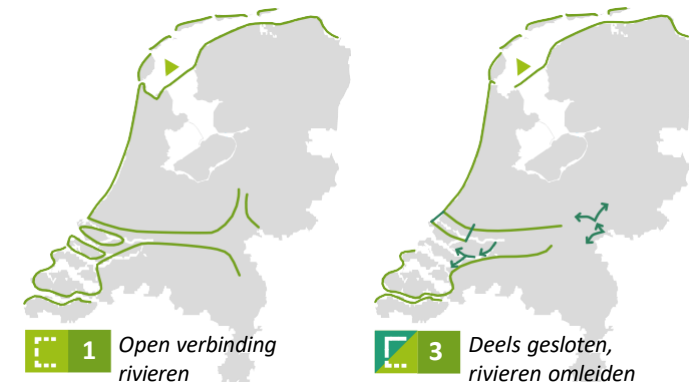


4 types of strategies for adaptation to sea-level rise

Protect-closed



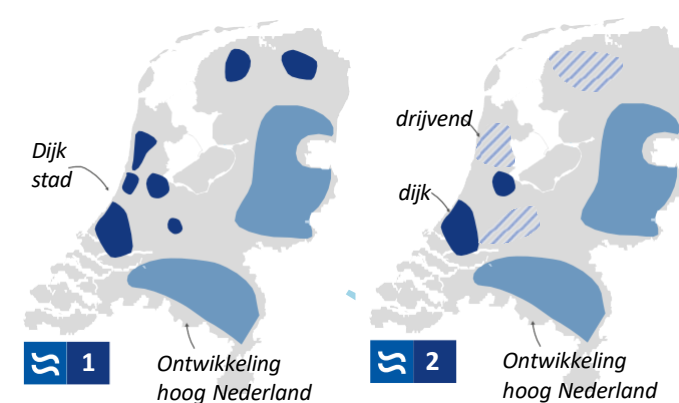
Protect-open



Advance



Accommodate



<http://nladapt.deltares.nl>

Haasnoot et al 2019

Van Alphen et al 2022

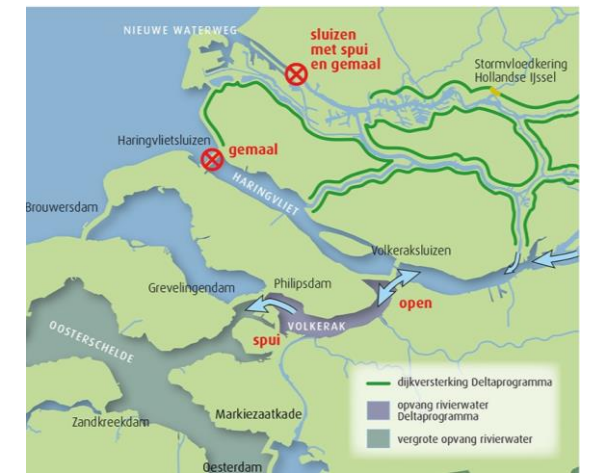
Protect-closed

- Reserve space for river widening, new river branches and pumping systems
- Research the feasibility of required pumping capacity.



River discharge are pumped to the sea via Nieuwe Waterweg, Haringvliet (and Grevelingen)

Change river discharge distribution and pumps in Nieuwe Waterweg and/ or Haringvliet



Source: Plan Sluizen, Frank Spaargaren, 2014



(Source: Frédéric Ruys, Vizualism, 2016)



Protect-open

- Space reservations for dike reinforcements.
- Research needed for feasibility mega dike and impact of open system on groundwater
- Scaled-up pilots needed for sediment trapping that stimulates natural land rising



Bron: Rijkswaterstaat



Deltares

Open connection
rivers

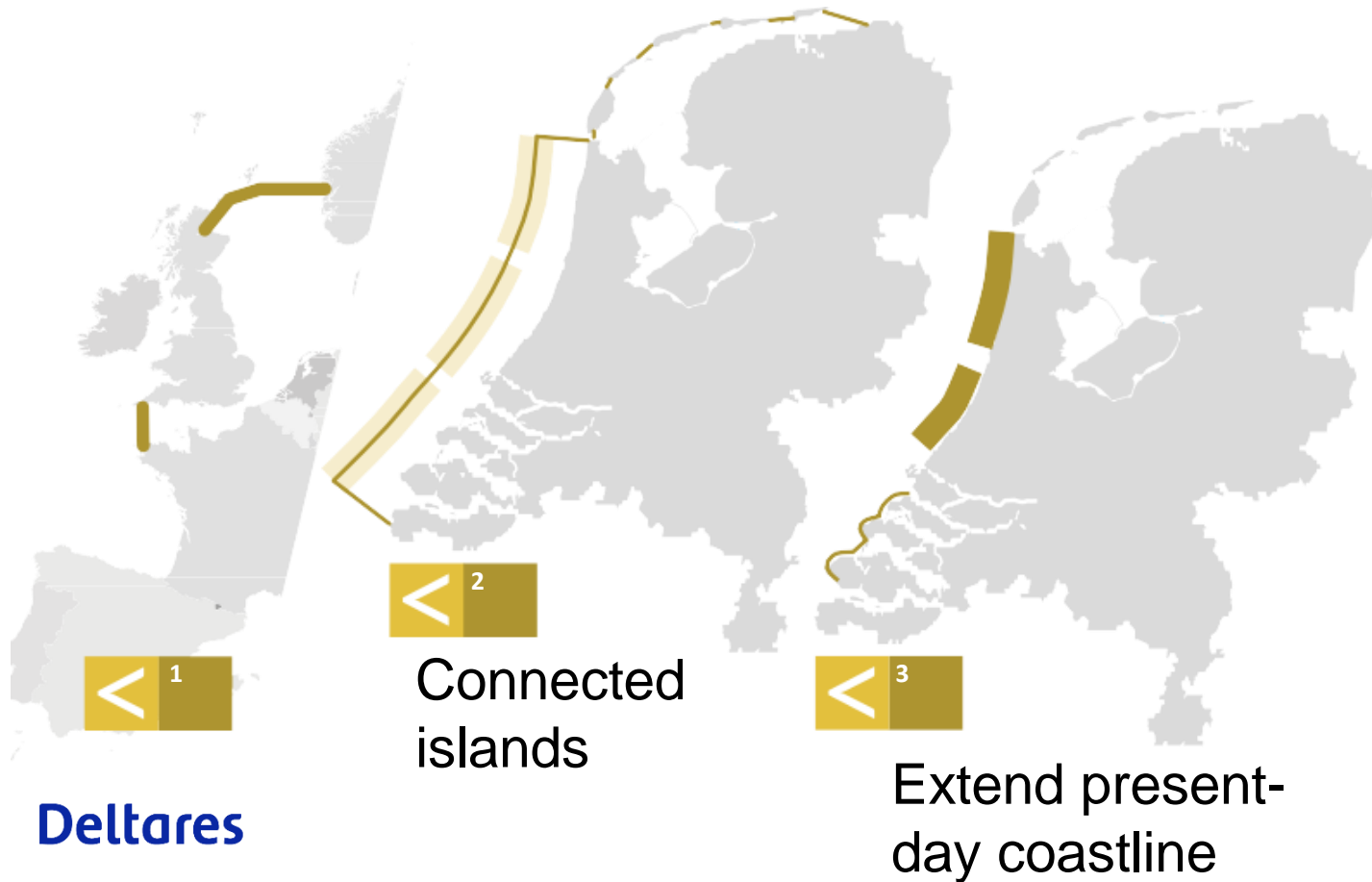


Hybrid, partly closed,
party rerouted river
discharge, partly open



Advance

- Allocate and reserve sand extraction areas and space for seaward extension
- Research needed in impact on ecology, water quality, present-day shore, en neighbouring countries.



Bron beeld: Boskalis 2006

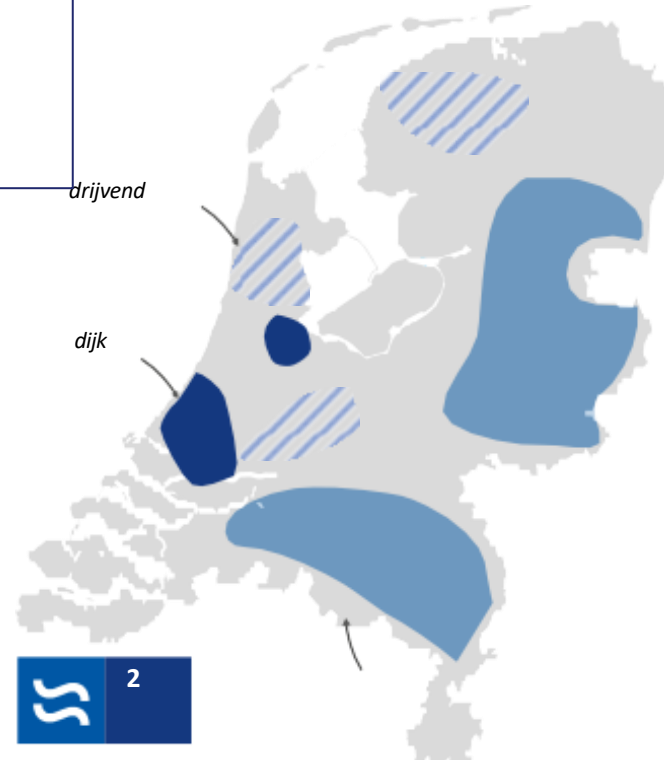


Bron beeld: Plan Waterman, Ronald Waterman, 1980

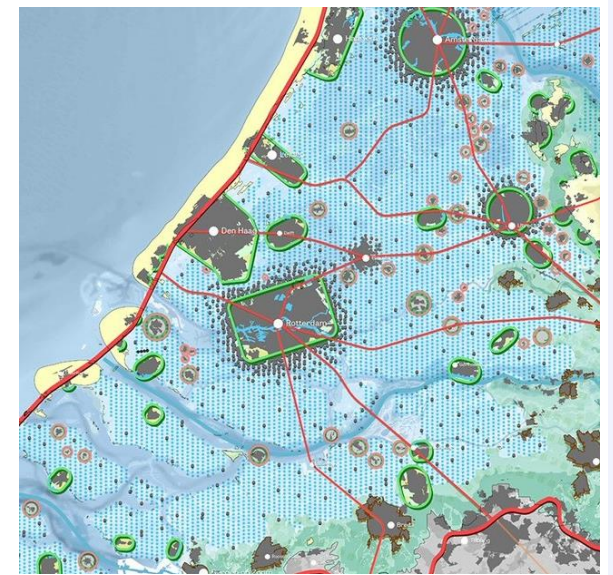


Accommodate

- No-build zones in floodplains. In deep polders only temporary or floating construction.
- Increase attractiveness of higher areas of NL by creating employment and housing.
- Large-scale experimentation with floating districts and land level rise.
- Research needed into ring dike cities via compartmentalization.



Developments in “higher” areas
 Floating houses
 Stimulate natural sedimentation



Bron beeld: Plan B: NL2200, LOLA, 2020



Bron beeld: Blue Revolution, Blue 21, 2020