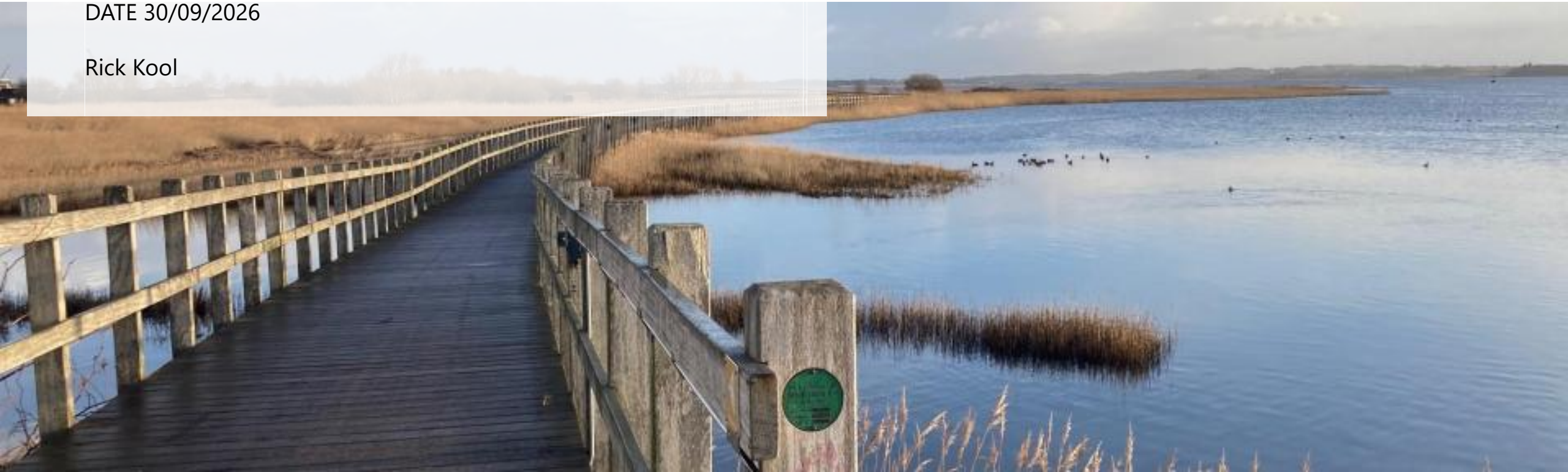


From Adaptation Pathway Development to Adaptive Planning

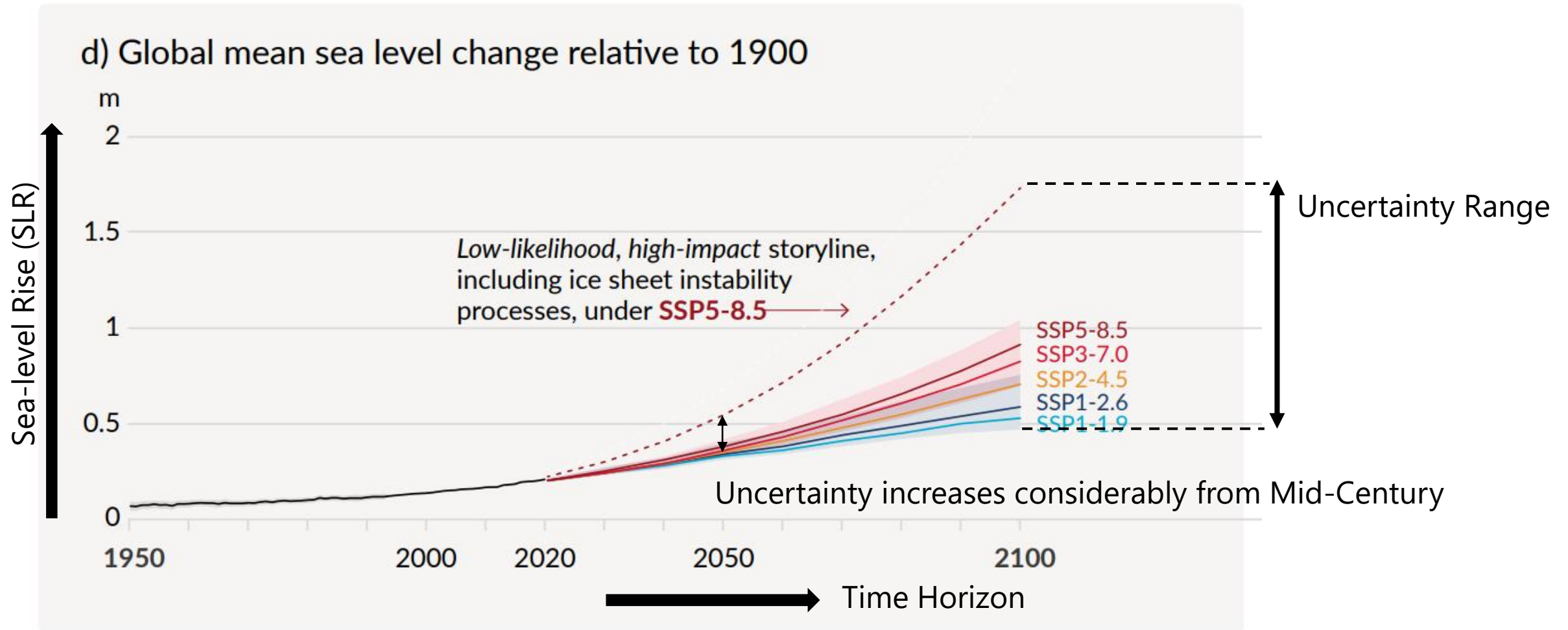
Learnings from applying DAPP in Denmark

DATE 30/09/2026

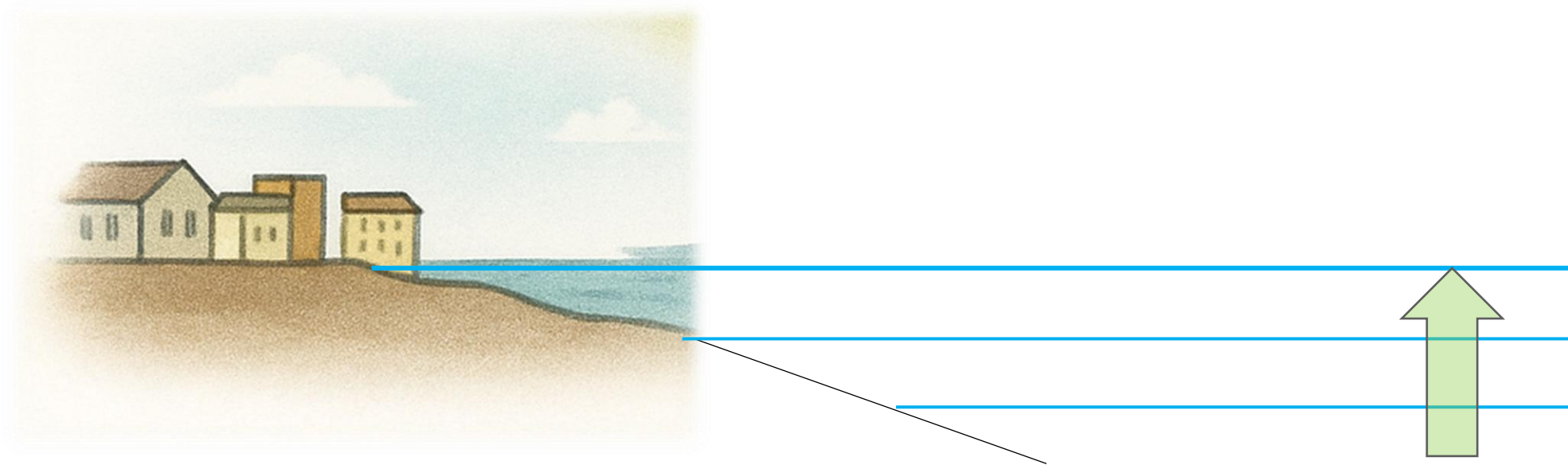
Rick Kool



Growing Uncertainty | Sea-level Rise



Sea-level Rise | From extreme to mean

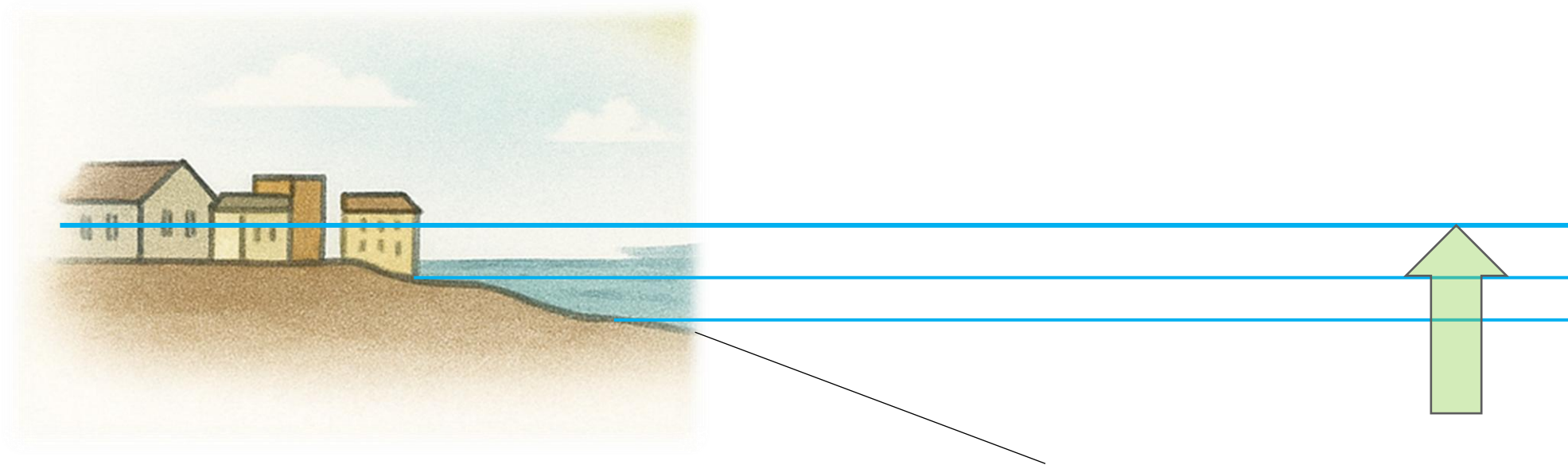


1/100 Current

1/10 Current

MHW

Sea-level Rise | From extreme to mean

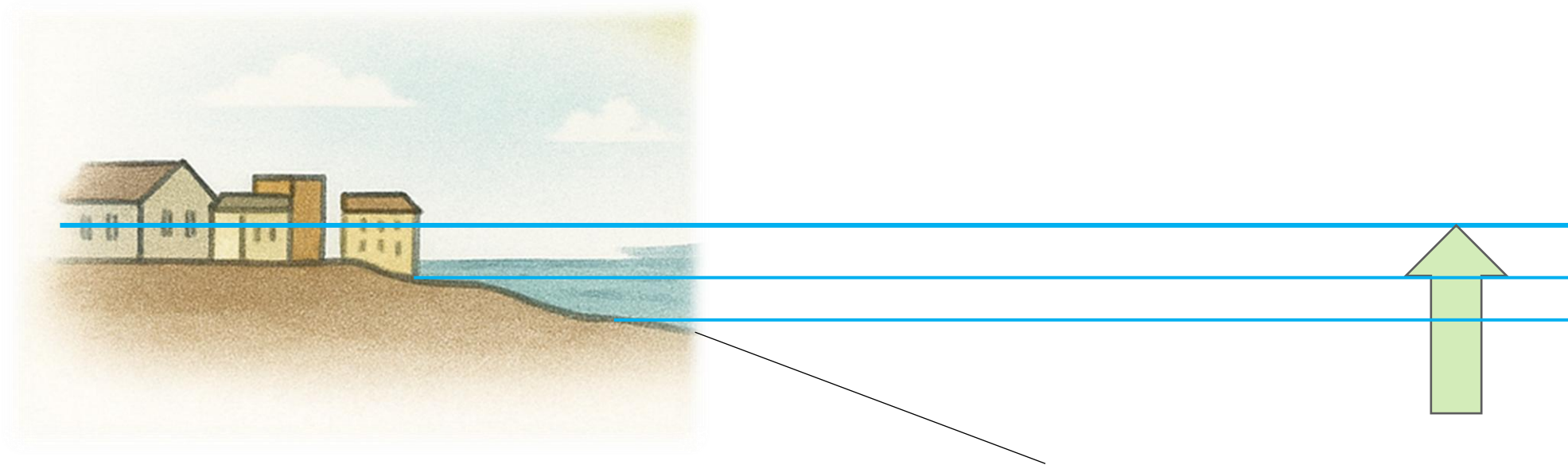


1/100 ?

1/10 ?

MHW

Sea-level Rise | From extreme to mean



1/100 Current

1/10 Current

MHW

Climate Change Risk | Risk Determinants



Hazard

- Sea-level rise
- Increased Rainfall



Vulnerability

- Preparedness
- Adaptive Capacity



Exposure

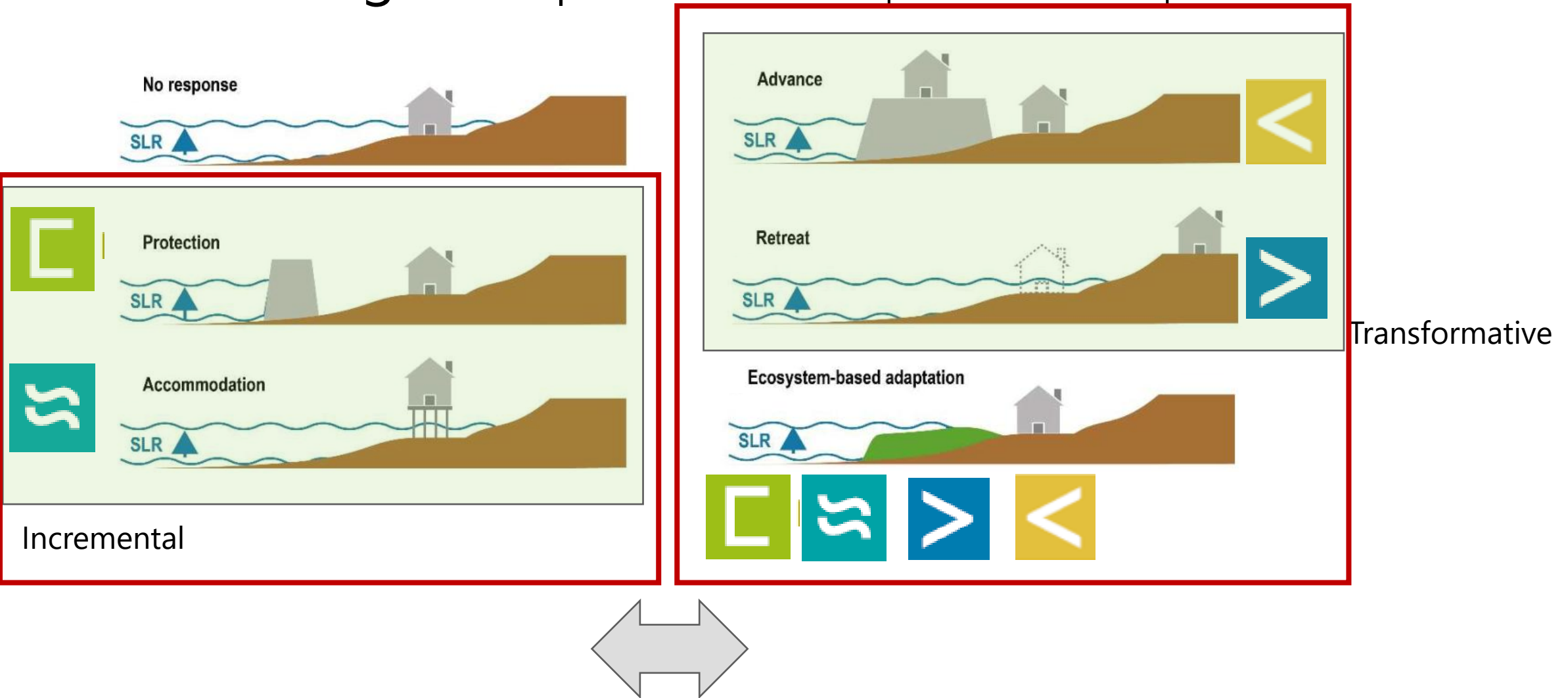
- Infrastructure exposure
- Increased building density



Adaptation Responses

- Planned or Autonomous
- Coastal Adaptation Responses

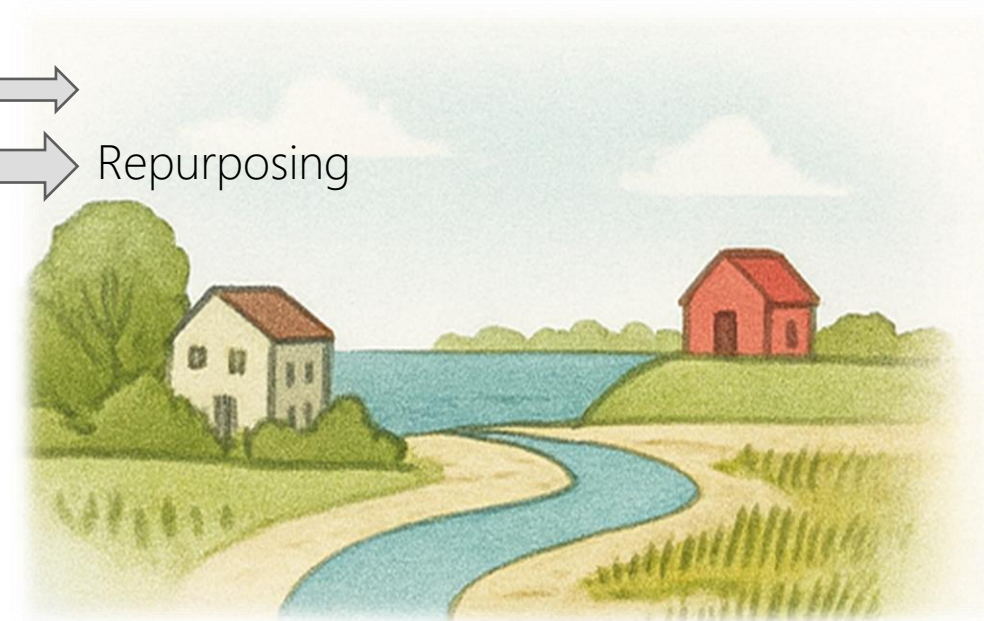
Climate Change Risk | Coastal Adaptation Responses



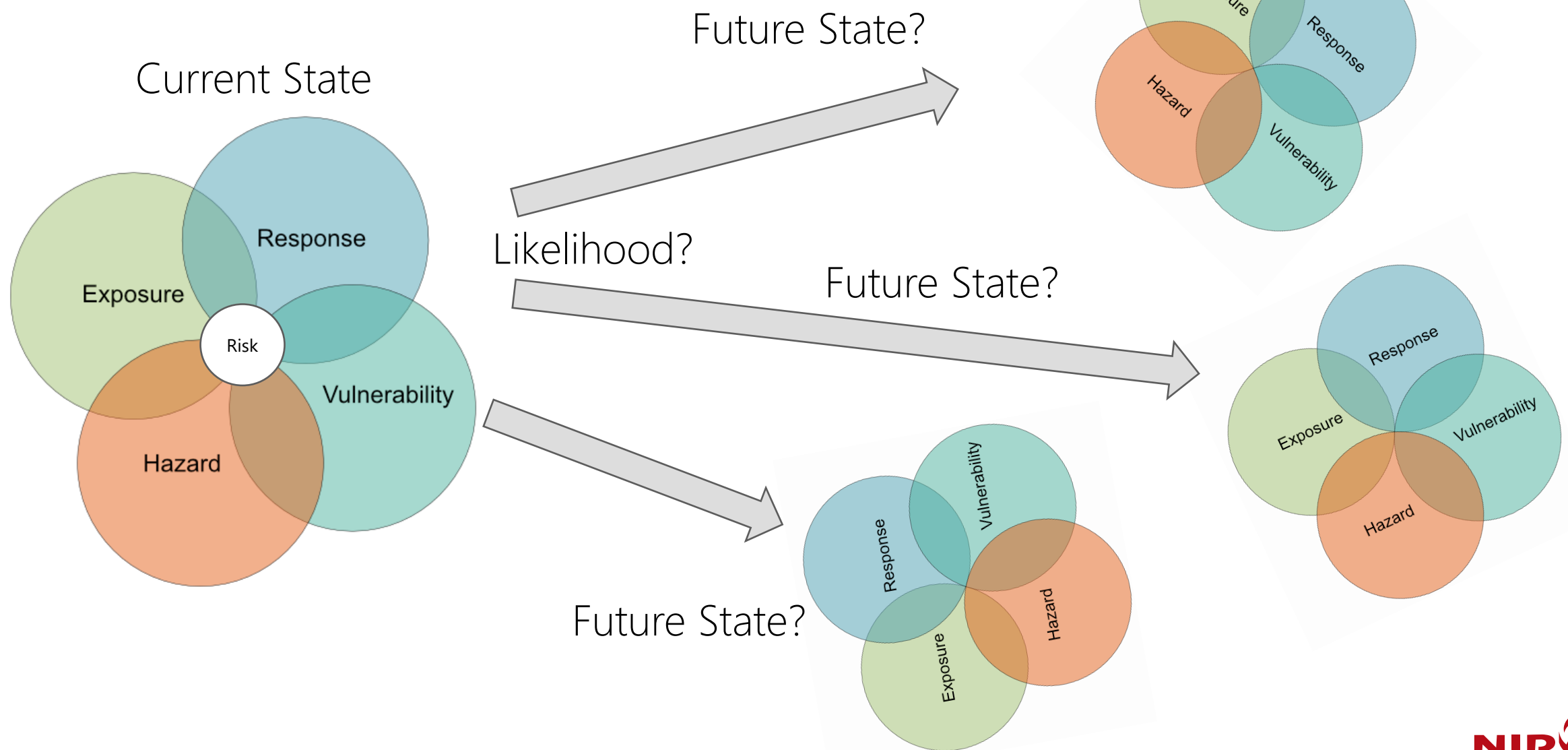
Climate Change Risk | Incremental to Managed Retreat

'Planned retreat that moves people and their assets, pre-emptively and permanently, away from hazards such as sea-level rise and flooding'
(Lawrence et al., 2020)

Prepare and Engage



Climate Change Risk | What is the future risk?

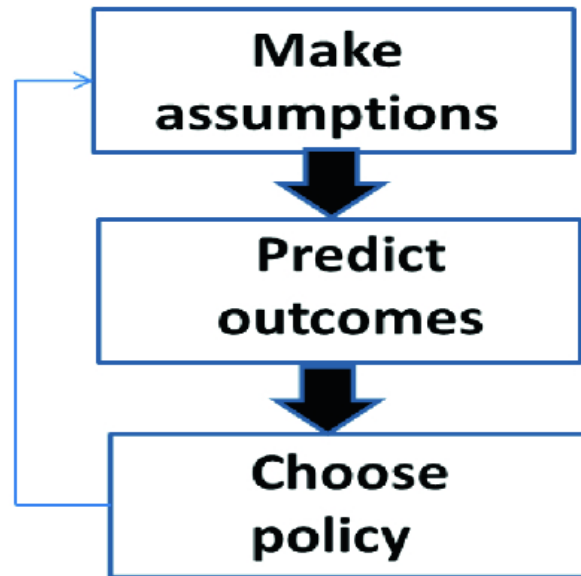


Decision Making under Deep Uncertainty (DMDU) |

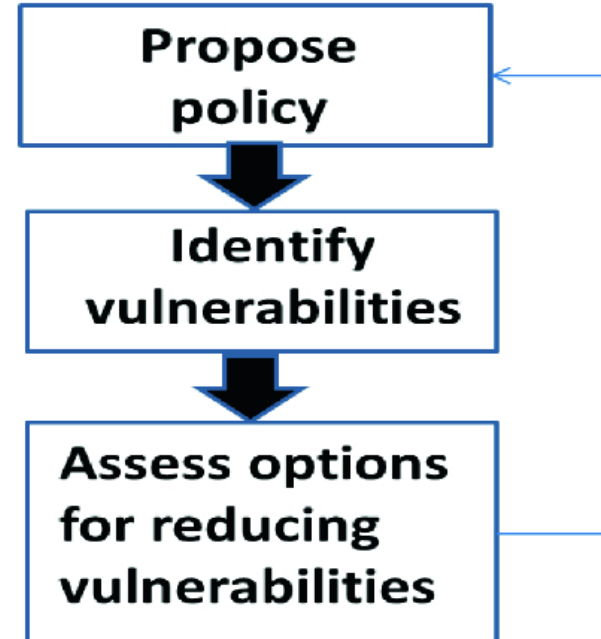
From predict-and-act toward decision-centric approaches

Objective is not to resolve uncertainty, but to investigate how it affects our decisions over time

(a) Traditional Approaches

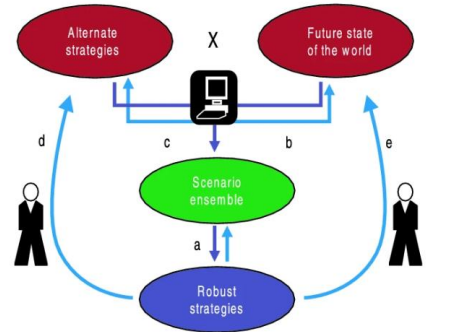


(b) DMDU Approaches



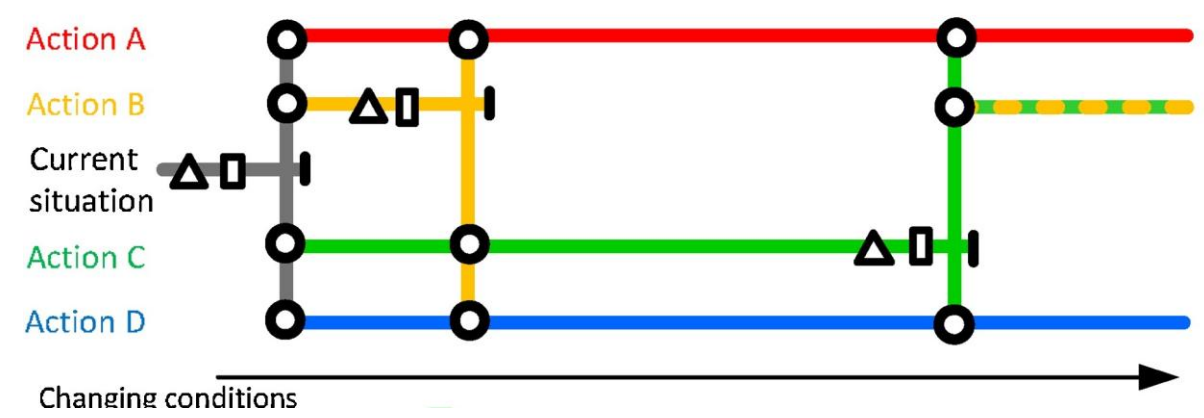
DMDU | Overview

Robust Decision Making (RDM): Focusses on increasing robustness of the adaptation response

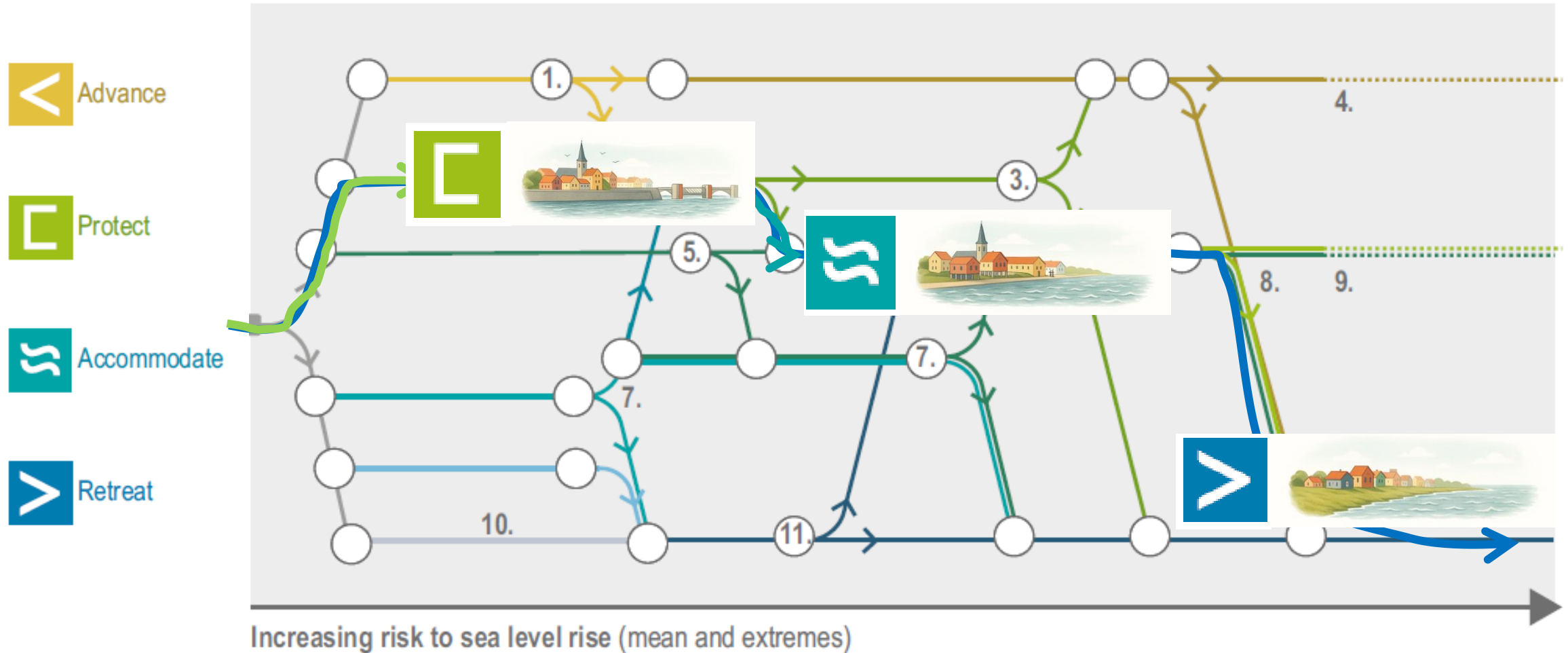


NOTE: Central lines (a, b, and c) represent computer calculations. Lines on the left and right of the figure (d and e) represent new information added by humans.
RAND MR1626

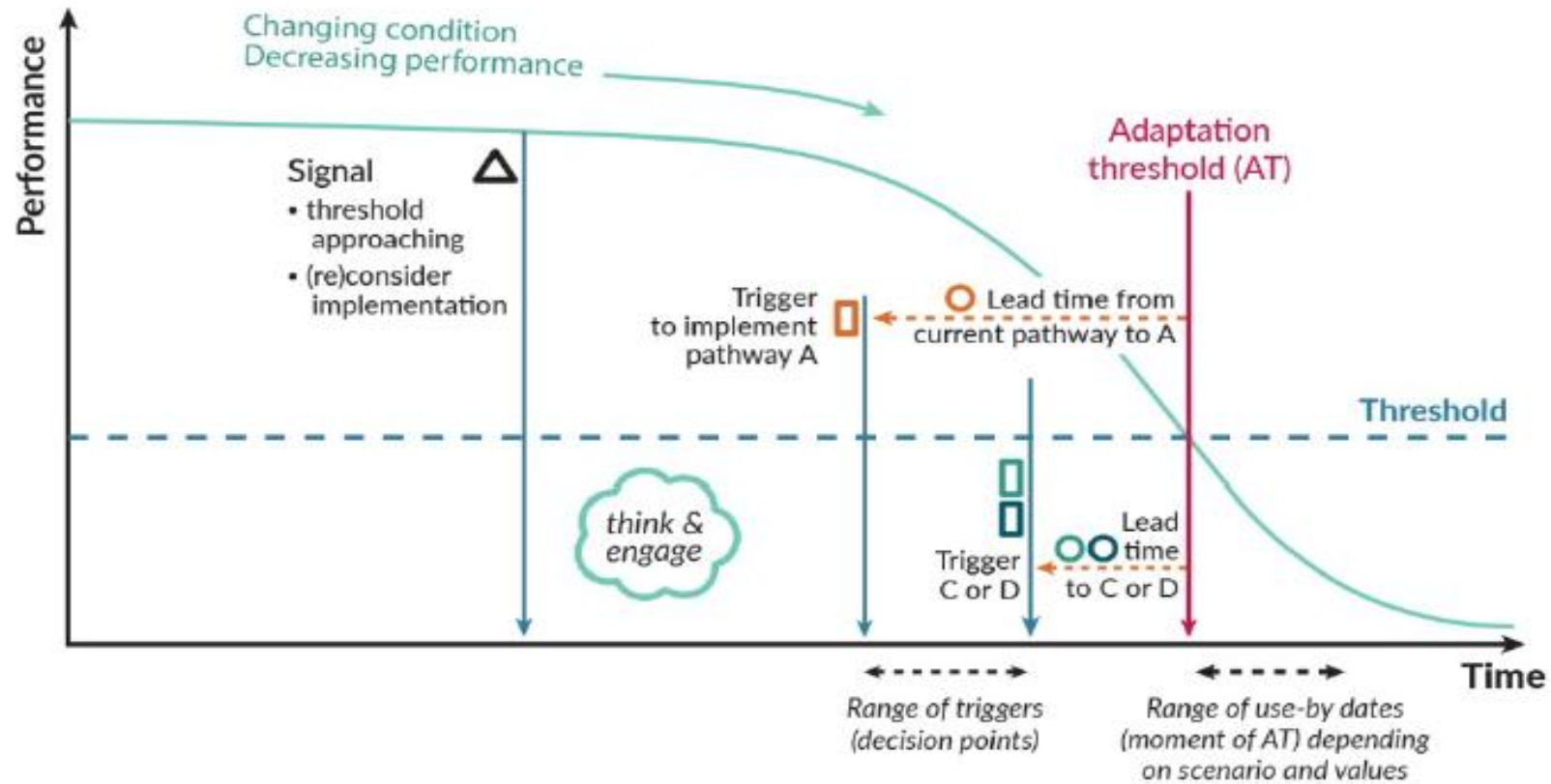
Dynamic Adaptive Pathway Planning (DAPP): Dynamic adaptation sequencing adaptation responses



DAPP | Dynamic Adaptive Pathway Planning

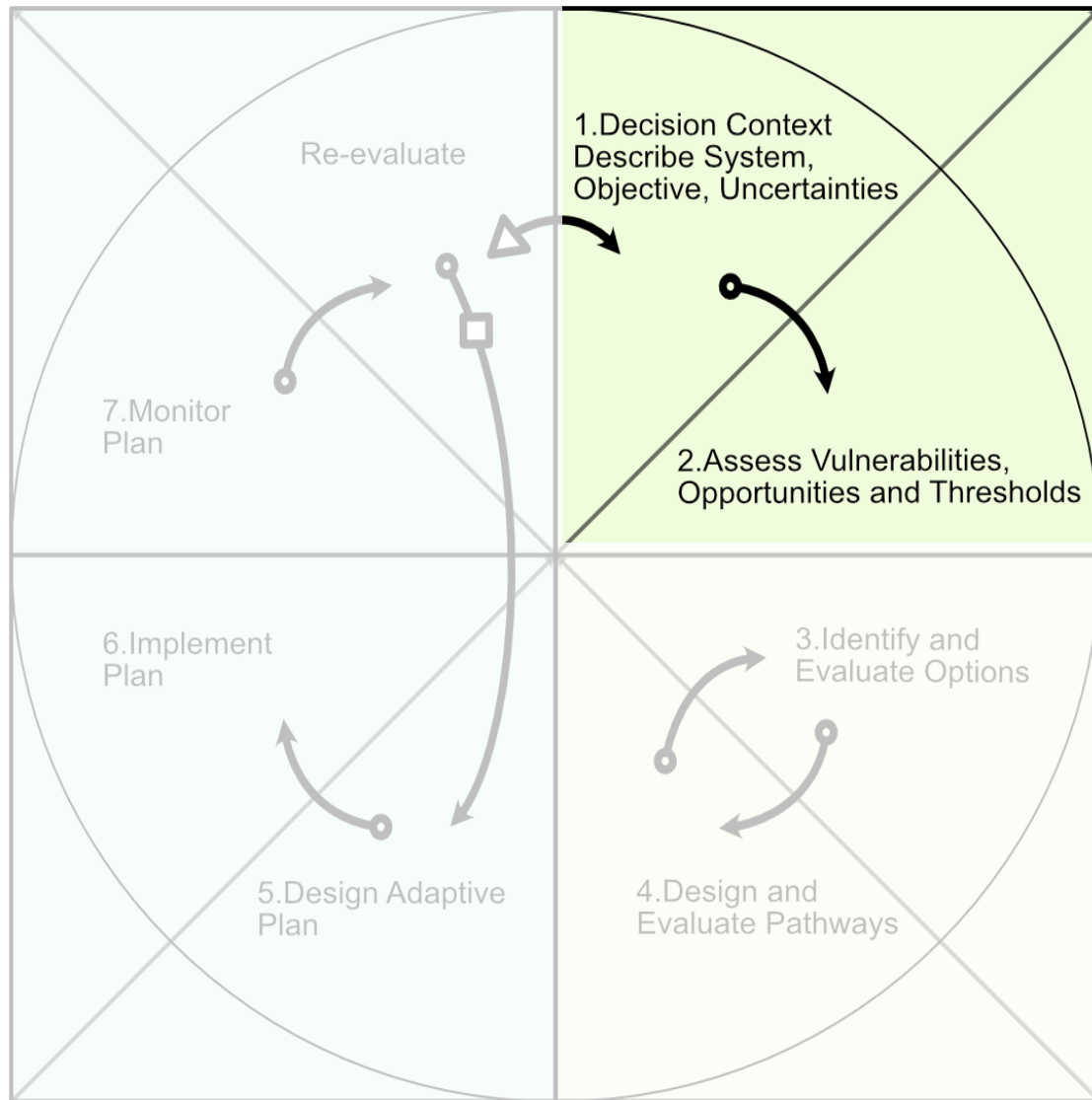


DAPP | Adaptation Threshold



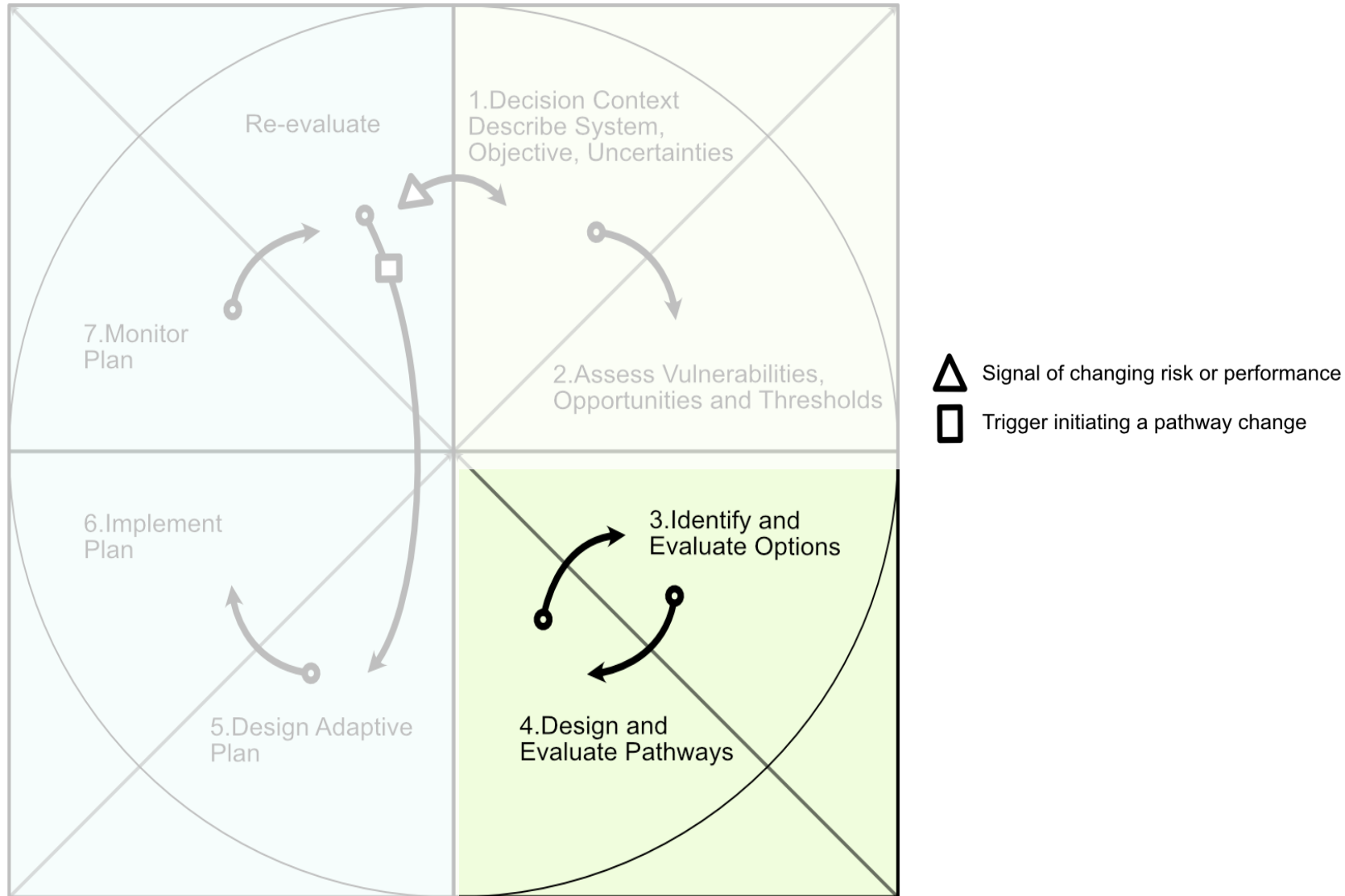
Adapted from: Haasnoot, 2018

DAPP | Uncertainty Objectives and Decisions

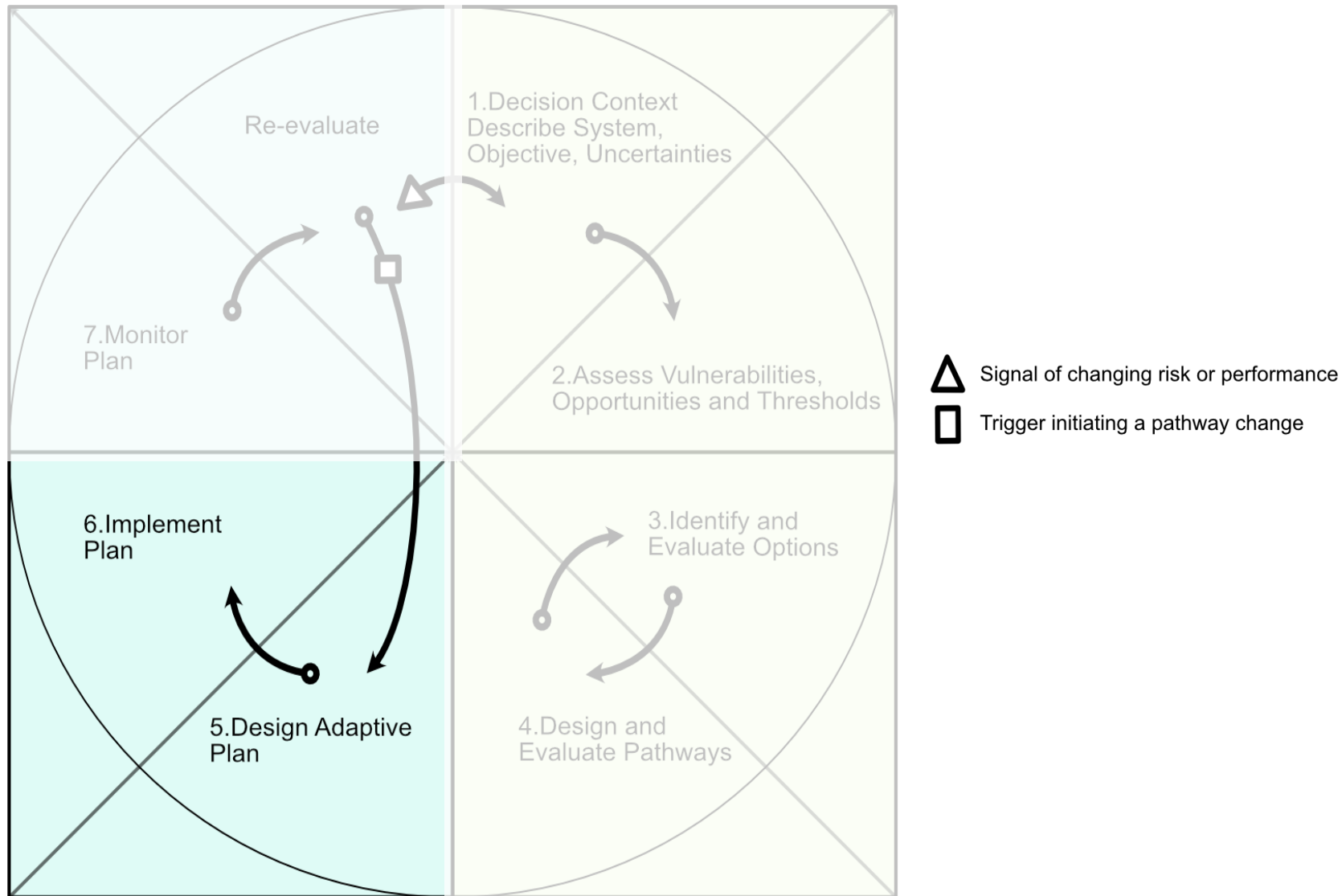


Adapted from Haasnoot et al. (2019)

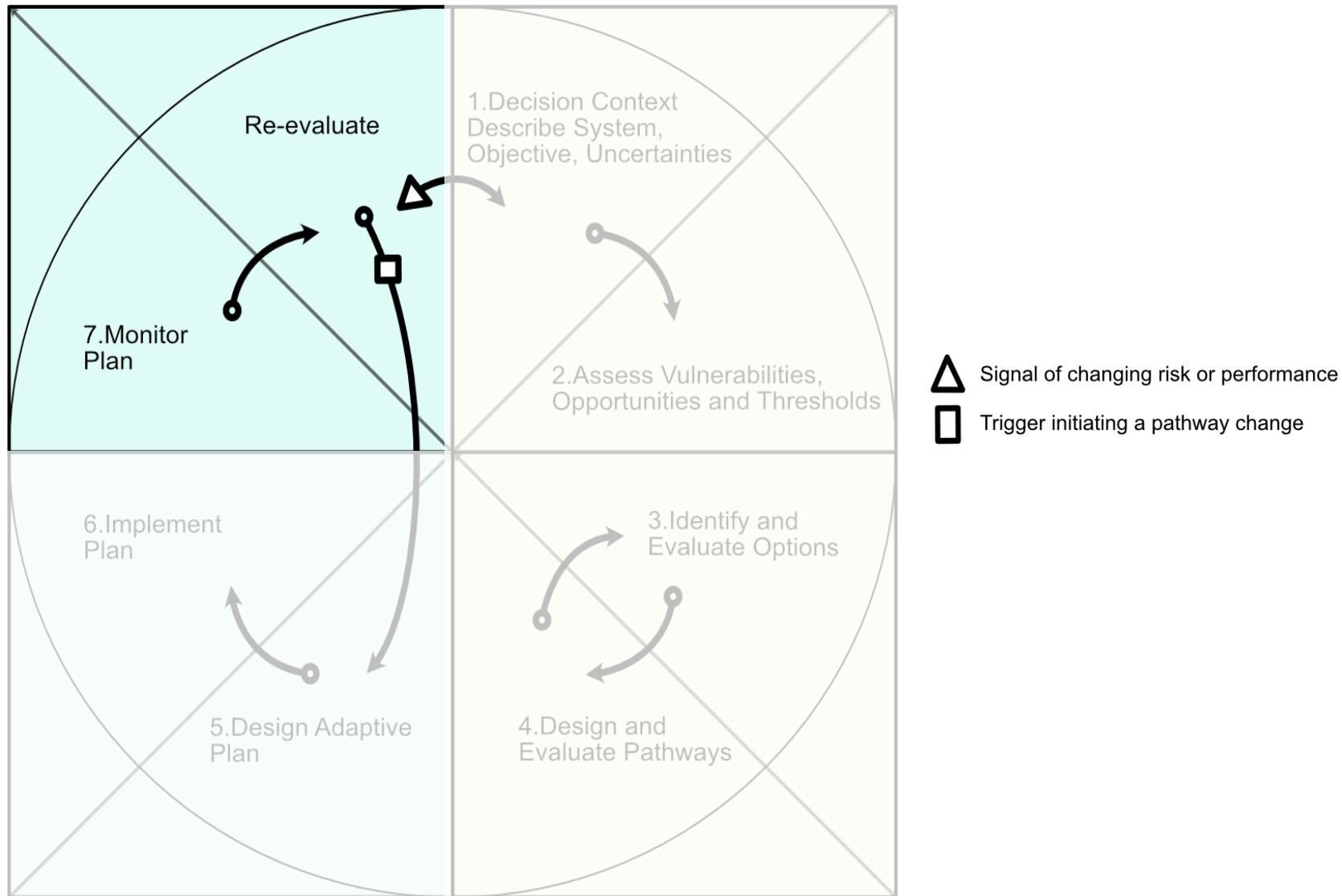
DAPP | Design and Evaluation of Adaptation Responses



DAPP | Design and Implementation of Adaptation Pathways



DAPP | Monitoring and Re-Evaluation



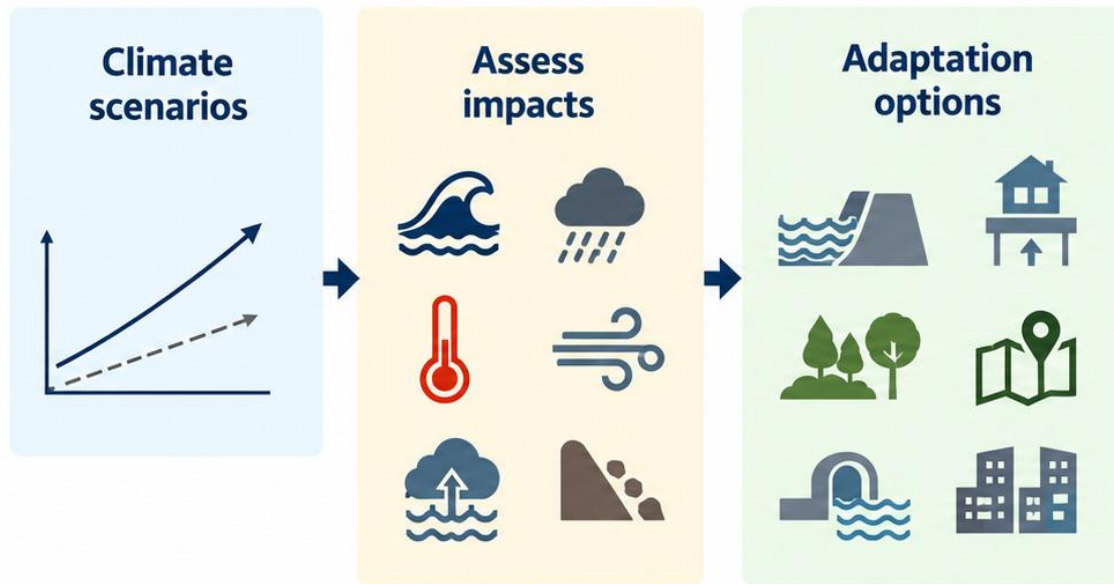
Adapted from Haasnoot et al. (2019)

Climate Change Adaptation | Changing approach to risk

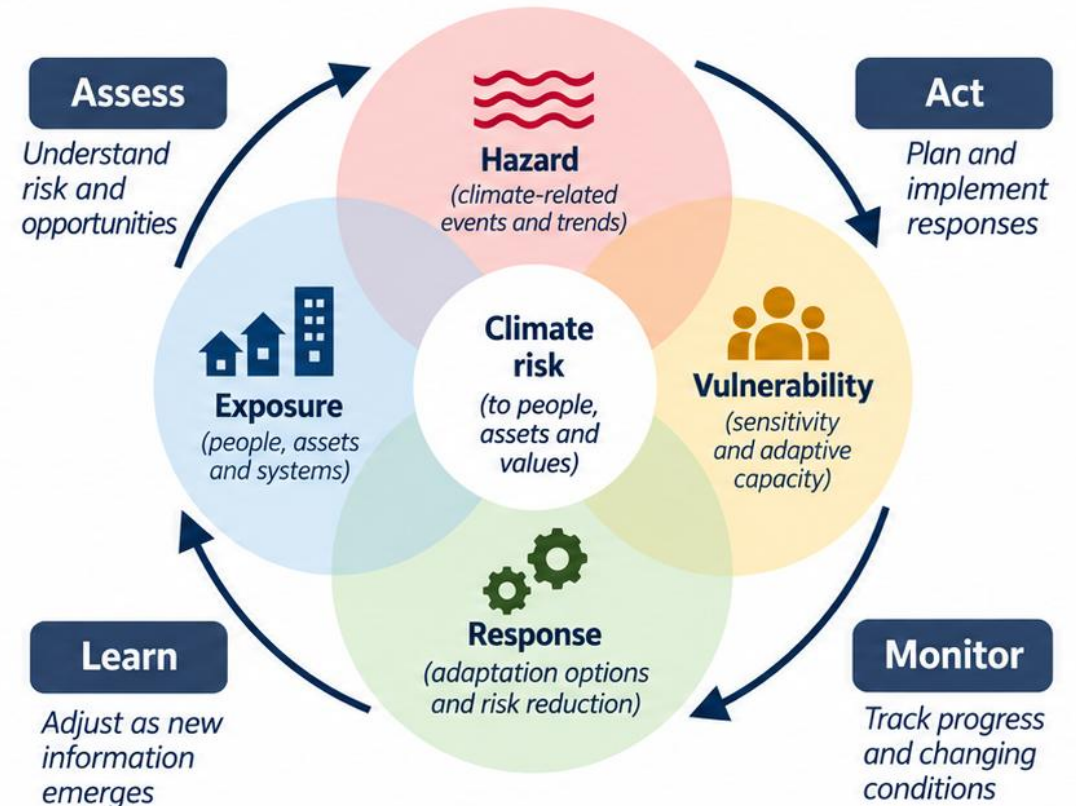
Technical Adaptation Guidelines 1994

IPCC WG2 AR6 2022
Chapter 17, Cross-Chapter 2

Scenario-based assessment to predict and act

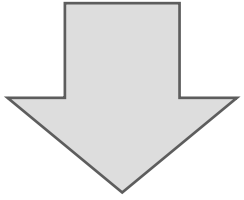


Understanding and managing climate risk in a changing system



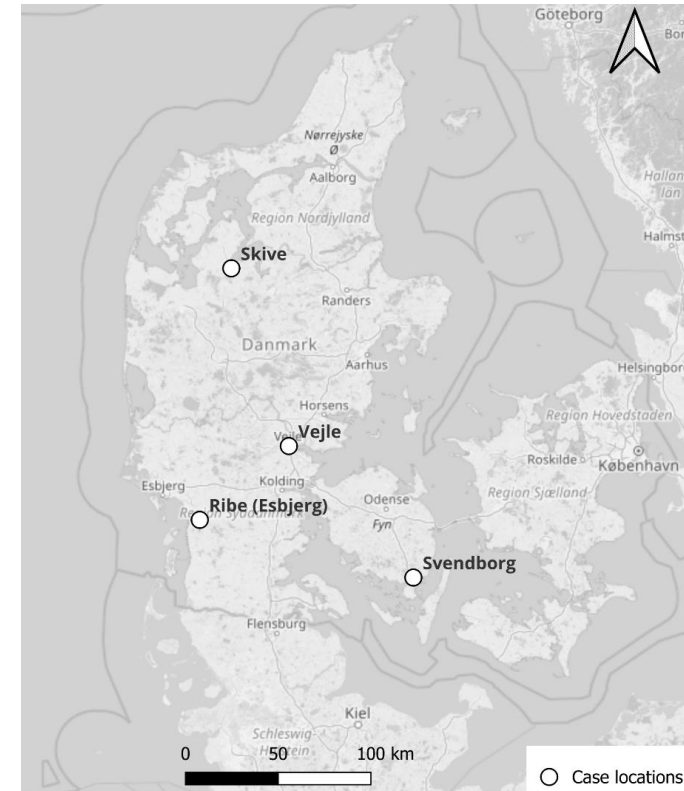
Why? | Increased capabilities decision-centric approaches

Different resources and knowledge needed



How has DAPP been implemented for adaptation in Denmark?

- Four Danish municipal case studies
- Coastal adaptation and urban development



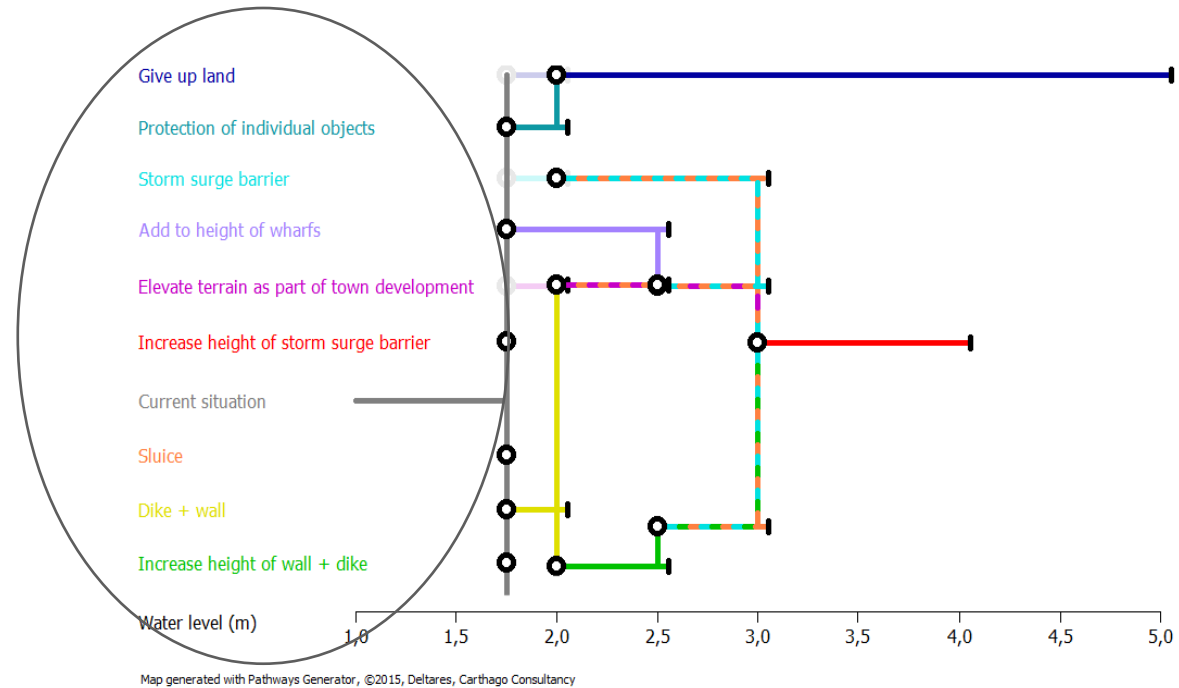
Description | Four Cases

	Vejle	Skive	Esbjerg	Svendborg
Hazard and Uncertainties	Flooding (sea-level rise, fluvial and pluvial)	Flooding (sea-level rise, groundwater, fluvial and pluvial)	Flooding (sea-level rise, fluvial (backwater))	Flooding (sea-level rise)
Sectors	Flood risk management	Flood risk management	Flood risk management	Flood risk management
	Urban Planning	Urban Planning	Urban Planning	Urban Planning
	Emergency Responses	Utilities Land Use	Land Use	Utilities Economic Development
Objective	Evaluate the use of DAPP to support flood risk on a municipal level	Use DAPP to facilitate integration of urban development and climate change adaptation	Evaluate the use of DAPP to support flood risk on a municipal level	Use DAPP to facilitate integration of urban development and climate change adaptation
Process Overview	Pilot project EU InterReg (FRAMES)	Consultancy project (Step 1-6)	Pilot project and invitation of experts	As part of 'Cities and the rising sea level'

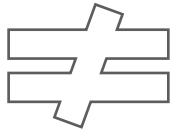
What is going well? | Good things first

Adaptation pathways are being developed in response to changing climate risk

- Mapping of options
- Stakeholder involvement
- Urban planning integration
- Multiple responses to adapt

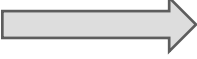


Mapping options



Dynamic Adaptive Pathway Planning

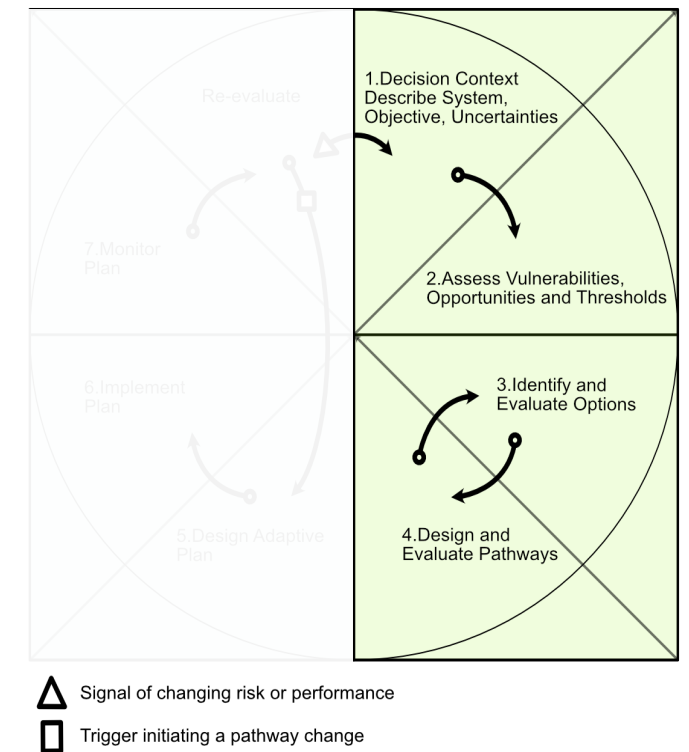
Findings | Pathway Development

Unclear what constitutes a DAPP  Knowledge Broker

Limited Testing Against future scenarios (Technical consequences / Economic consequences / Social consequences)

No Adaptation Threshold development (What is acceptable and unacceptable?)

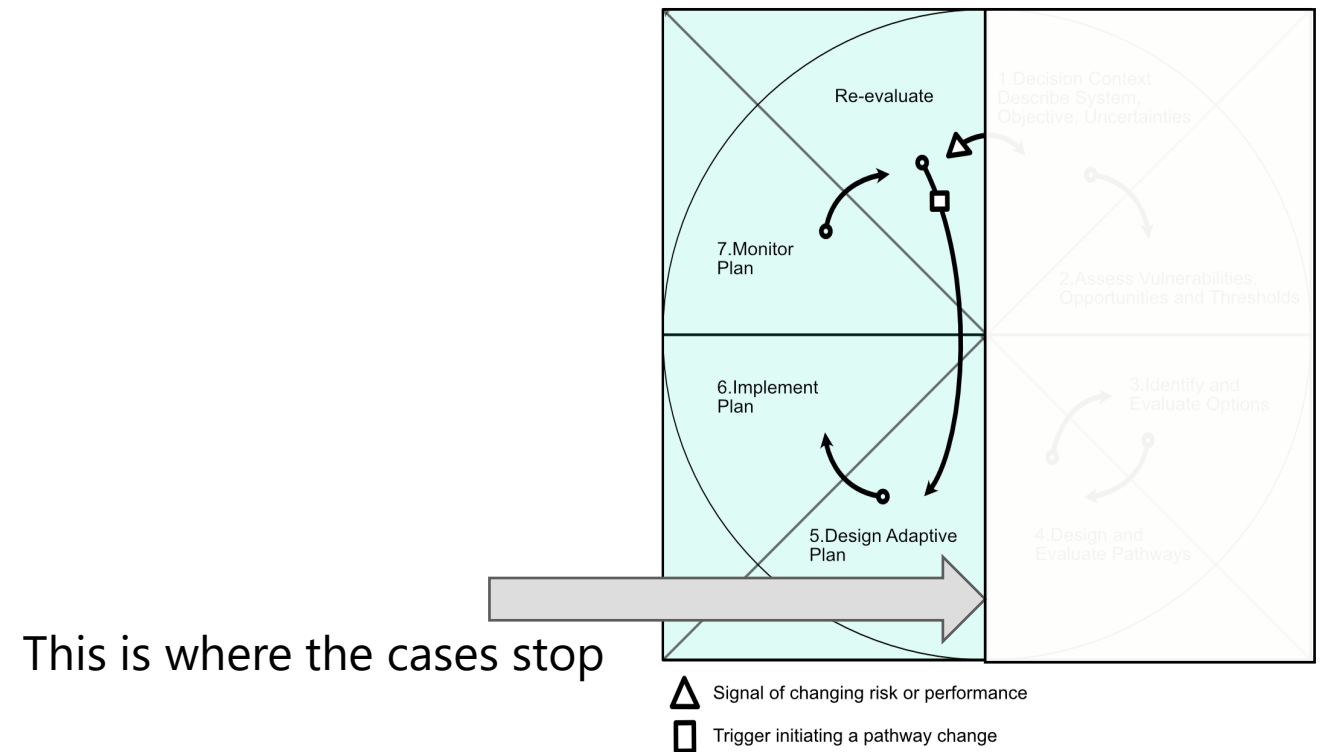
Compare both short and long-term pathways to assess trade-offs



Findings | Re-evaluating ongoing risk

None of the four cases established formal monitoring mechanisms or anchored responsibilities for following up or re-evaluating risk.

Therefore it is unclear how future changes in risk will trigger adaptation decisions

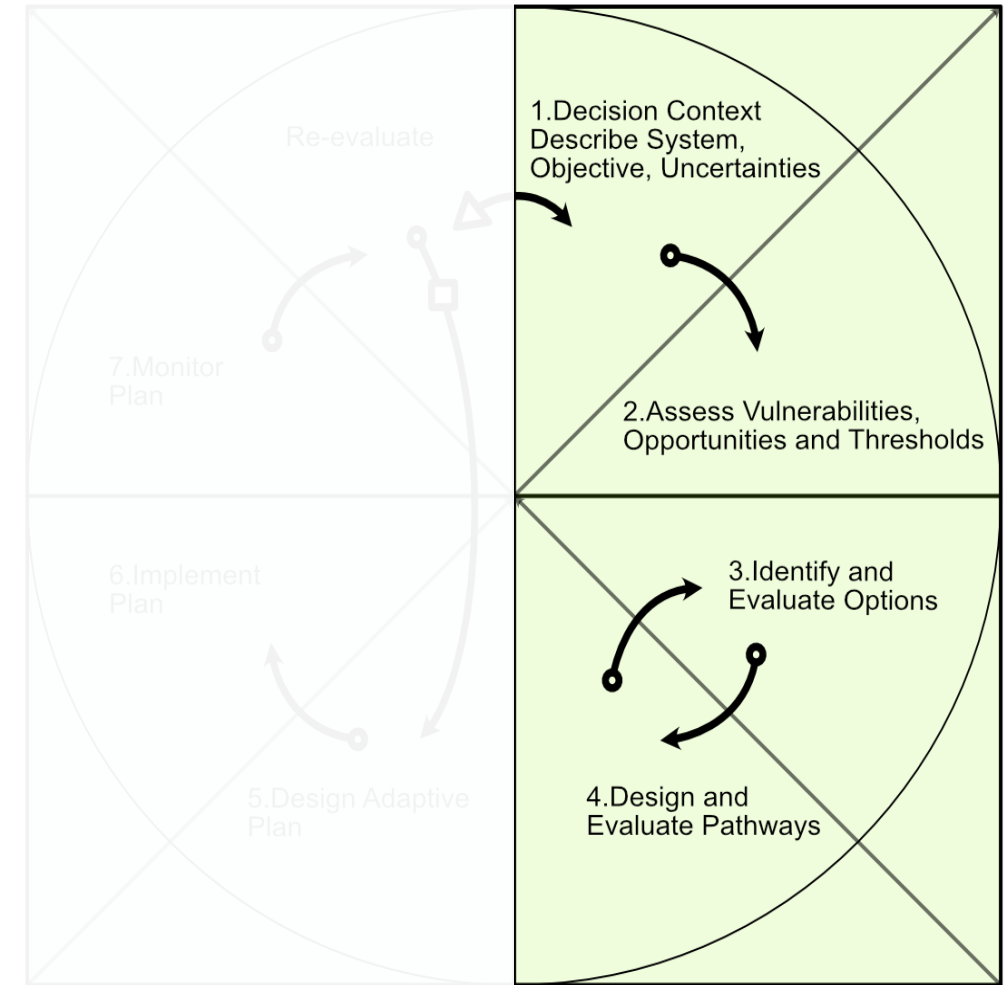


Learnings | Future Directions

Scaling DAPP:

Technical and economic evaluation of adaptation responses
PRIOR to pathway development for different scenarios

Agreement on adaptation thresholds, what is acceptable?
Under what conditions do we take action?



Signal of changing risk or performance



Trigger initiating a pathway change

Learnings | Future Directions

Scaling DAPP:

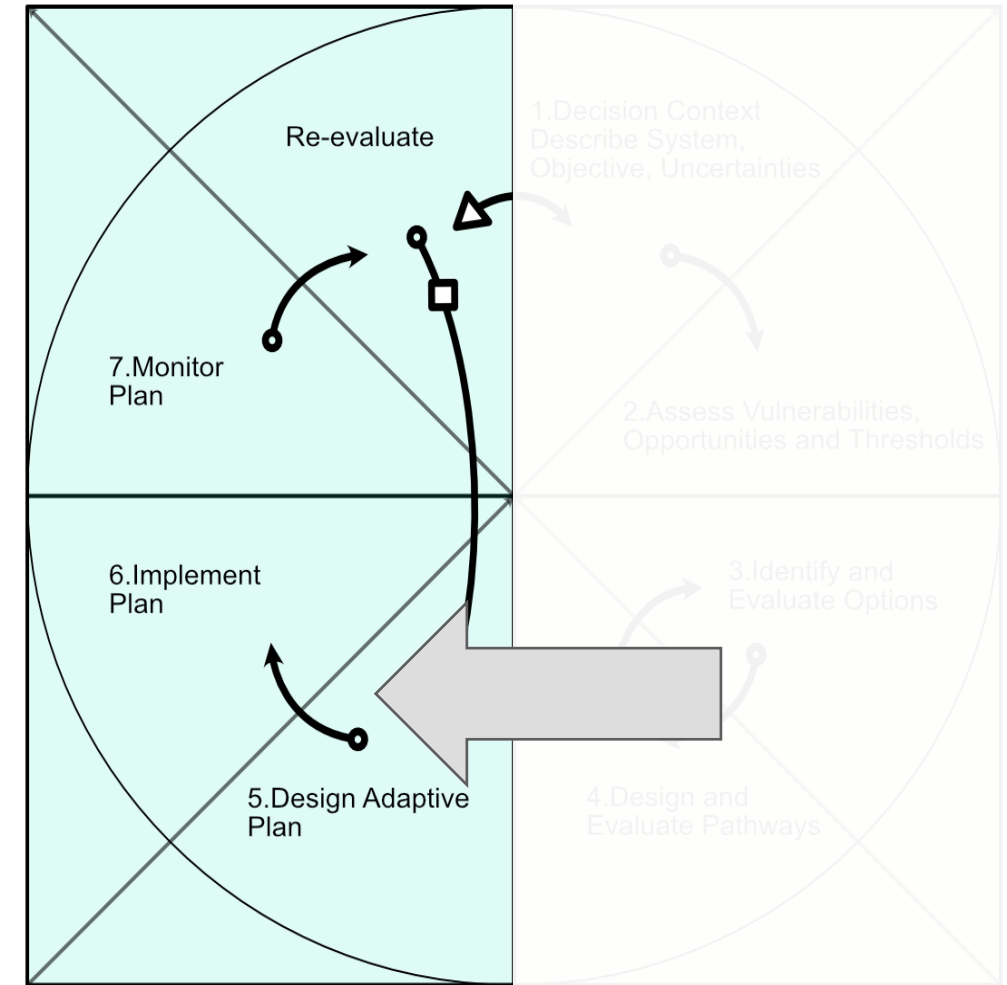
Technical and economic evaluation of adaptation responses
PRIOR to pathway development for different scenarios

Agreement on adaptation thresholds, what is acceptable?
Under what conditions do we take action?

Embedding of responsibilities for re-evaluating risk

Institutional ownership and long-term financial
commitment

Guidance on how to treat climate change uncertainty
(Within the DAPP process)



- △ Signal of changing risk or performance
- Trigger initiating a pathway change

Thank you for your
attention

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RPKO@NIRAS.DK

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Some of our papers on DAPP, infrastructure and spatial planning:

Kool, R.; Lawrence, J.; Drews, M.; Bell, R. Preparing for Sea-Level Rise through Adaptive Managed Retreat of a New Zealand Stormwater and Wastewater Network. *Infrastructures* **2020**, 5, 92. <https://doi.org/10.3390/infrastructures5110092>

Kool, R., Lawrence, J., Larsen, M. A. D., Osborne, A., & Drews, M. (2024). Spatiotemporal aspects in coastal multi-risk climate change decision-making: Wait, protect, or retreat? *Ocean and Coastal Management*, 258. <https://doi.org/10.1016/j.ocecoaman.2024.107385>

Kool, R., Drews, M., Andreas, M., Larsen, D., & Lawrence, J. (2026). Title: Spatially Explicit Climate Adaptation Pathways for Coastal Archetypes: A Quantitative Narrative Approach. <https://doi.org/10.1016/j.ocecoaman.2025.108022>

