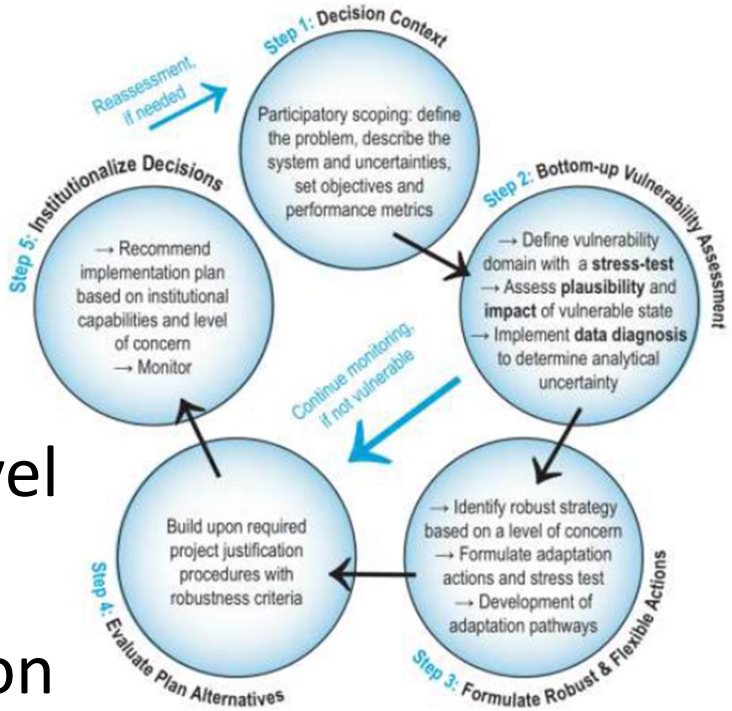
Risk informed planning for Urban adaptation and resilience

Ad Jeuken (Deltares) & John Matthews (AGWA)

What is CRIDA?

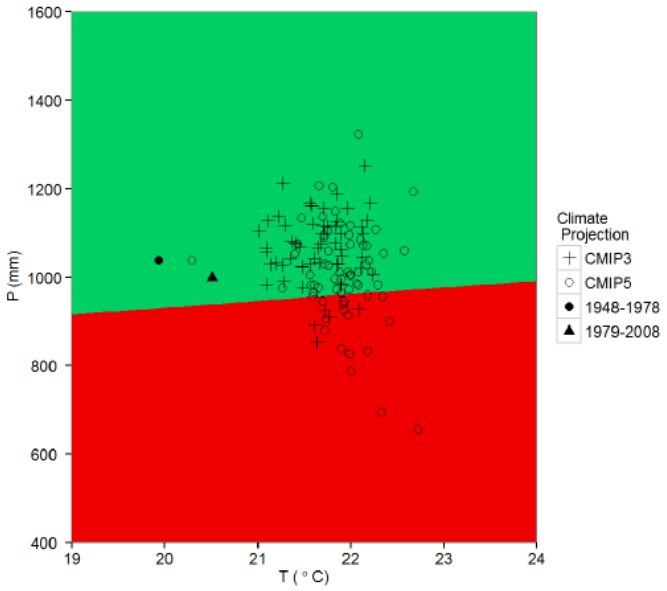
- Guidance to incorporate future risk into standard planning
- Match technical analysis with decision needs
- Offer a set of collaborative tools
- Reaching a practical technical level audience of decision support
- Sign up for publication notification (agwaguide.org/about/CRIDA)



Two Key Elements of CRIDA

Decision Scaling Stress Test (robust solutions)

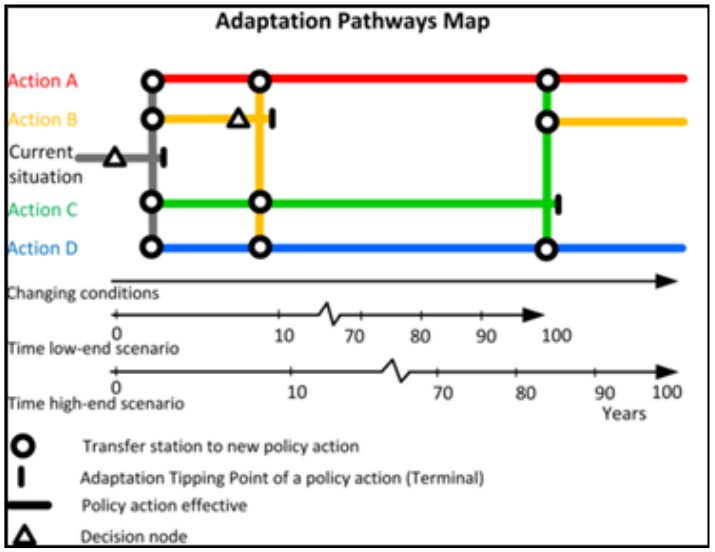
- Available climate data doesn't always meet the problem at hand: time-scale differs, models perform poorly in geographic region, observed data not available for downscaling
- Limiting analysis to GCM derived scenarios confines your decision space
- Allow stakeholders to define system failure



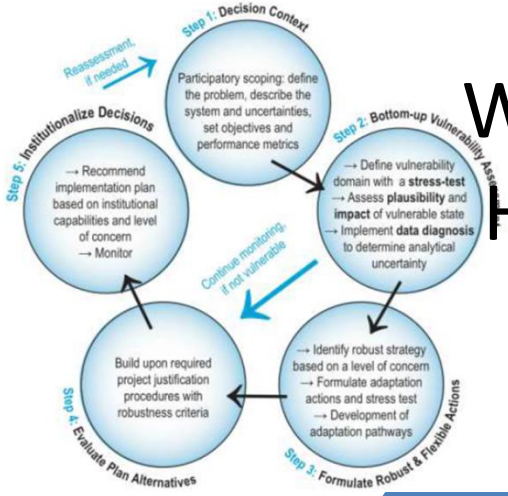
Climate Response Map for a Proposed Run-of-the-River Hydropower Project (Ray and Brown, 2015).

Adaptation Pathways (flexible solutions)

- With limited information, decision makers risk over- or under-designing solutions
- Adaptation pathways illustrate flexible strategies to the decision maker
- Choosing an action that has many transfer points in the future provides a low regret option as the science progresses



What does CRIDA add to Planning Cycle? How does it influence decision making?



Identify Problems and Opportunities

Stress Test and Level of Concern Analysis

Vulnerability Assessment: Inventory and forecast conditions

Decision Point 1: *Key drivers? Strategy Direction?*

Formulate alternative plans

Build bigger? Or Adaptation pathways?

Evaluate alternative plans

Decision Point 2:
Complexity of economic analyses

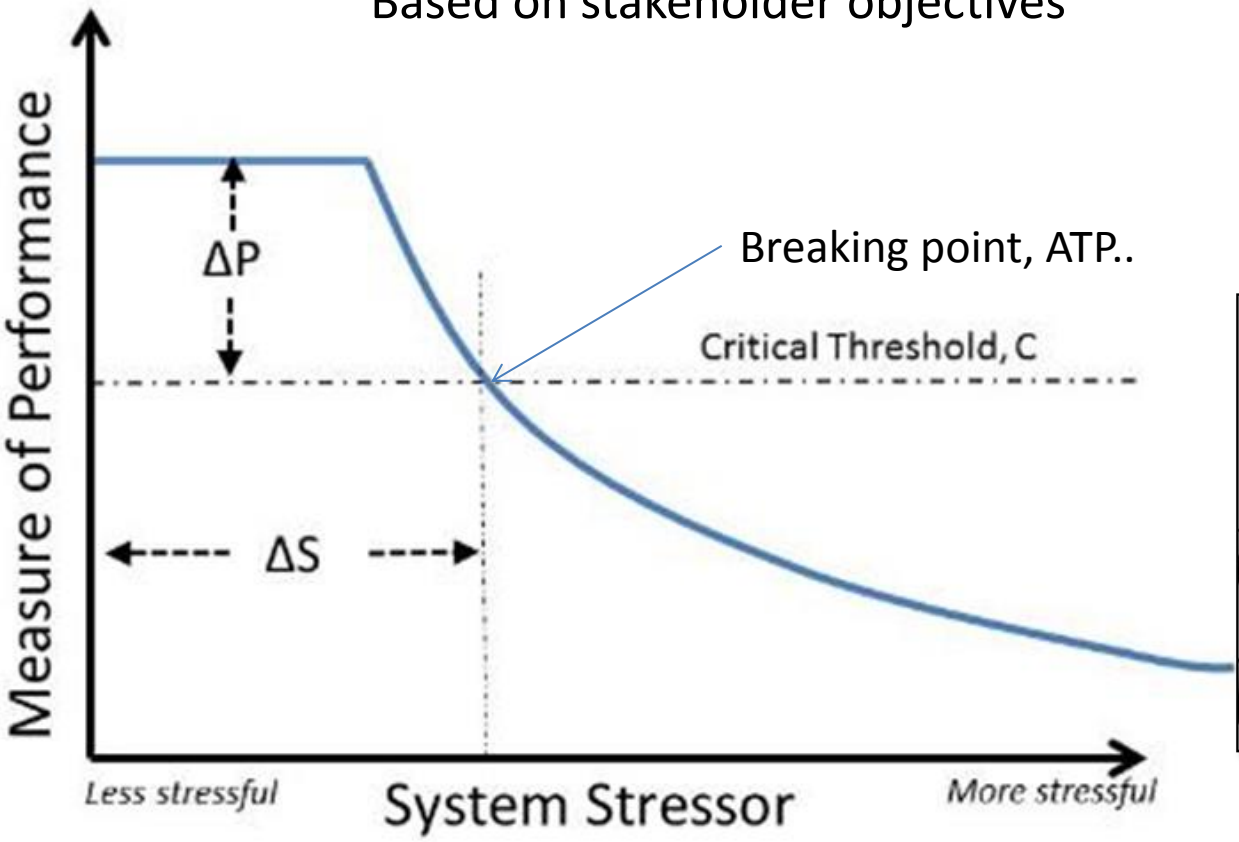
Select and Implement

Decision Point 3:
Influence of institutional/gov't capacity?

Monitor

Principles of bottom up stress test

Based on stakeholder objectives



Next : What is the plausibility and impact of this happening?

5. Results

Identified thresholds

Current Conditions

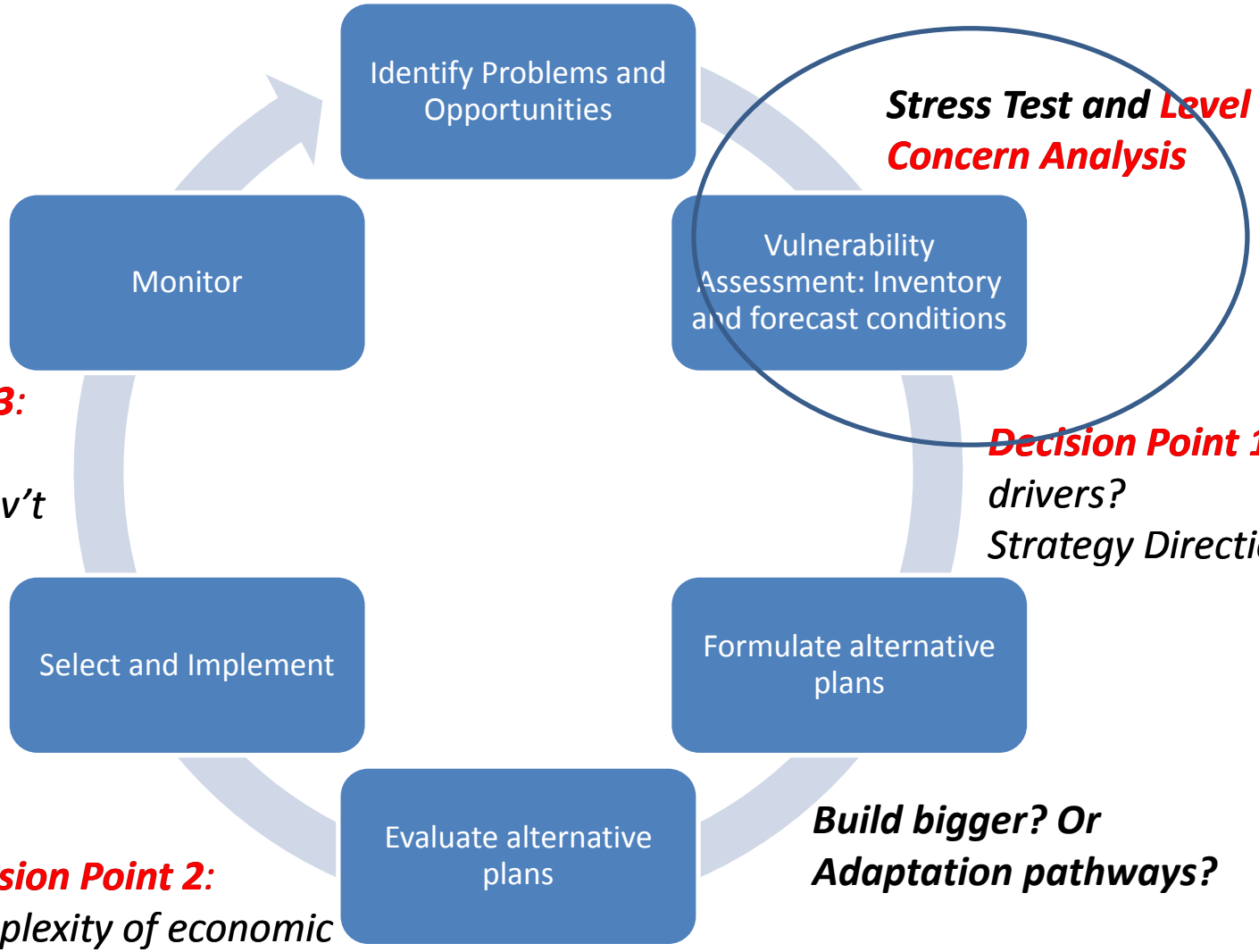
Trigger 1
Flooding of the streets more than **20cm** reduce income in the business in the area, decrease the value of property, increase skin problems and impede access to the area
3 times per week

Trigger 2
When flood events are more than **50cm** the business have to close completely, and there is no transportation in the area, damage in property and assets and skin problems in legs and feet
1 per month

Trigger 3
When flood events are more than **60cm** the area collapses




Examples of stress tests



Stress Test and Level of Concern Analysis

Decision Point 1: *Key drivers? Strategy Direction?*

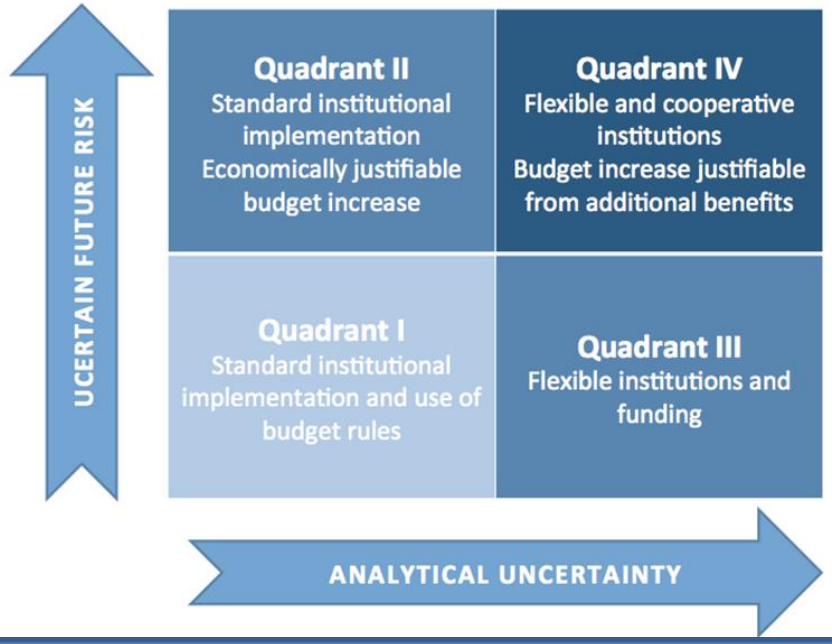
Build bigger? Or Adaptation pathways?

Decision Point 2: *Complexity of economic analyses*

Decision Point 3: *Influence of institutional/gov't capacity?*

Scale the approach: *when do you know if you have to do something different?*

Level of worry



Consistency in
- Science
- Observations
- Projections

Level Confidence

(a) (b) (c)

CRIDA and NL adaptation

- CRIDA has taken up many elements from NL adaptation approach:
  - Adaptive planning approach (ADM)
  - Using performance indicators with critical thresholds (adaptation tipping points)
  - Adaptation pathways (DAPP, pathways.deltares.nl)

Climate Stress test in Netherlands

Marco Hoogvliet

Deltares
Enabling Delta Life

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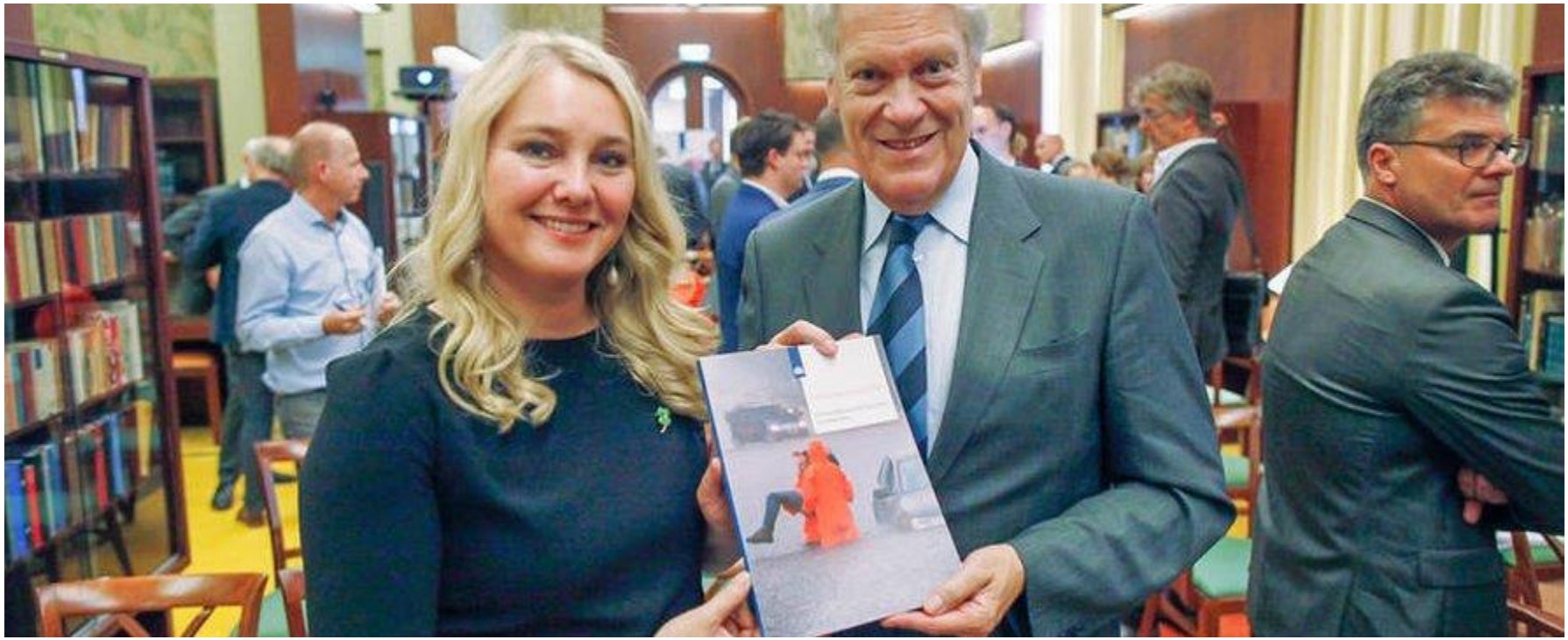
30 november 2017

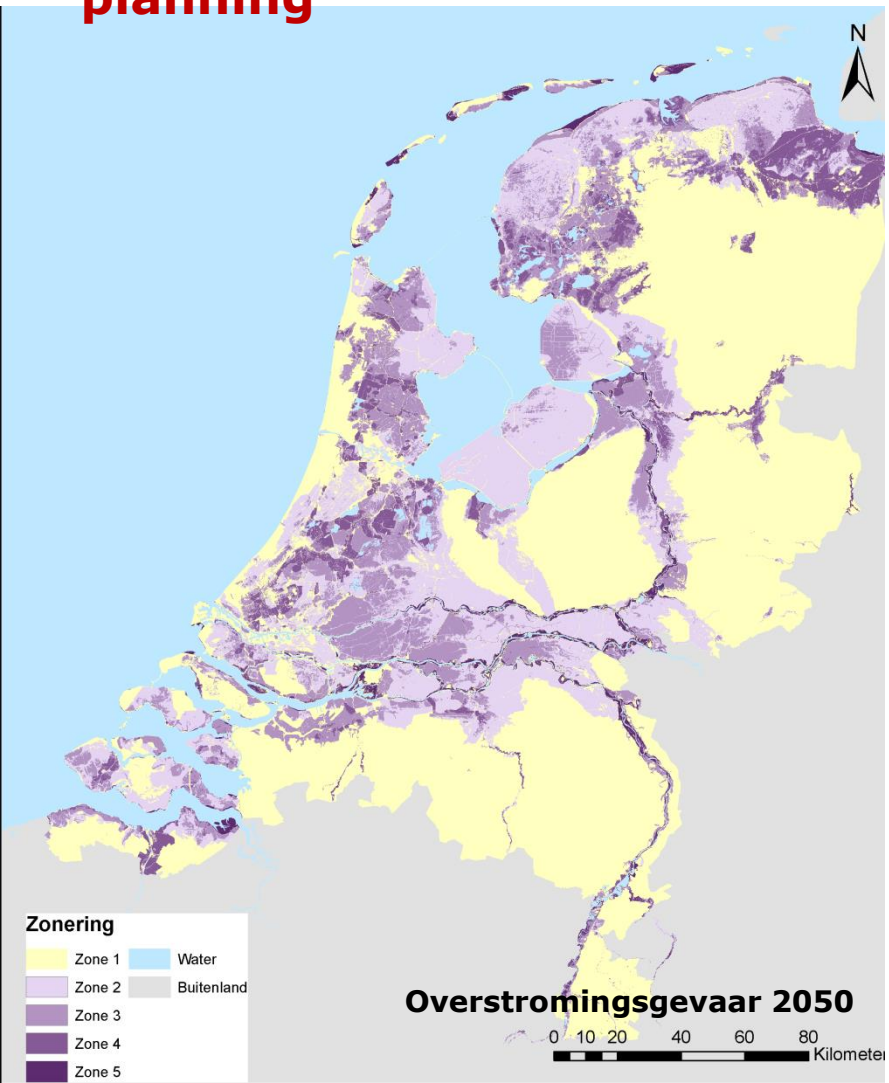
Stress test for all Dutch cities in 2019



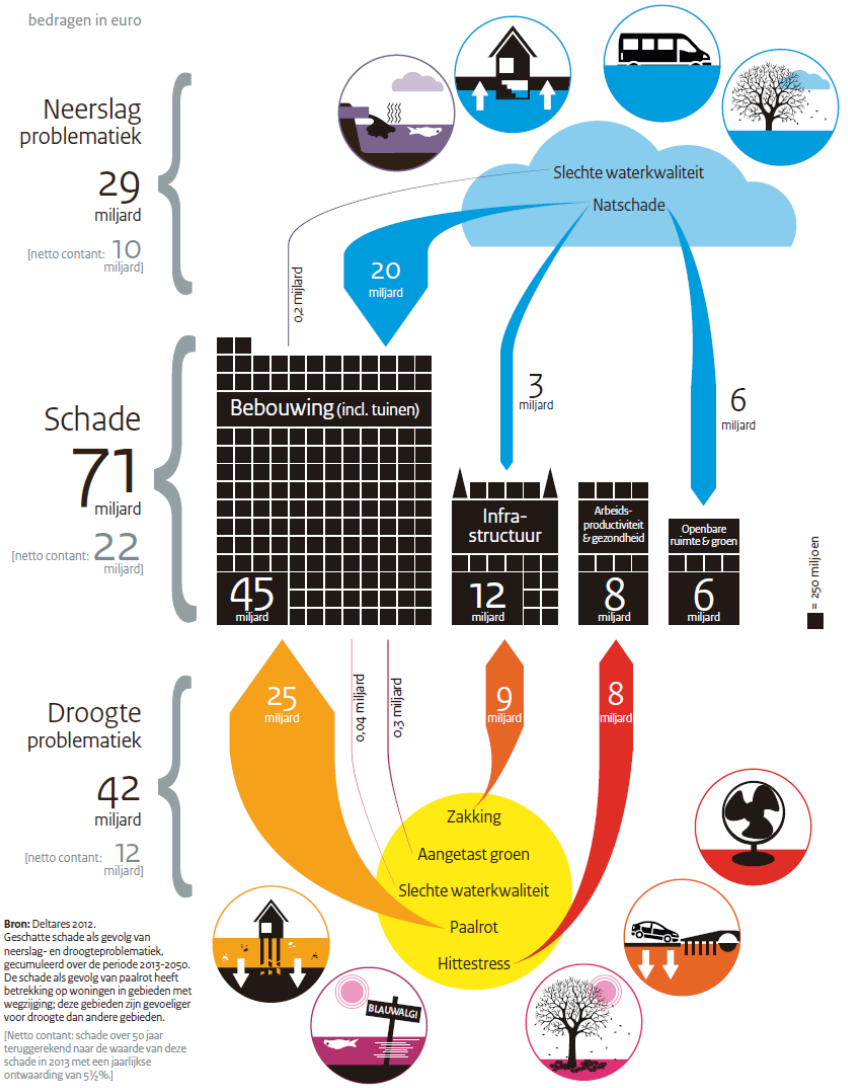
Is the built environment resilient against?

Two main themes in spatial adaptation

Water robust spatial planning



Climate resilient Cities



Why ? Anticipate !

- **Prevent and decrease damage**
  - Probability is increasing
  - As well as sensitivity
- **Protect** vulnerable objects, networks and groups
- **Inform and activate** civilians and businesses
- Based on the outcomes **define joint ambition**
- Make **stress test part of** all planning activities in municipality

Approach in stress test guideline

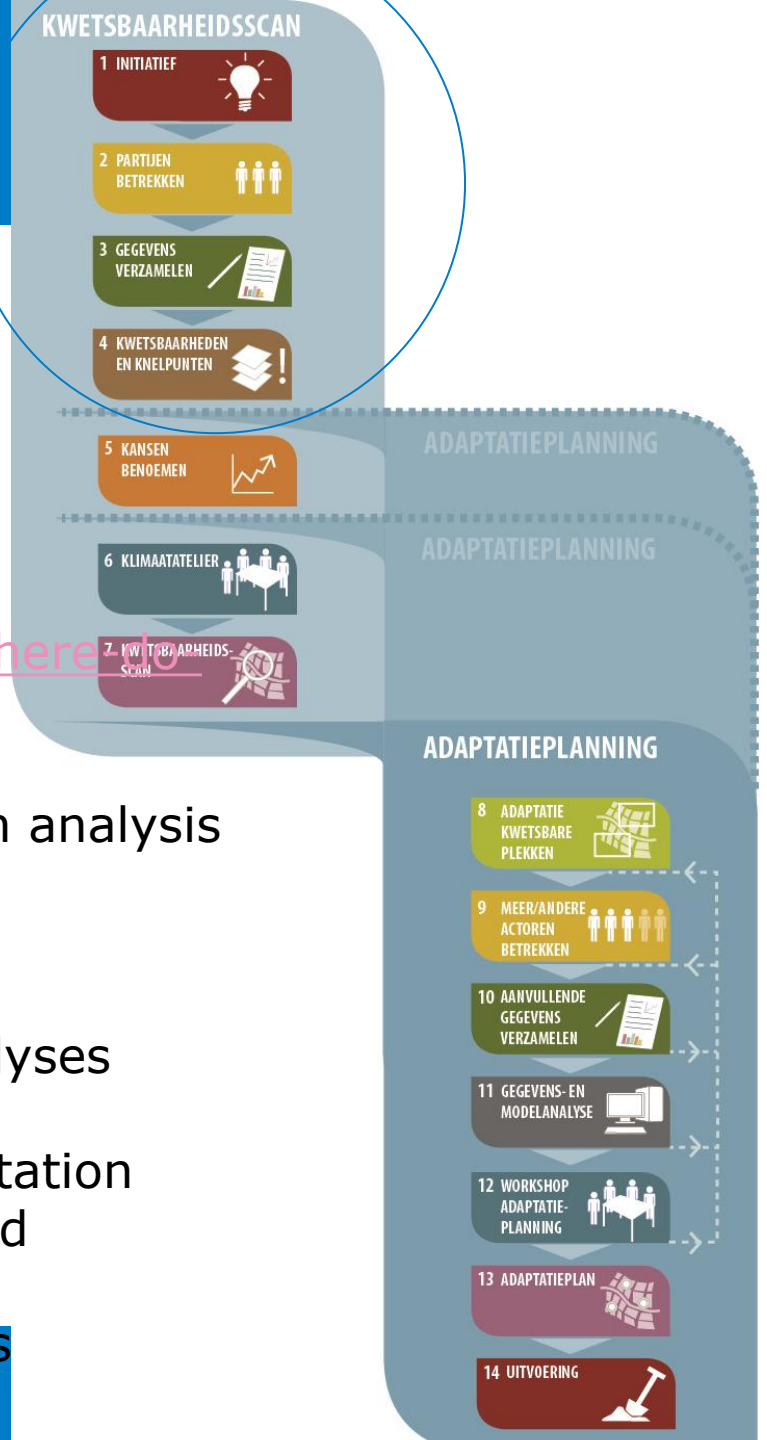
Two phases

1) Sensitivity scan

- Based on existing knowledge and data
- Strongly supported by public portal
- http://ruimtelijkeadaptatie.nl/english/where-do-start
- Maps with Plausible extremes available
- First get frightened, next more thorough analysis

2) Adaptation planning

- more parties, more dedicated data, analyses
- Actions (what, how, when)
- Evaluation on costs, benefits, implementation
- Make plan and integrate in municipal and provincial spatial plans
- Integrate with asset management cycles

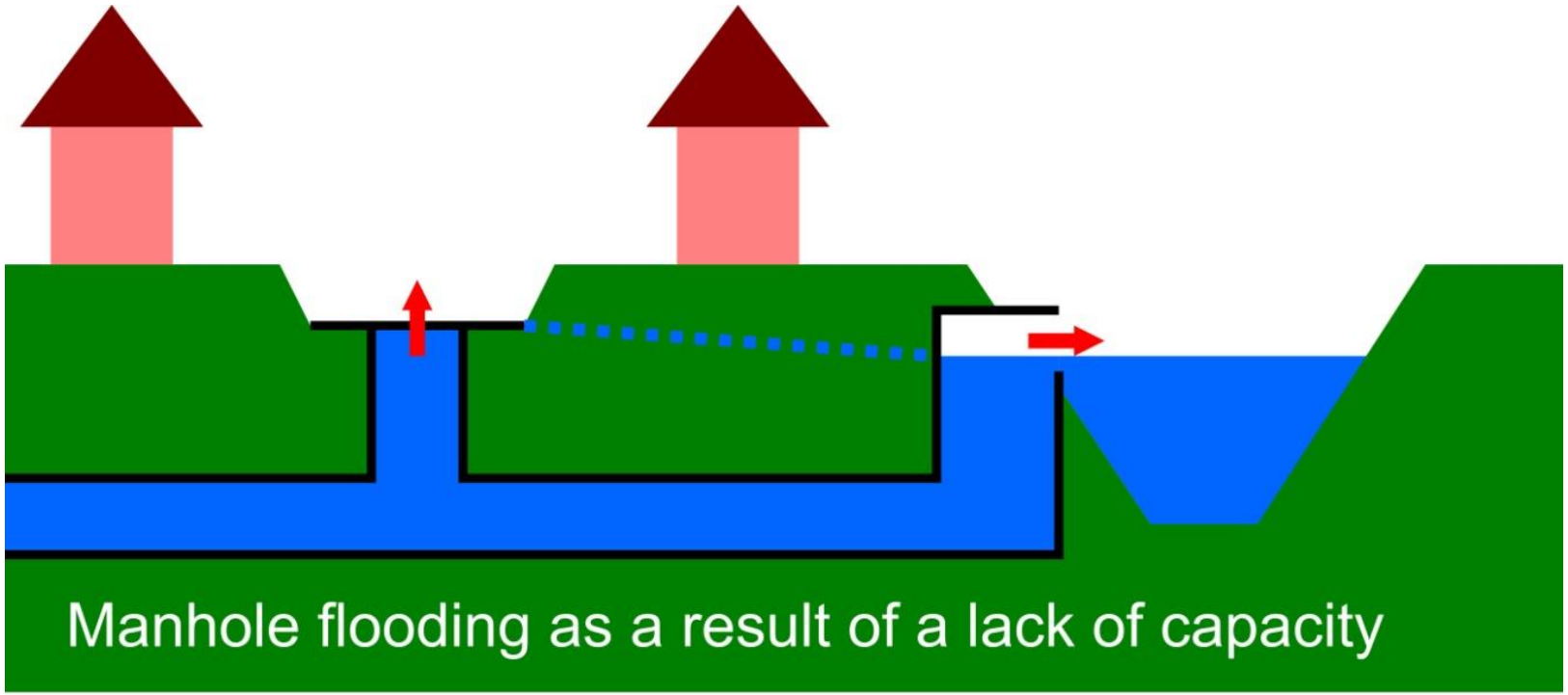


Example Storm water management for the city of Dordrecht

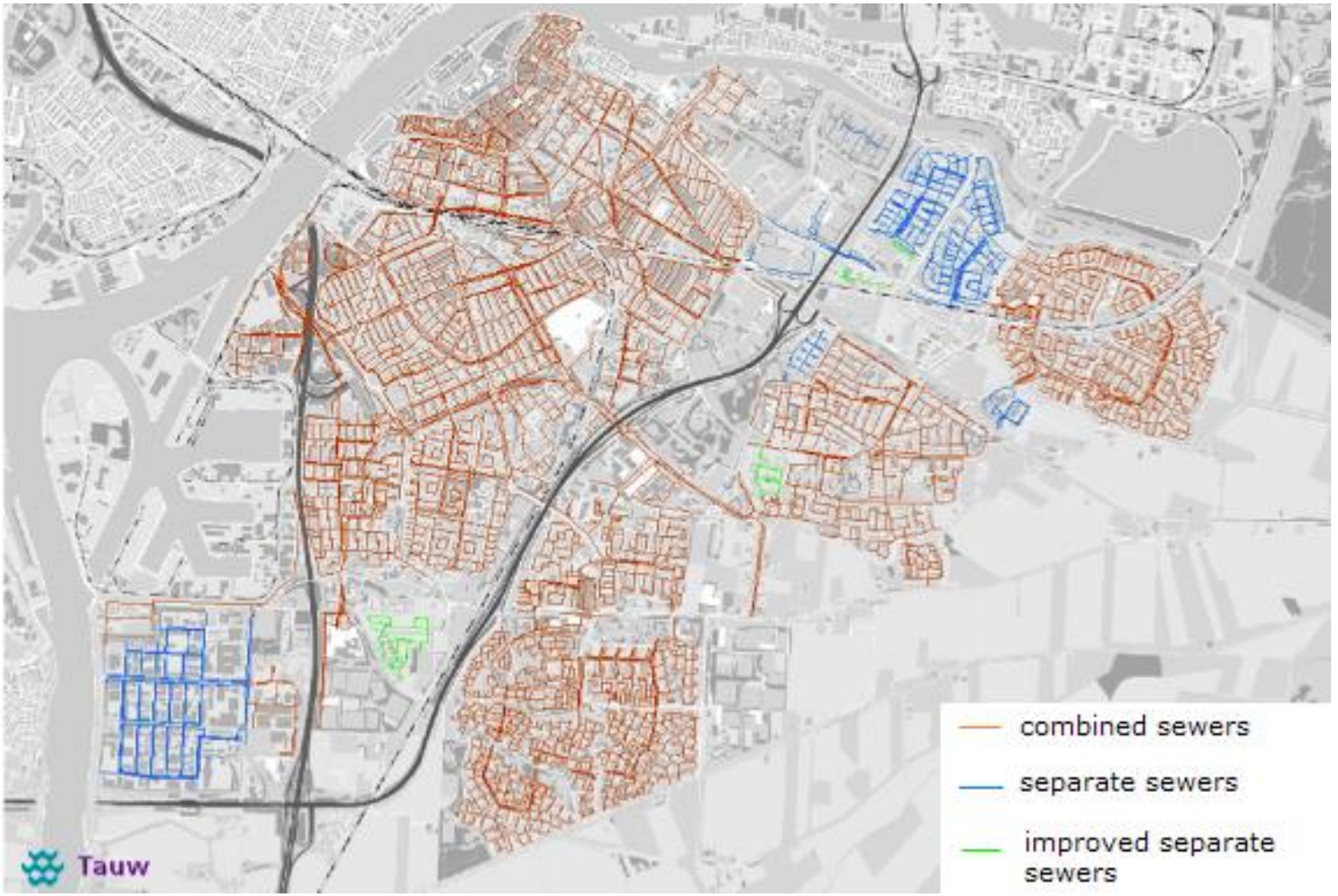
- Berry Gersonius (UNESCO-IHE). *Koukoui et al. 2015. DOI: 10.2166/wcc.2015.093*

Objective for stormwater management

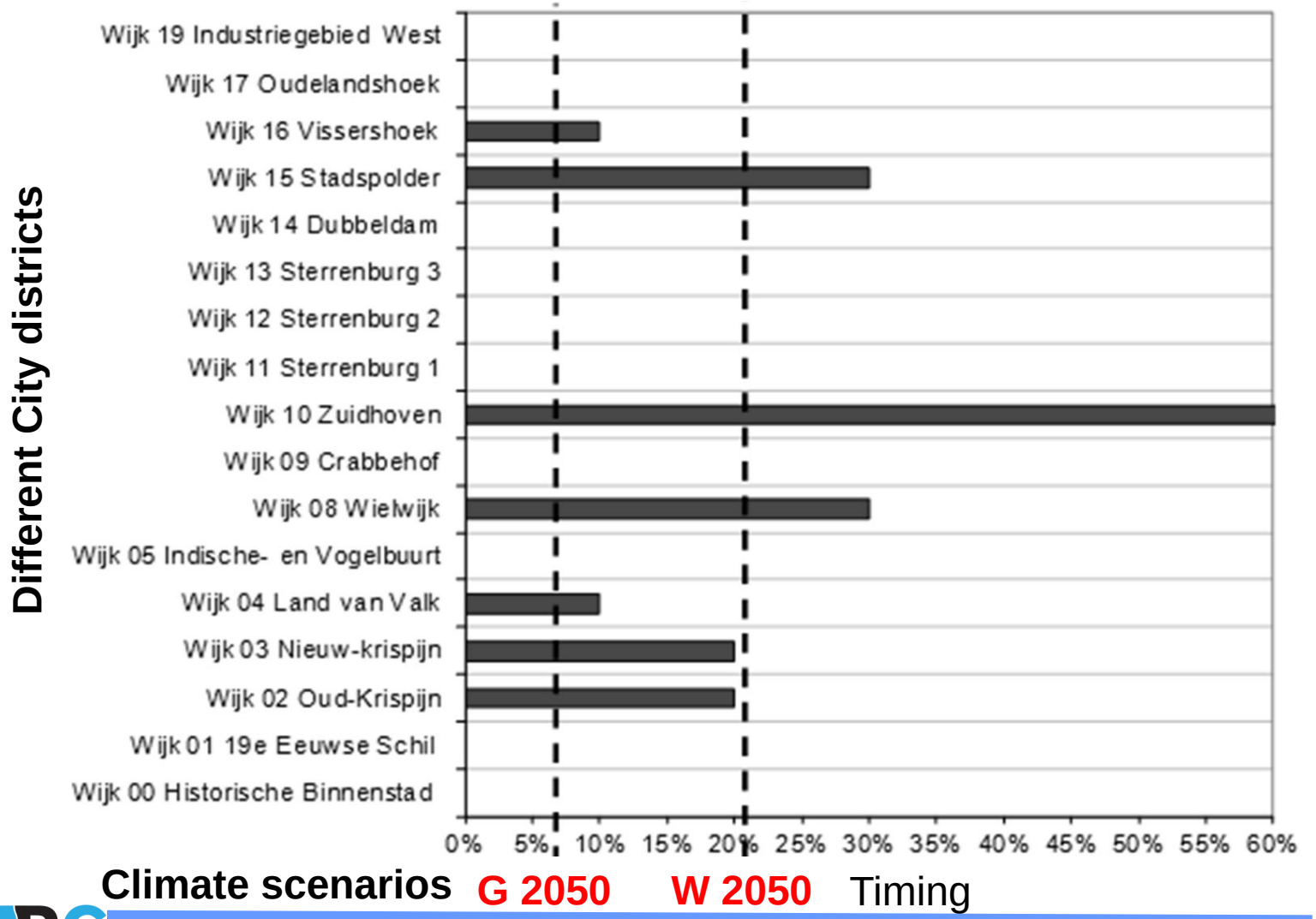
1 in 2 years event (20 mm / 2 hr)



Sewer system Dordrecht



Increase design precipitation event to stress Sewage system (simulation)

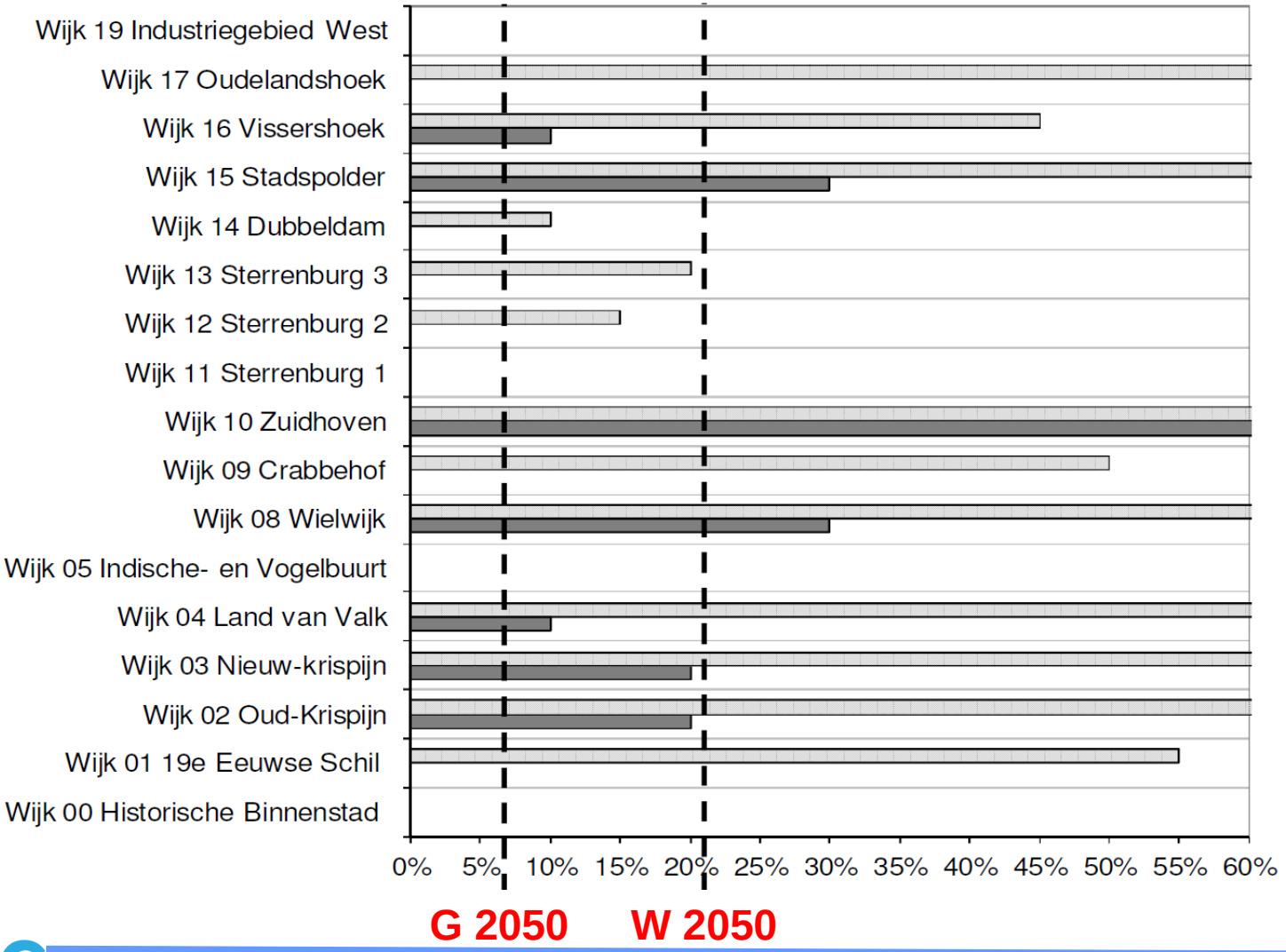


Current management strategy

- Current strategy involves disconnecting 40% of the publicly-owned buildings and paved areas from sewers

When retrofitting areas of the city

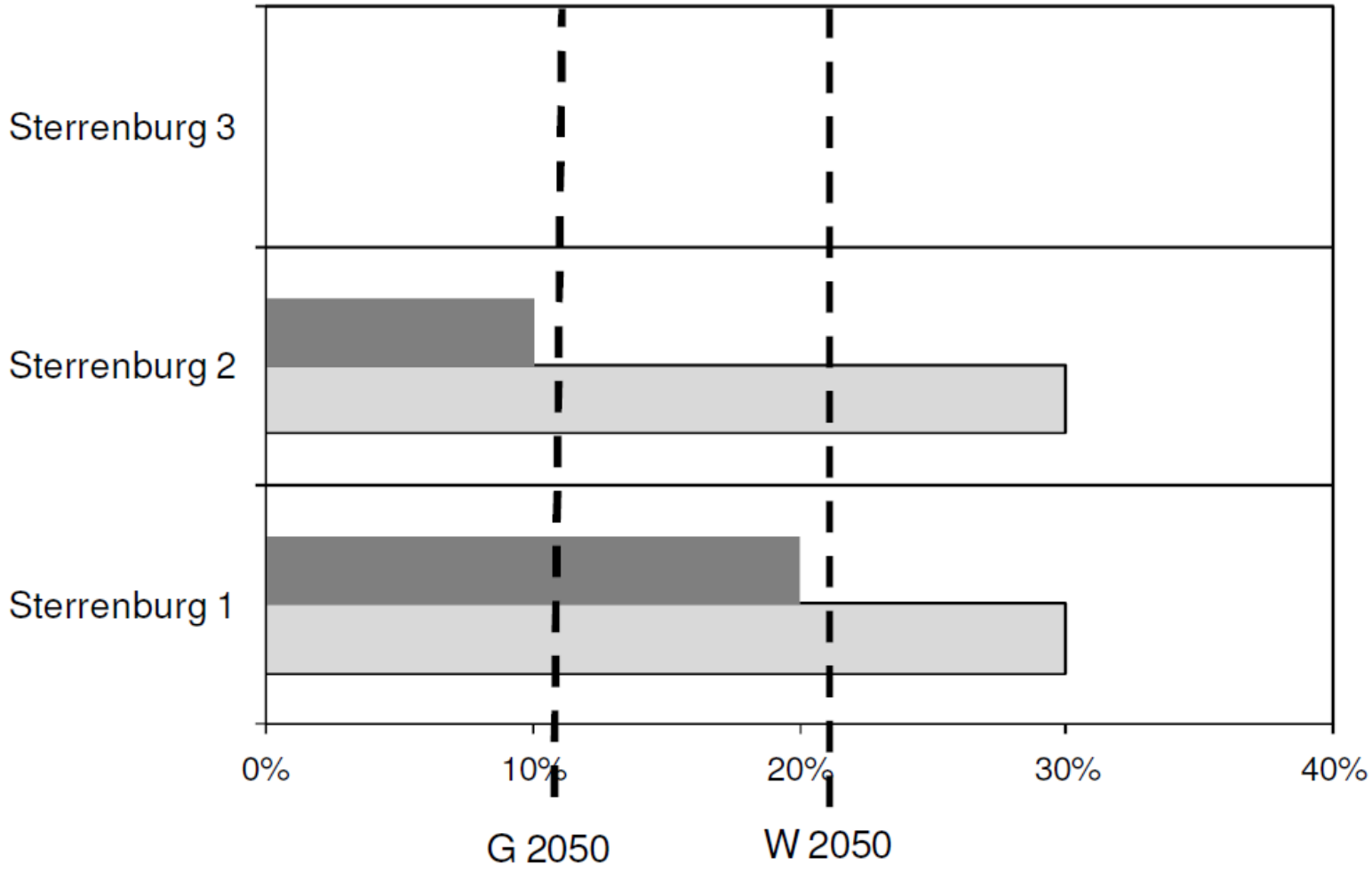
Shift in ATPs by disconnection from sewers



Need for alternative management strategy in some areas

- The current strategy is effective in postponing ATPs (until 2050) in 76% of the districts
- 4 Out of 17 (24%) districts fail to meet the objective with the current strategy
- An alternative strategy aimed at the use of the overland drainage system was developed and analysed with ATP

Shift in ATPs by using overland pathways

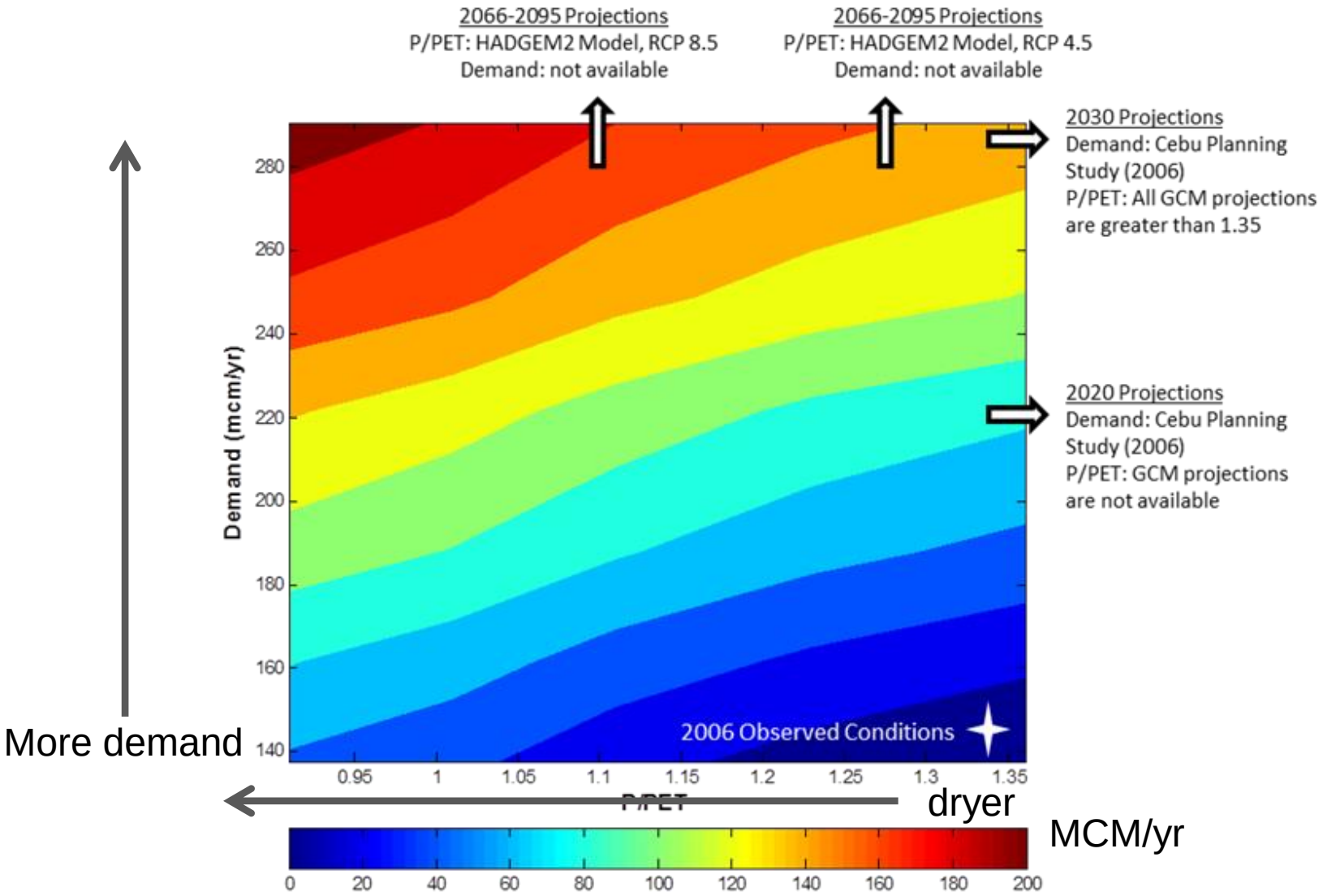


CASE STUDY: WATER RESOURCES MANAGEMENT ACTION PLAN FOR CENTRAL CEBU

CHALLENGES:

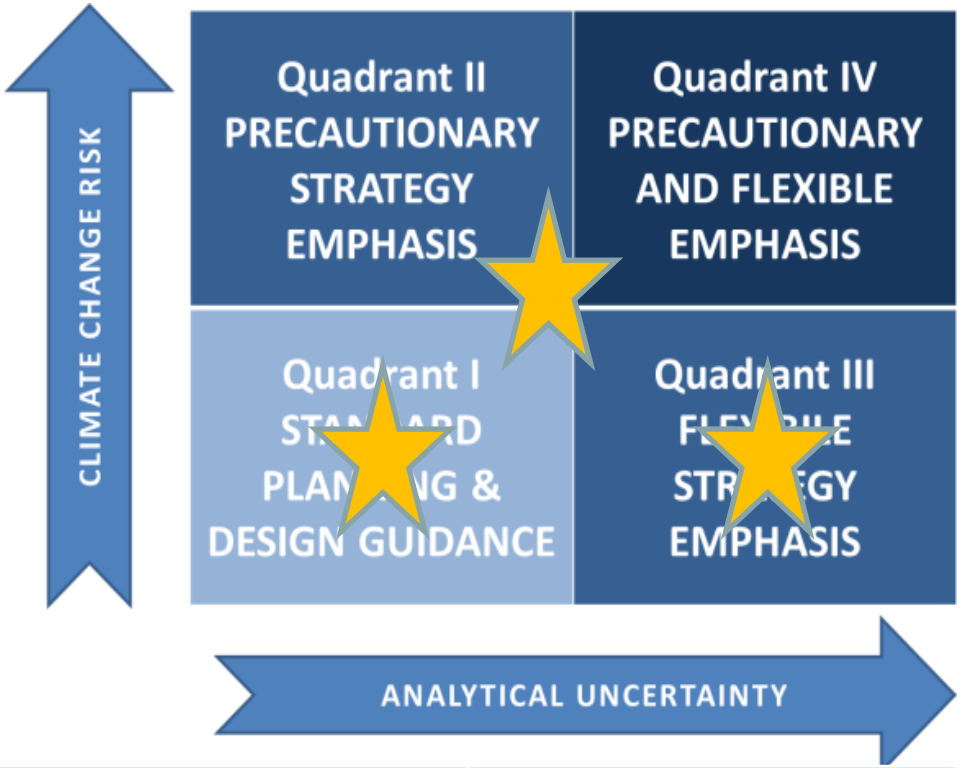
- GROWING POPULATION
- SLR THREATENING GW
- DRYER CONDITIONS DUE TO CC
- OBJECTIVE: WATER FOR ALL CEBUANOS

Stress test for the water supply to Cebu showing watershortage (MCM/yr) under increasing stress



Interpretation of Level of Concern Analysis:

Is there any justification to deviate from Quadrant I, standard planning?



Driver	Uncertain Future Risk	Analytical Uncertainty
P/PET	Low	Med

End of part one

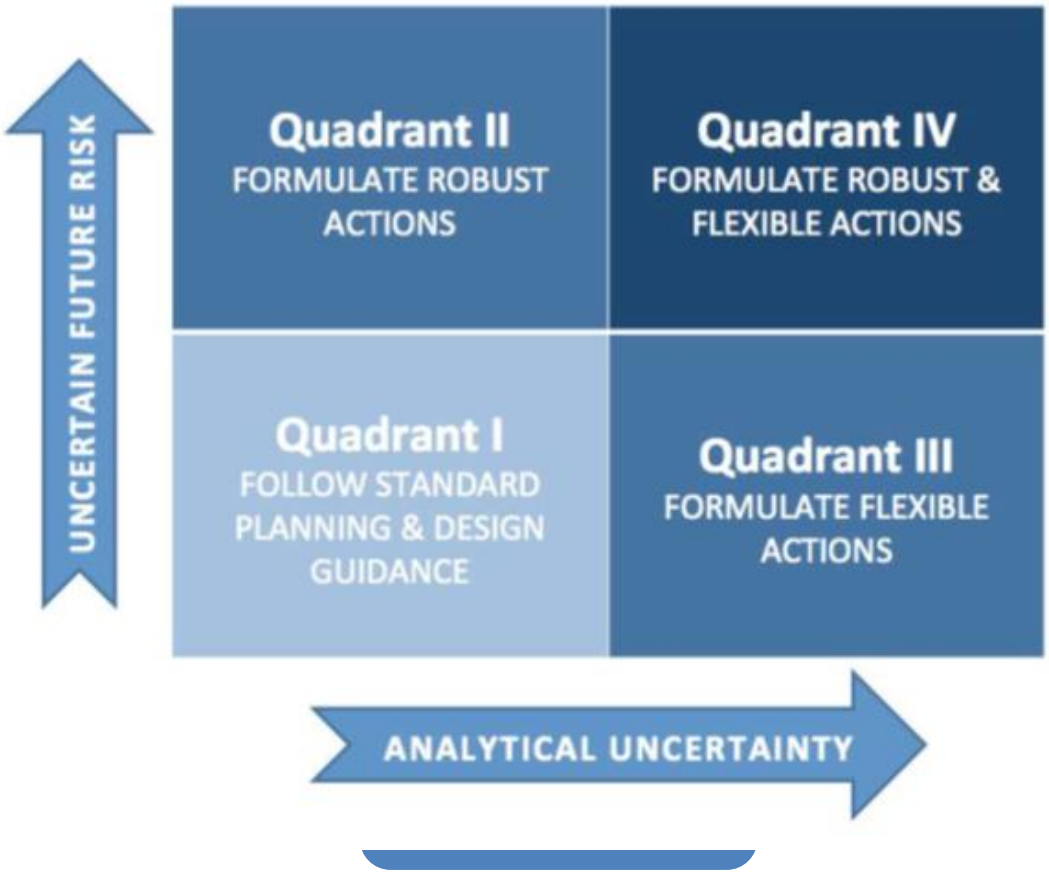
For more info see:

- agwaguide.org/about/CRIDA/
- pathways.deltares.nl
- ruimtelijkeadaptatie.nl/english/tools/
- www.deltares.nl/en/software/adaptation-support-tool-ast/

Risk informed planning for Urban adaptation and resilience PART 2

Ad Jeuken (Deltares) & John Matthews (AGWA)

Formulate plan alternatives



Stress Test and Level of Concern Analysis

Vulnerability Assessment: Inventory and forecast conditions

***Decision Point 1**: Key drivers?*
Strategy Direction?

Formulate alternative plans

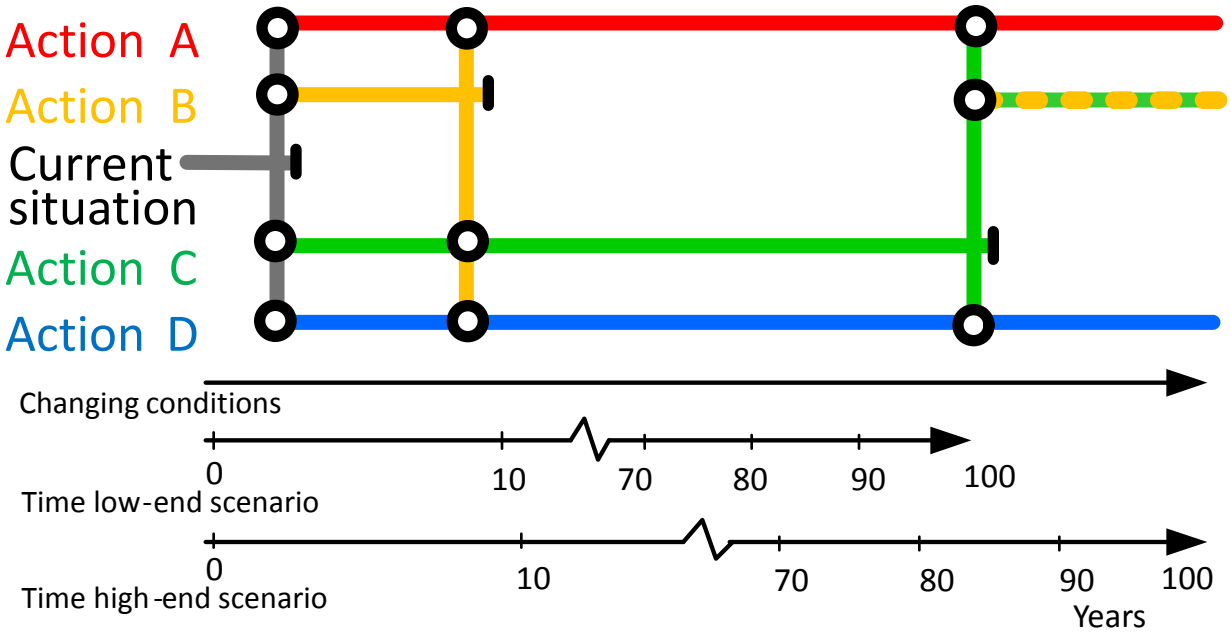
Build bigger? Or Adaptation pathways?

Evaluate alternative plans

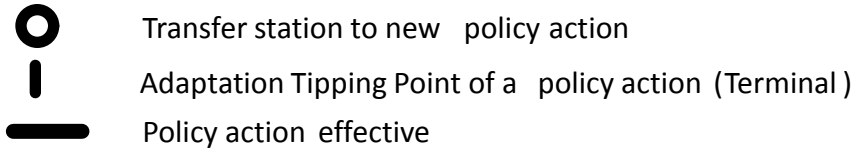
***Decision Point 2**:*
Complexity of economic analyses

An **adaptation pathways** map shows different possible sequences of decisions to achieve objectives.

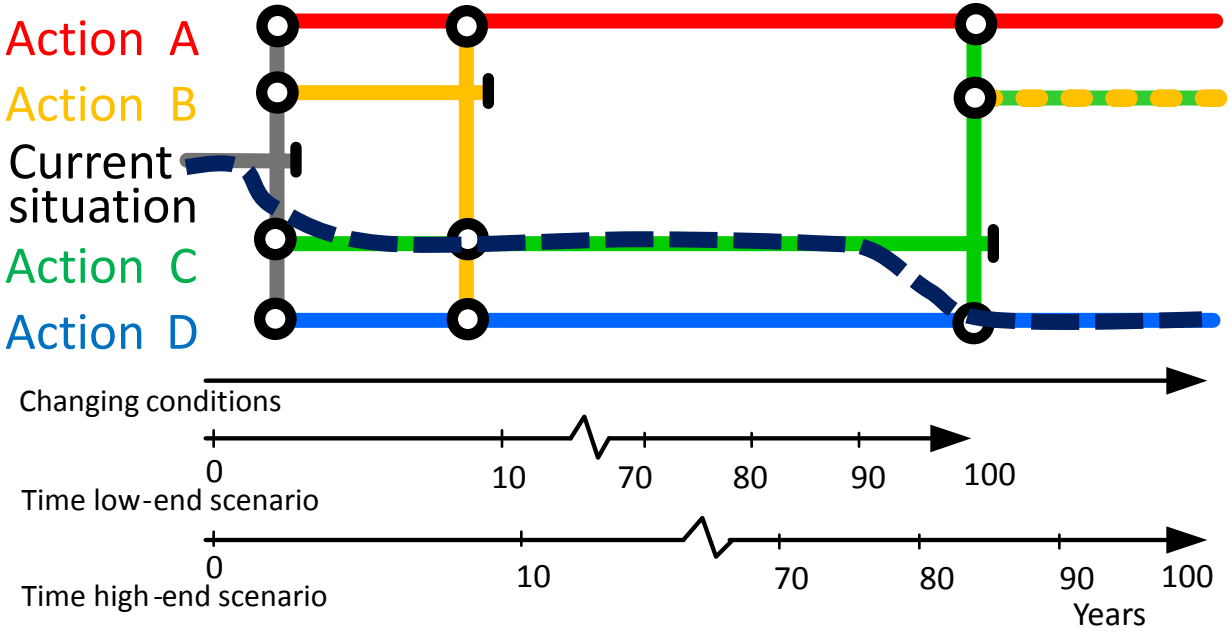
Haasnoot et al 2013



Time horizon 100 years			
Pathway	Costs	Benefits	Co-benefits
1	+++	+	0
2	+++++	0	0
3	+++	0	0
4	+++	0	0
5	0	0	-
6	++++	0	-
7	+++	0	-
8	+	+	- - -
9	++	+	- - -



Adaptive plan could be Action C. Monitor and switch to action D, if high-end scenario becomes reality. Identify actions to mitigate adverse impacts.



Time horizon 100 years

Pathway	Costs	Benefits	Co-benefits
1	+++	+	0
2	+++++	0	0
3	+++	0	0
4	+++	0	0
5	0	0	-
6	++++	0	-
7	+++	0	-
8	+	+	- -
9	++	+	- -

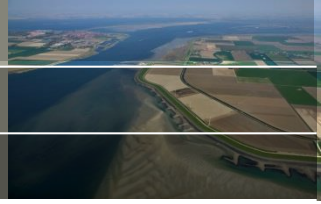
Transfer station to new policy action

Adaptation Tipping Point of a policy action (Terminal)

Policy action effective

Some examples

Guidance for coastal adaptation

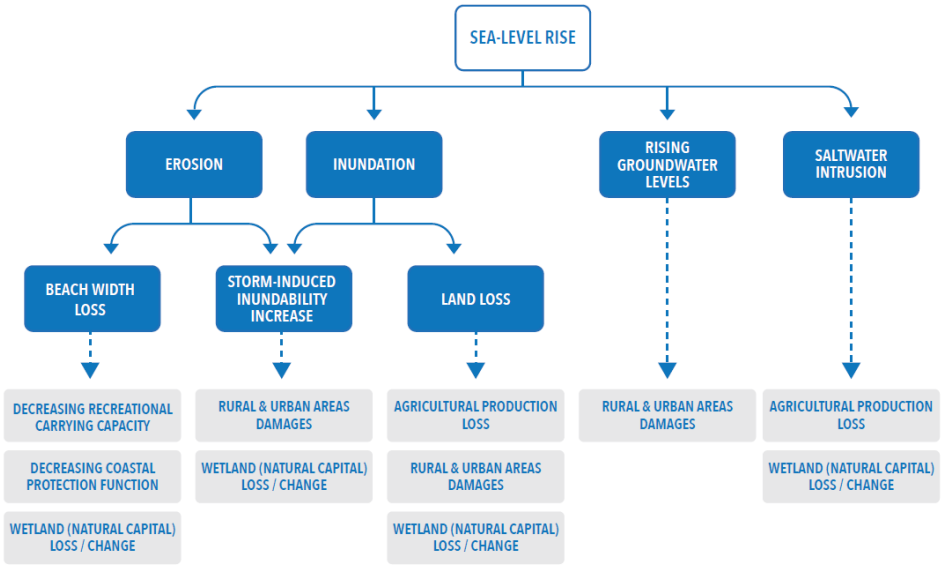


COASTAL ZONES AT RISK

SIX HIGH-RISK COASTAL ARCHETYPES

Based on the RISES-AM project, six high-risk coastal archetypes for sea level rise were identified. These coastal types will suffer from sea level rise, which are generally speaking the low-lying coastlines, deltas or estuaries. Impacts, in terms of casualties and economic damage, environmental and social issues, are expected to be different in urbanised (industrial) areas and in rural areas. Hence, the adaptation strategies in each of these coastal zones-at-risk will also be different.

ARCHETYPE	DESCRIPTION	IMPACT OF SEA-LEVEL RISE	EXAMPLE
1a OPEN, URBANIZED COAST WITH BEACH AND/OR SAND DUNES	Urbanised areas, low lying and attractive for tourism. May be protected by sand dunes and sand nourishment to maintain coastline	Erosion of beaches and dunes, damage to tourism. Increased risk of inundation.	Holland coast (the Netherlands), Catalan coast (Spain)
1b OPEN RURAL COAST	Rural area, slightly elevated, unprotected	Increased risk of inundation and loss or change of (wet)land. Loss of agricultural production due to salinization	Norfolk and Suffolk coast (UK)
2a URBAN DELTA	Urbanised area, with river delta	Increased risk of inundation both from sea as river. Rising groundwater levels may affect underground infrastructure	Mekong delta with Ho Chi Minh City (Vietnam), Nile delta with Alexandria (Egypt)
2b RURAL DELTA	Rural area, with river delta. Less protected than urban delta	Increased risk of inundation both from sea as river. Loss or change of wetlands. Loss of agricultural production due to salinization	Ebro delta (Spain), Ganges-Brahmaputra-Meghna delta (Bangladesh)
3a URBAN ESTUARY	Urbanised area, with brackish estuaries	Increased risk of inundation. Interference of port operation. Rising groundwater levels may affect underground infrastructure.	Elbe with Hamburg (Germany), Thames with London (UK)
3b RURAL ESTUARY	Rural area, with brackish estuaries	Agricultural production loss due to salinization. Loss or change of wetlands.	Mersey and Severn estuary (UK)



Adaptation strategies and options for the high risk coastal archetypes:

ACCOMMODATE

- Land raising (natural or artificial)
- Elevated building (houses and roads on piles)
- Salt-tolerant crops
- Floating agriculture/aquaculture
- Drainage systems and pumps
- Retrofit buildings (dry and wet-proofing)
- Flood water storage space (retention areas)
- Flood early warning system

DEFEND

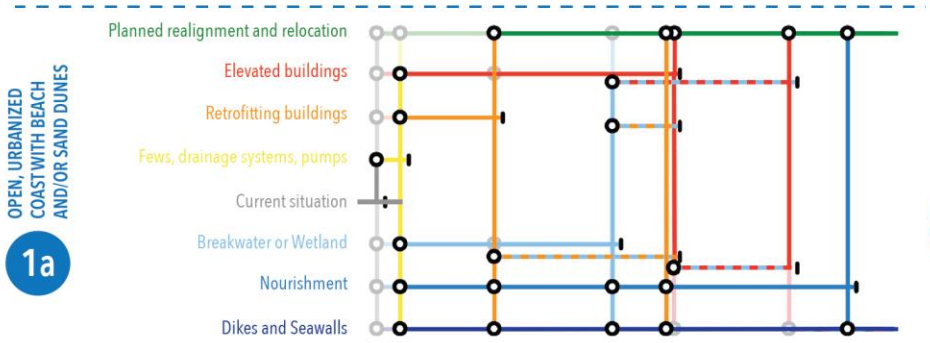
- Breakwater
- Wetland creation (incl. forests) and restoration
- Nourishments for beach and dunes
- Dikes or seawalls (with or without land reclamation)
- Flood gate (local actions within one area)
- Storm surge or tidal barriers
- Saltwater intrusion barriers

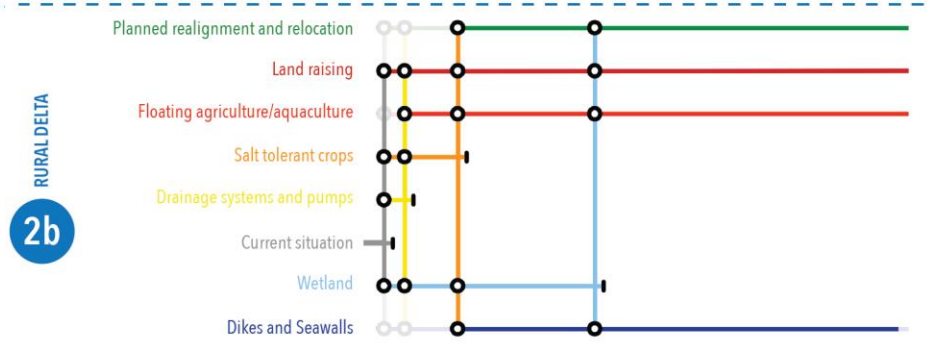
RETREAT

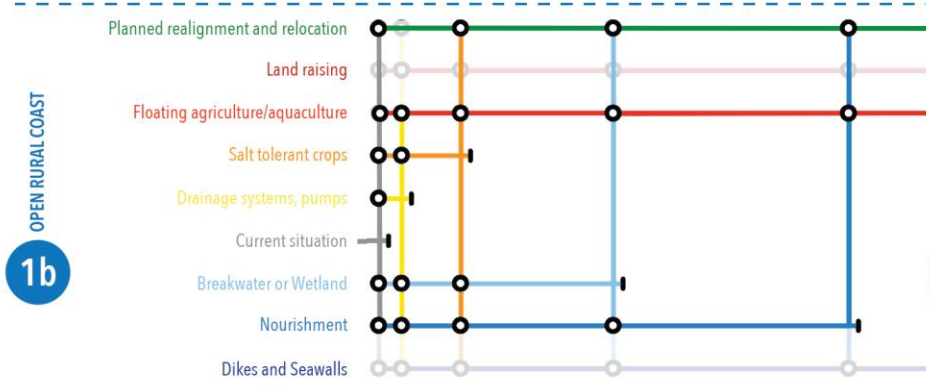
- Planned no-build zones (set-back)
- Planned managed realignment and relocation of key infrastructure and assets

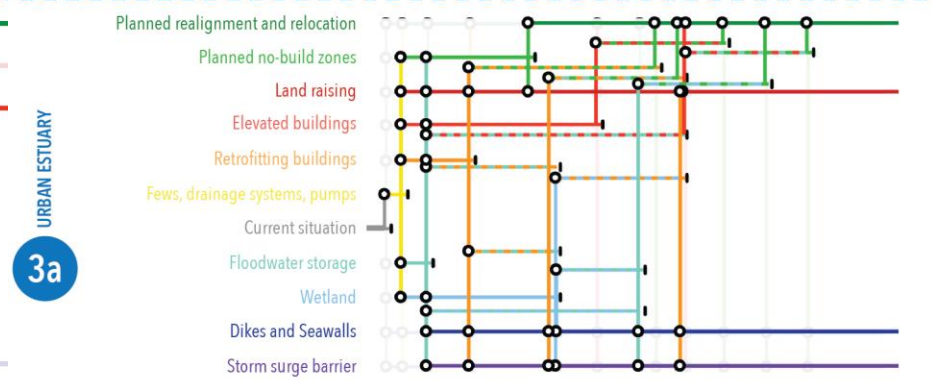
Deltares

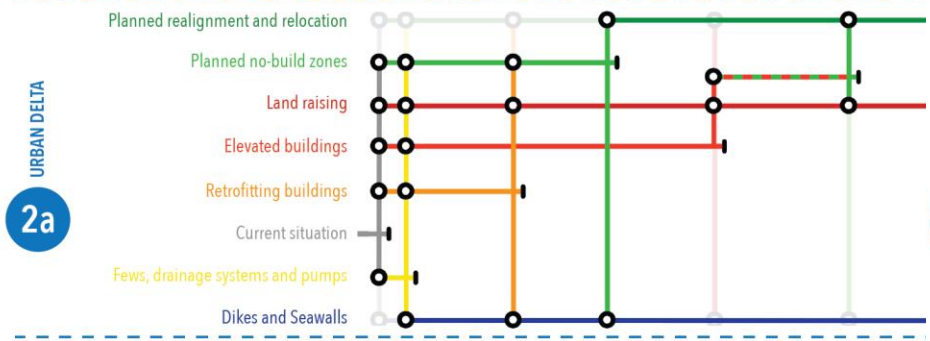
Six archetypical pathways for SLR (RISES-AM)

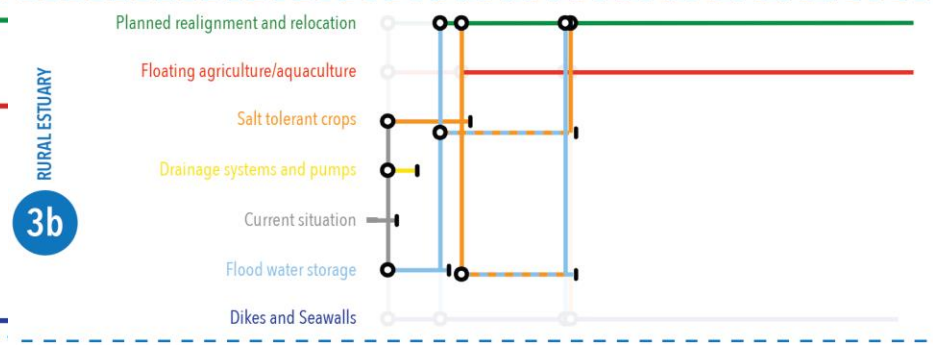


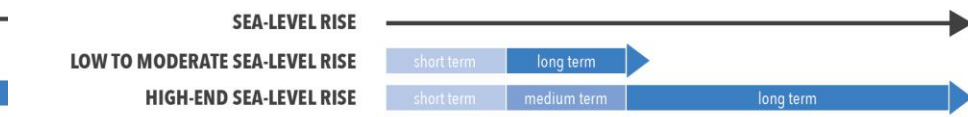








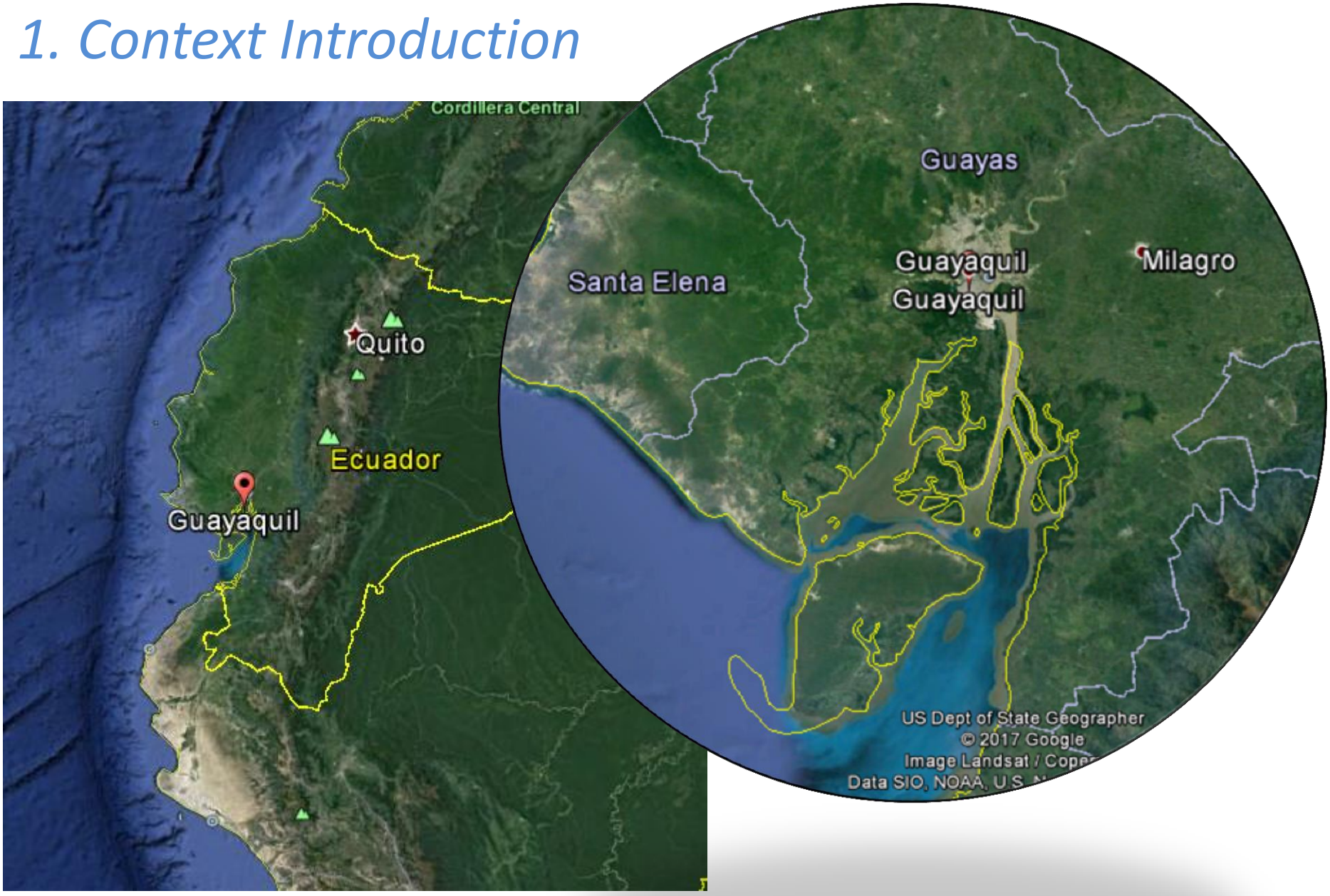




Exploring Urban Flood Risk Management Measures Guayaquil, Ecuador

Alexandra Garcés Santander
Ad Jeuken and Otto de Keizer

1. Context Introduction



1. Context Introduction

1. Context Introduction

- Conditions that contribute to the floods:
  - Tropical semi-humid climate
  - Heavy rainfall in short periods
  - Poor drainage system and open outlets (return period 1 to 5 years)
  - Tidal system
  - Sedimentation of the Guayas River
  - Sea level rise and El Niño

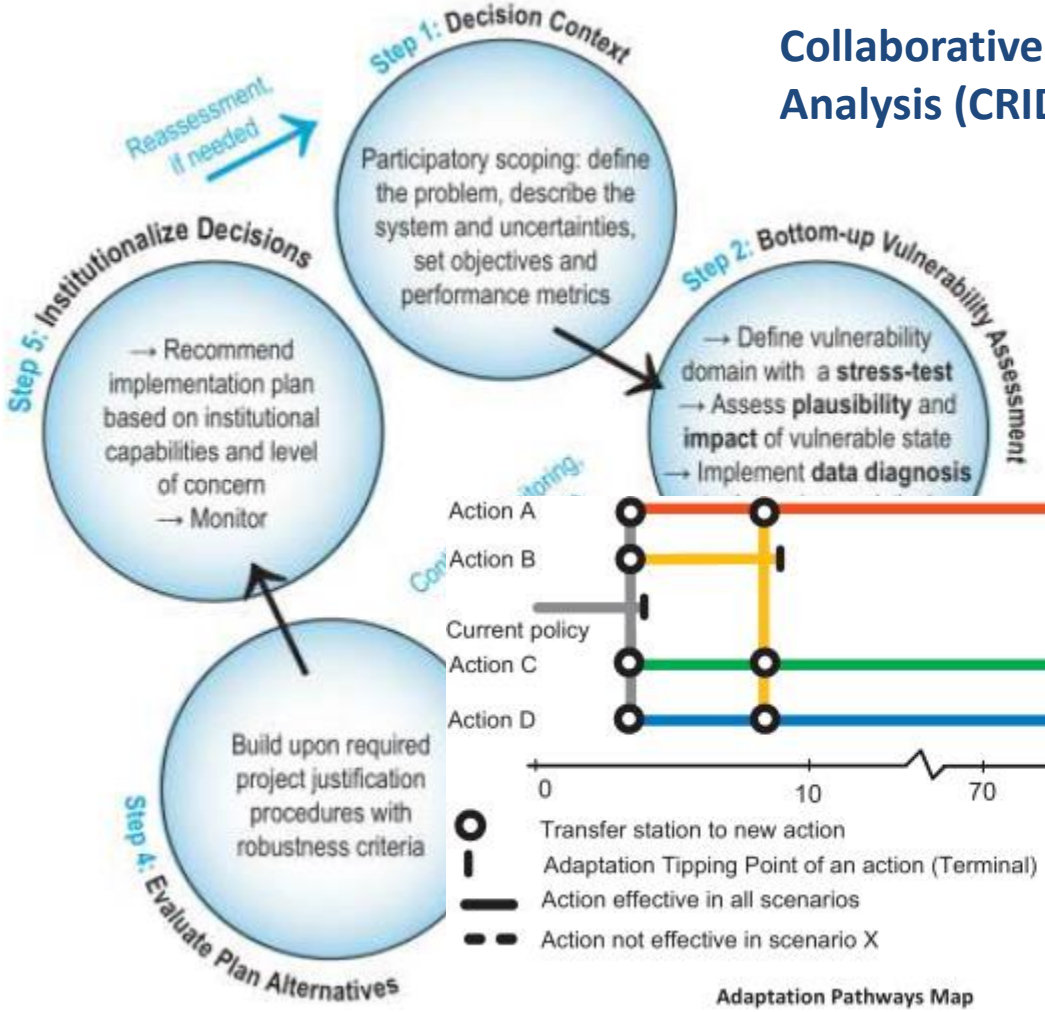
2. Objective

- Exploration of possible urban flood risk management options in Guayaquil

1) Define socially acceptable flood levels of Guayaquil citizens
2) Define urban flood risk management measures
3) Define possible adaptation pathways

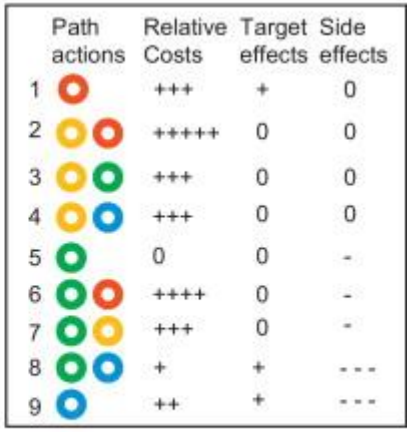
3. Approaches used

Collaborative Risk Informed Decision Analysis (CRIDA)



Adaptation Pathways

Adaptation Pathways Map



	Path actions	Relative Costs	Target effects	Side effects
1		+++	+	0
2		+++++	0	0
3		+++	0	0
4		+++	0	0
5		0	0	-
6		++++	0	-
7		+++	0	-
8		+	+	- - -
9		++	+	- - -

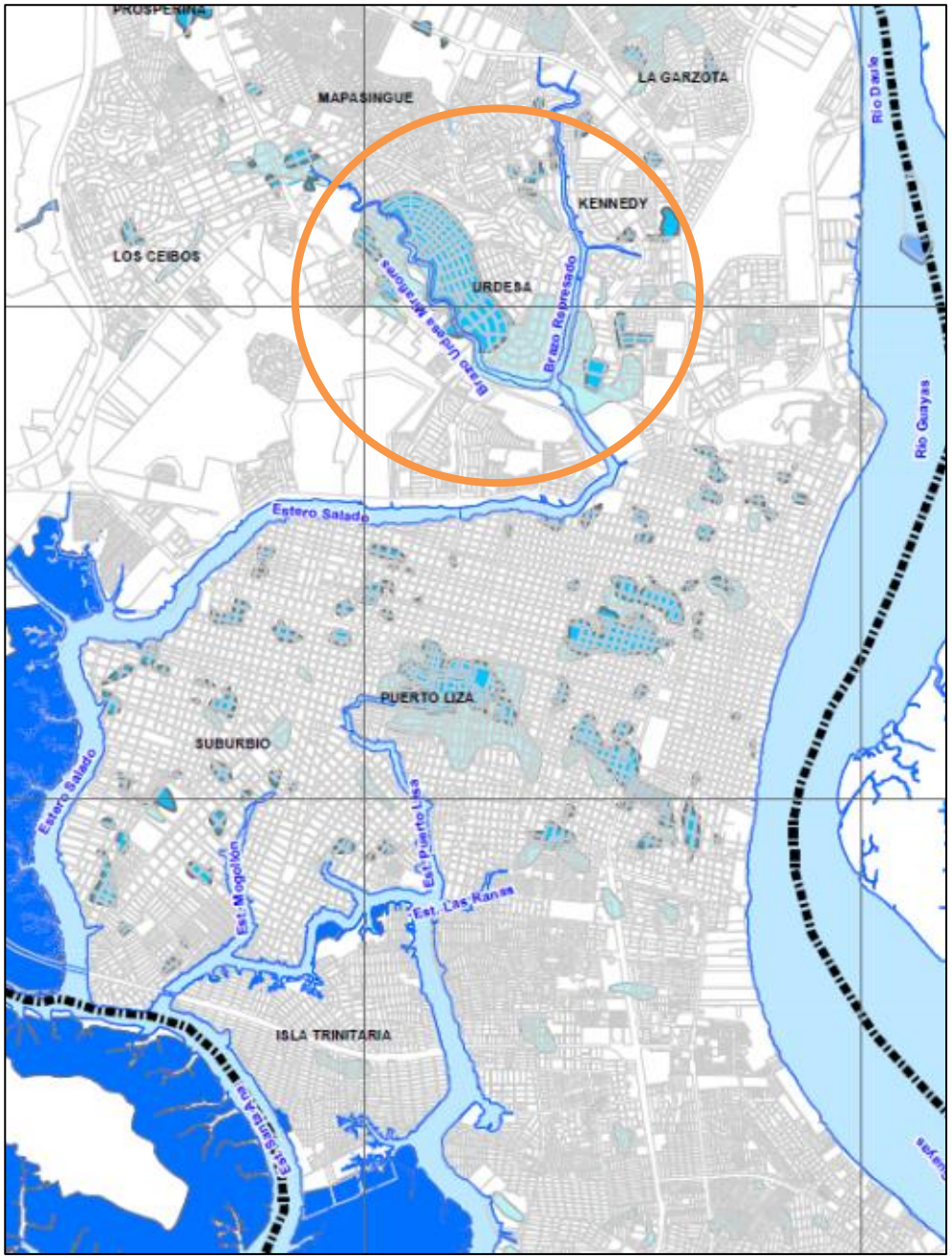
Scorecard pathways

Source: Mendoza et al., 2017

Source: Haasnoot et al., 2013

5. Results

- Floods occur in the city in periods of **high tide** (4m) and **heavy rainfall**
- **Urdesa**, the recurrent flooded area



Source: Guayaquil municipality 2015

5. Results

Identified thresholds

Current Conditions

Trigger 1
Flooding of the streets more than **20cm** reduce income in the business in the area, decrease the value of property, increase skin problems and impede access to the area
3 times per week

Trigger 2
When flood events are more than **50cm** the business have to close completely, and there is no transportation in the area, damage in property and assets and skin problems in legs and feet
1 per month

Trigger 3
When flood events are more than **60cm** the area collapses




5. Results

5. Results

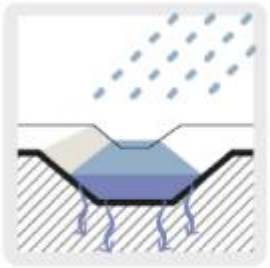
Identified measures using a collaborative tool

5. Results

Identify measures with the AST

5. Results Identified measures

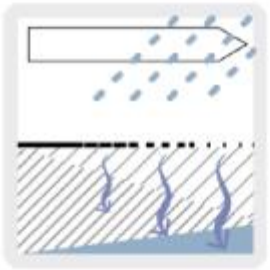
Bioswale



Bioswales are similar to bioretention cells in that they are depressed planted areas with overflow structures that collect, detain, infiltrate, and filter runoff. However, bioswales differ from bioretention cells in that they are also conveyance facilities (linear systems) that are greater in length than width; they are often equiped with an underdrain.



Amended Soils



Amending soils improves the conductivity, or infiltration (in/hr) of the soil. This is achieved by increasing the permeability of the soil, allowing water to move through the spaces between soil particles more freely. Amended soils are typically used on small soil particles with little void space in between and low permeability.



Install New Storm Sewer (15' Pipe)

Increasing storm sewer capacity provides a higher rate of flow (typically cubic feet per second, CFS), a larger storage volume within drainage pipes, and an increased discharge rate for a grey infrastructure system. This type of facility can be quite effective when paired with green infrastructure measures on the surface.


5. Results

Identified measures

- Workshop measures

Awareness Campaign

Educational Campaign

COOTAD Reformation

New territorial planning

Strengthen Stakeholders Capacity

Building Regulations

Inter-institutional Cooperation

Economic Incentives

Rain water harvest

Pervious Pavement

Extensive Green Roofs

Bio Swale

Grassed Swale

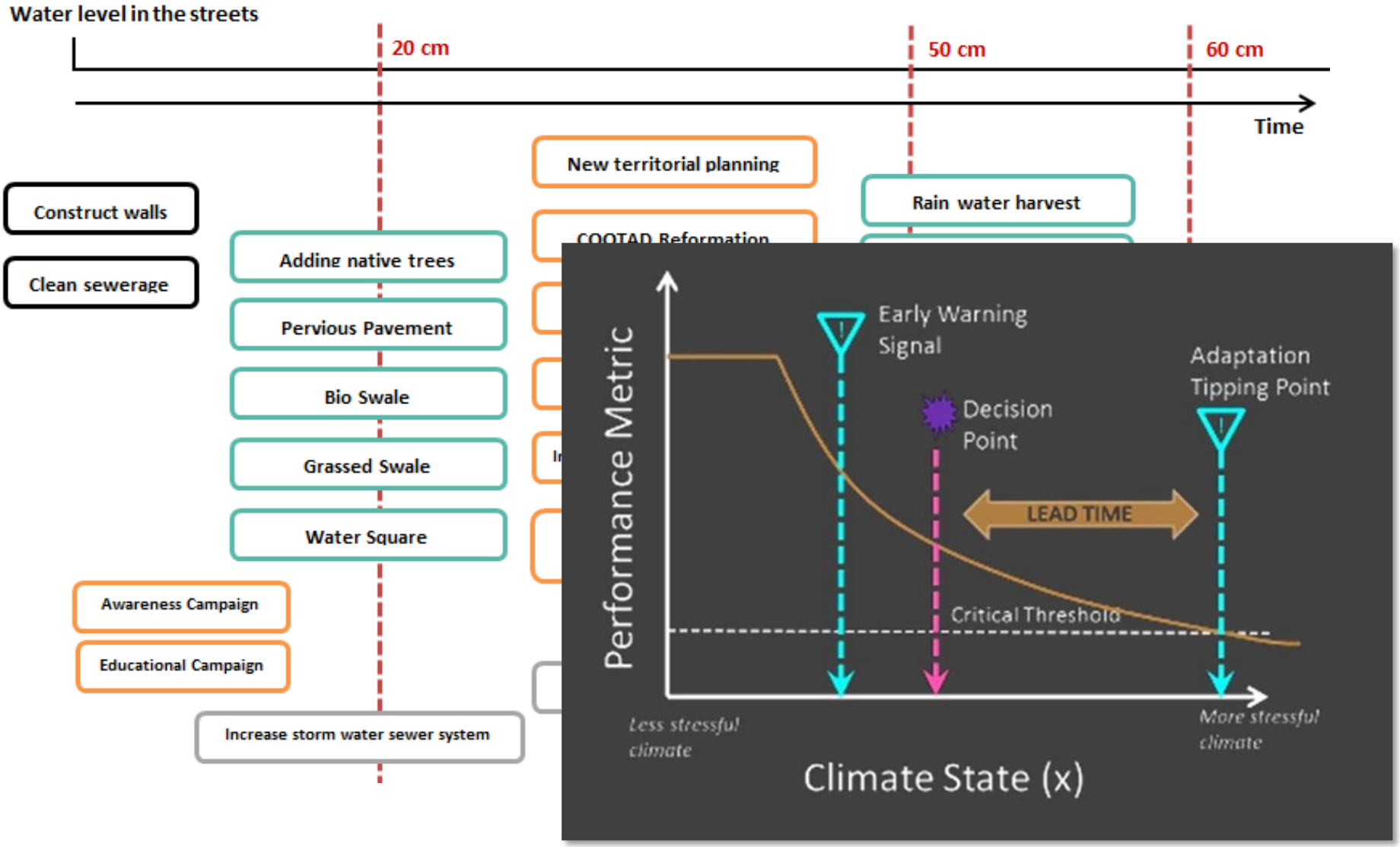
Adding native trees

Water Square

Increase storm water sewer system

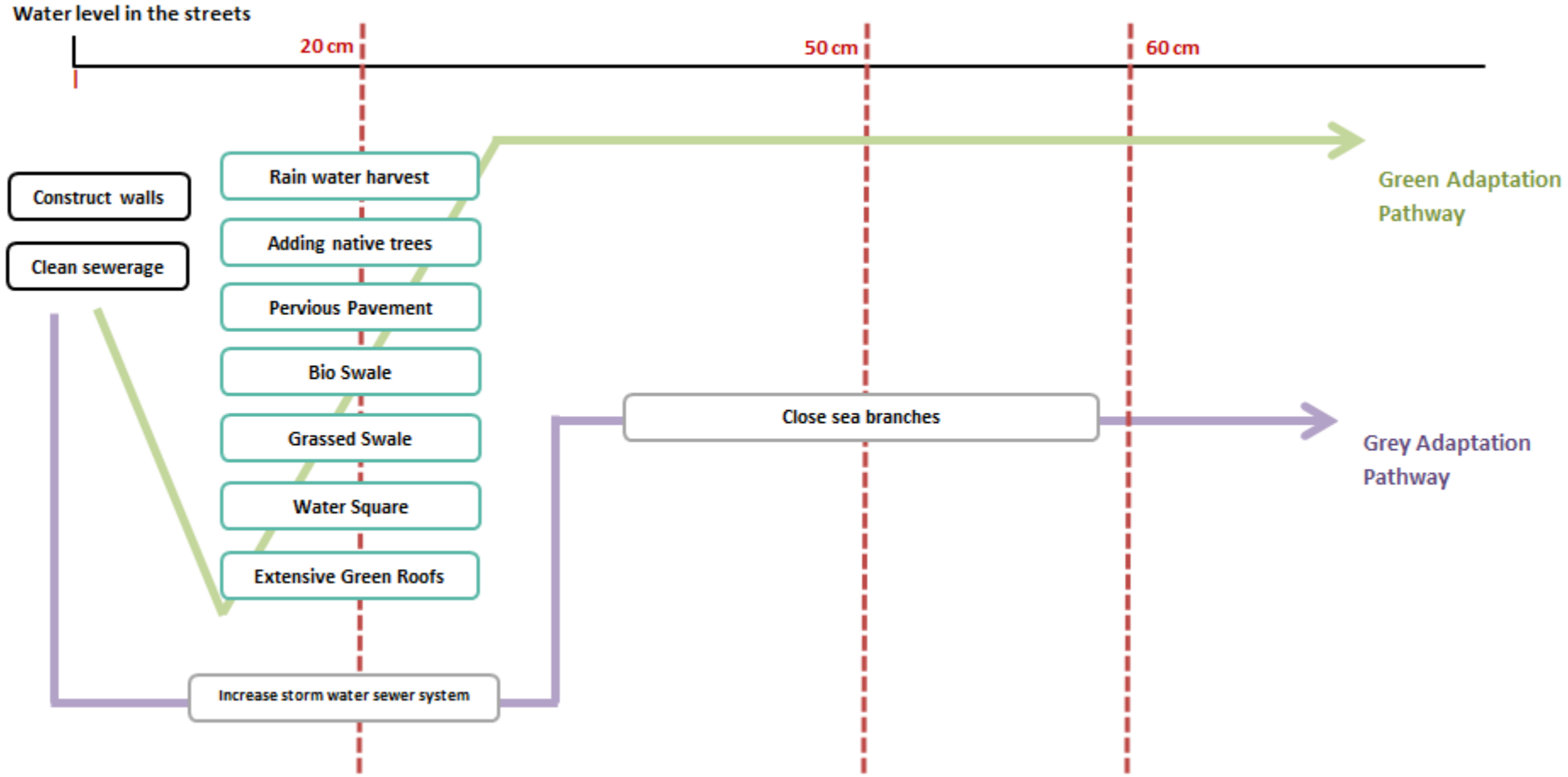
5. Results

Identified measures



5. Results

Possible pathways



5. Results

Identified measures

- Measures from studies

Source: Stenfert et al, 2016

1. Storage areas in the city with an area of 7,1 km2

5. Results

Identified measures

- Measures from studies

2. Gates at the entrance of the branches as storage area

Source: Stenfert et al, 2016

5. Results

Identified measures

- Measures from studies

3. Levees at sea branches

Source: Stenfert et al, 2016

5. Results

Identified measures

- Measures from studies

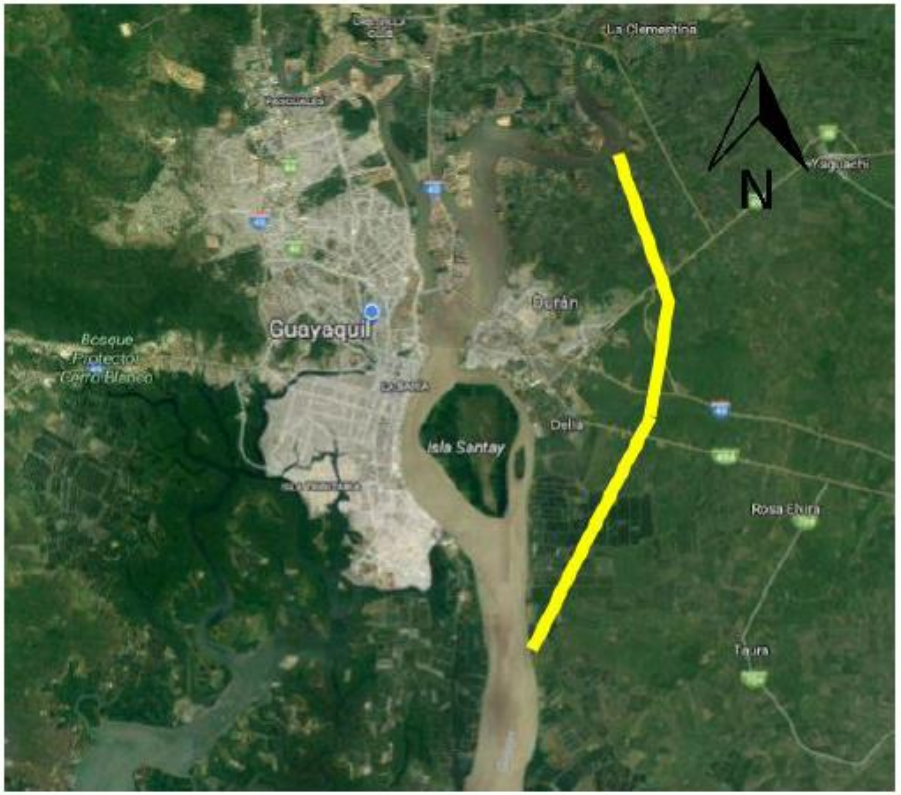
4. Barrier to close the Guayas River

Source: Stenfert et al, 2016

5. Results

Identified measures

- Measures from studies

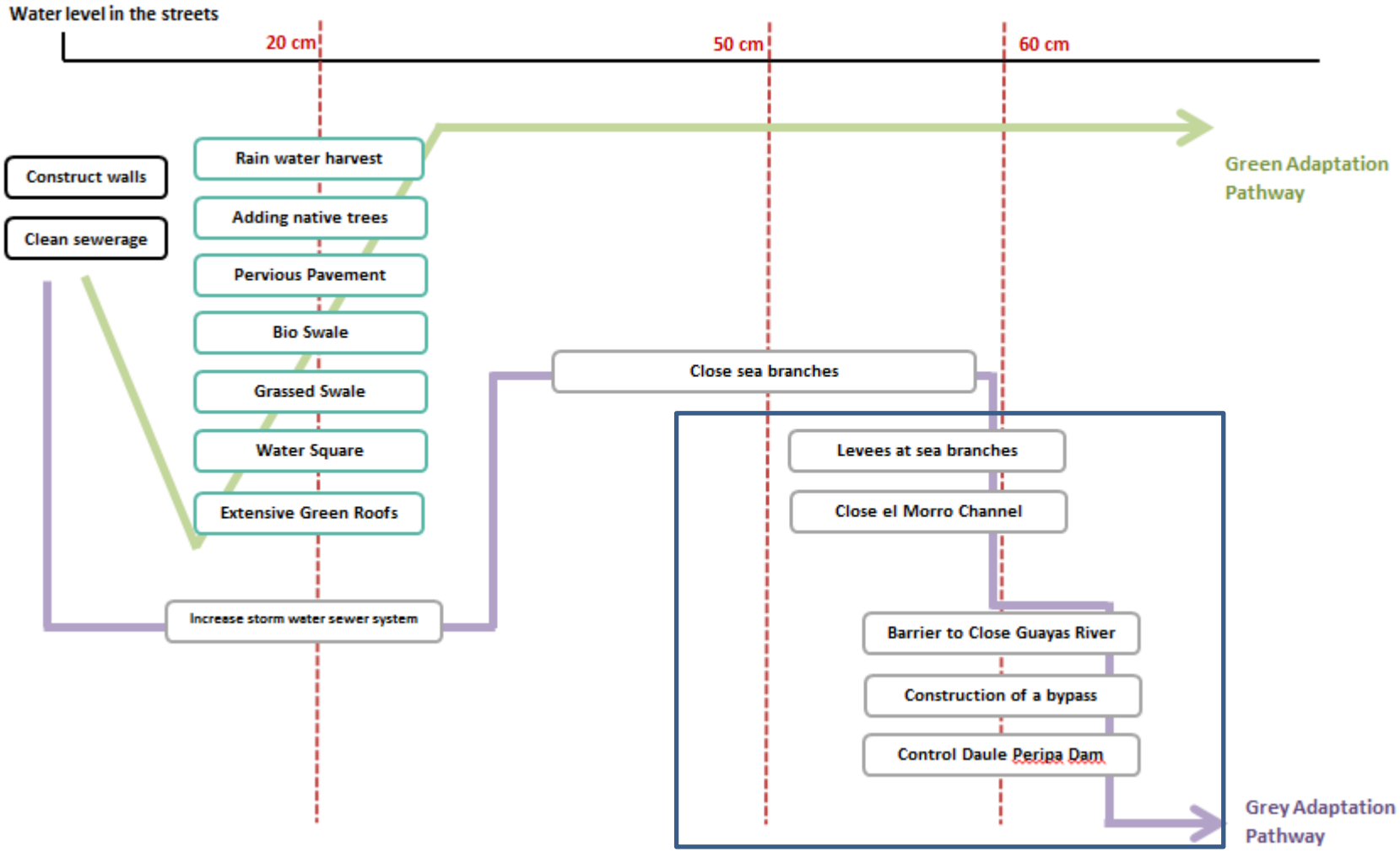


5. Bypass to lower water levels in Guayas River

Source: Stenfert et al, 2016

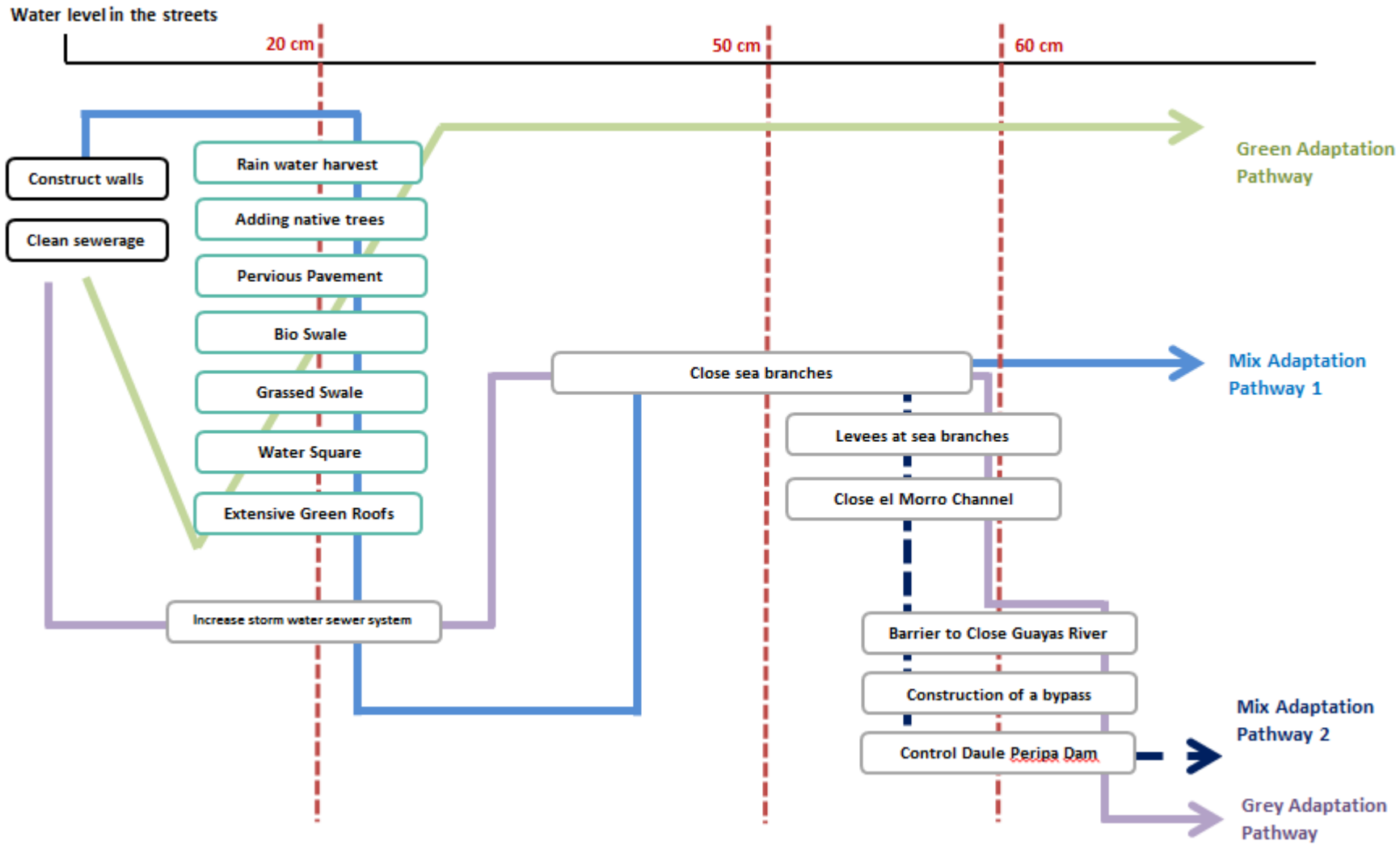
5. Results

Possible pathways



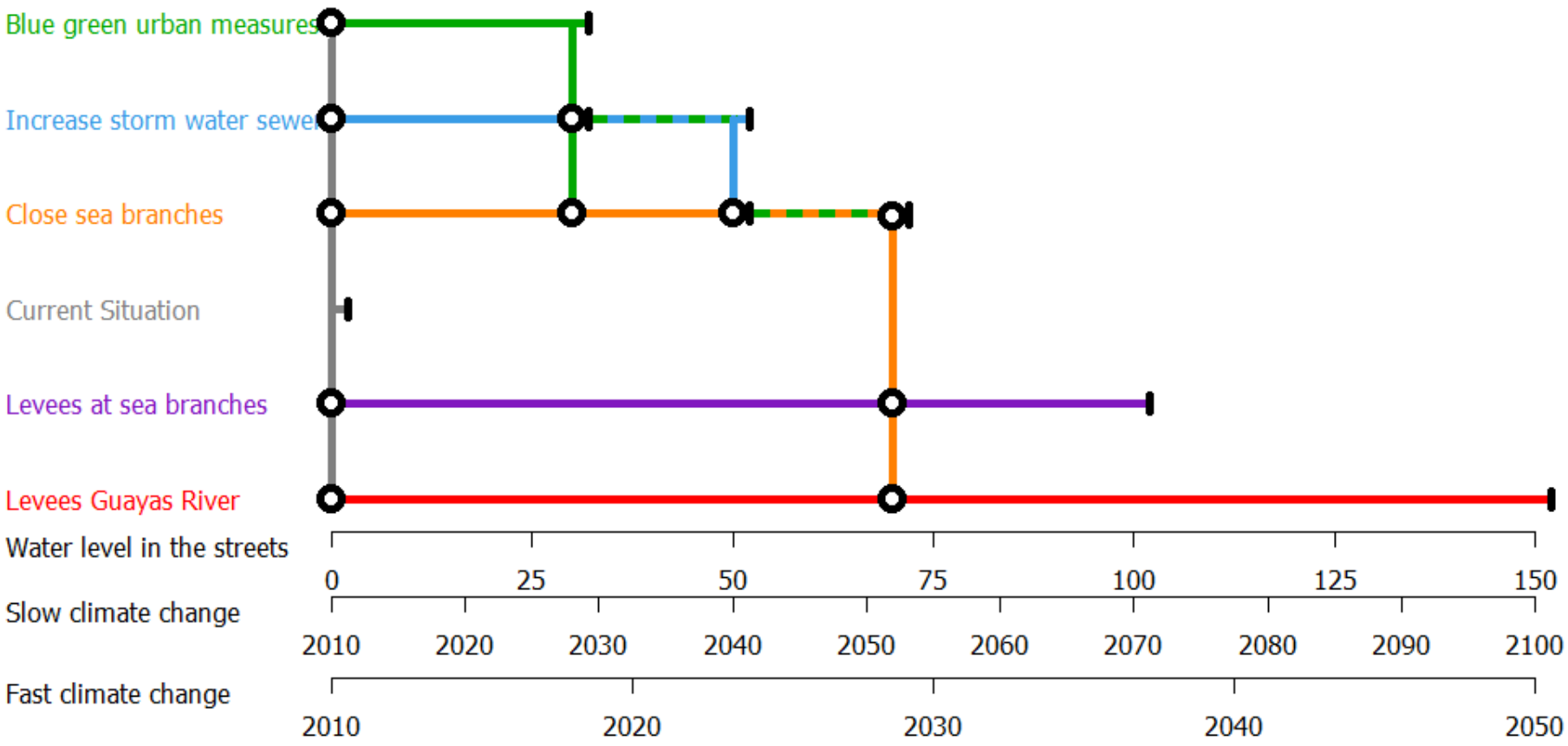
5. Results

Possible pathways



5. Results

Possible pathways



Map generated with Dynamic Pathways Generator, @2015, Deltares, Carthago Consultancy

Some conclusions

- Local green-blue measures can postpone larger scale infrastructure investments
- Pathways provide a tool to explore flexibility:
  - What decisions can and need to be made on the short term
  - What options to keep open for the longer term
  - Possible path dependencies
- Take into account that enabling measures are preceding physical measures and contribute to the lead time.

Thank you

For more info see:

- agwaguide.org/about/CRIDA/
- pathways.deltares.nl
- ruimtelijkeadaptatie.nl/english/tools/
- www.deltares.nl/en/software/adaptation-support-tool-ast/