

# Sustainable Delta

a **serious game** about  
water management under uncertainty

<http://deltagame.deltares.nl>

# Acknowledgements



Sustainable Delta was originally developed by a team from Deltares, University Utrecht, Maastricht University-ICIS, Carthago Consultancy, Pantopicon, KNMI, and University of Twente.

It has been further developed by Deltares, Carthago Consultancy, and the New Zealand Climate Change Research Institute, Victoria University of Wellington.

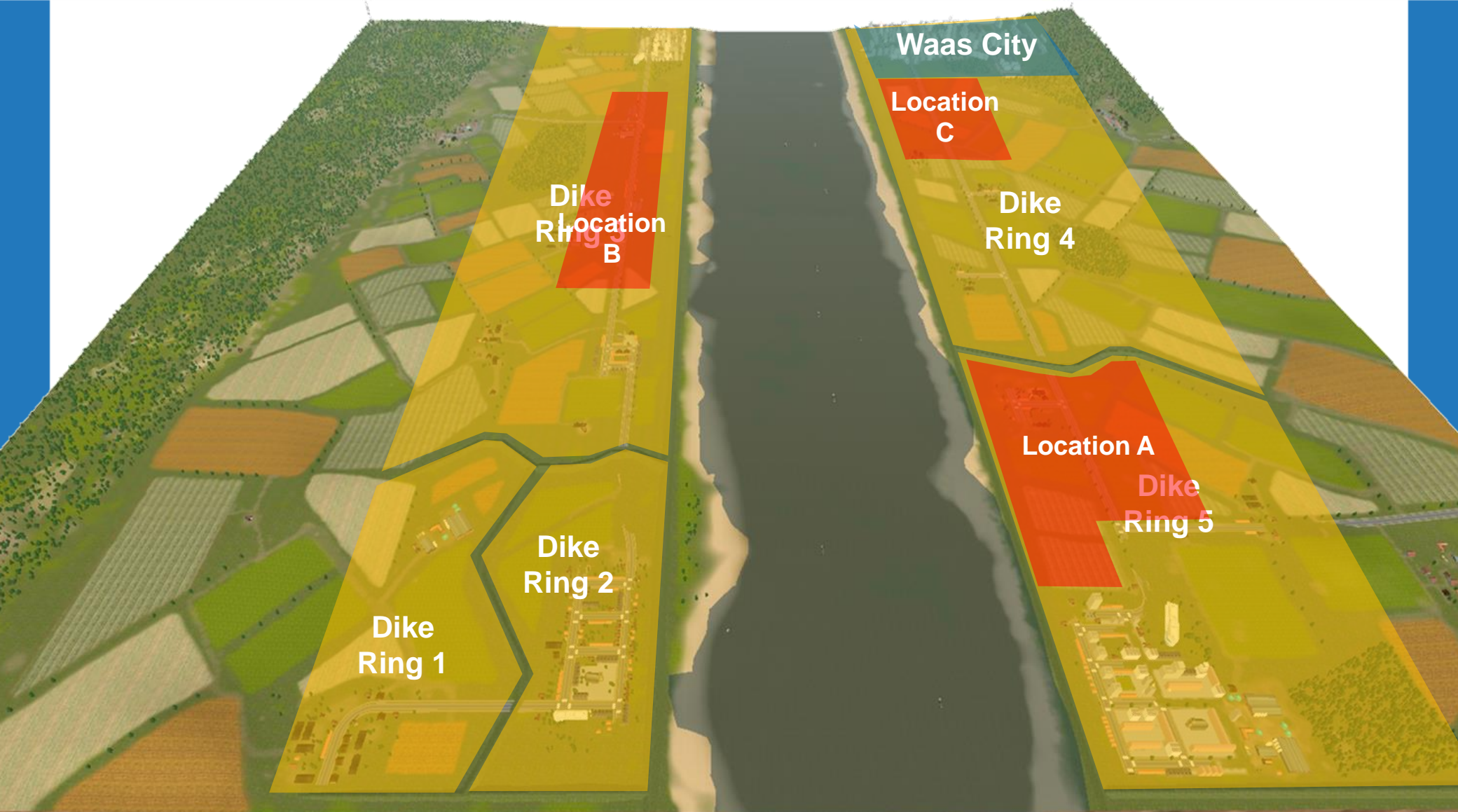
It has been played over 60 times with water managers, spatial planners, and students during workshops and international conferences all over the world.

# Why play the game?

- Experience the future and its uncertainties
- Awareness about adaptive water management
- Awareness of the role of negotiation and collaboration
- Reflect on policy decisions
- Discuss robust and flexible policy actions



# Waas River



# Waas River



**15 years ago...**

# **Delta times**

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Tuesday

DESIGNATED AREAS HIGHER 50c

**Severe drought in Waas delta!  
River unnavigable in places!**

**Farmers demand more water for crops!**

4 years ago...

# Delta times

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Tuesday

DESIGNATED AREAS HIGHER 50c

## Another flood hits the delta!

Despite all the recent studies and measures, the Waas delta has flooded a second time in 3 years.

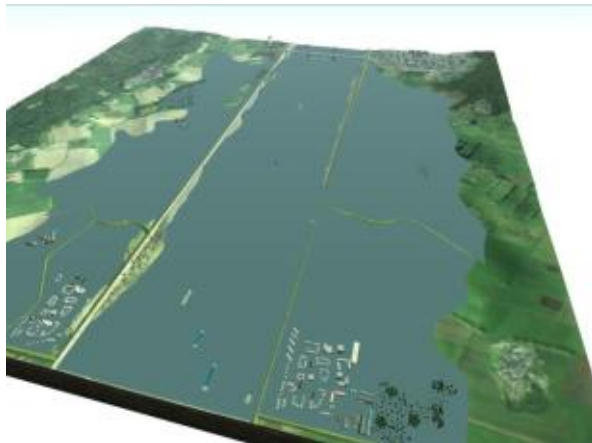
Mayor: This may never happen again!





# History

## Floods

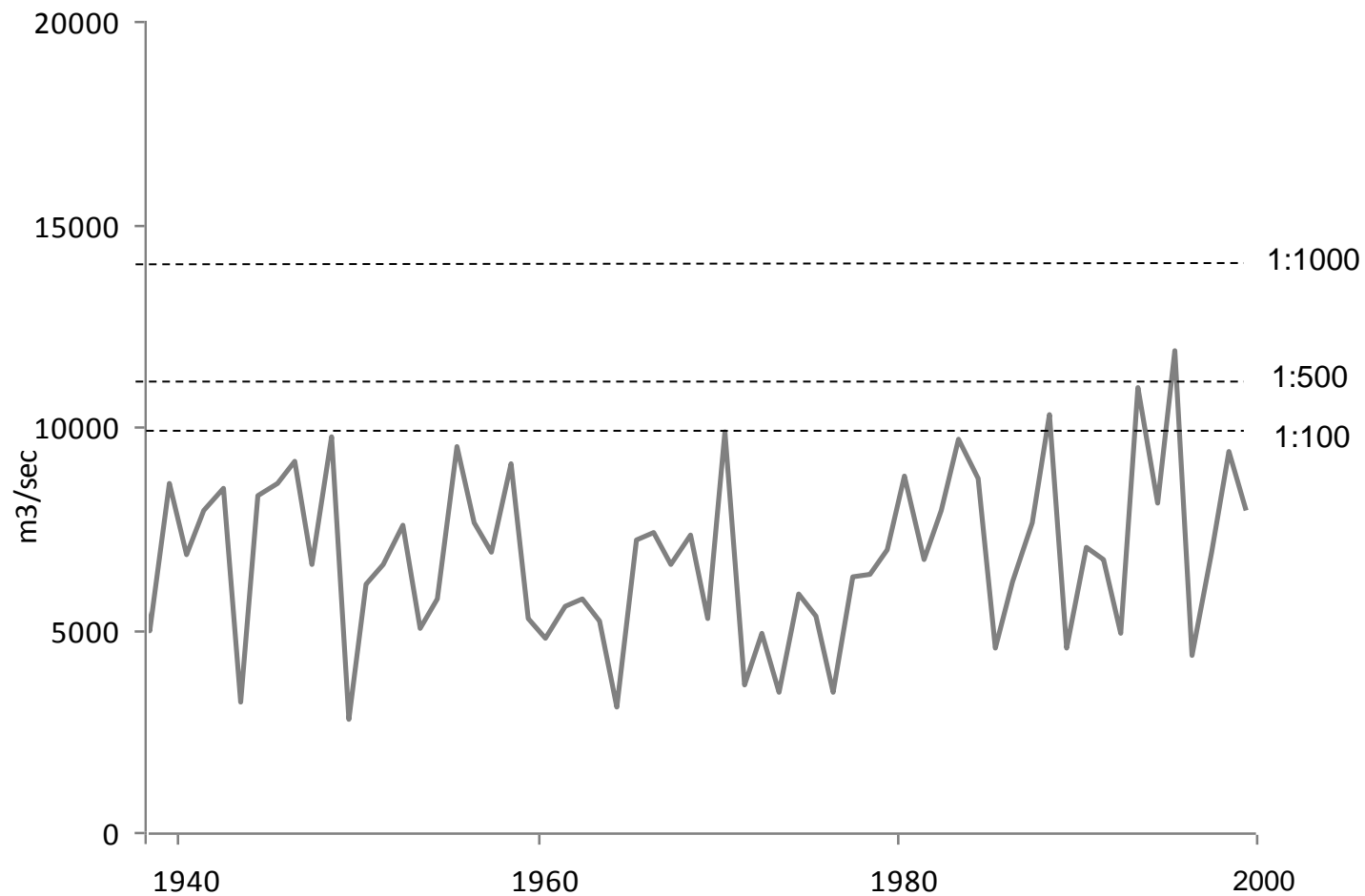


## Droughts





# Historical Peak Discharges



# In the future...

Climate change?



Socio-economic growth?

# Climate Change

**Climate is  
changing!**



**Bigger peak flows?**



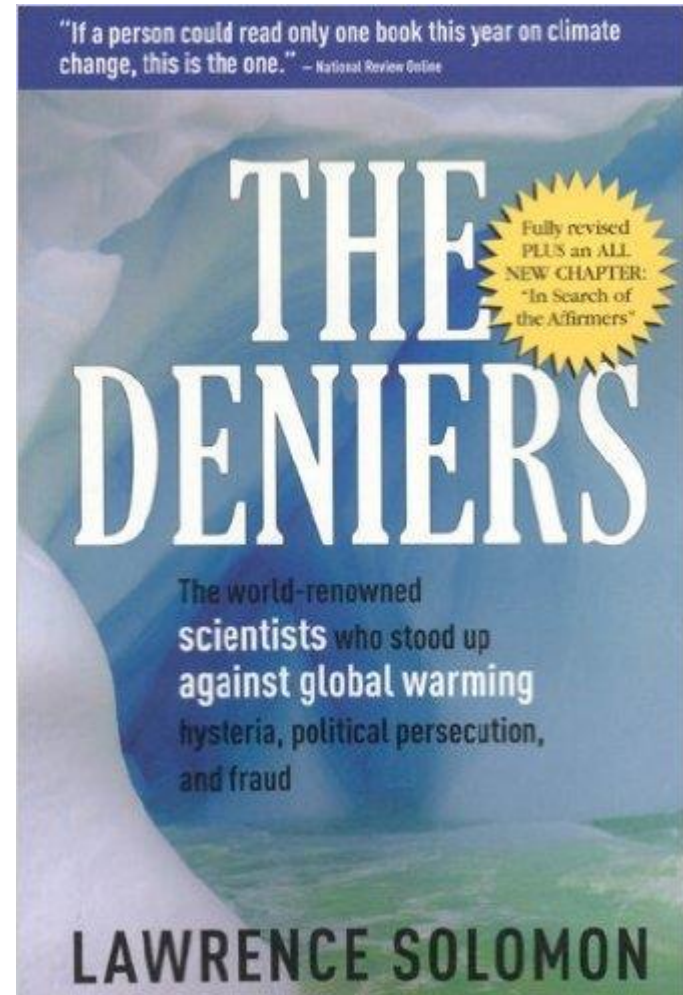
**Lower summer flows?**





# Climate Change?

**There is no  
such thing as a  
climate crisis**



# Socio-Economic Change?

Population growth?



Economic growth?



# Your role

To develop a sustainable management plan for the Waas area for the next 100 years in the context of an uncertain and changing environment.

- Mitigate flood risks
- Pay attention to navigability
- Pay attention to nature
- Pay attention to community attitudes
- Acknowledge uncertainties

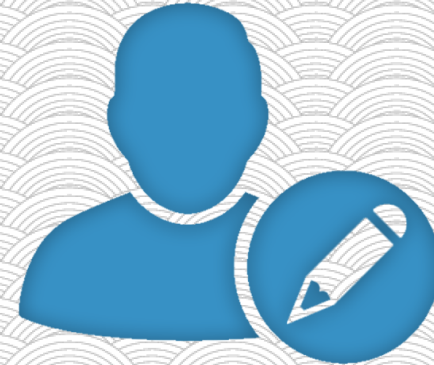


# Rules

# Two Teams



**Captain**



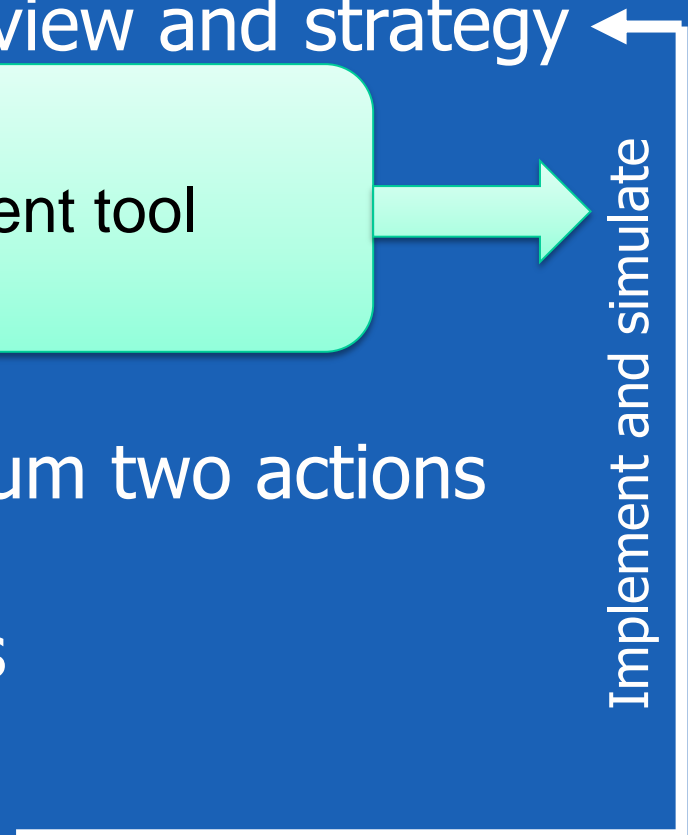
**Log Keeper**

# Game Round

1. Determine team's point of view and strategy
2. Take into account local context  
(Local context)
3. Each team chooses maximum two actions
4. Negotiate preferred actions
5. 'Overrule society'

Rapid assessment tool

Implement and simulate



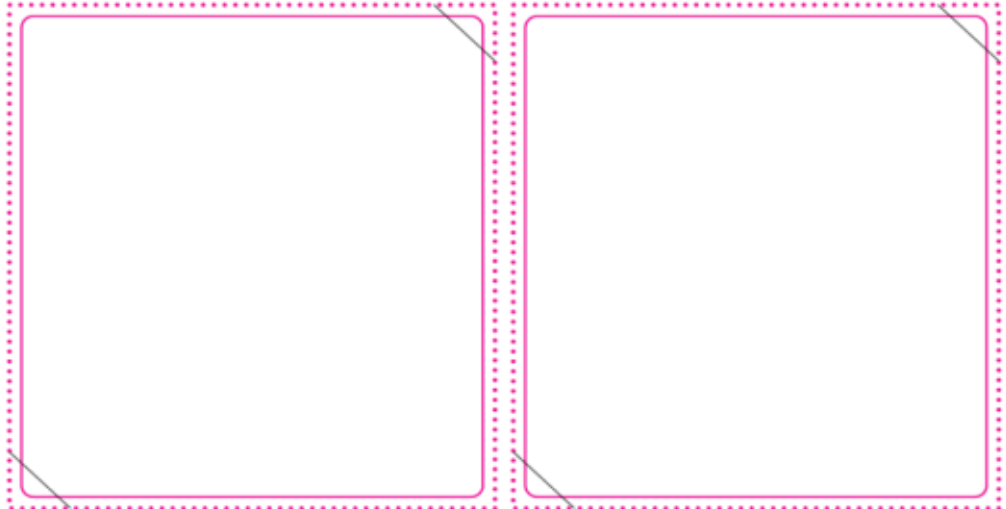


# 1. Determine team name, point of view and strategy

Team name:

We have chosen  
the following measures:

The most important reasons therefore are:



Two empty rectangular boxes for notes, each with a solid magenta border and a dotted magenta border. The boxes are positioned side-by-side, with the left box slightly larger than the right one. Each box has a small diagonal line in the top right corner, possibly indicating a fold or a specific orientation.

## 2. Take into account society's point of view



### 3. Discuss and select two actions only

**Room for the River**  
Large Scale



**Costs**  
 🏠 90  
 🚧 2.7

**Impact**

- 🏠 ☐
- 🚧 ☐
- 🌳 ☐
- 🌊 ☐
- 👤 ☐
- 🌾 ☐

More room for the river created by widening the river bed. This results in a large increase in nature area.

- Blocks development vulnerable to flooding in Areas A and B
- No social support in case of financial crisis

**Upstream Cooperation**  
Medium Scale



**Costs**  
 🏠 3  
 🚧 1.5

**Impact**

- 🏠 ☐
- 🚧 ☐
- 🌳 ☐
- 🌊 ☐
- 👤 ☐
- 🌾 ☐

Cooperation with upstream water managers, yielding a reduced maximum river discharge of 18 000 m³/s. This action is shrouded in uncertainty: cooperation is not always successful.

- Implementation of this action is uncertain

**Levee Strength**  
Wave Resistant Dikes




**Costs**  
 🏠 40  
 🚧 1.6

**Impact**

- 🏠 ☐
- 🚧 ☐
- 🌳 ☐
- 🌊 ☐
- 👤 ☐
- 🌾 ☐

Dikes covered with asphalt, increasing embankment strength. These dikes can overflow without breaching.

**Levees to Design Discharge**  
1 : 1000 yr + 0.5m



**Costs**  
 🏠 40  
 🚧 0.4

**Impact**

- 🏠 ☐
- 🚧 ☐
- 🌳 ☐
- 🌊 ☐
- 👤 ☐
- 🌾 ☐

Raise level of dikes to 1:1000 year design discharge, with a safety margin of 0.5m.

**Levee Height: Dike Ring 1**  
Raise Dike Ring 1 by 2m



**Costs**  
 🏠 7  
 🚧 0.1

**Impact**

- 🏠 ☐
- 🚧 ☐
- 🌳 ☐
- 🌊 ☐
- 👤 ☐
- 🌾 ☐

Increase the height of dike ring 1 by 2m.

**Training**  
Evacuation training



**Costs**  
 🏠 3  
 🚧 0.6

**Impact**

- 🏠 ☐
- 🚧 ☐
- 🌳 ☐
- 🌊 ☐
- 👤 ☐
- 🌾 ☐

Provide education to citizens regarding what to do in case of flooding. This results in an increased response rate when flood alarms are given.

**Dredging**  
Small scale dredging



**Costs**  
 🏠 5  
 🚧 4

**Impact**

- 🏠 ☐
- 🚧 ☐
- 🌳 ☐
- 🌊 ☐
- 👤 ☐
- 🌾 ☐

The navigation channel undergoes small-scale deepening, resulting in a minimum depth of 4m at 700 m³/s.

**Boat types**  
Small boats



**Costs**  
 🏠 50  
 🚧 5

**Impact**

- 🏠 ☐
- 🚧 ☐
- 🌳 ☐
- 🌊 ☐
- 👤 ☐
- 🌾 ☐

Small vessels up to 1500 tonnes. Smaller boats have the ability to navigate the river during lower discharges. A minimum depth of 2m is required.

**Land Use: Area A**  
Nature



**Costs**  
 🏠 20  
 🚧 0

**Impact**

- 🏠 ☐
- 🚧 ☐
- 🌳 ☐
- 🌊 ☐
- 👤 ☐
- 🌾 ☐

Increase the area used for nature at the expense of farmland in Area A.

**Land Use: Area C**  
Urban area



**Costs**  
 🏠 40  
 🚧 0

**Impact**

- 🏠 ☐
- 🚧 ☐
- 🌳 ☐
- 🌊 ☐
- 👤 ☐
- 🌾 ☐

Increase the urban area at the expense of farmland in Area C.



# Card legend

## Impact



Flood damage



Casualties



Drought (Navigation)



Nature

## Cost



Initial costs



Recurrent costs

No effect



Very small positive effect



Small positive effect



Moderate positive effect



Strong positive effect



Very strong positive effect



Very small negative effect



Small negative effect



Moderate negative effect



Strong negative effect



Very strong negative effect





# Policy Actions





Room for the river

## Medium scale


**Costs**


	60
	1.8

**Impact**

	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>

More room for the river is created by widening the river bed. This results in a moderate increase in nature area. Space in area B cannot be used for developments that are not flood proof.

 Blocks development vulnerable to flooding in area B





Room for the river

# Policy Actions

Levees to design discharge  
1 : 500 yr + 0.5 m



**Costs**

	30
	0.3

**Impact**

	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>

Raise dike years plus

Set levee height 1  
Raise dike ring 1 by 2 m



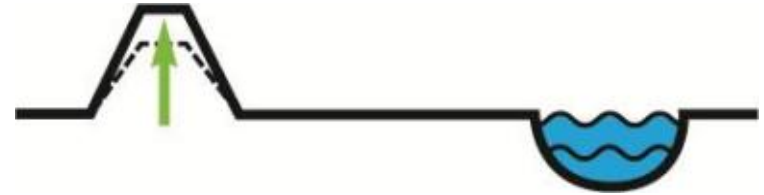
**Costs**

	7
	0.1

**Impact**

	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>

Increase the height of dike ring 1 by 2 m.




Raise dike levels



# Policy Actions

Levee strength




## Dikes around urban areas




**Costs**

	80
	0.8

**Impact**

	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>

Large cities will be embanked, resulting in a lower damage to urban areas and less casualties in case of flooding.

 No social support in case of financial crisis




Dikes around urban areas




# Policy Actions


Levee strength

## Climate dikes





**Costs**


 80


 0.8

**Impact**


 ☐

 ☐

 ☐

 ☐

Strong wide embankments that result in a lower chance of failure in case water levels are lower than the dike height.

 No social support in case of financial crisis



Climate dikes



# Policy Actions

Training



## Evacuation training



**Costs**

	3
	0.6

**Impact**

	<input type="text"/>
	<input type="text"/>
	<input type="text"/>
	<input type="text"/>

Provide education to citizens of what to do in case of flooding



**Be Prepared  
Be Aware  
Be Ready**

Evacuation training

# Policy Actions





Cooperation  
with upstream  
communities

# Policy Actions





Land use area A

## Floating houses

**Costs**

	40
	0

**Impact**

	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>
	<input type="checkbox"/>

Increase the urban area at the expense of farmland in area A. Houses are built so that they will float in case of floods .







# Policy Actions





## Dredging

### Small scale dredging

**Costs**

	5
	4

**Impact**

	<input type="text"/>
	<input type="text"/>
	<input type="text"/>
	<input type="text"/>

The navigation channel is deepened at a small scale, resulting in a minimum depth of 4 m at 700 m<sup>3</sup>/s



Dredging





# Policy Actions

Boat types


## Medium boats


**Costs**


 40


 4

**Impact**

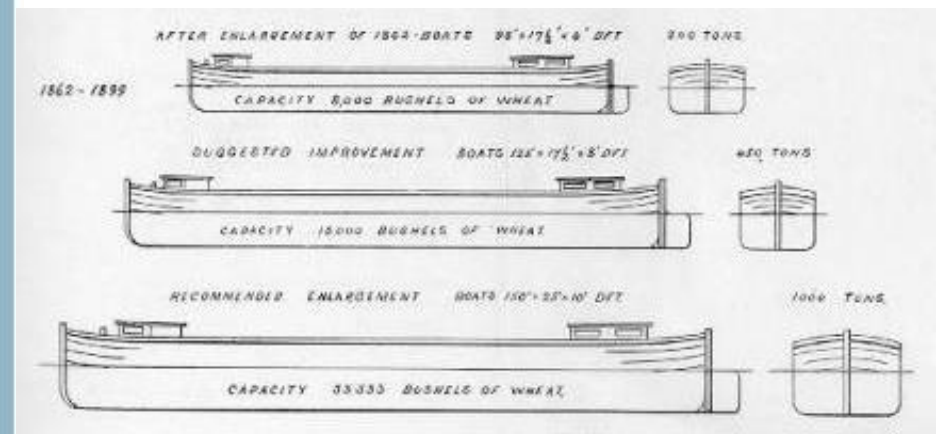









Vessels up to 3000 ton. Smaller boats have the ability to navigate the river in case of lower discharge. A minimal depth of 3 m is required.




Boat size


# Limits on Actions

Levee Strength

Dikes Around Urban Areas





Costs


 80

 0.8

Impact


 ☐

 ☐

 ☐

 ☐

Additional embankments around large urban areas, resulting in reduced damage and casualties in these areas during peak flows.

 No social support in case of financial crisis

# Choose preferred two team actions and provide rationale

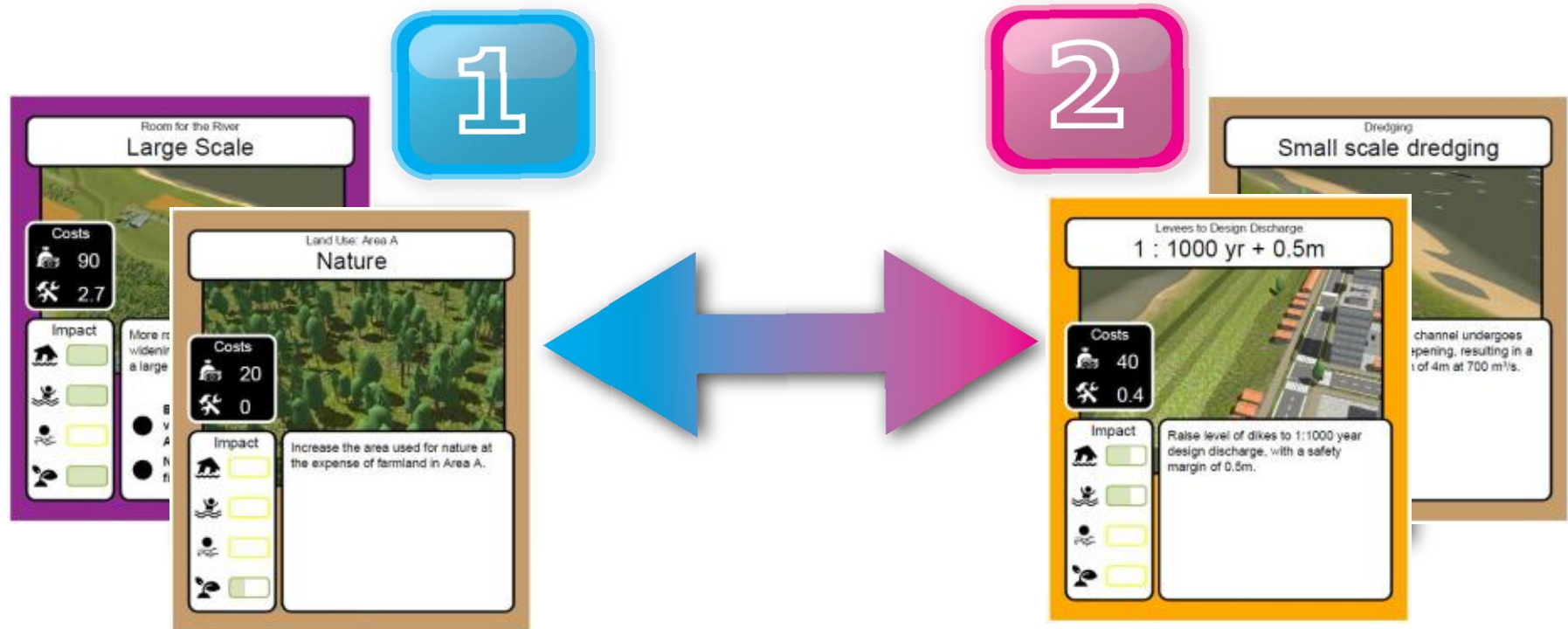
Team name:

We have chosen  
the following measures:



The most important reasons therefore are:

## 4. Negotiate



## 5. Overrule society (if needed to implement negotiated actions)





## 6. Simulate to assess impacts

Flood Damage



Casualties



Nature



Drought (Navigation)



**Let's Play!**

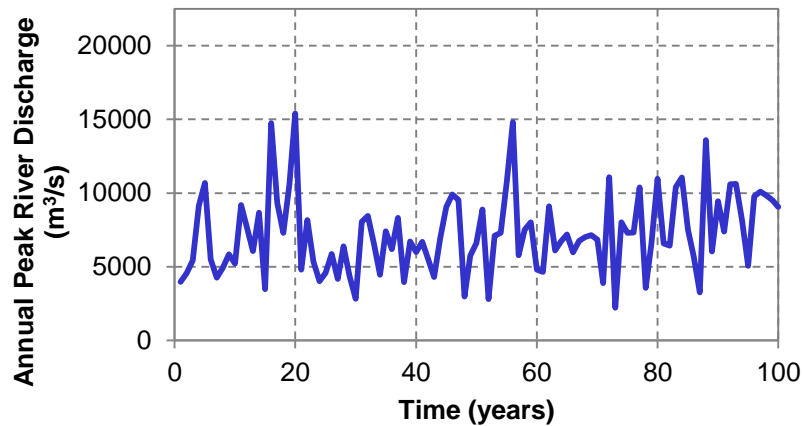
# Debriefing

## Evaluation after simulating 100 years

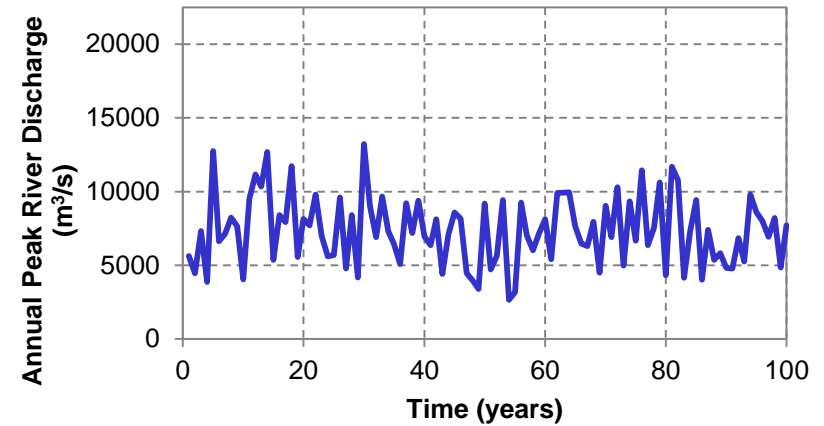
- Were there actions that were more effective than others?
- Did you notice any changes in your decision-making behaviour?
- (When) did you experience change in strategy or vision?
- What arguments did you use to change?
- Which uncertainties did you experience?
- What was the role of negotiation?
- In hindsight, would you have played the game differently?

# Alternative Scenarios

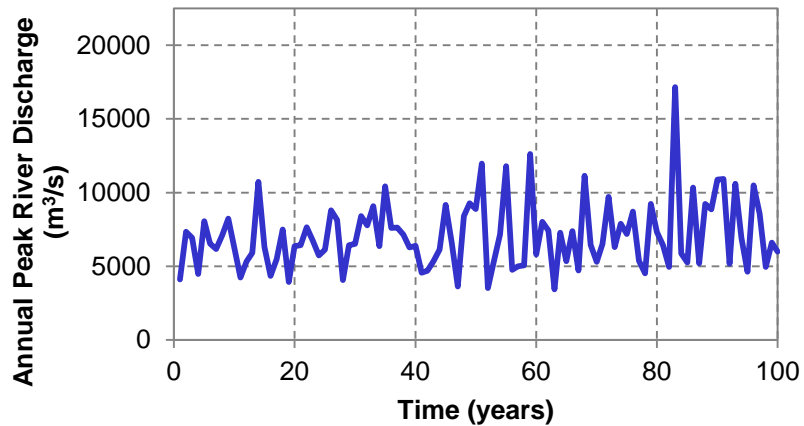
**Scenario 18: G**



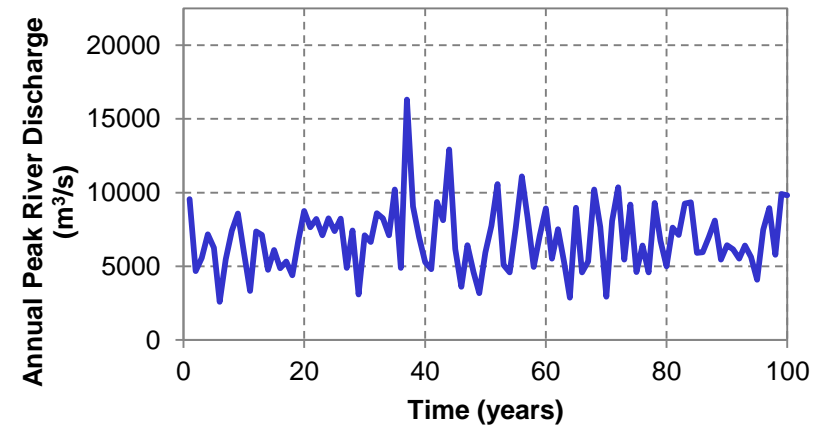
**Scenario 14: G**



**Scenario 20: G**



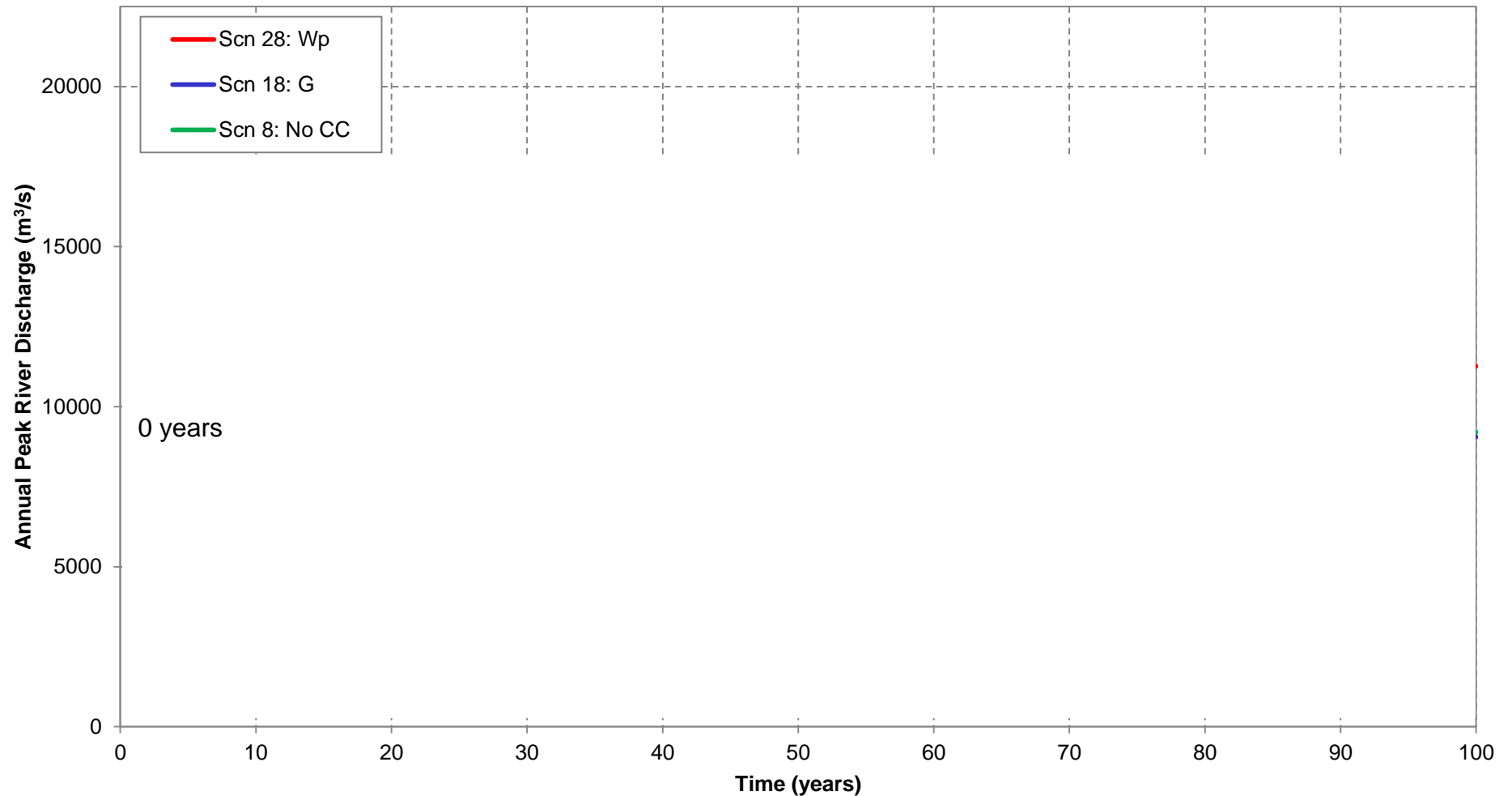
**Scenario 11: G**



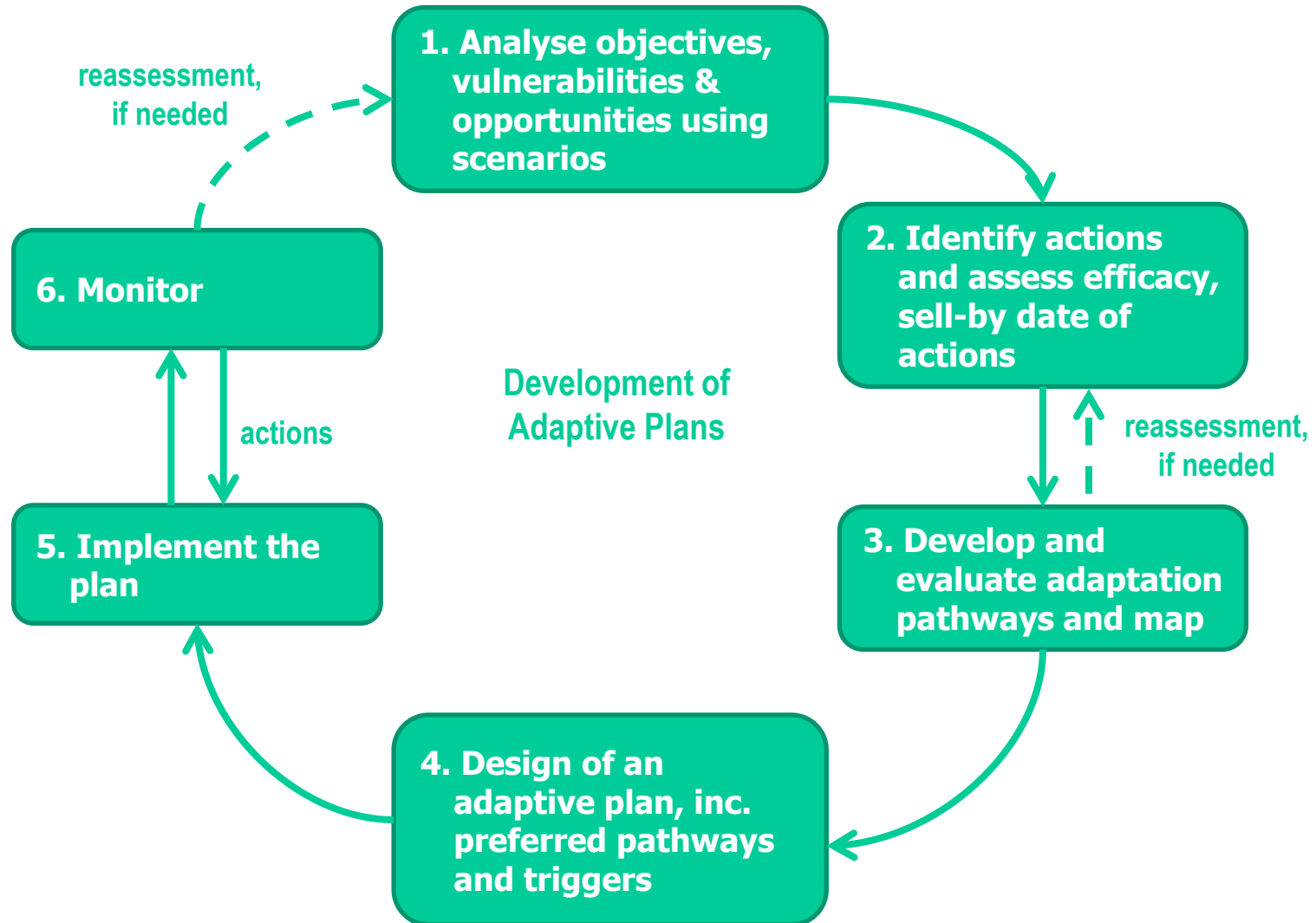


# Alternative Scenarios

Scenarios Comparison: 8, 18, 28

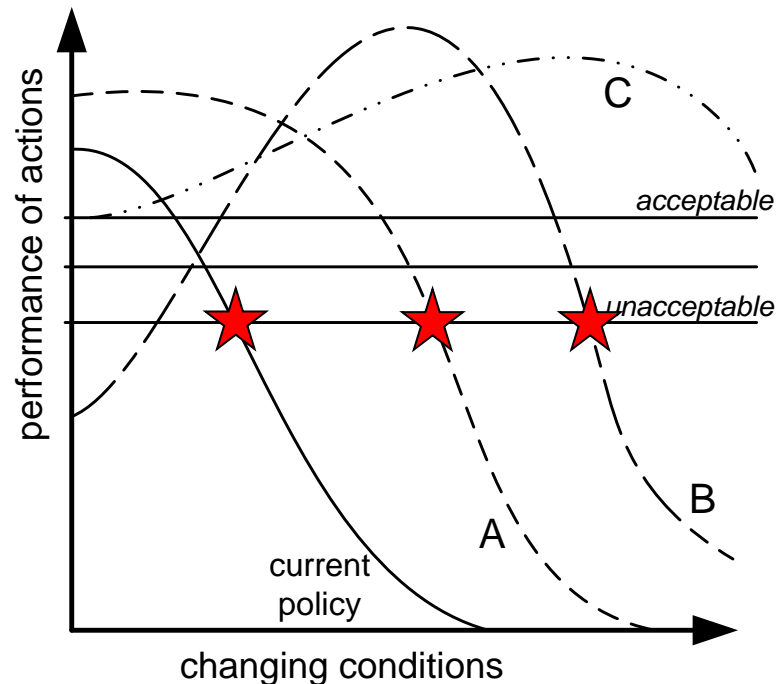


# DAPP approach



# Adaptation Tipping Points

Performance of actions  
for an ensemble of possible futures

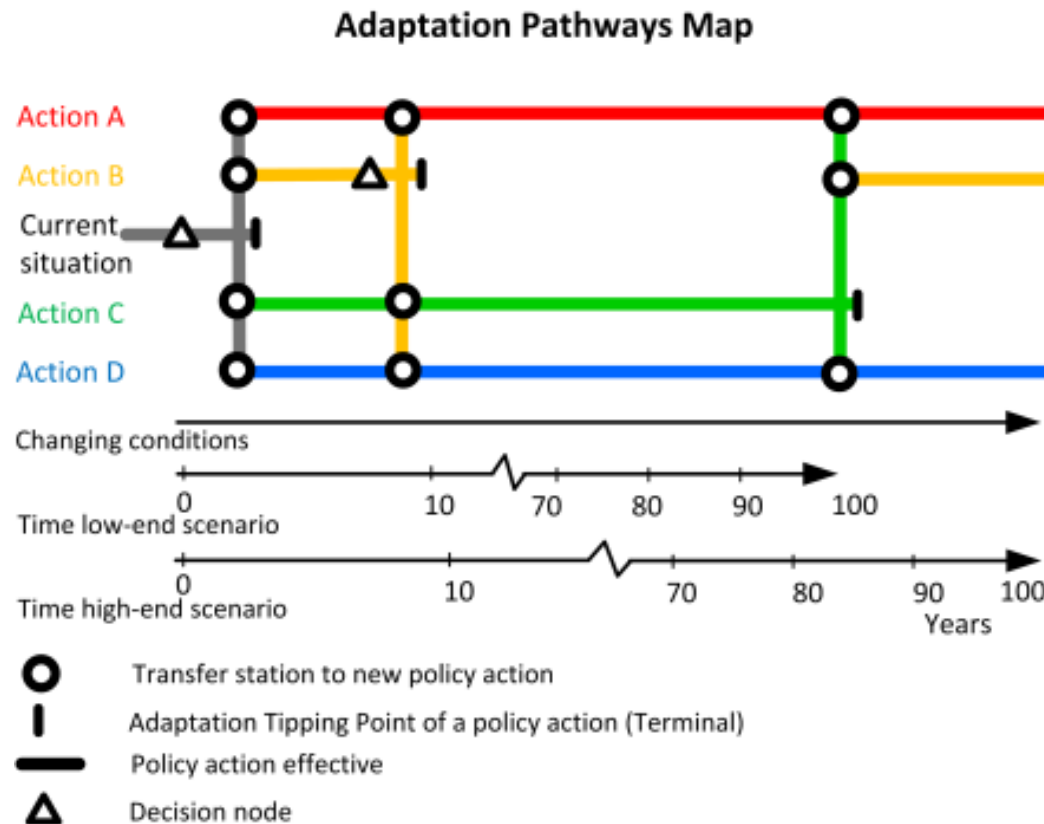


Conditions at which a  
policy begins to perform  
unacceptably

Haasnoot et al. (2012).

[DOI: 10.1007/s10584-012-0444-2](https://doi.org/10.1007/s10584-012-0444-2)

# Adaptation Pathways



## Costs and benefits of pathways

Time horizon 20 years				
Time horizon 50 years				
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	○	++	+	---

Pathways that are not necessary in low-end scenario

A sequence of policy actions

# Adaptation Pathways

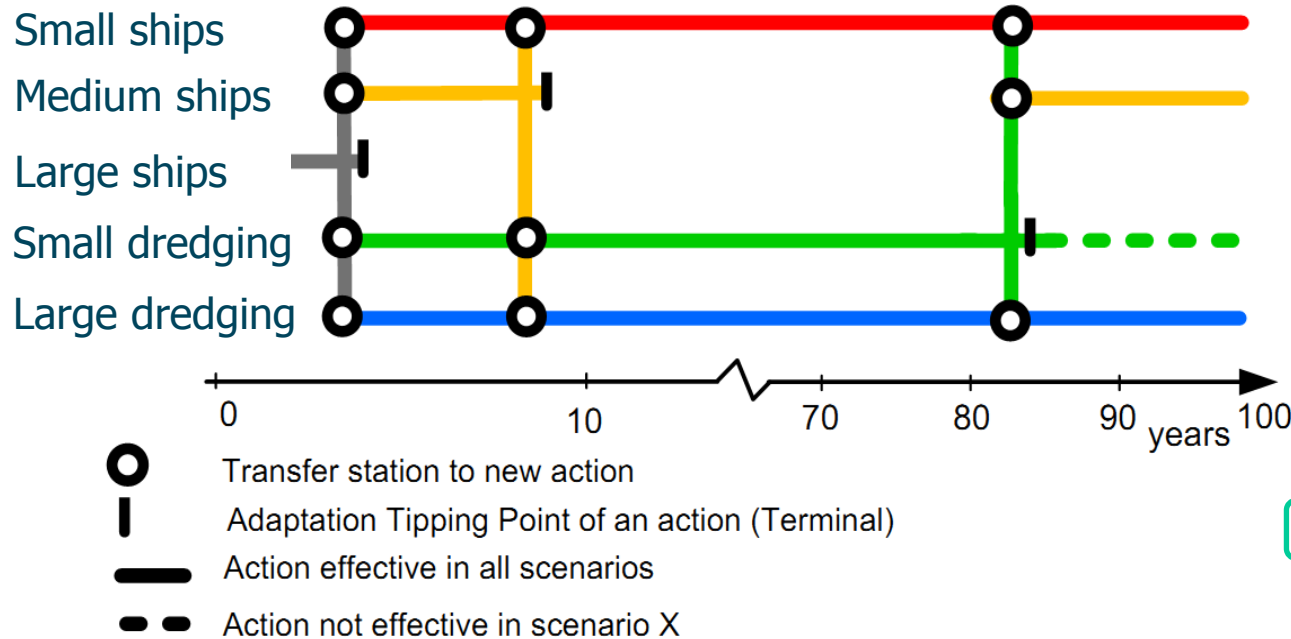
- Adaptation pathways can support robust decision-making (options, lock-ins)
- Water managers tend to respond to events and near events. Climate variability is important.
- Win-win may result in loss-loss (negotiation)



## In practice...

- What are the vulnerabilities and opportunities?
- What could be (un)acceptable impacts and thresholds (adaptation tipping points) to implement adaptation actions?
- Are there specific drivers that cause these vulnerabilities?
- What adaptation actions can be taken? What could make these fail? What is their path-dependency?
- What adaptations are robust or flexible options?

# In practice...



Adaptation Pathways Map

Path actions	Relative Costs	Target effects	Side effects
1 <span style="color:red">●</span>	+++	+	0
2 <span style="color:yellow">●</span> <span style="color:red">●</span>	+++++	0	0
3 <span style="color:yellow">●</span> <span style="color:green">●</span>	+++	0	0
4 <span style="color:yellow">●</span> <span style="color:blue">●</span>	+++	0	0
5 <span style="color:green">●</span>	0	0	-
6 <span style="color:green">●</span> <span style="color:red">●</span>	++++	0	-
7 <span style="color:green">●</span> <span style="color:yellow">●</span>	+++	0	-
8 <span style="color:green">●</span> <span style="color:blue">●</span>	+	+	- - -
9 <span style="color:blue">●</span>	++	+	- - -

Scorecard pathways

An Adaptive Plan could be:

- Small dredging and switch to large scale dredging, if necessary.
- Implement corrective actions to mitigate negative side effects.
- Monitor river discharges and transport developments.

**Flexible action**= small scale dredging

**Robust action**= small ships

# Questions?



<http://deltagame.deltares.nl>