

Go with the flow

An adaptive approach to managing
urban floods

Dr. Rinus Vis, NUSDeltares
May, 2017

Flood management plans

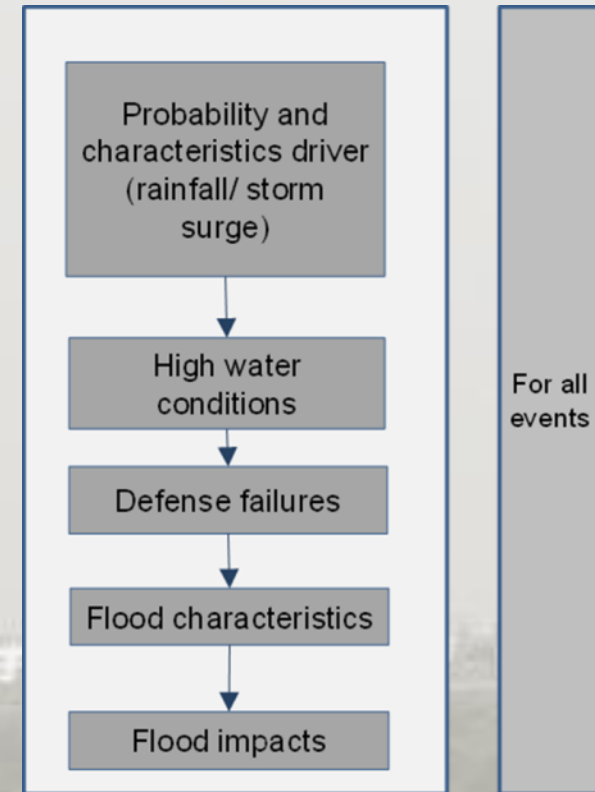
In designing flood management plans, commonly a risk based approach is followed:

$$\text{Risk} = \text{likelihood} \times \text{consequences}$$

Steps in the procedure:

1. Analysis of probabilities and magnitudes of events causing flooding
2. Assessing the corresponding flood pattern (extent, depth, velocities)
3. Assessing the impacts corresponding with the flood pattern of the various events
4. Integrating the probabilities of the events and their impacts to one single risk figure
5. Design measures and combine those in strategies that may solve the problem

Such an approach assumes the future can be predicted and creates a static optimal plan



UNCERTAINTY

What goes wrong?

If the future turns out to be different from what was assumed or predicted, the plan fails:

- We do either too little too late or too much too early, and
- Plans are too costly, occupy too much space etc.

What is needed is a flexible approach that produces plans that can be adapted if future conditions turn out to be different from what was expected: decision making under deep uncertainty



Michigan Engineers, Univ of Michigan



WaterflonTSNL

A dynamic, flexible and robust plan



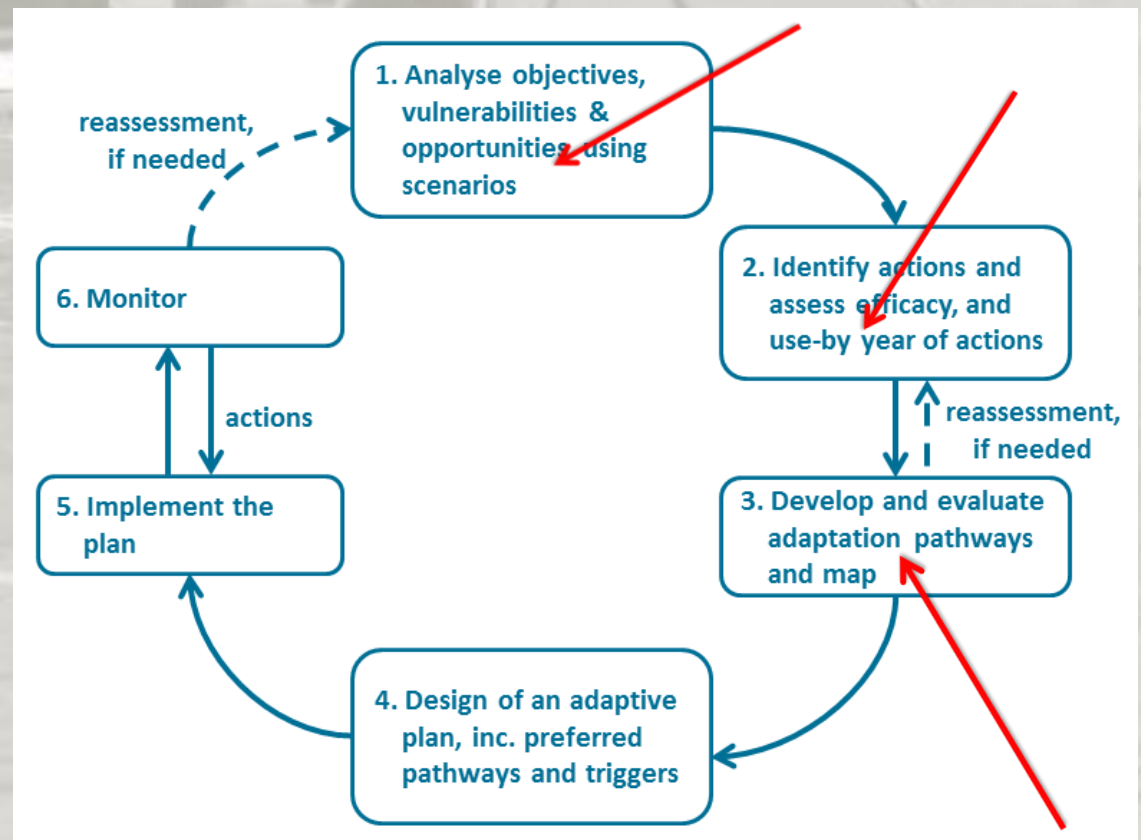
Dynamic Adaptive Policy Pathway Approach

Basic idea:

Dealing with uncertainties in a transparent and sensible way by generating an array of 'pathways' through which policy objectives can be achieved under a variety of climate and socio-economic conditions

Steps:

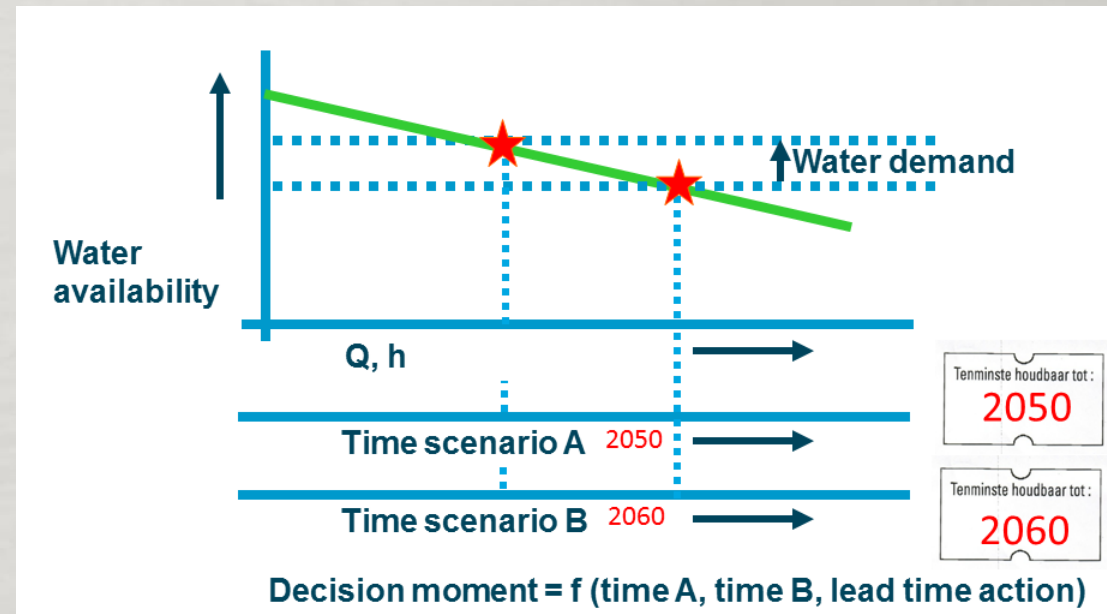
1. Problem analysis (urgency, nature, extent, timing of problems)
2. Identification of measures, quantifying effects
3. Design of multiple adaptation pathways
4. Design of an adaptation plan
5. Implementation of the plan
6. Monitoring (critical trends) enabling adjustment when needed



Key concepts

Adaptation tipping points:

A tipping point is reached when the magnitude of external change is such that a measure (or a policy) no longer meets the objectives (the use by year)



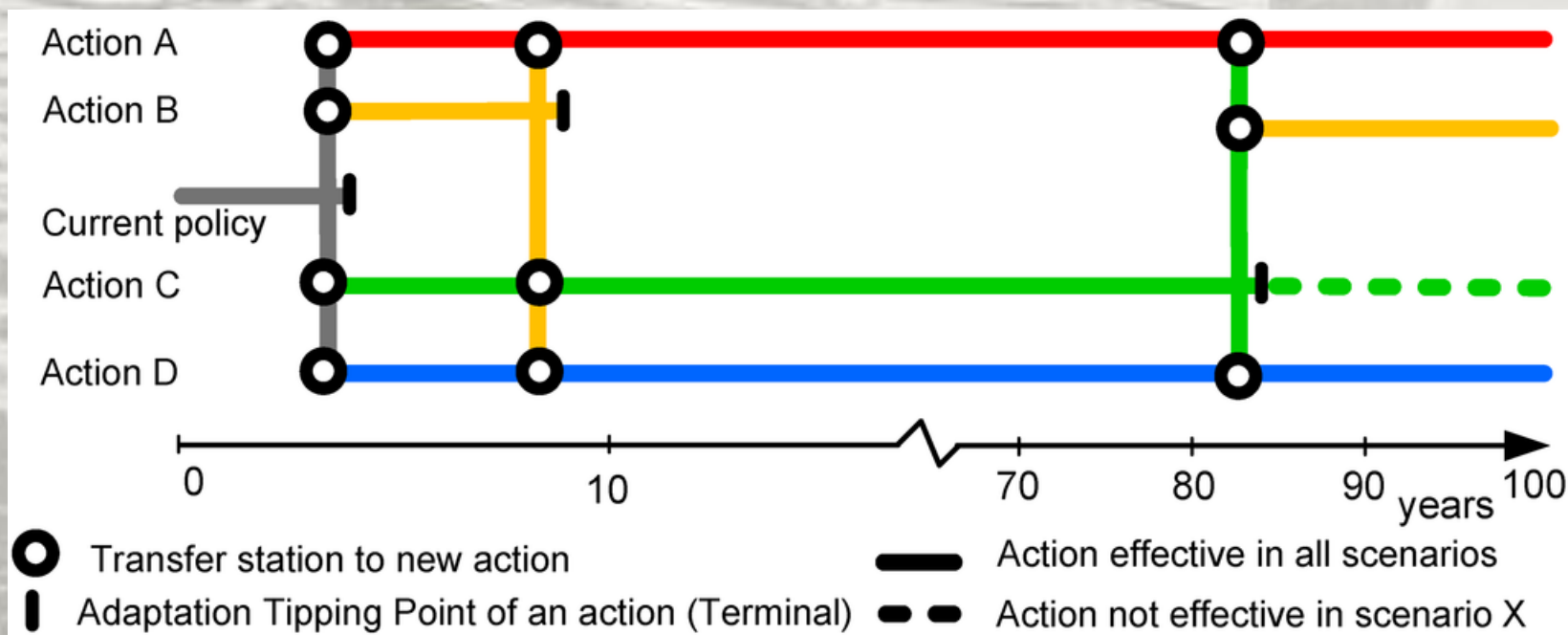
Key concepts

Adaptation pathways:

A sequence of measures (policy actions or investments in institutions or infrastructure over time) to achieve a set of pre defined objectives under uncertain changing conditions

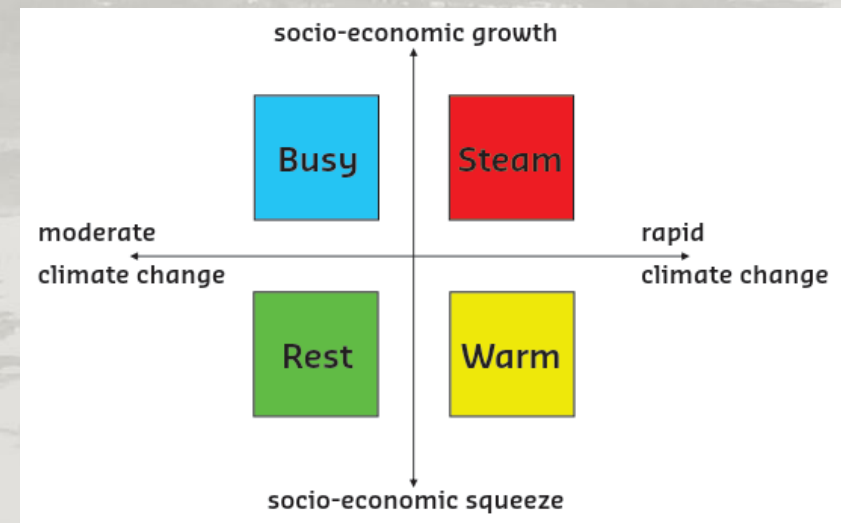
Costs and benefits of pathways

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	●●	+	---



Essentials

- Not based on a prediction of what **will**, but on exploration of what **can** happen: preparation and knowing what to expect
- Takes the lifetime of decisions (measures) into account (tipping points, use by years)
- Measures taken on the short term do not foreclose future options or unnecessarily constrain future choices
- Possibility to adapt the strategy (switch between options) depending on what evolves over time, leading to flexible and strategies that are robust over time under a wide range of plausible future scenarios
- Monitoring of the situation and continuous updating of scenarios



What is the Pathway Generator?

A software tool that supports development of policy pathways, e.g. together with stakeholders

Developed by:

- Deltares
- Carthago Consultancy

With support of:

- Wellington City Council NZ
- Ministry of Environment NZ
- NZ Climate Change Research Inst, Victoria University, Wellington
- Rises, European Union 7th for Research, Technological Development and Demonstration

Downloadable from the Deltares Public Wiki: <https://publicwiki.deltares.nl/display/AP/Pathways+Generator>

- Free for all to use and distribute
- Instruction Manual available
- Video Tutorials available

The screenshot shows the 'Pathways Generator' application window. On the left is a menu with options: 'Open', 'Open existing Pathway file', 'Start with empty Pathway (Condition based)', 'Start with empty Pathway (Time based)', and 'Close application'. Below the menu is a text box: 'We are looking for budget and projects to further develop the pathways generator. If you find this tool useful, please consider making us partner in your projects. Contact marjolijn.haasnoot@deltares.nl or wvandeursen@carthago.nl for more information'. At the bottom left of the window, it says 'Pathways Generator uses icons from icons8.com' and 'Compile date 30-Nov-17'. On the right side of the window, there is a 'Developed by' section listing 'Willem van Deursen' and 'Marjolijn Haasnoot'. Below this are the logos for 'Deltares' (with the tagline 'Enabling Delta Life') and 'CARTHAGO consultancy'. Further down, it lists funding support from 'Deltares, Delft, The Netherlands', 'Carthago Consultancy, Rotterdam, The Netherlands', 'Wellington City Council, NZ', and 'Ministry for the Environment, NZ'. It also mentions the 'Rises Project: European Union's Seventh Programme for Research, Technological Development and Demonstration' with ID 'No:FP7-ENV-2013-Two-Stage-603396- RISES-AM-' and 'NZ Climate Change Research Institute, Victoria University of Wellington'. At the bottom right, there is a 'License Agreement' button and a link to 'See the Pathways Website at pathways.deltares.nl'. A disclaimer at the very bottom states: 'The authors shall not be responsible for any loss, damage or other expenses of any kind incurred by you as user of The Pathway Generator or third parties (partially or wholly) due to the use of The Pathway Generator and the interpretation and the use of the results generated by The Pathway Generator.'

Hypothetical case: urban rainwater flooding in Fantasia City

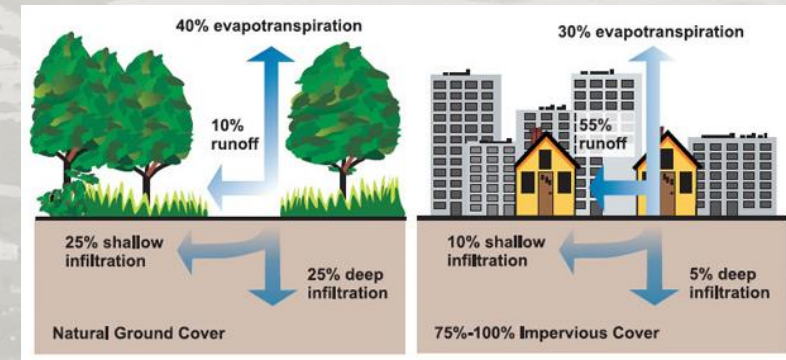


- Densely build-up urban area
- Climate change induced increasing rainfall intensities
- Expected in future: rainwater flooding



Current situation

- Increasing rainfall intensities
- Increasing area with impermeable surface
- There are some open green spaces available in the city
- Drainage channels are being used for illegal waste disposal
- Area is low-lying, drainage under gravity to the tidal river may become impossible in future
- Densely built-up area, any construction of new infrastructure will lead to involuntary resettlement



Source: EPA 2003



Source: SIBC 2018

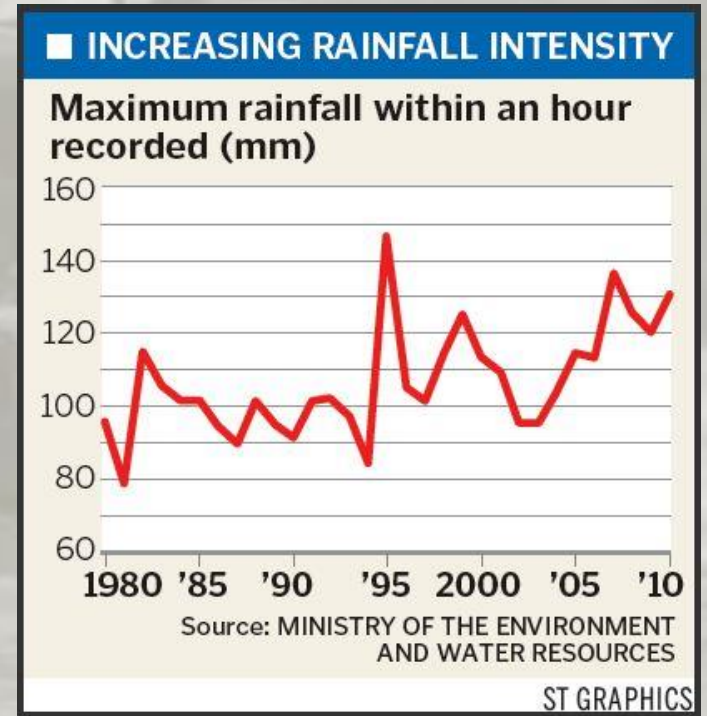
Present condition and scenarios

Present maximum rainfall amount of 100 mm in one hour can be discharged without too many problems

Problems are expected to start when rainfall amounts exceed 110 mm in one hour

Long term Climate Change scenario's (2100)

- Moderate scenario: rainfall amounts expected to increase to 150 mm in 1 hour
- Extreme scenario: rainfall amounts expected to increase to 200 mm in 1 hour



Possible actions

1 Flood proofing of houses and infrastructure



<http://floodcontrolam.com/flood-wall-applications/flood-proofing>

2 Construction of green roofs



iStock photo

3 Increase infiltration (pavements, parking lots, etc.)



4 Improve storage (ponds, underground reservoirs, etc.)



Rainwater capture and storage system at the Monterrey Institute of Technology and Higher Education, Mexico City.

5 Construct dikes around critical infrastructure



Olson/Getty Images

6/18/2018

6 Remove rubbish from and dredge drainage channels



7 Construct new drainage channels



<http://akinwunmiambode.com>

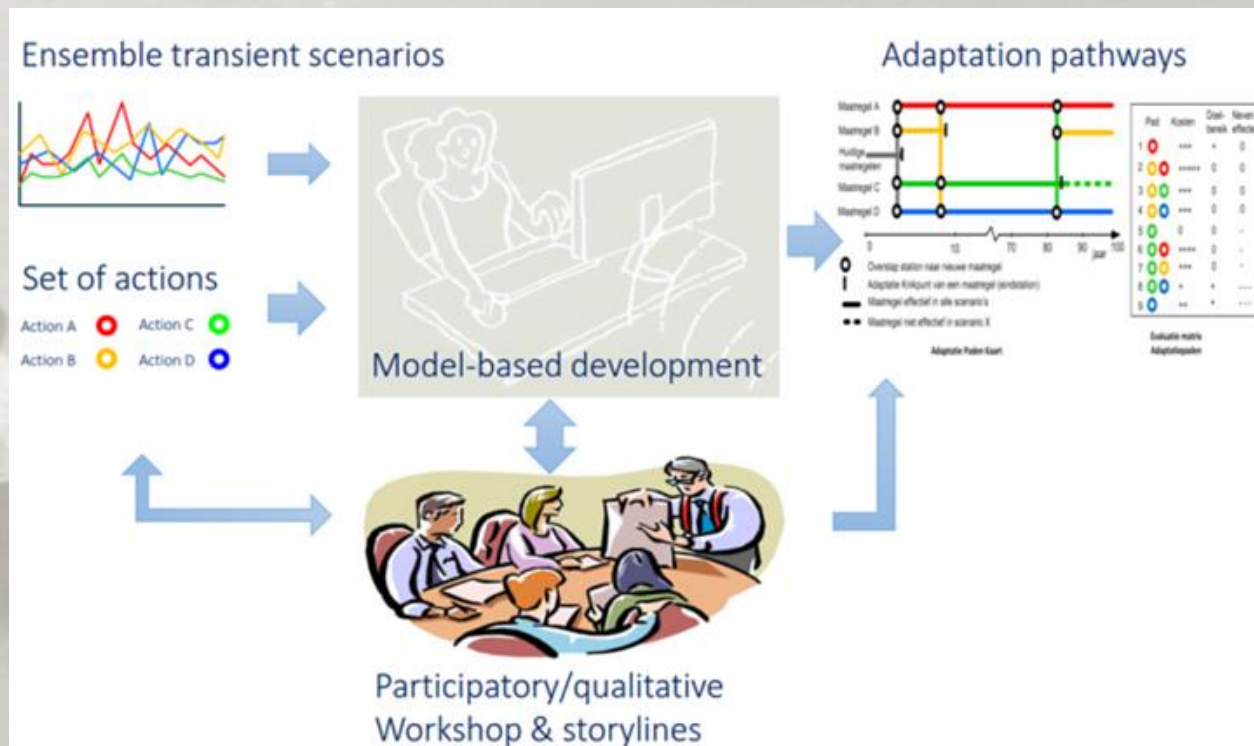
8 Install pumps



Interactive creation of a Pathway Map

Steps to be taken:

- Choose scenario(s)
- Choose actions (measures)
- Generate pathways
- Modify the Pathway Map
- Evaluate your pathways



Choose approach

Pathways Generator

Open

Open existing Pathway file

Start with empty Pathway (Condition based)

Start with empty Pathway (Time based)

Close application

We are looking for budget and projects to further develop the pathways generator.

If you find this tool useful, please consider making us partner in your projects.

Contact marjolijn.haasnoot@deltares.nl or wvandeursen@carthago.nl for more information

Pathways Generator uses icons from icons8.com
Compile date 30-Nov-17

Developed by
Willem van Deursen
Marjolijn Haasnoot

Pathways Generator is ©2015, Deltares, Carthago Consultancy

Deltares
Enabling Delta Life

CARTHAGO
consultancy

Deltares, Delft, The Netherlands
Marjolijn.Haasnoot@deltares.nl

Carthago Consultancy, Rotterdam, The Netherlands
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Define scenario's



Pathways Generator

Pathways Scenarios Scorecard

[none]

Current Situation

[no caption]

0 10 20 30 40 50 60 70 80 90 100

Map generated with Pathways Generator, ©2015, Deltares, Carthago Consultancy

Condition Based

Elements at current position

Property	Value
----------	-------

Parents

Dependents

Define scenario's 2


Pathways Generator

Pathways Scenarios Scorecard

← ⊕ ⊗

2018,00
2019,00
2020,00
2021,00
2022,00
2023,00
2024,00
2025,00
2026,00
2027,00
2028,00
2029,00
2030,00
2031,00
2032,00
2033,00
2034,00
2035,00
2036,00
2037,00
2038,00
2039,00
2040,00
2041,00
2042,00
2043,00
2044,00
2045,00
2046,00

Condition Based



Define scenario's 3

The screenshot displays the 'Pathways Generator' application interface. At the top, there are three tabs: 'Pathways', 'Scenarios', and 'Scorecard'. Below the tabs are navigation icons. A 'Specify Timeframe' dialog box is open, featuring the following fields and controls:

- 'Enter Begin Year' text box containing '2018', with a red arrow pointing to it.
- 'Time Steps' spinner box set to '82'.
- 'End Year' text box containing '2100'.
- 'Cancel' and 'OK' buttons at the bottom.

The background shows a table with years from 2018 to 2045. The status bar at the bottom left reads 'Condition Based'.

Define scenario's 5

Pathways Generator

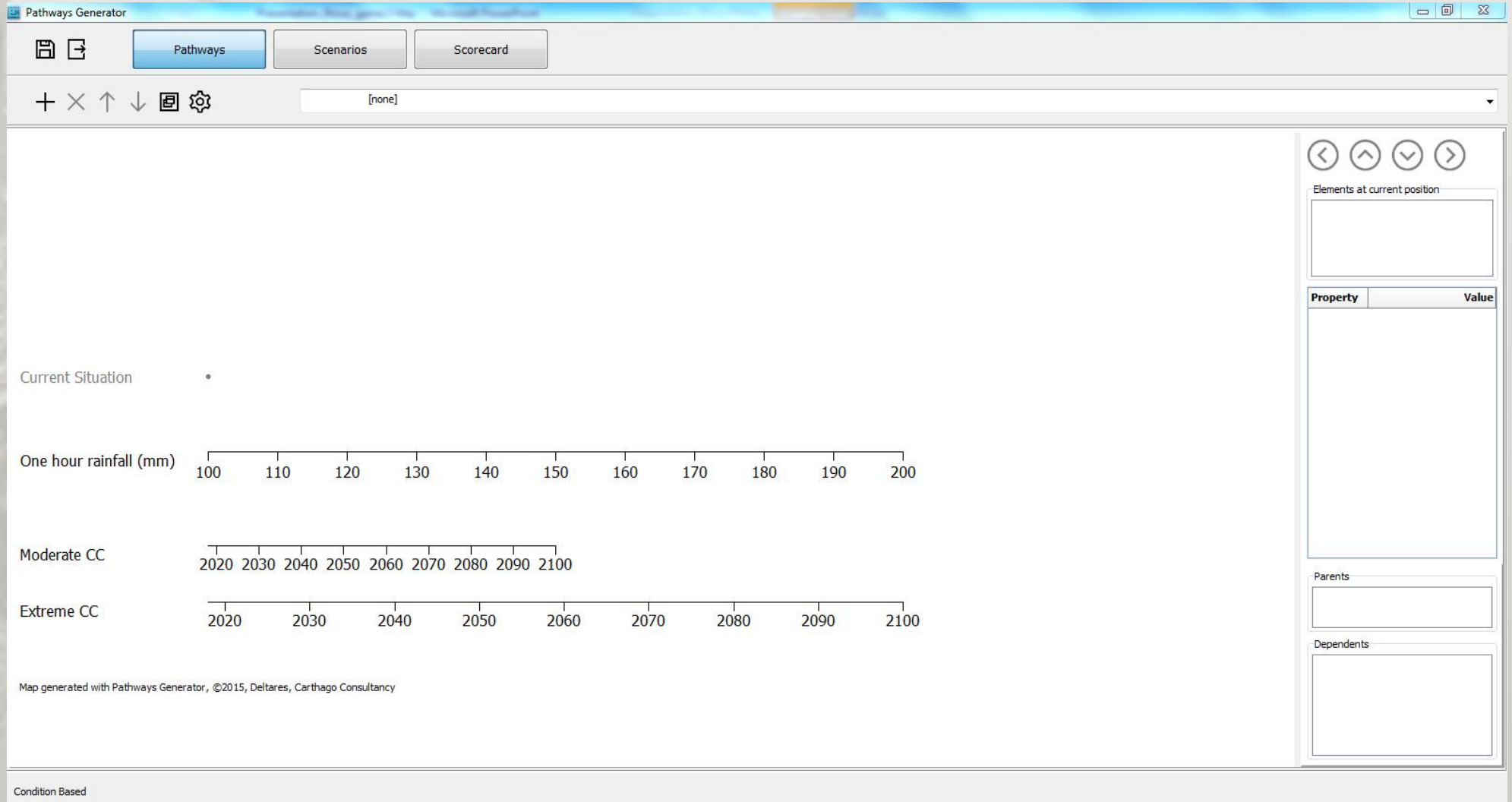
Pathways Scenarios Scorecard

↔ + -

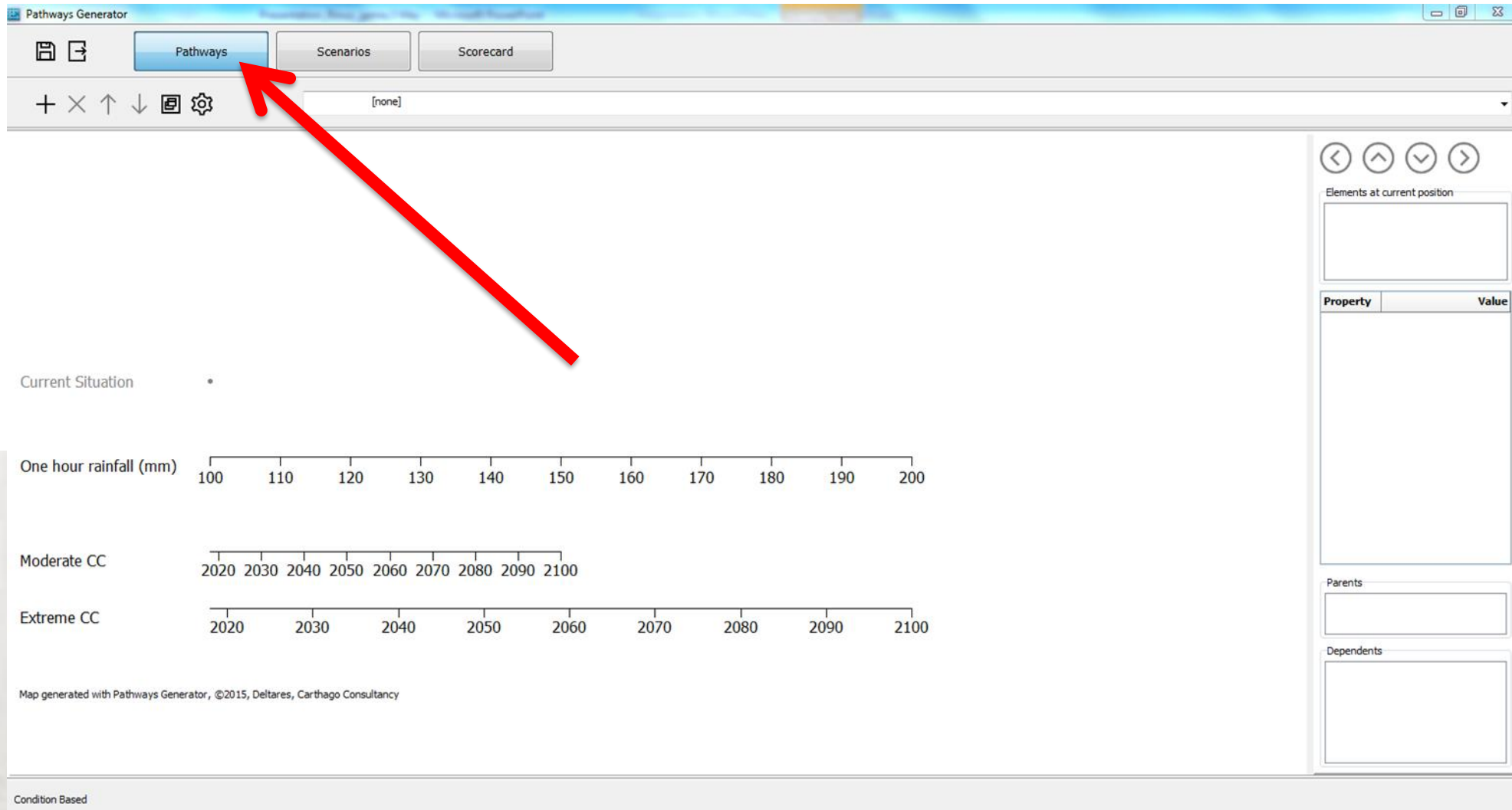
	Moderate CC	Extreme CC
2018,00	100,00	100,00
2019,00	100,61	101,22
2020,00	101,22	102,44
2021,00	101,83	103,66
2022,00	102,44	104,88
2023,00	103,05	106,10
2024,00	103,66	107,32
2025,00	104,27	108,54
2026,00	104,88	109,76
2027,00	105,49	110,98
2028,00	106,10	112,20
2029,00	106,71	113,41
2030,00	107,32	114,63
2031,00	107,93	115,85
2032,00	108,54	117,07
2033,00	109,15	118,29
2034,00	109,76	119,51
2035,00	110,37	120,73
2036,00	110,98	121,95
2037,00	111,59	123,17
2038,00	112,20	124,39
2039,00	112,80	125,61
2040,00	113,41	126,83
2041,00	114,02	128,05
2042,00	114,63	129,27
2043,00	115,24	130,49
2044,00	115,85	131,71
2045,00	116,46	132,93

Condition Based

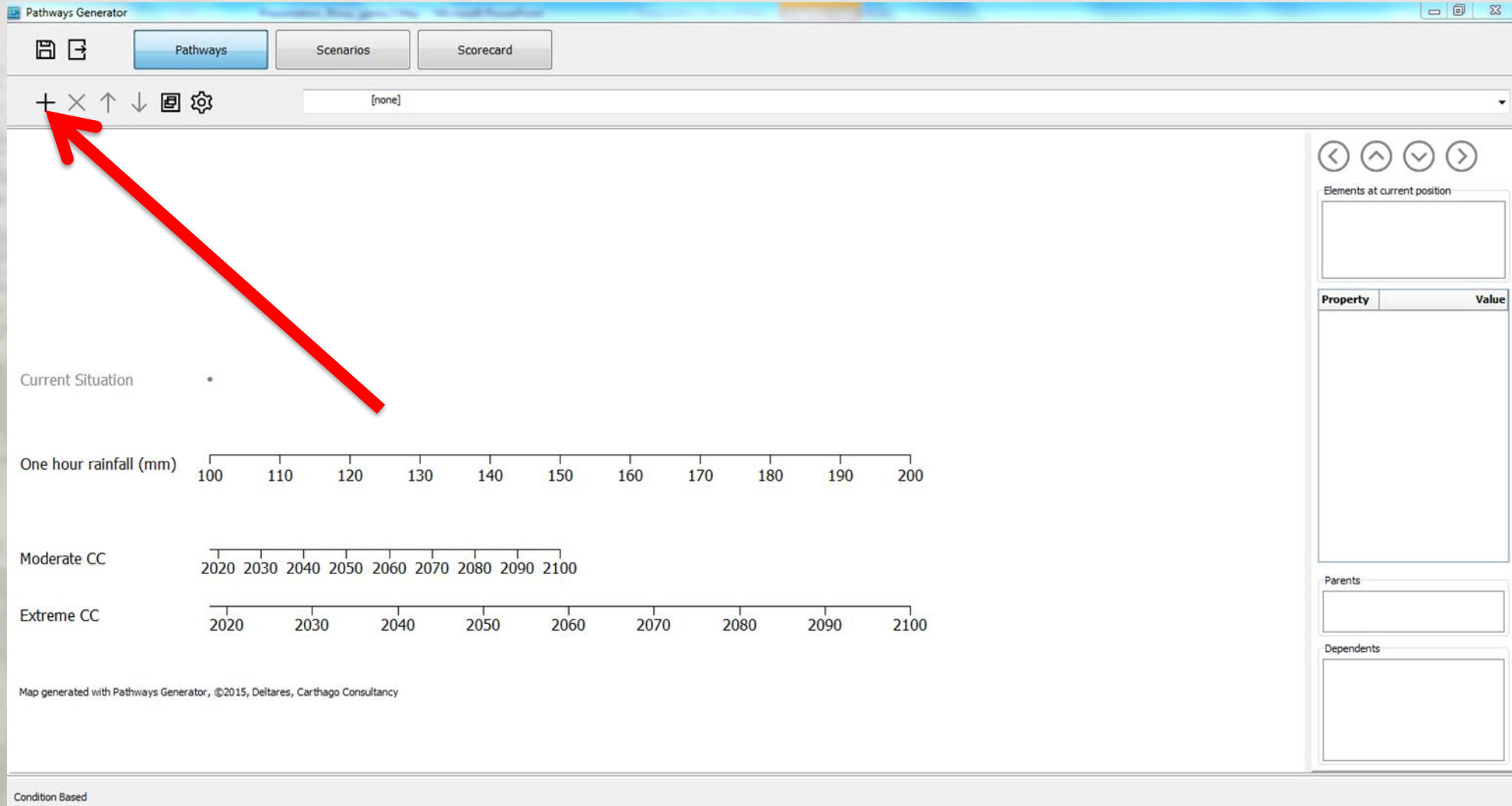
Define scenario's 6



Define actions (measures) 1



Define actions (measures) 2



Define actions (measures) 3

The screenshot shows the Pathways Generator software interface. At the top, there are three buttons: 'Pathways' (highlighted in blue), 'Scenarios', and 'Scorecard'. Below these is a dropdown menu with '[none]' selected. A context menu is open, showing three options: 'Add action', 'Add pathway', and 'Cancel'. A large red arrow points from the 'Add action' button to the 'Add action' option in the context menu.

The main area displays a graph for 'One hour rainfall (mm)'. The x-axis represents years from 2020 to 2100. The y-axis represents rainfall in mm, ranging from 100 to 200. The graph shows three scenarios: 'Current Situation' (a single point at approximately 165 mm in 2020), 'Moderate CC' (a line starting at 165 mm in 2020 and increasing to 200 mm by 2100), and 'Extreme CC' (a line starting at 165 mm in 2020 and increasing to 2100 mm by 2100).

At the bottom left, there is a footer: 'Map generated with Pathways Generator, ©2015, Deltares, Carthago Consultancy'.

At the bottom left of the interface, there is a label: 'Condition Based'.

On the right side, there is a panel with navigation icons (back, up, down, forward) and sections for 'Elements at current position', 'Property Value', 'Parents', and 'Dependents'.

Possible actions (measures)

1 Flood proofing of houses and infrastructure



<http://floodcontrolam.com/flood-wall-applications/flood-proofing>

2 Construction of green roofs



iStock photo

3 Increase infiltration (pavements, parking lots, etc.)



4 Improve storage (ponds, underground reservoirs, etc.)



Rainwater capture and storage system at the Monterrey Institute of Technology and Higher Education, Mexico City.

5 Construct dikes around critical infrastructure



Olson/Getty Images

6/18/2018

6 Remove rubbish from and dredge drainage channels



7 Construct new drainage channels



<http://akinwunmiambode.com>

8 Install pumps



Define actions (measures) 4

The screenshot displays the Pathway Generator software interface. The main window title is "Pathway Generator [D:\vis\01 Singapore\SeCUREWorld Bank\Game\test.pathway]". The interface includes a top navigation bar with buttons for "Pathways", "Scenarios", and "Scorecard". Below this is a toolbar with icons for zooming and settings, and a dropdown menu currently set to "[none]".

The main workspace shows a "Current Situation" line graph and two x-axis scales: "One hour rainfall (mm)" ranging from 100 to 140, and "Moderate CC" and "Extreme CC" ranging from 2020 to 2050. A "Map generated with Pathways Generator, ©2015, Deltares, Carthago Consultancy" is visible at the bottom left.

The "Add Action" dialog box is open, showing the following fields:

- Name: Flood proofing
- Color: A green color swatch
- Adaptation Tipping Point: 120,0
- Opportunity Tipping Point: (empty)
- Predecessor: Current Situation

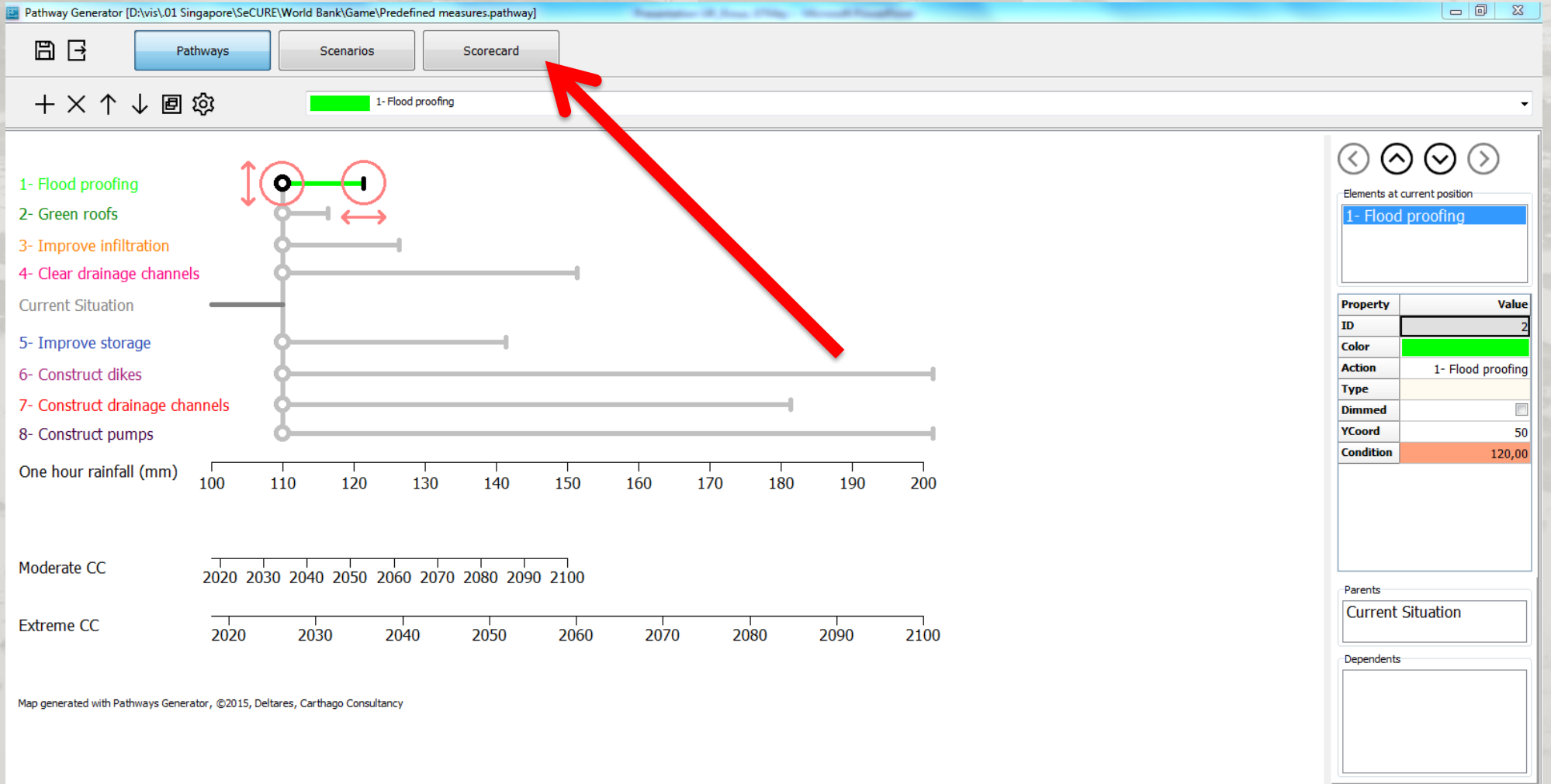
Red arrows point to the "Name", "Color", and "Adaptation Tipping Point" fields. The "Elements at current position" panel on the right shows "Flood proofing" selected. The "Property" and "Value" table is empty. The "Parents" and "Dependents" panels are also empty.

Define actions (measures) 5



Condition Based

Scorecard 1



Condition Based

Scorecard 2

Pathway Generator [D:\vis\01 Singapore\SeCURE\World Bank\Game\Predefined measures.pathway] November 28, 2013 11:46 AM

Save Export
Pathways Scenarios **Scorecard**

+ - ☰

Color	Action or pathway	Target effects	Costs	Side Effects
	Current Situation	0	0	0
	Flood proofing	+	+	0
	Green roofs	+	++	+
	Improve infiltration	++	+	0
	Improve storage	++	+++	--
	Construct dikes	+	+++	---
	Clear drainage channels	+++	+	++
	Construct drainage channels	+++	+++	---
	Construct pumps	+++	+++	--

Using the tool 'life'

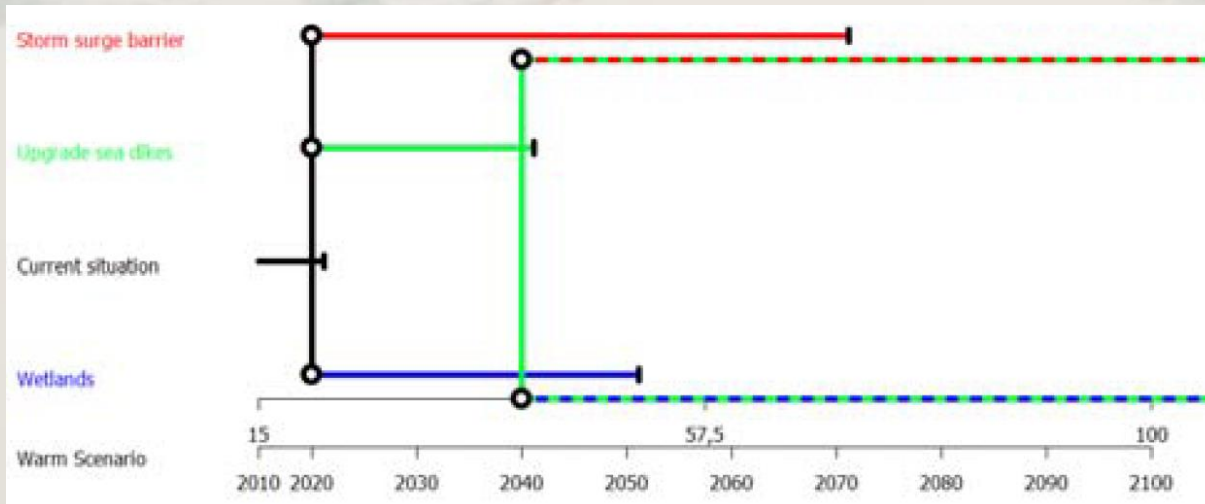
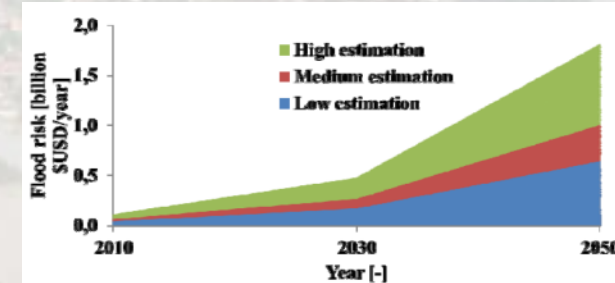
Case 1: Shanghai, PR China

Exploring adaptation pathways in terms of flood risk management at a city scale – a case study for Shanghai city (Deltares, Technical University Delft, University Utrecht)

- Current flood risk: 70 million US\$/year
- Expected increase till 2015:16 fold
- Sea level rise, land subsidence, socio-economic development
- Coastal flooding

Possible measures:

- Storm Surge Barrier
- Upgrade of sea dikes
- Coastal wetlands restoration



- Option to Upgrade sea dikes only effective till 2040
- Combination with either a storm surge barrier or wetland restoration provides long term solution
- Choice depends on 'value system', cost, impacts, etc.

Case 2: Bangladesh, Deltaplan

Yeusuf Ahmed, Giasuddin Ahmed Choudhury and
Md. Sabbir Ahmed, Bangladesh Delta Plan 2100
Formulation project

Vulnerable low lying coastal area, susceptible to flooding

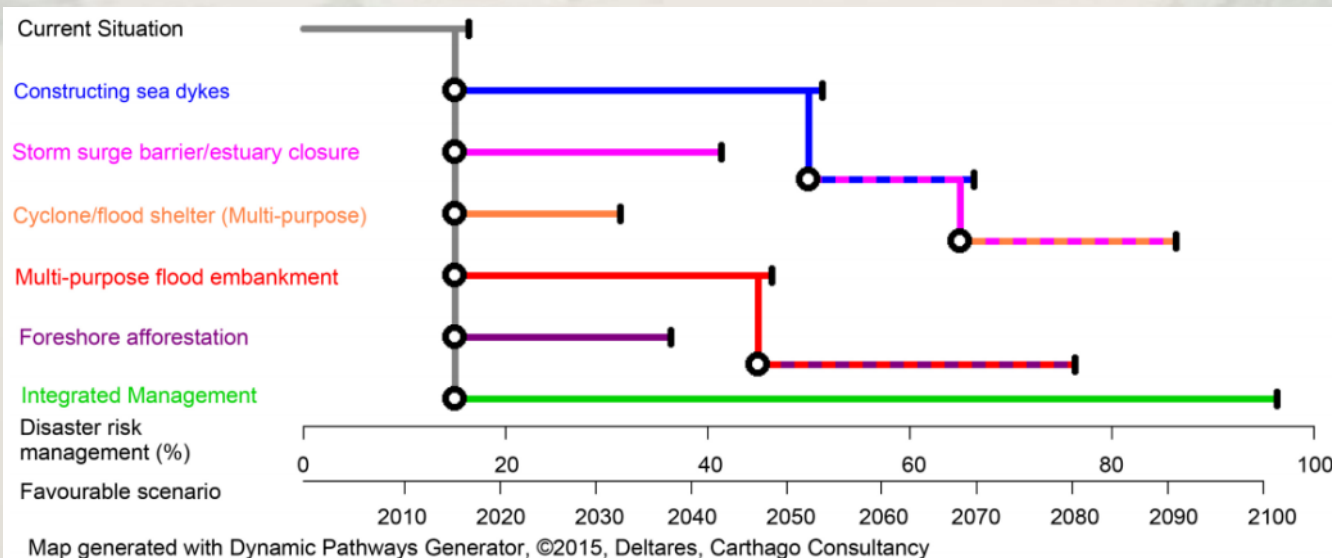
Development of sustainable and supported strategy and implementation
programme

Outputs:

- Delta vision
- Set of future scenarios
- Implementation programme

Pathway generator used to:

- Design a short to medium investment plan
- Identification of no or low regret measures
- Identification of a set of measures that can be scheduled flexible

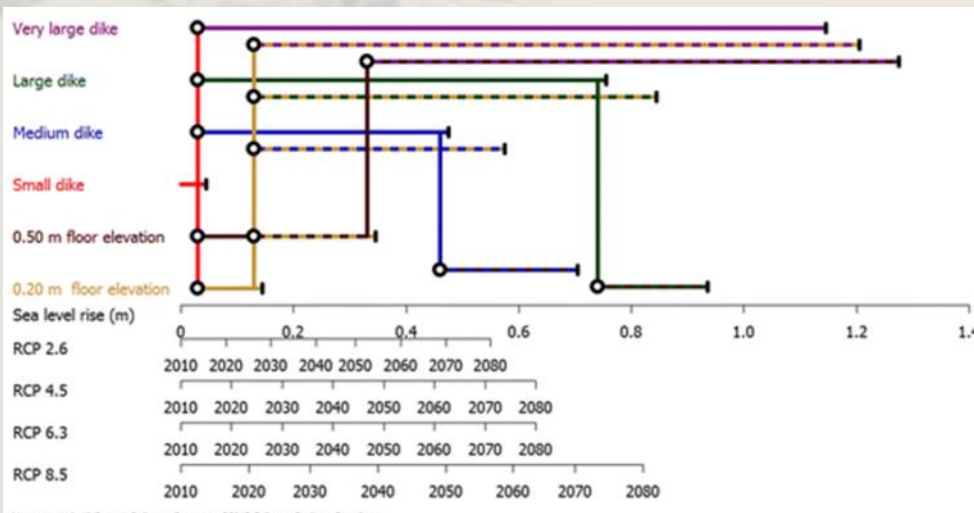


Case 3: Improving Flood resilience of Can Tho city*

*Mohanasundar Radhakrishnan, Assela Pathirana, Richard Ashley and Chris Zevenbergen, UnescoIHE (Delft) and CRC Melbourne)

The pathway generator was used to demonstrate the effect of household level coping capabilities on flood protection measures

- Coping measure considered: elevation of property floor levels
- Effect demonstrated: considerable postponement of sell by time of costly structural measures (dike construction)



Photos:ppt by Assela Pathirana and Mohanasundar Radhakrishnan

Concluding remarks

Evaluation by Bloemen et al^{*}: lessons learned and challenges for further development of adaptation pathways

- Effective in designing flexible and robust flood management plans
- Helps to increase awareness about uncertainties
- Helps to incorporate long-term objectives in short-term decisions
- Offers visualization of multiple alternatives
- Helps to gain approval and buy in to the plan with decision makers and other key stakeholders
- Provides political support for keeping long term options open

* Lessons learned from applying adaptation pathways in flood risk management and challenges for the further development of this approach. P. Bloemen, T. Reeder, C. Zevenbergen, J. Rijke, and A. Kingsborough. Mitig Adapt Strateg Glob Change, <https://doi.org/10.1007/s11027-017-9773-9>