Go with the flow

An adaptive approach to managing urban floods

Dr. Rinus Vis, NUSDeltares

May, 2017

Flood management plans

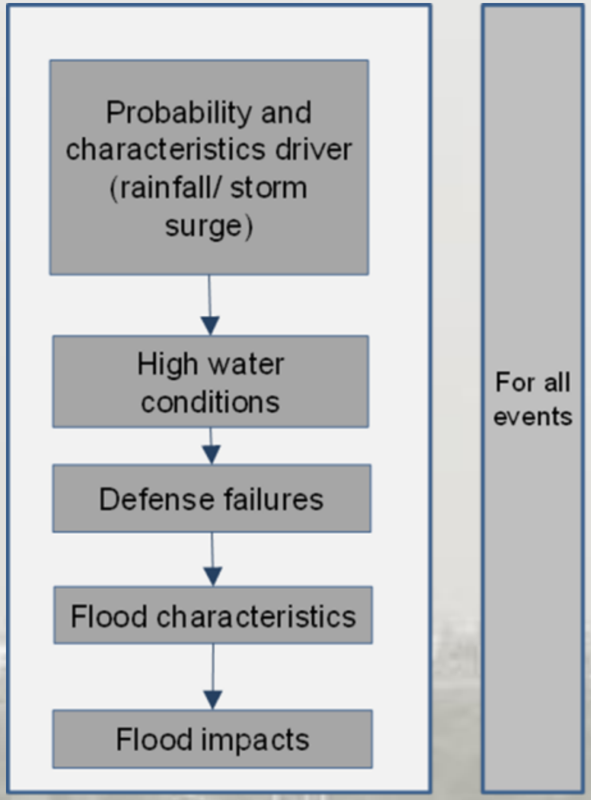
In designing flood management plans, commonly a risk based approach is followed:

Risk = likelihood x 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.

Michigan Engineers, Univ of Michigan

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

WaterflontsNL

A dynamic, flexible and robust plan

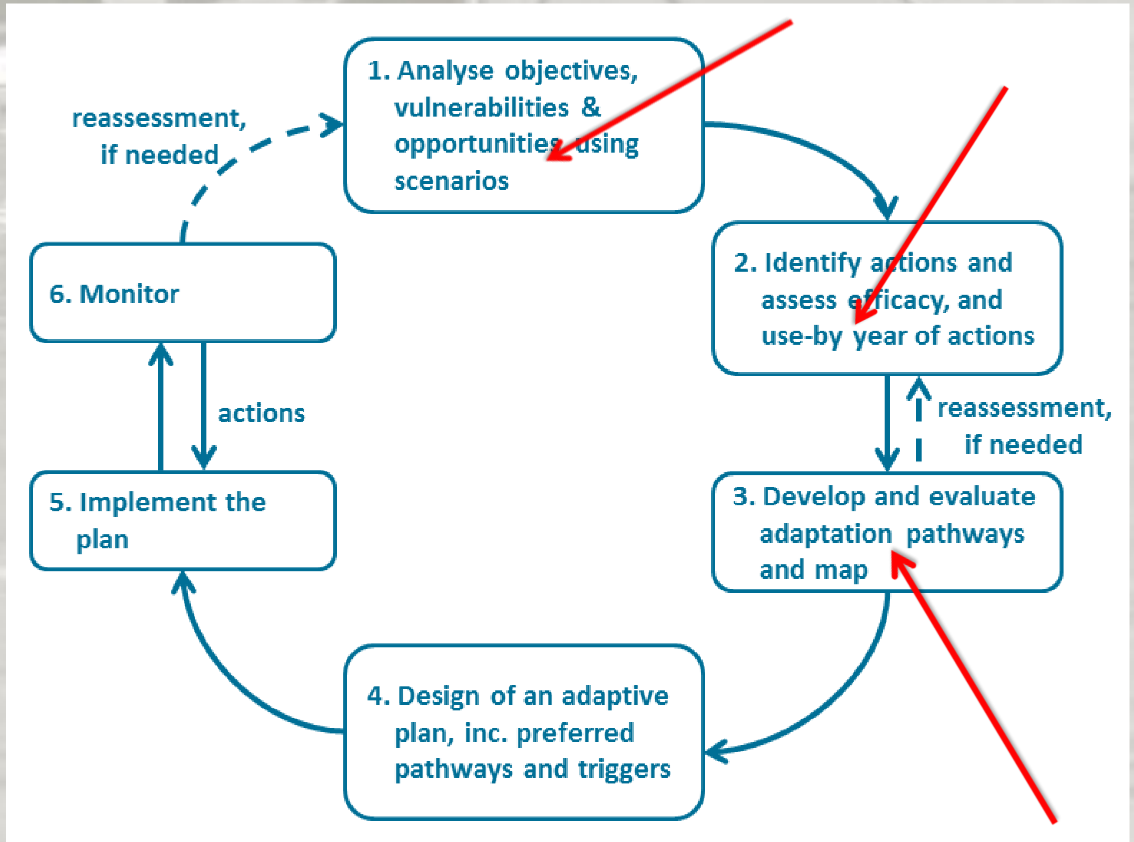
Dynamic Adaptive Policy Pathway Approach

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:

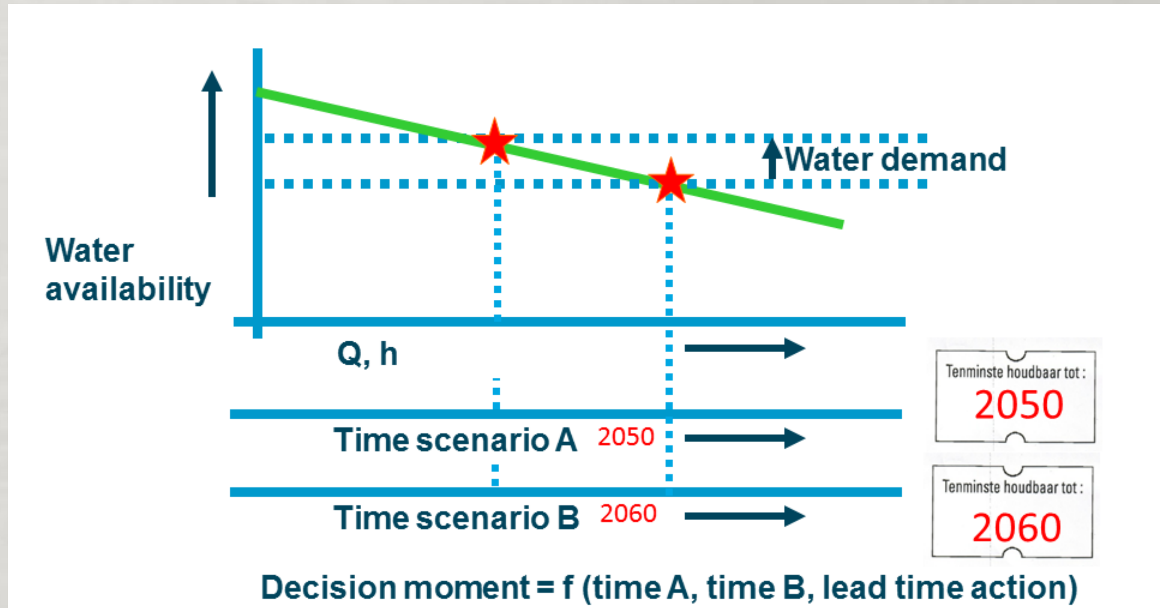
1. Problem analysis (urgency, nature, extent, timing of problems)
2. Identification of measures, quantifying effects
3. Design of multiple adaptation pathways
4. Design of an adaptation plan
5. Implementation of the plan
6. Monitoring (critical trends) enabling adjustment when needed



Key concepts

Adaptation tipping points:

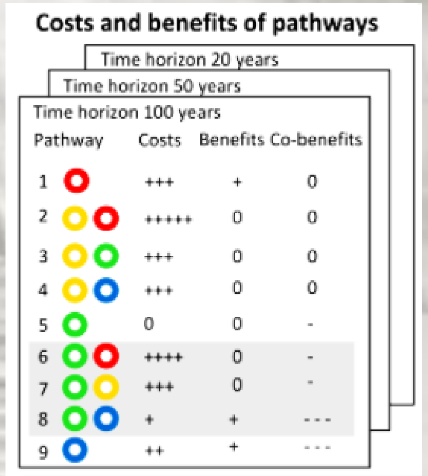
A tipping point is reached when the magnitude of external change is such that a measure (or a policy) no longer meets the objectives (the use by year)



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



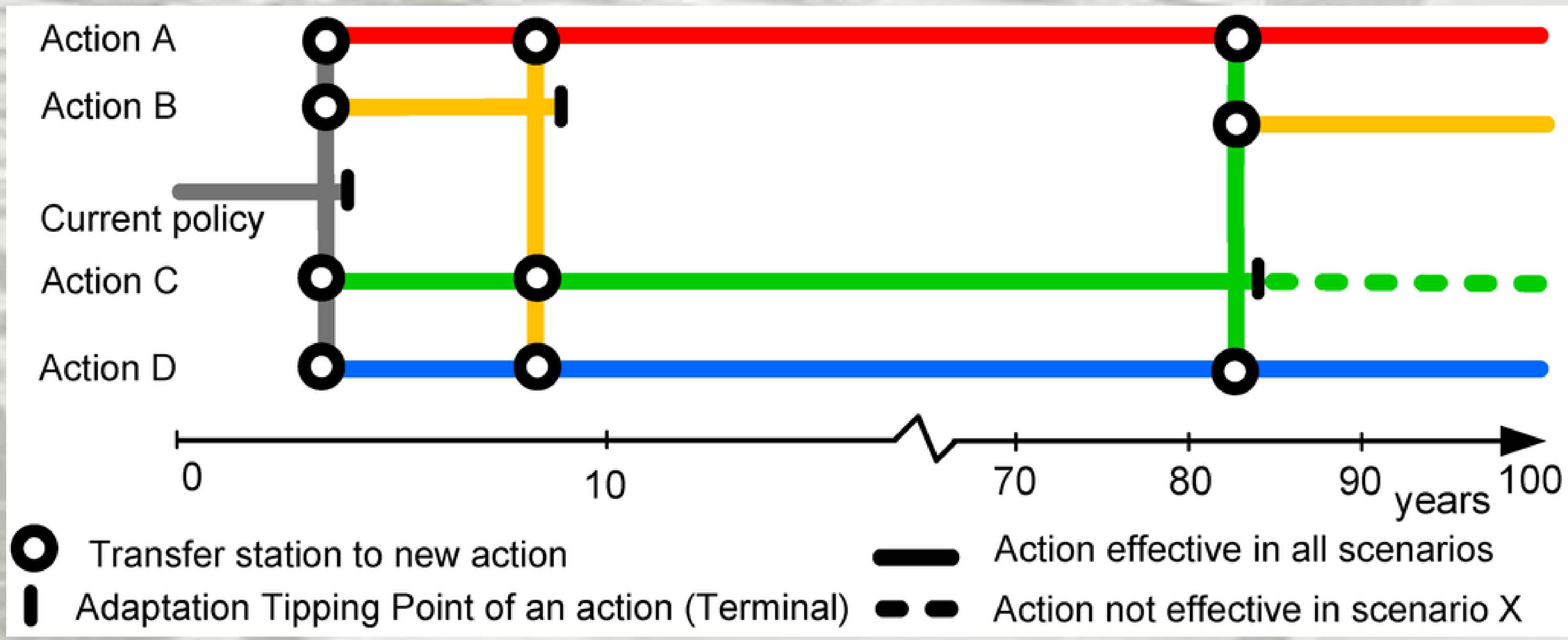
Costs and benefits of pathways

Time horizon 20 years

Time horizon 50 years

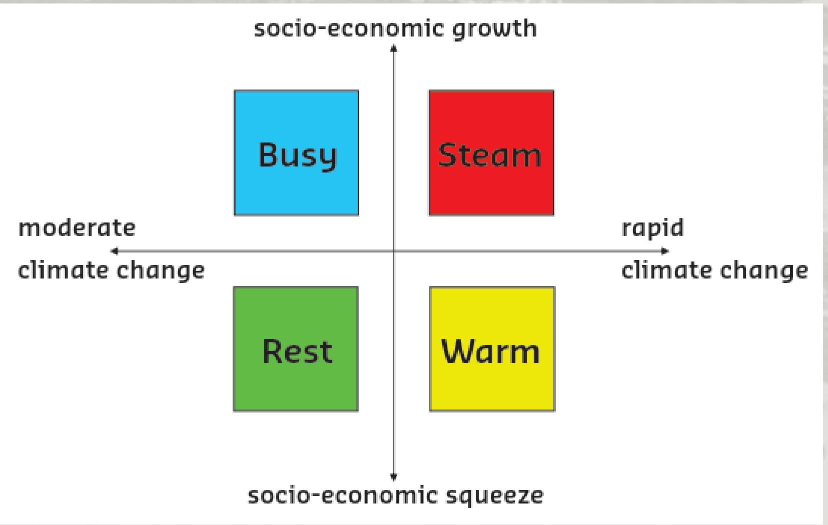
Time horizon 100 years

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	++	+	- - -



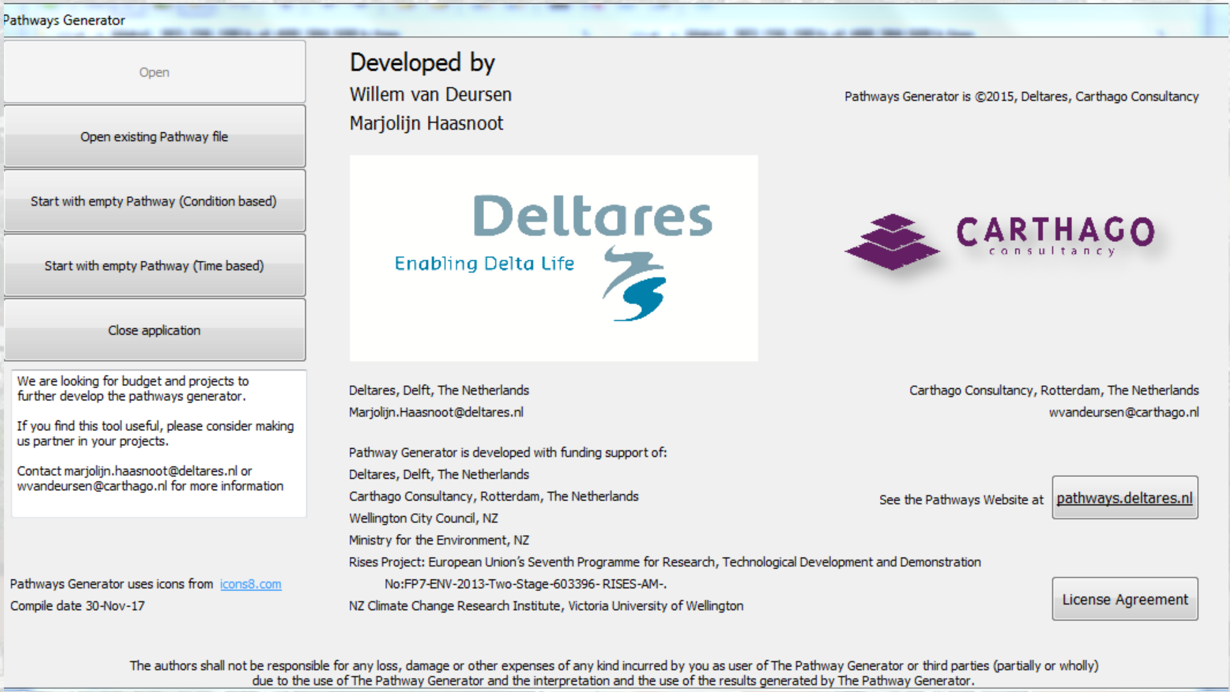
Essentials

- 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

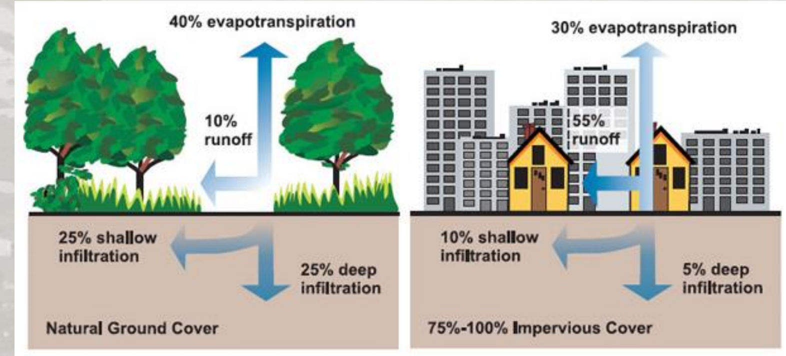
Downloadable from the Deltares Public WiKi: https://publicwiki.deltares.nl/display/AP/Pathways+Generator

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

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



Source: EPA 2003

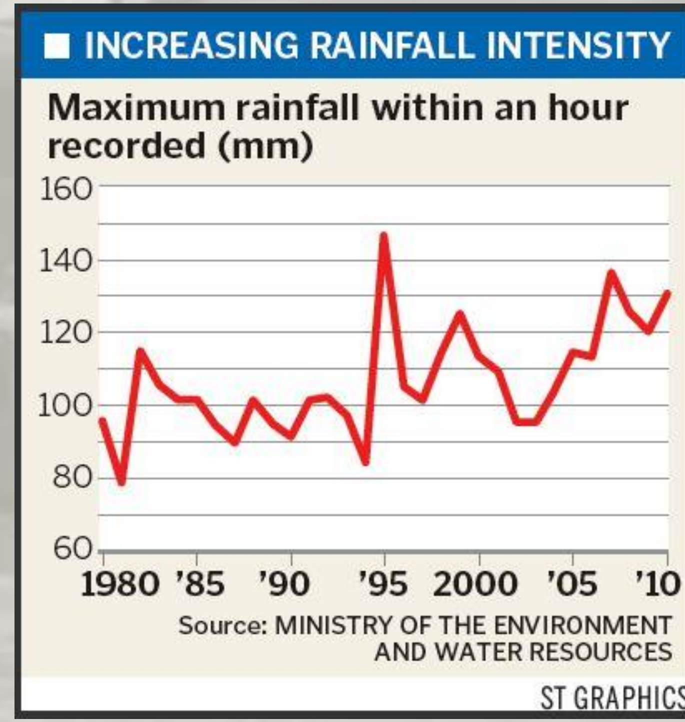
- Increasing rainfall intensities
- Increasing area with impermeable surface
- There are some open green spaces available in the city
- Drainage channels are being used for illegal waste disposal
- Area is low-lying, drainage under gravity to the tidal river may become impossible in future
- Densely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

Source: 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 Remove rubbish from and dredge drainage channels

7 Construct new drainage channels

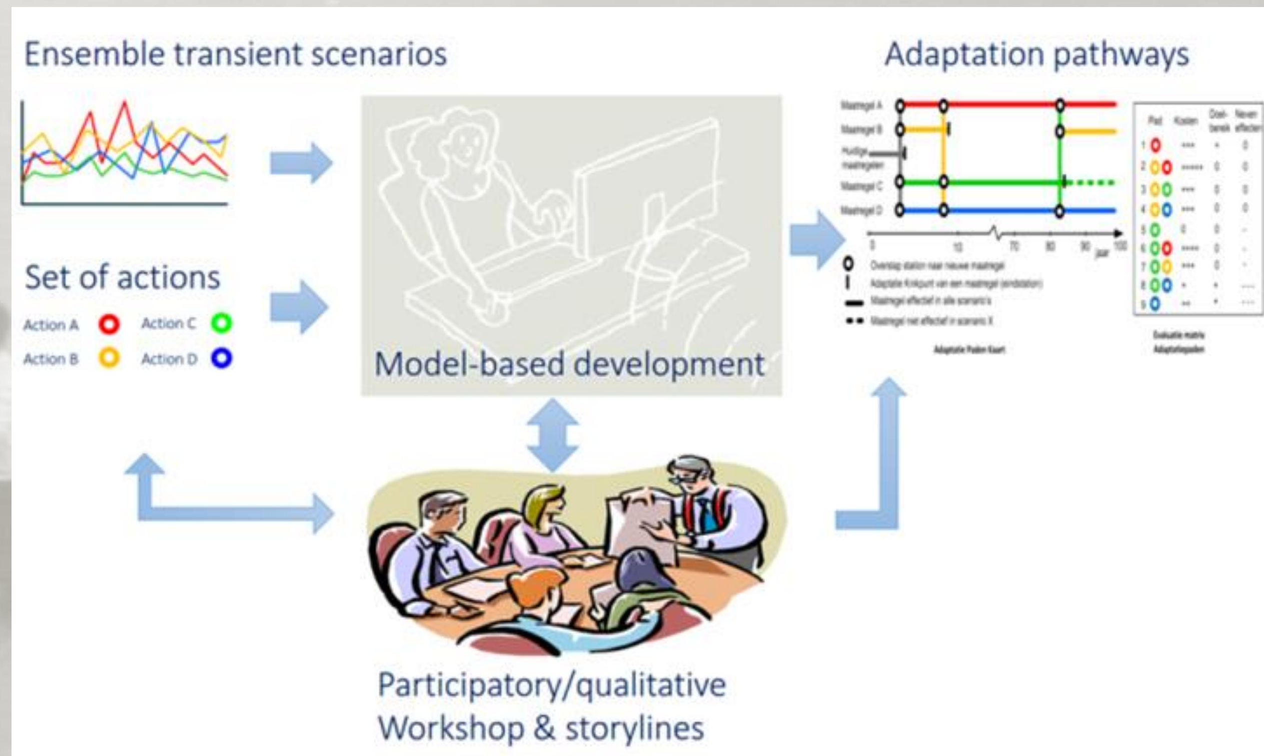
http://akinwunmiambode.com

8 Install pumps

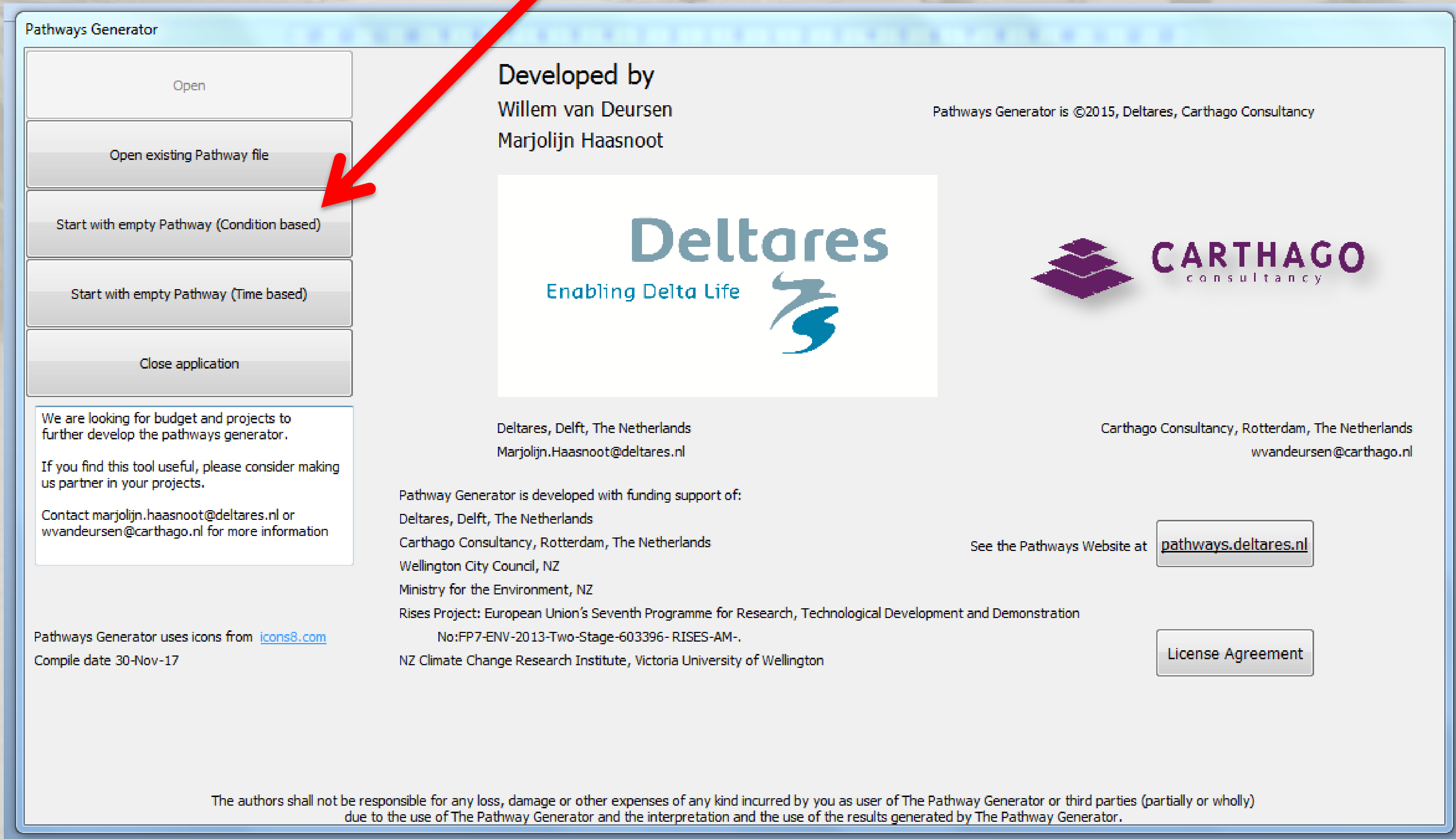
Interactive creation of a Pathway Map

Steps to be taken:

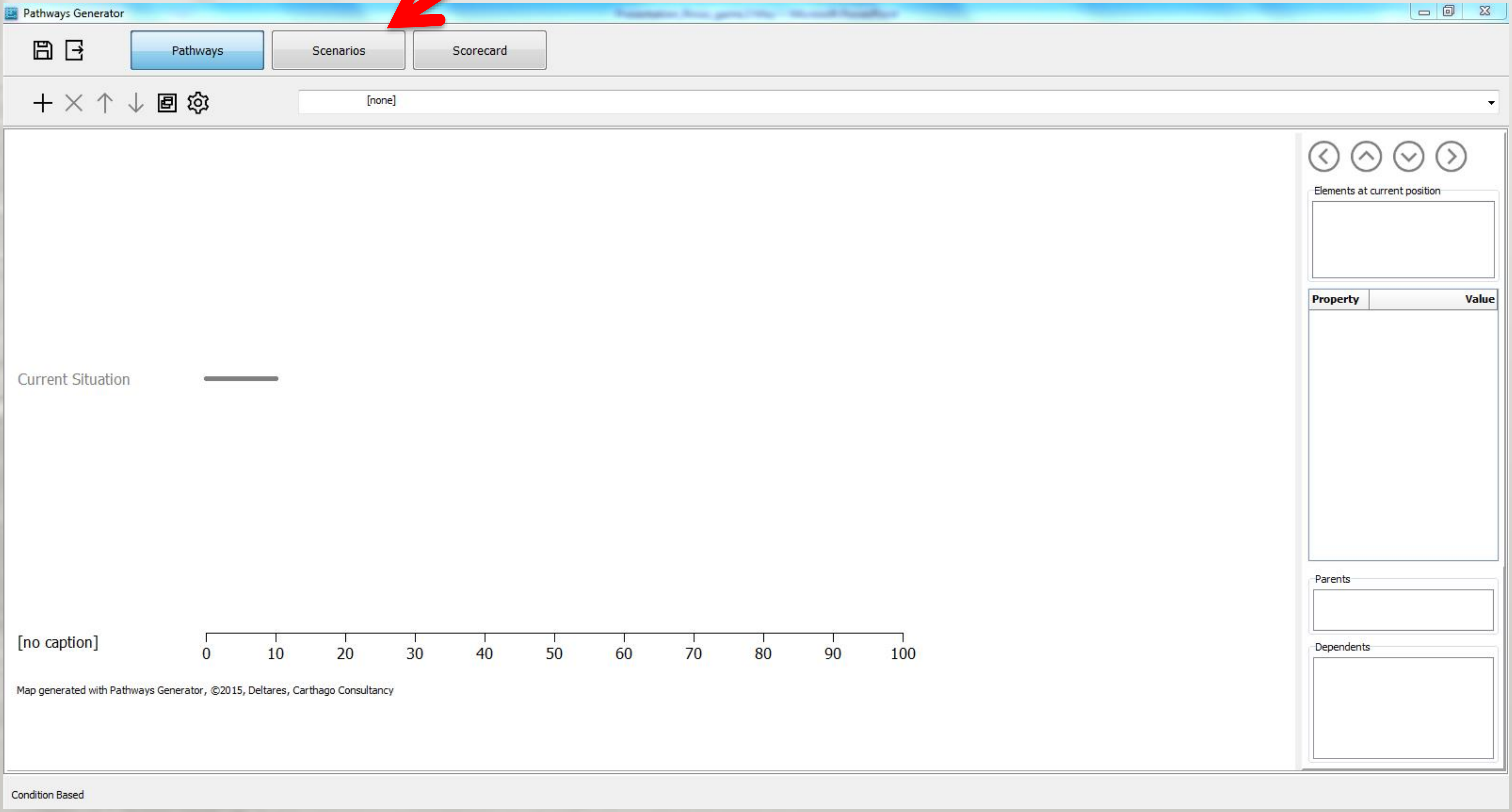
- Choose scenario(s)
- Choose actions (measures)
- Generate pathways
- Modify the Pathway Map
- Evaluate your pathways



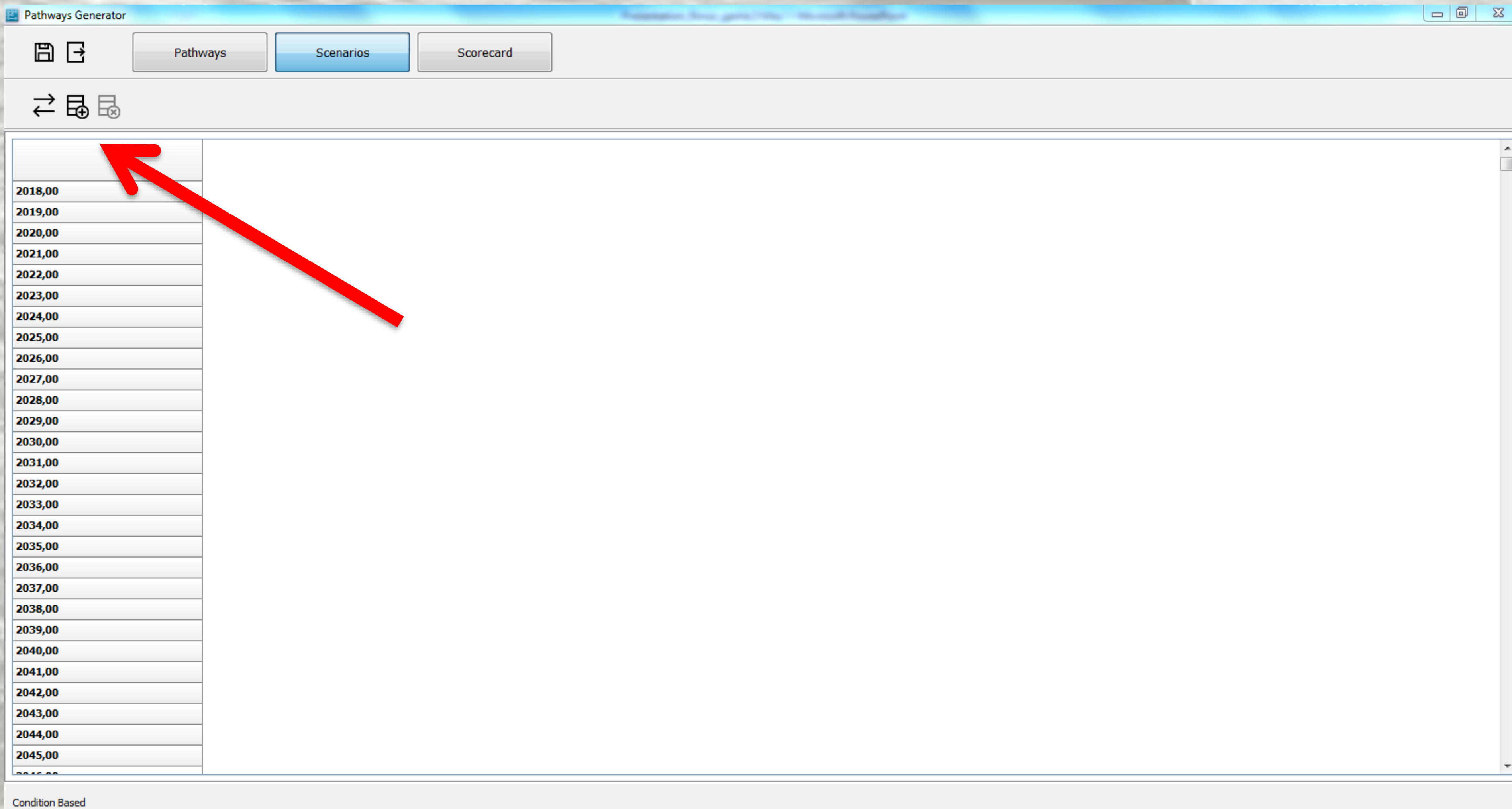
Choose approach



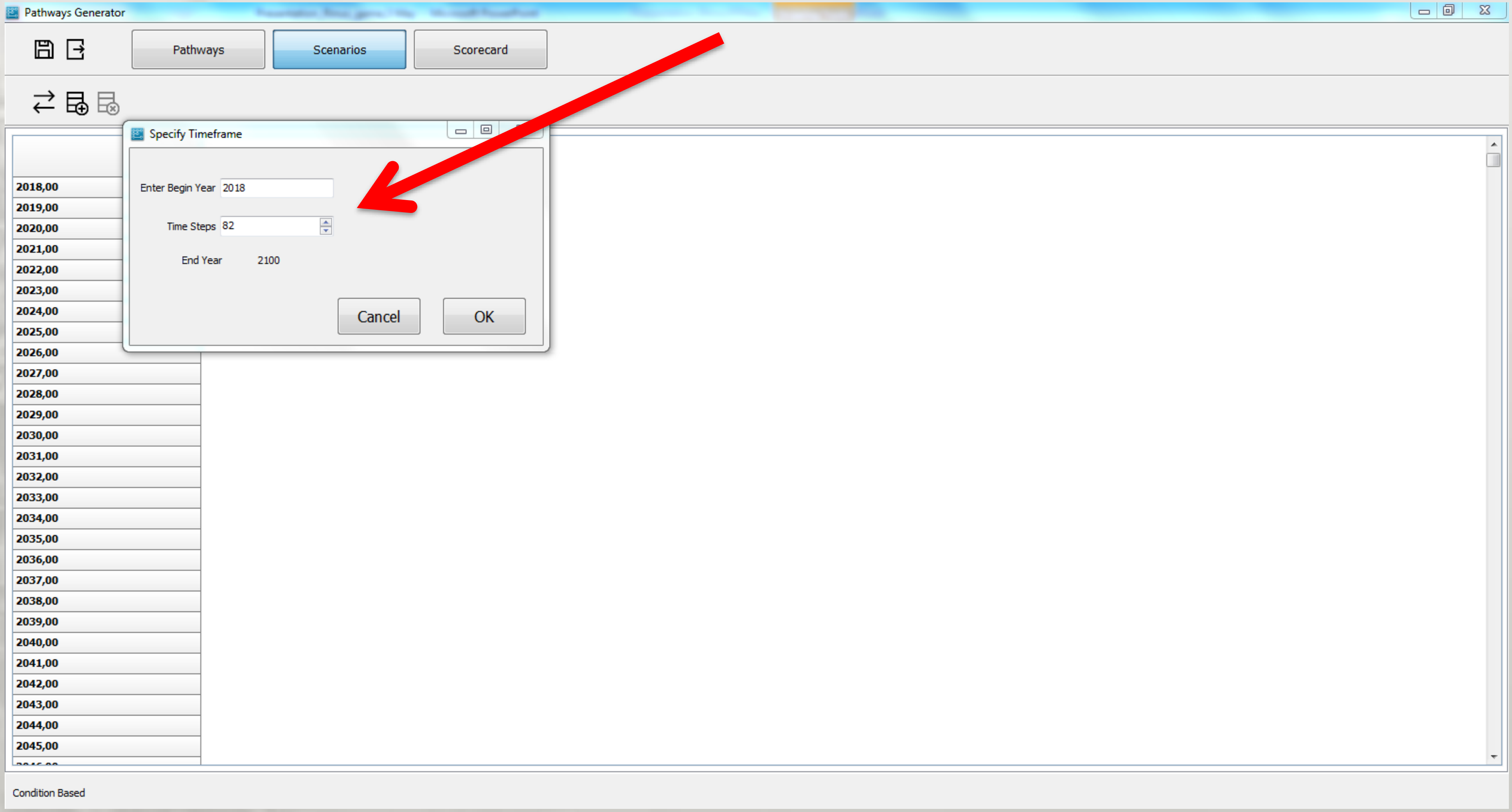
Define scenario’s



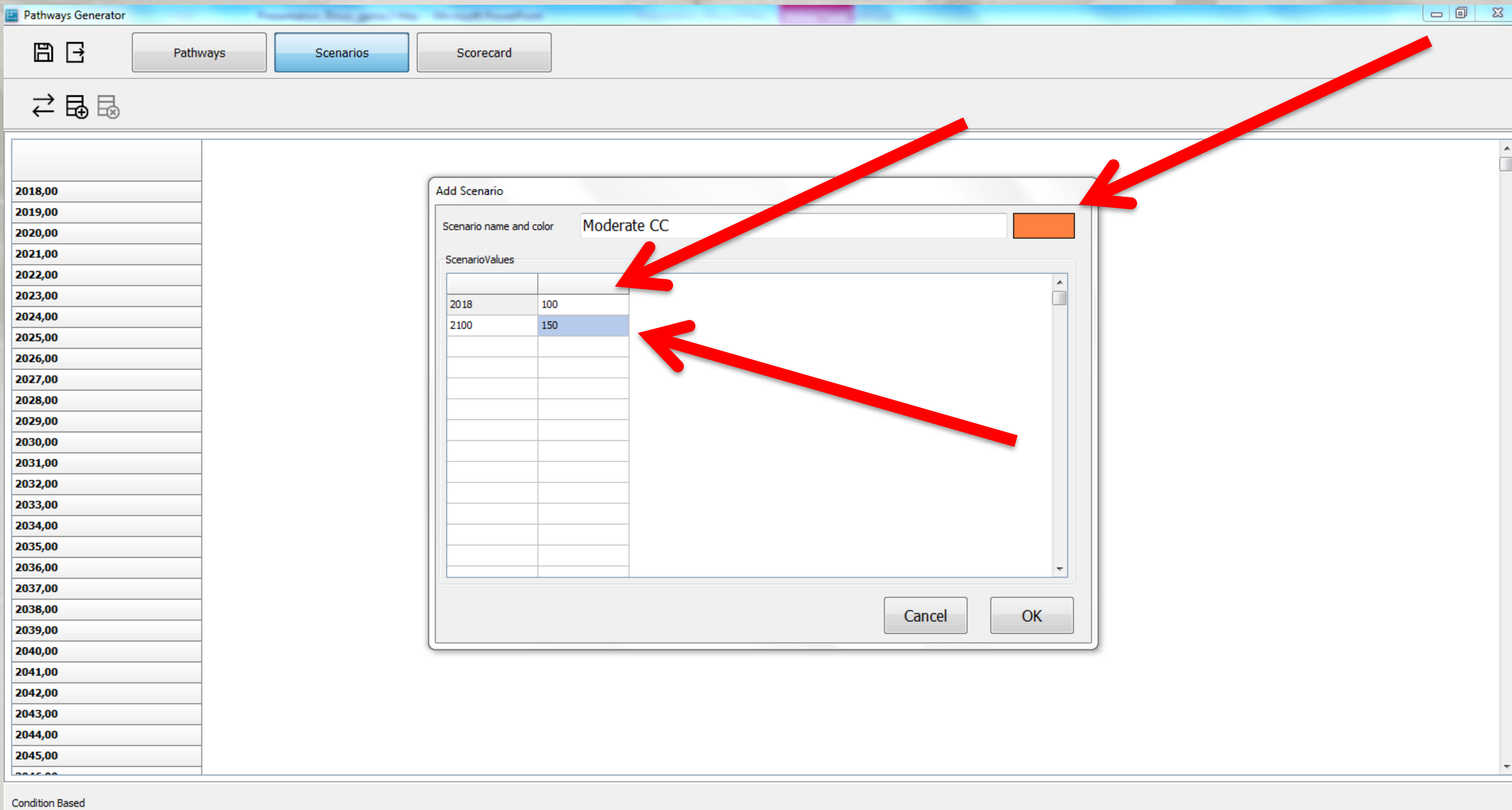
Define scenario’s 2



Define scenario's 3



Define scenario's 4



Define scenario's 5

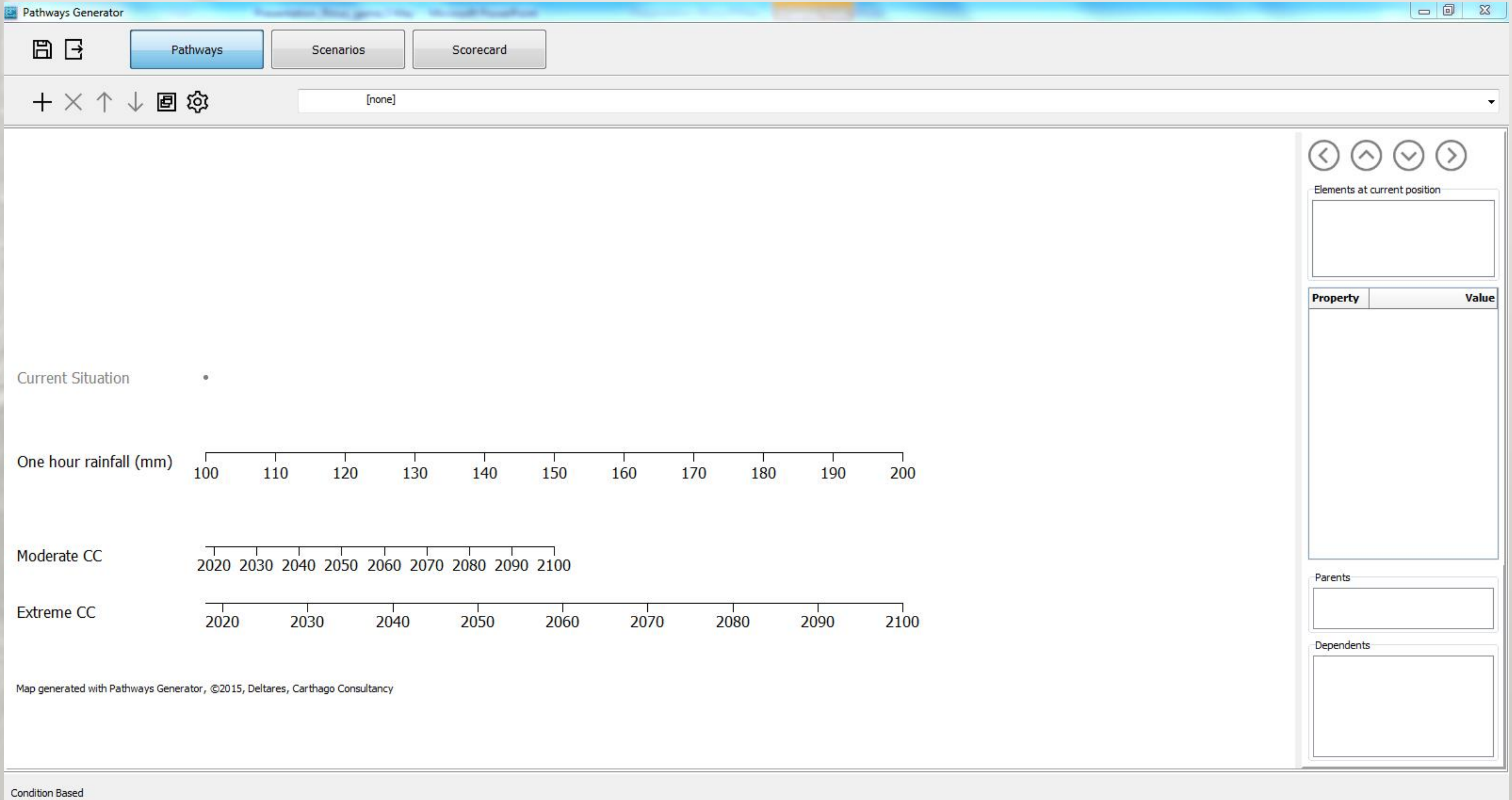
Pathways Generator

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

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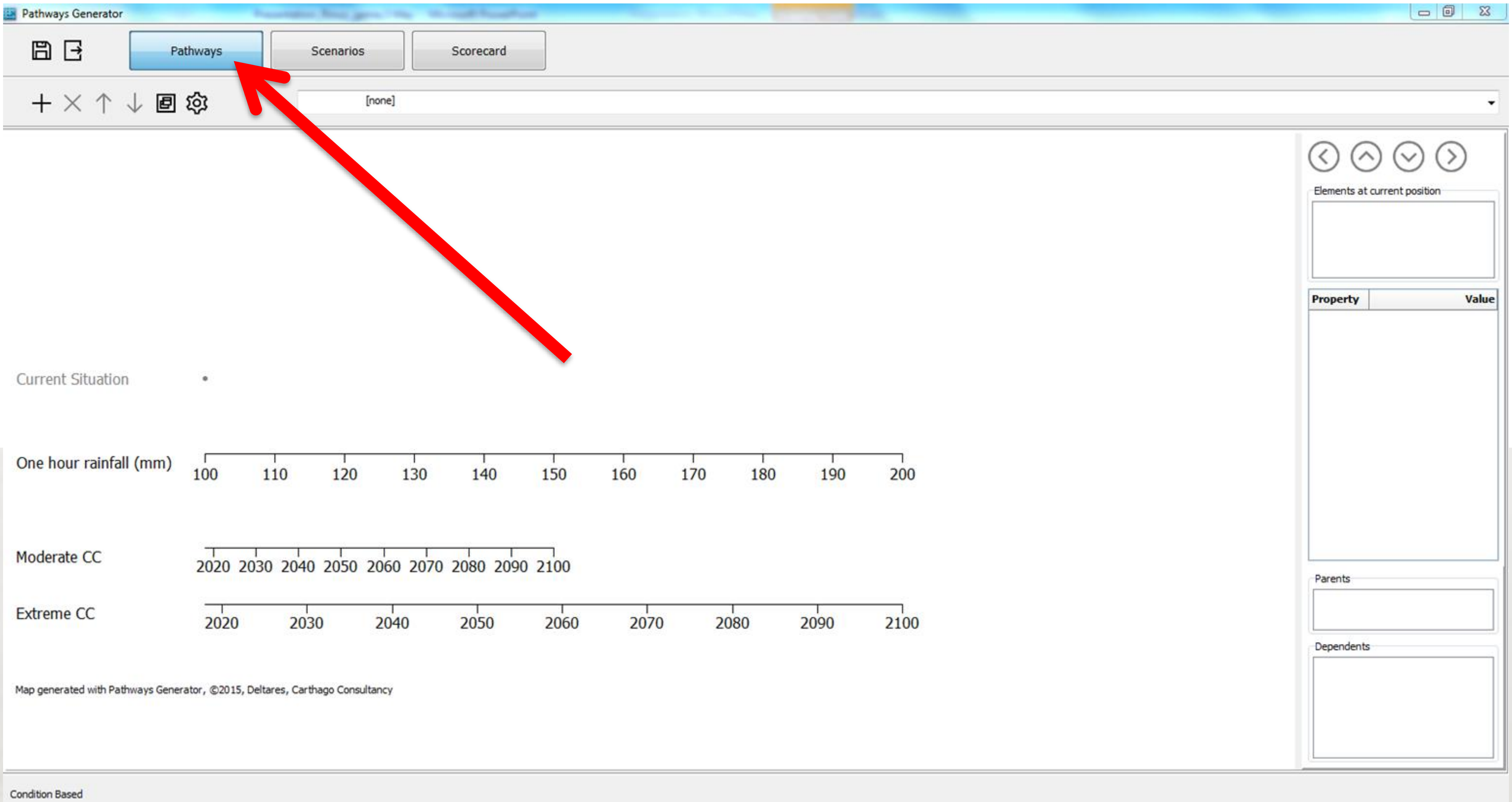
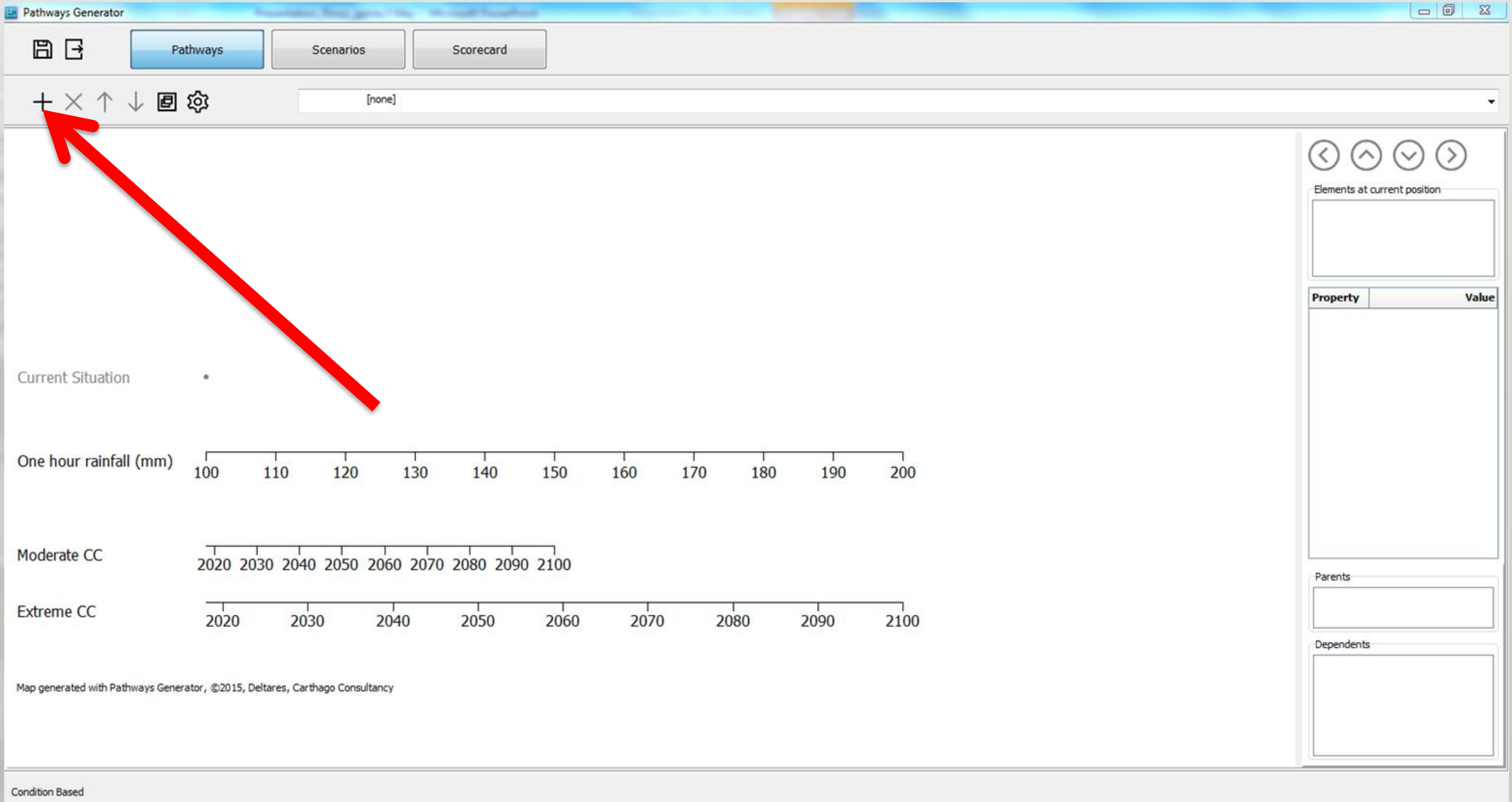
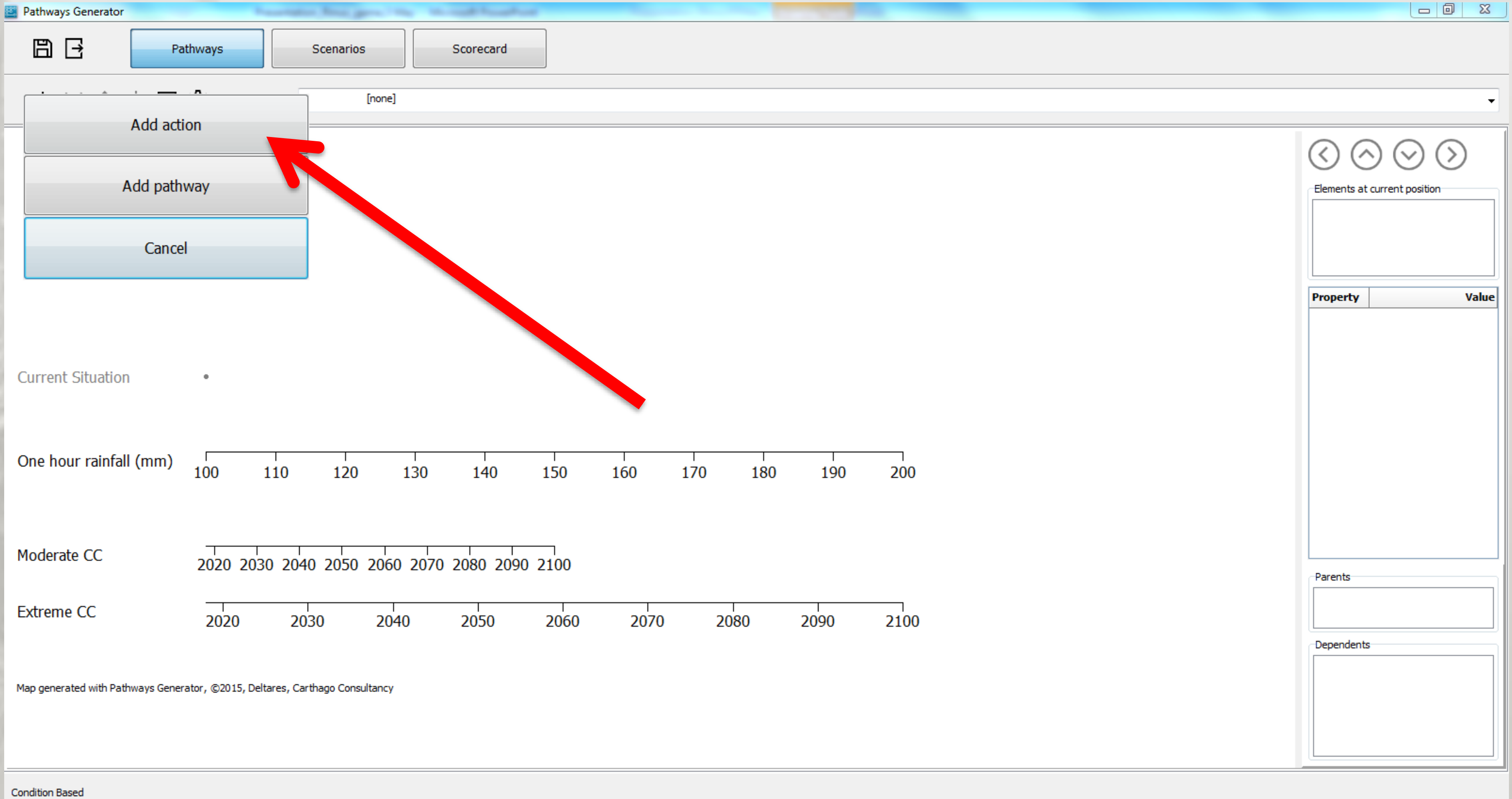


Define actions (measures) 2



Define actions (measures) 3



Possible actions (measures)

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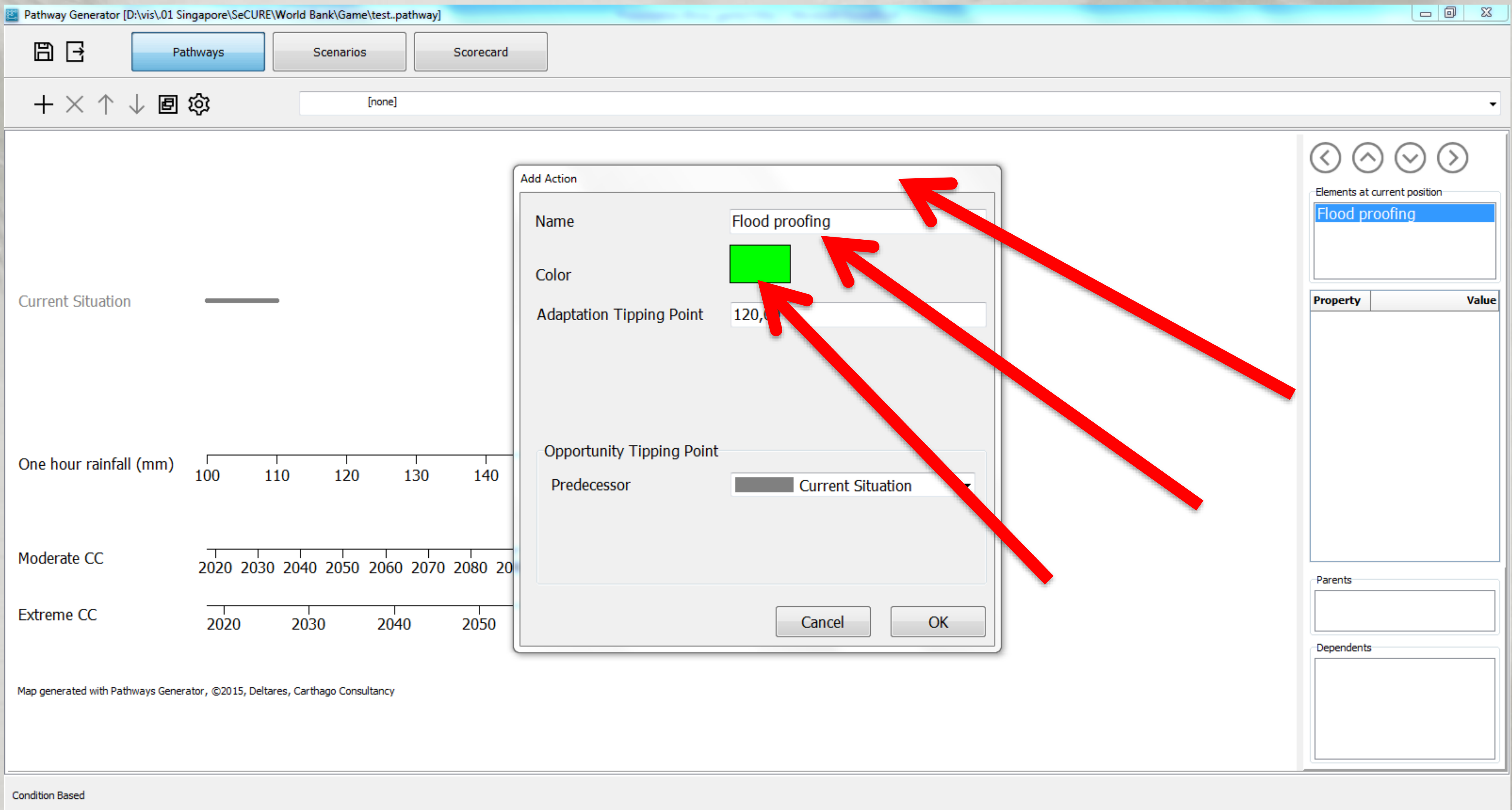
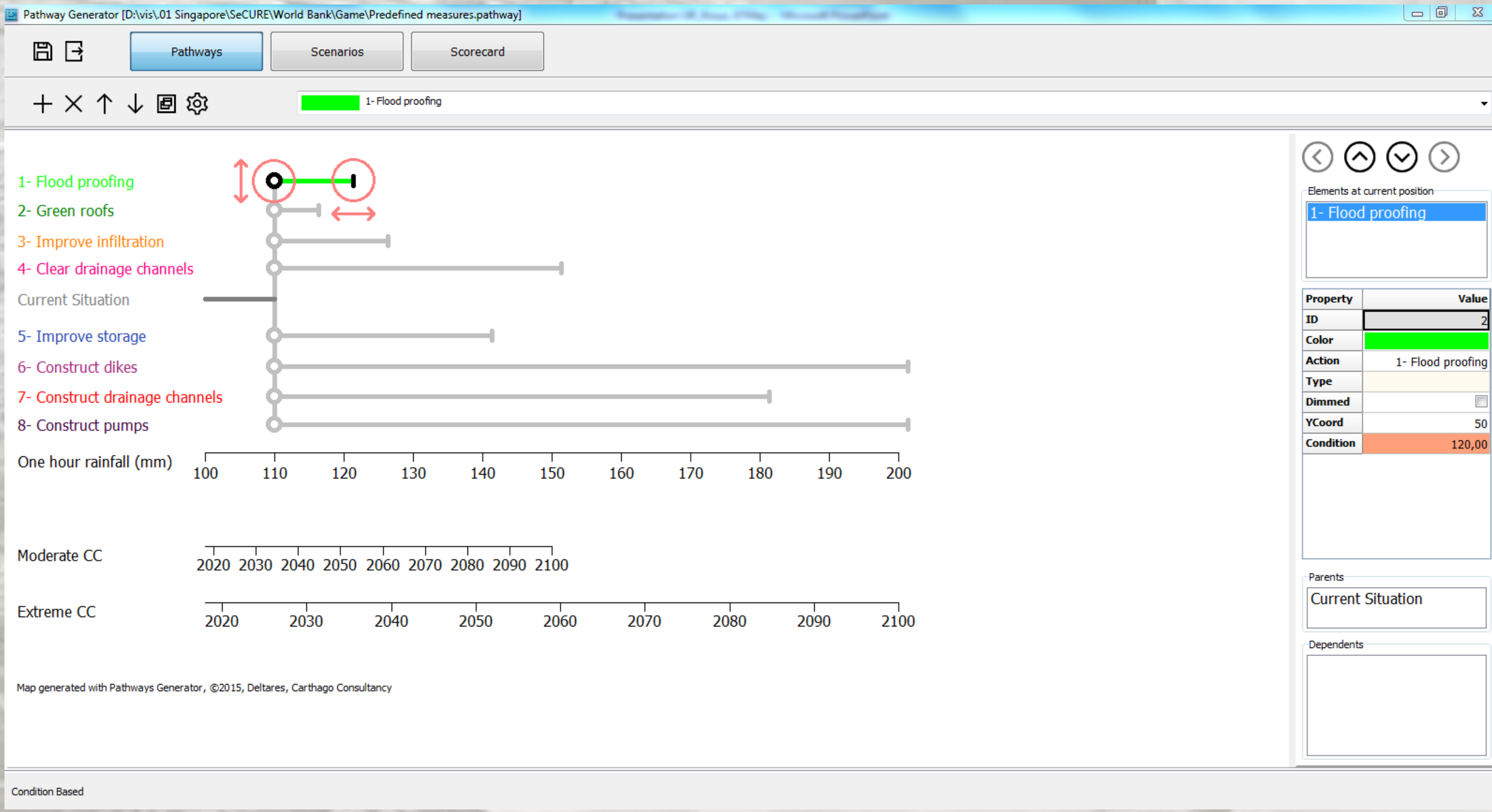
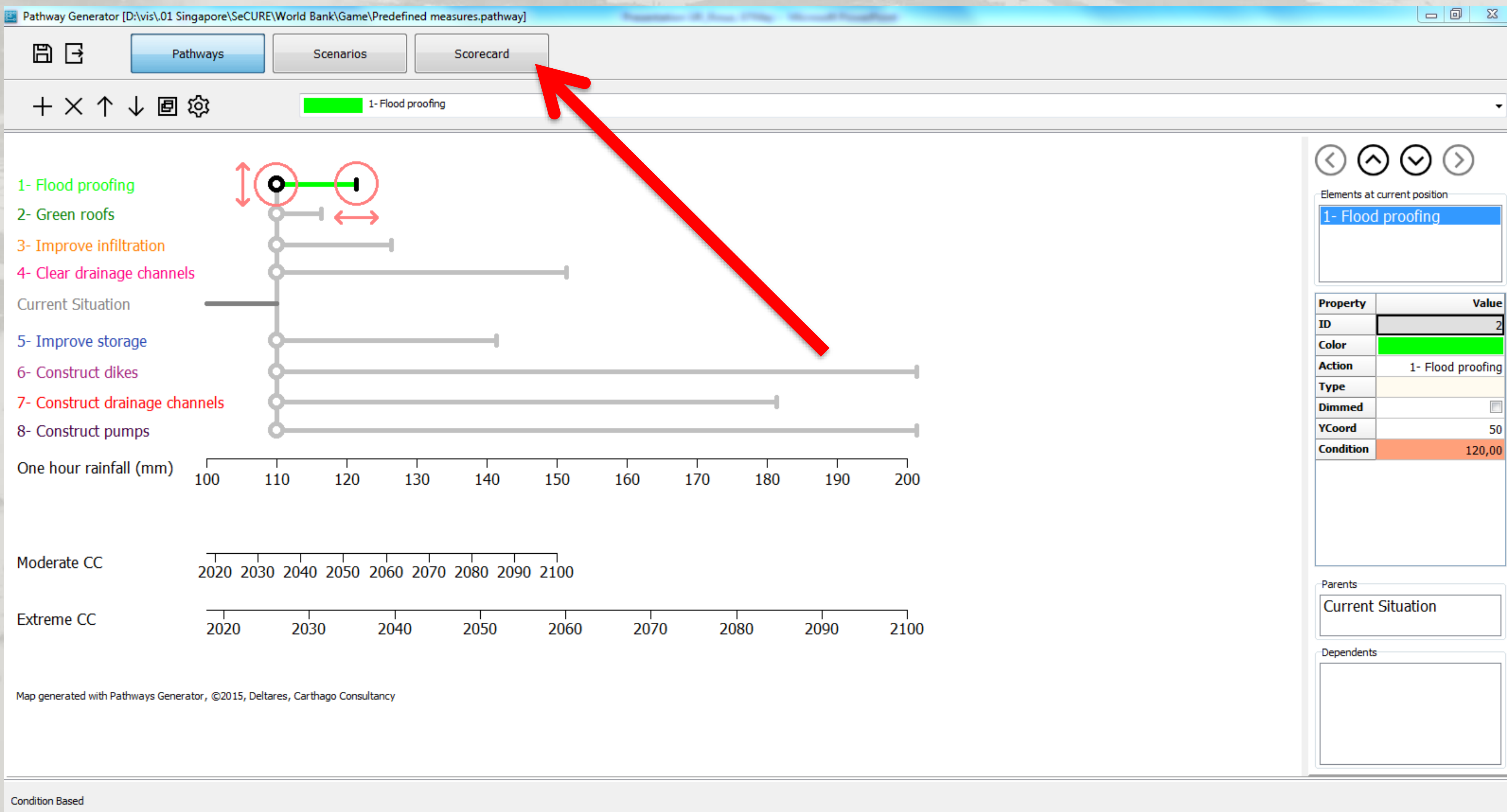
Define actions (measures) 4



Define actions (measures) 5



Scorecard 1



Pathway Generator [D:\vis\.01 Singapore\SeCURE\World Bank\Game\Predefined measures.pathway]
Pathways
Scenarios
Scorecard
1- Flood proofing
1- Flood proofing
2- Green roofs
3- Improve infiltration
4- Clear drainage channels
Current Situation
5- Improve storage
6- Construct dikes
7- Construct drainage channels
8- Construct pumps
One hour rainfall (mm)
100 110 120 130 140 150 160 170 180 190 200
Moderate CC
2020 2030 2040 2050 2060 2070 2080 2090 2100
Extreme CC
2020 2030 2040 2050 2060 2070 2080 2090 2100
Map generated with Pathways Generator, ©2015, Deltares, Carthago Consultancy
Elements at current position
1- Flood proofing
Property Value
ID 2
Color
Action 1- Flood proofing
Type
Dimmed
YCoord 50
Condition 120,00
Parents
Current Situation
Dependents
Condition Based

Scorecard 2

Pathway Generator [D:\vis\.01 Singapore\SeCURE\World Bank\Game\Predefined measures.pathway]

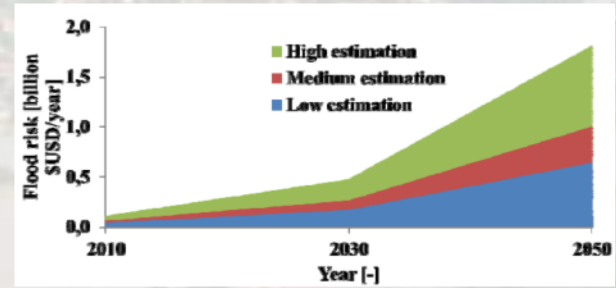
Pathways | Scenarios | Scorecard

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

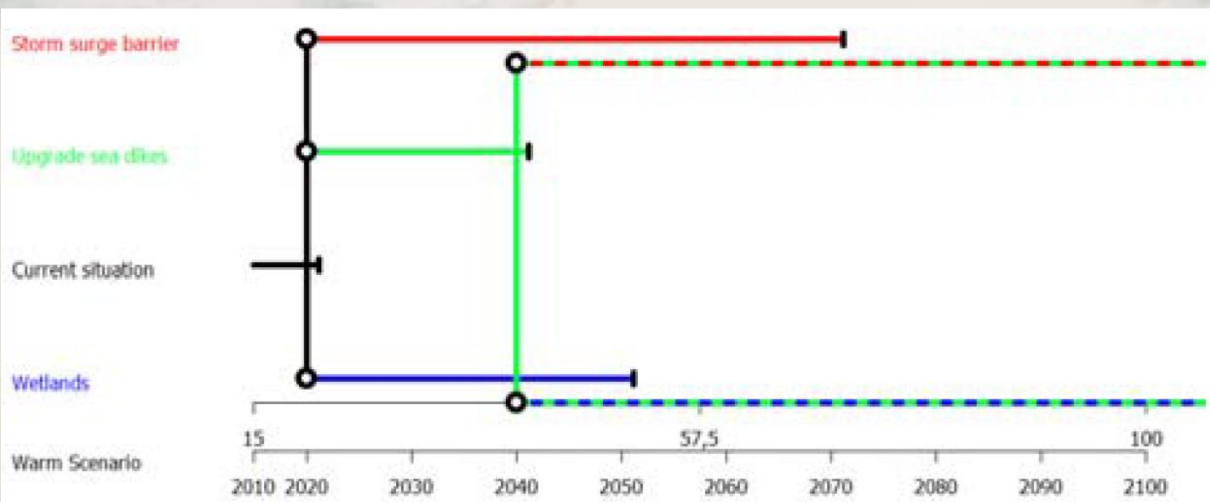
Exploring adaptation pathways in terms of flood risk management at a city scale – a case study for Shanghai city (Deltares, Technical University Delft, University Utrecht)



- 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

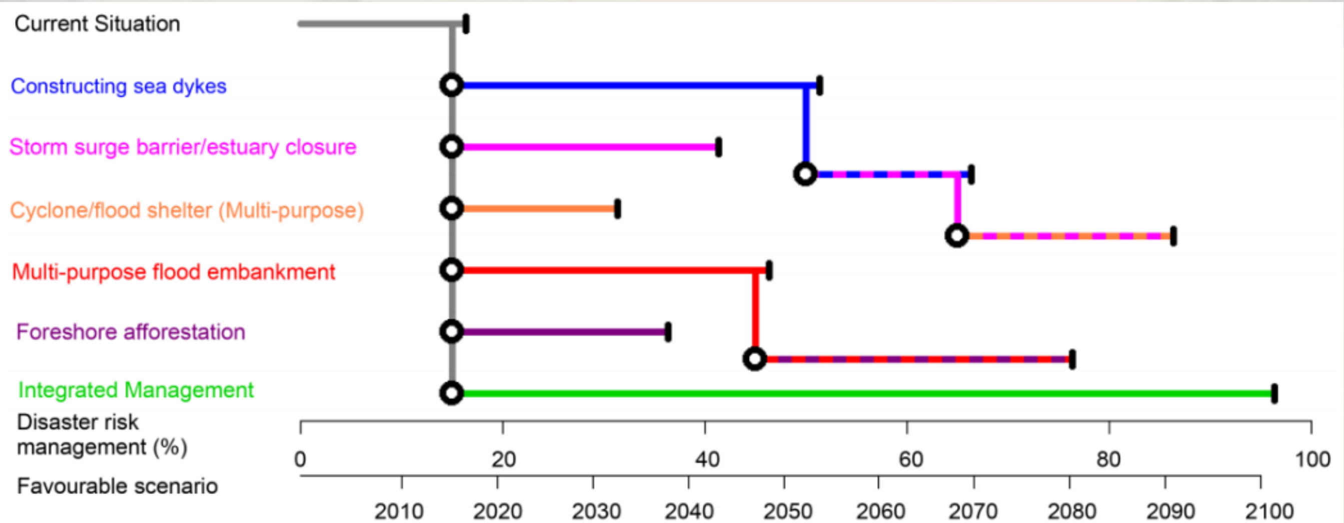
Development of sustainable and supported strategy and implementation programme

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



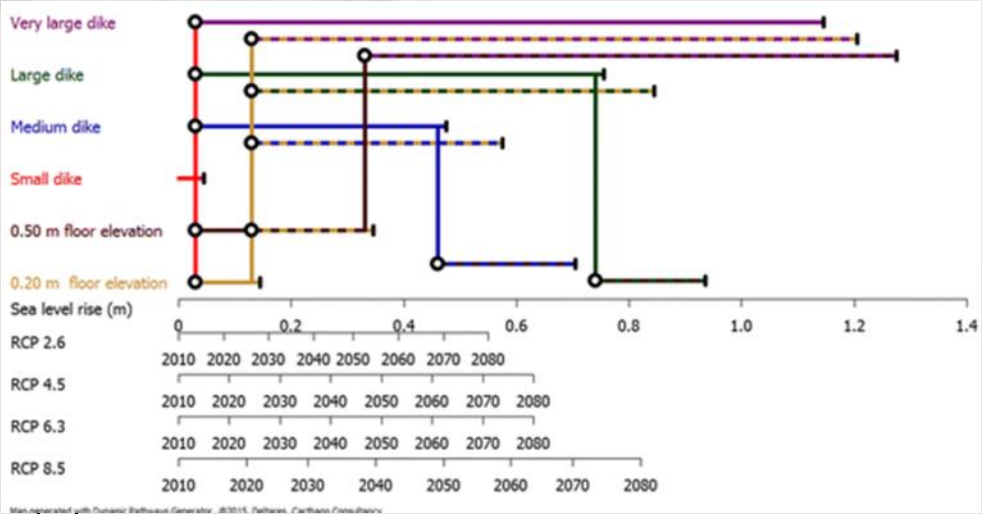
Map generated with Dynamic Pathways Generator, ©2015, Deltares, Carthago Consultancy

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