Development of Decision Support Matrices for Climate Change Adaptation Planning

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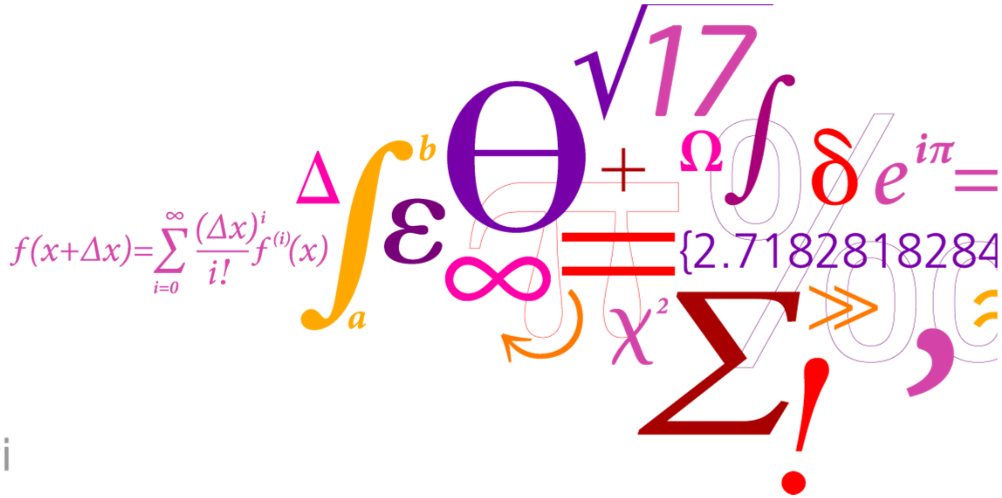

Outline

- I. Decision making within the context of climate adaptation
  - Identifying risk areas and adaptation options
  - Establishing decision making criteria
  - Assessing options
- II. Building a hypothetical decision support matrix

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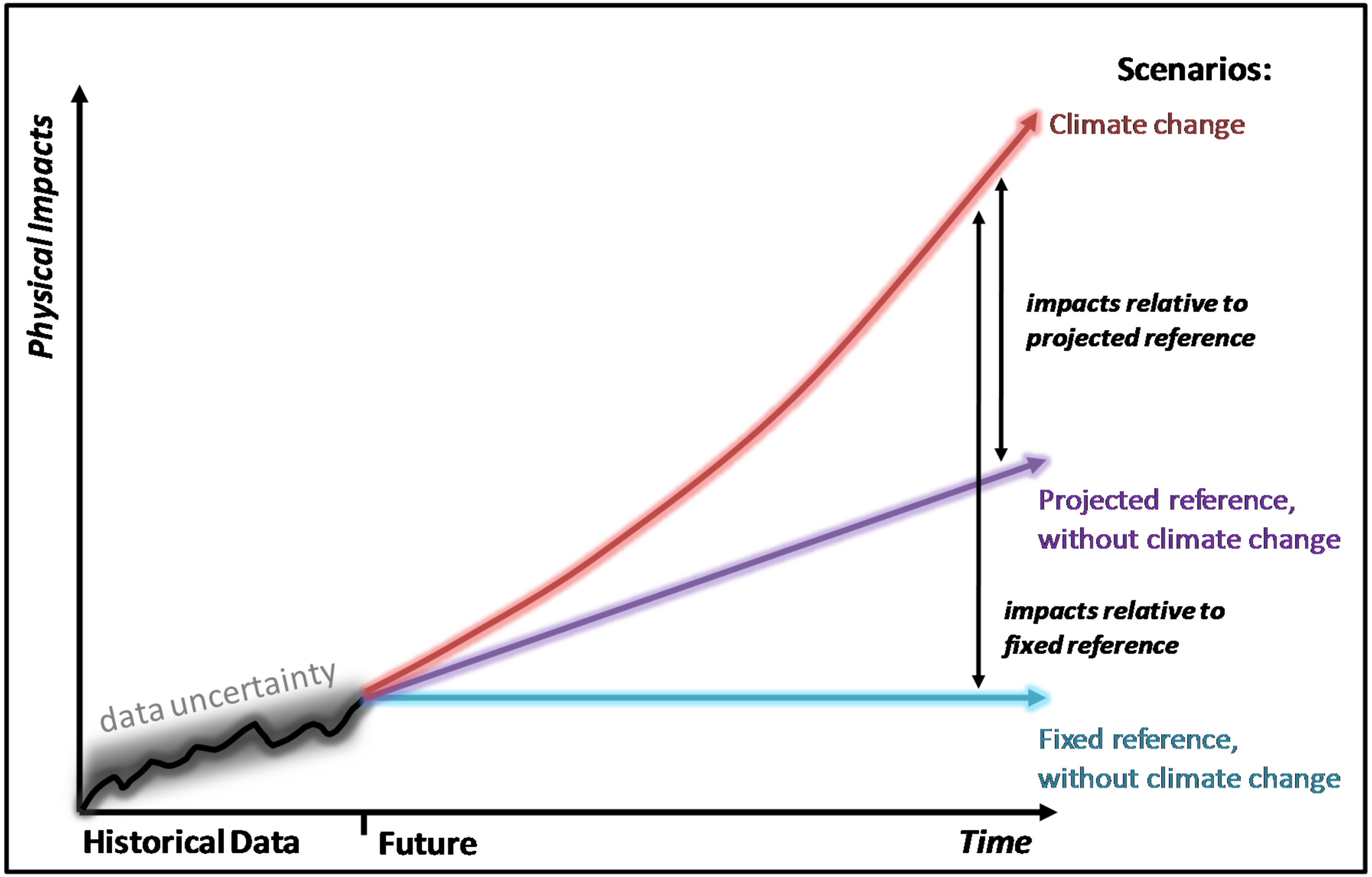
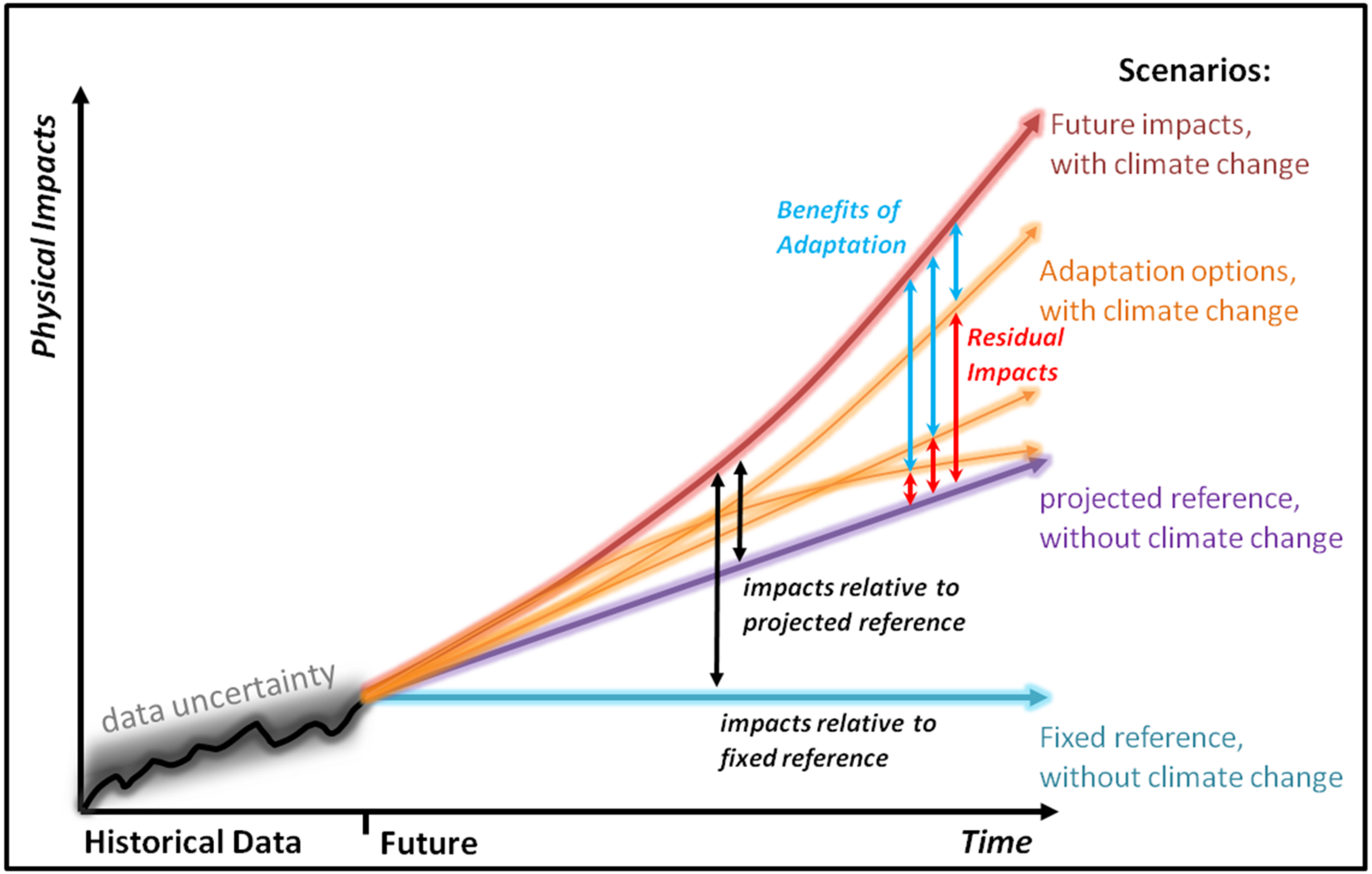
Impacts, Adaptation, and Decision Making



Adapted from:
Metroeconomica, 2004: Costing the impacts of climate change in the UK. UKCIP Technical Report. UKCIP, Oxford

Impacts, Adaptation, and Decision Making



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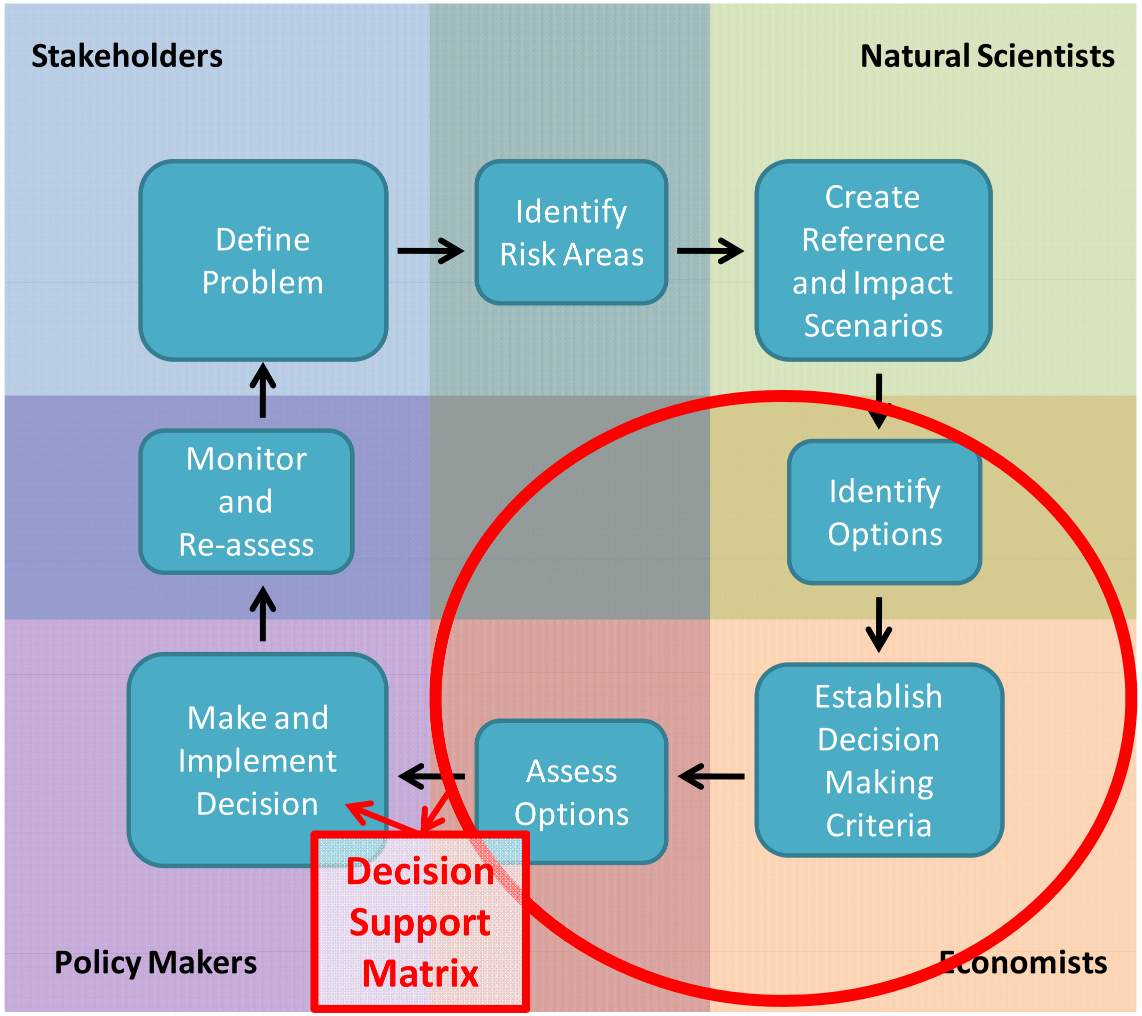
Adaptation Strategies and Decision Making: Actors and Process



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Identifying Risk Areas and Adaptation Options: How are these defined?

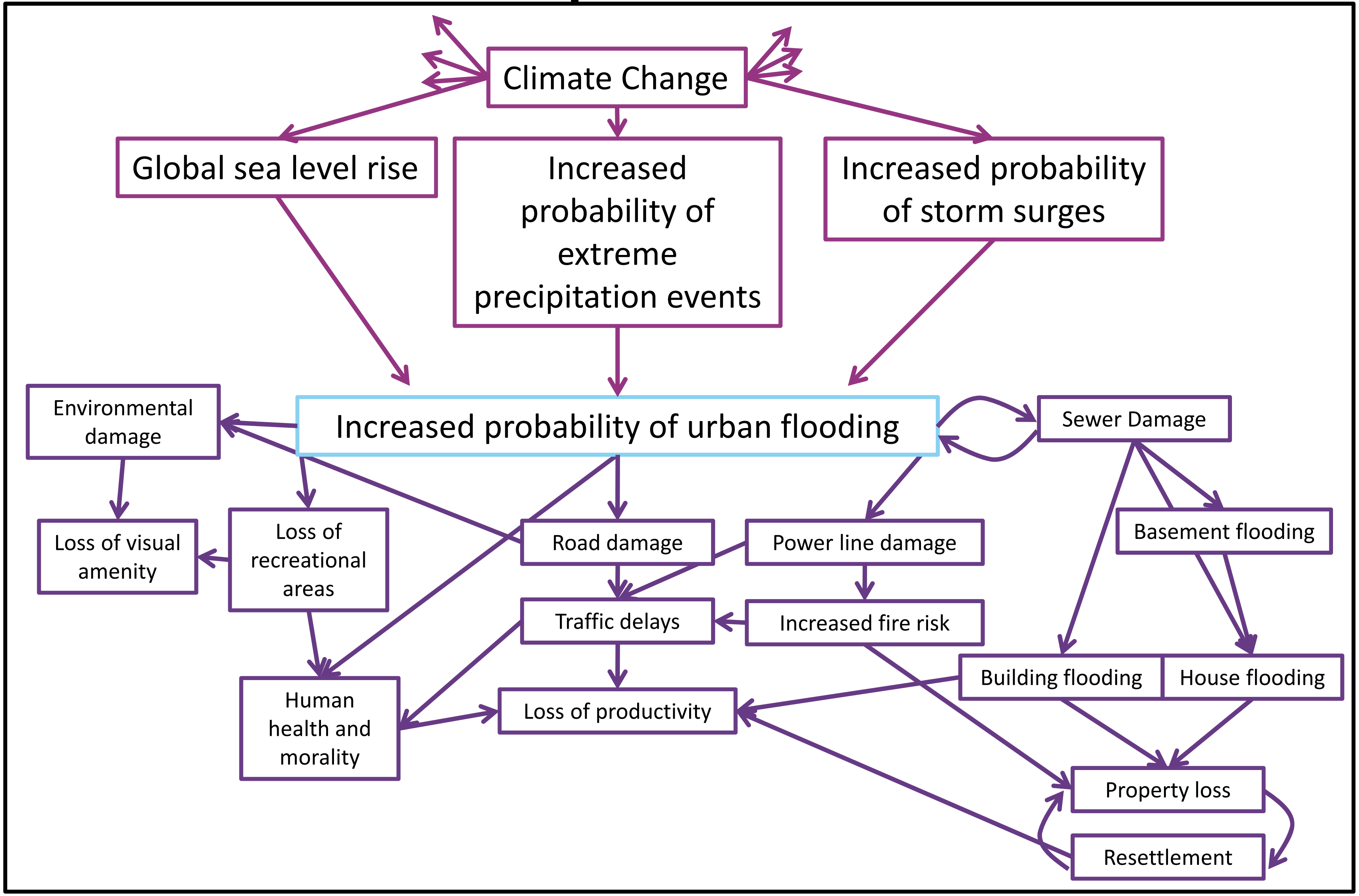
- Climate change can increase the probability of a number of different impacts
- Therefore, decision makers should explore a suite of adaptation options, rather than one.
- *so...*
- How do we decide what these options are?
- And how do we assess them in terms of residual impacts?

Identifying risks and impacts

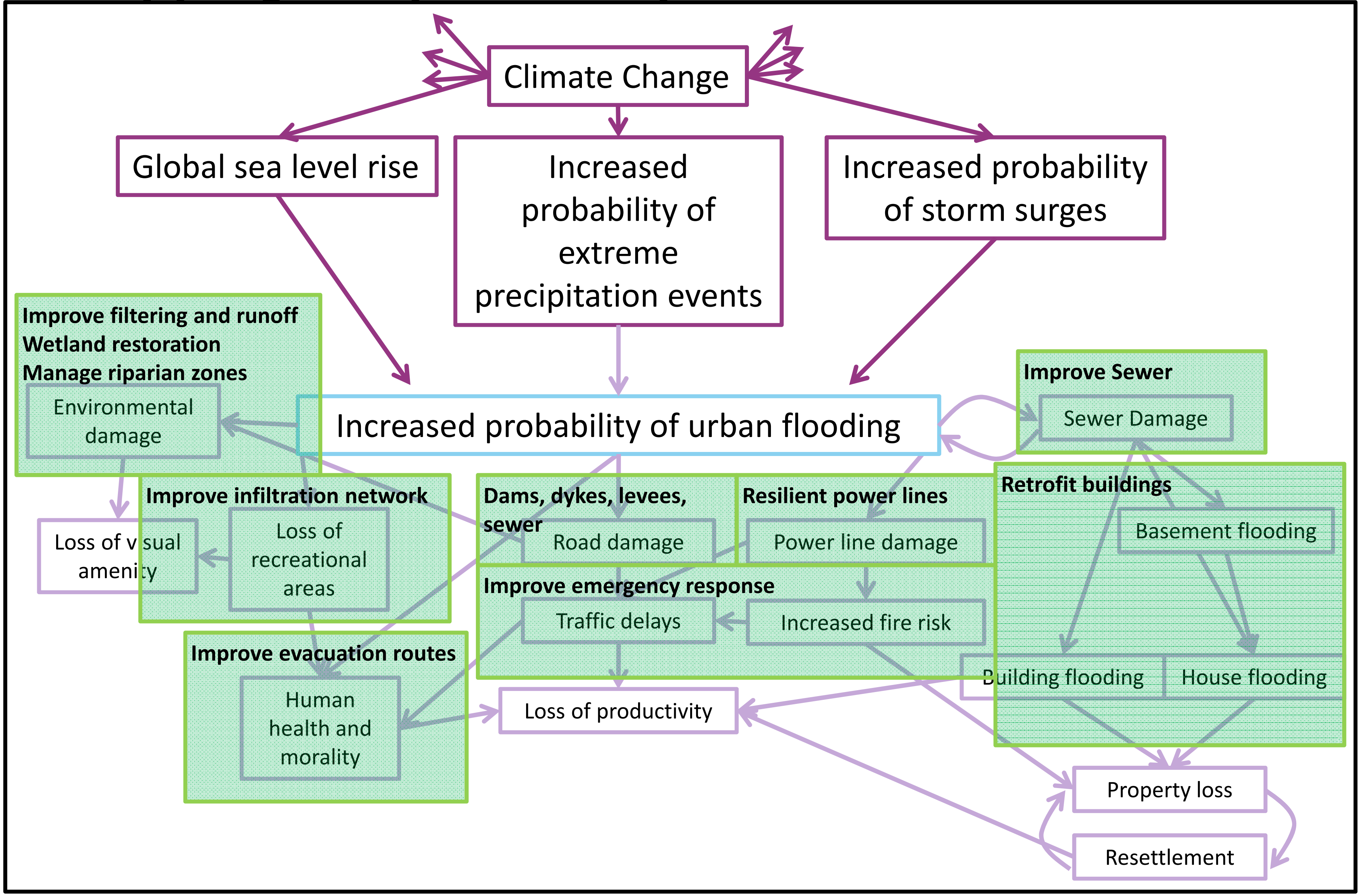
Impact	Physical measure	Cost	Consequences beyond cost
Flooding of basement in houses	Number of houses and area	Repair	Loss of irreplaceable objects
Erosion of road	Distance of road	Repair	Traffic congestion and delay
Illness from water pollution	Number of person days with sickness	Lost salary, Lost productivity	General loss of wellbeing loss of life
Flooding of local lake	Impacts on life in the lake water level	Clean up, restoration	Esthetic value, loss of recreational area illness
Flooding of unique historical building	Physical character of the building	Repair and replacement	Esthetic values
Traffic delay	Time	Lost salary, Lost productivity	Worker morale, lost time for leisure
Loss of recreational areas	Area inundated	Reparation, clean up, replacement	Lost leisure, visual amenity

etc.

Causal Chain of Impacts



Mapping Adaptation Options



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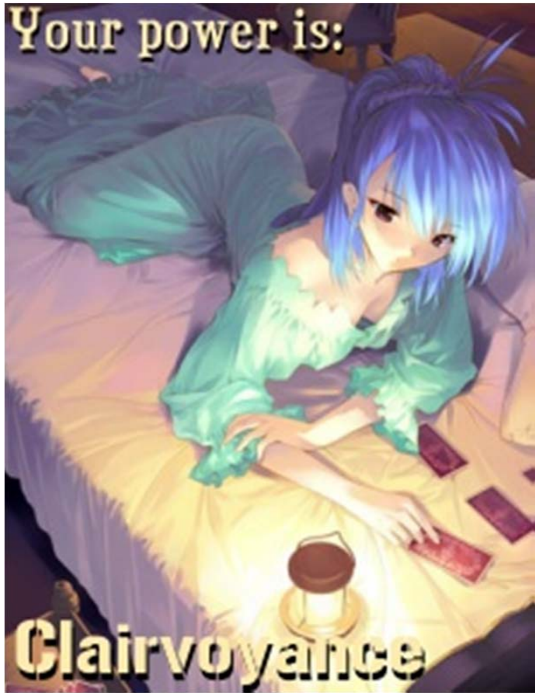
Decision Criteria: Planning for the Future

- We want to know how the extent of impacts and the effectiveness of adaptation measures, given a value structure. But how do we decide?
- How important will a given option be in the future relative to other options?
- How much will it cost and what will be the benefit?
- Would adaptation occur anyway on a private level?
- What will we learn in the mean time?



- Challenges of modeling the future:
  - Is it possible for a model to predict the future?
  - Is it possible to test the model by running from a past date to the present?

No!

Differences between modeling physical systems vs. conducting policy analysis

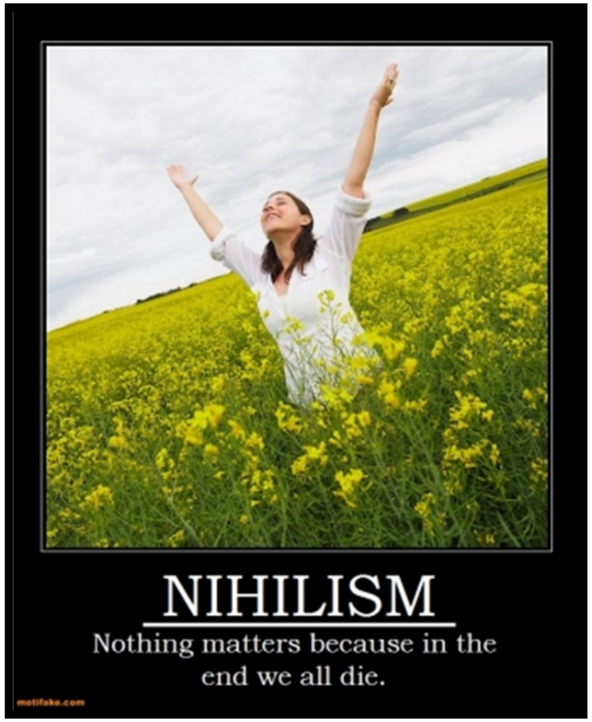
For policy analysis to make sense, we have two philosophical assumptions:

1. Non-Determinism:

- If we assume that whatever is going to happen is already predestined, then policy has no role. We have to assume that policy has the power to change the course we are on.

2. Non-Nihilism:

- We have to assume that some outcomes are better than others and that there exists a criteria for deciding between the different outcomes. If not, policy again would have no purpose because every possible future would be equally desirable.



The Time Dimension

- How do we represent future hypothetical states and risk in models?
- When does action on adaptation make sense?
- How do we know what future generations will value?
- Does it pay to wait?
- Is incomplete adaptation adoption a “better than nothing” option?
- Are there learning curves and “slow” adaptation?
- Humans make decisions and act; it is a dynamic and non-deterministic system

Uncertainty

e.g., Århus 2009 municipal plan: ***In the next 20 years:***

- +50,000 jobs
- +10,000-15,000 students
- +75,000 population
- The council has made environmental and social sustainability a priority in it vision for the future.

- How does this affect the analysis of future impacts?
- How does this change the decision making criteria?

Establishing Decision Making Criteria

- Different sets of values and assumptions about the future will result in different “optimal” decisions. In other words, there is *no* optimal decision.

- Different decisions makers will come to different decisions based upon attitudes toward risk, weighing of impacts, predefined non-negotiable constraints, and parallel/competing goals with existing and concurrent policies

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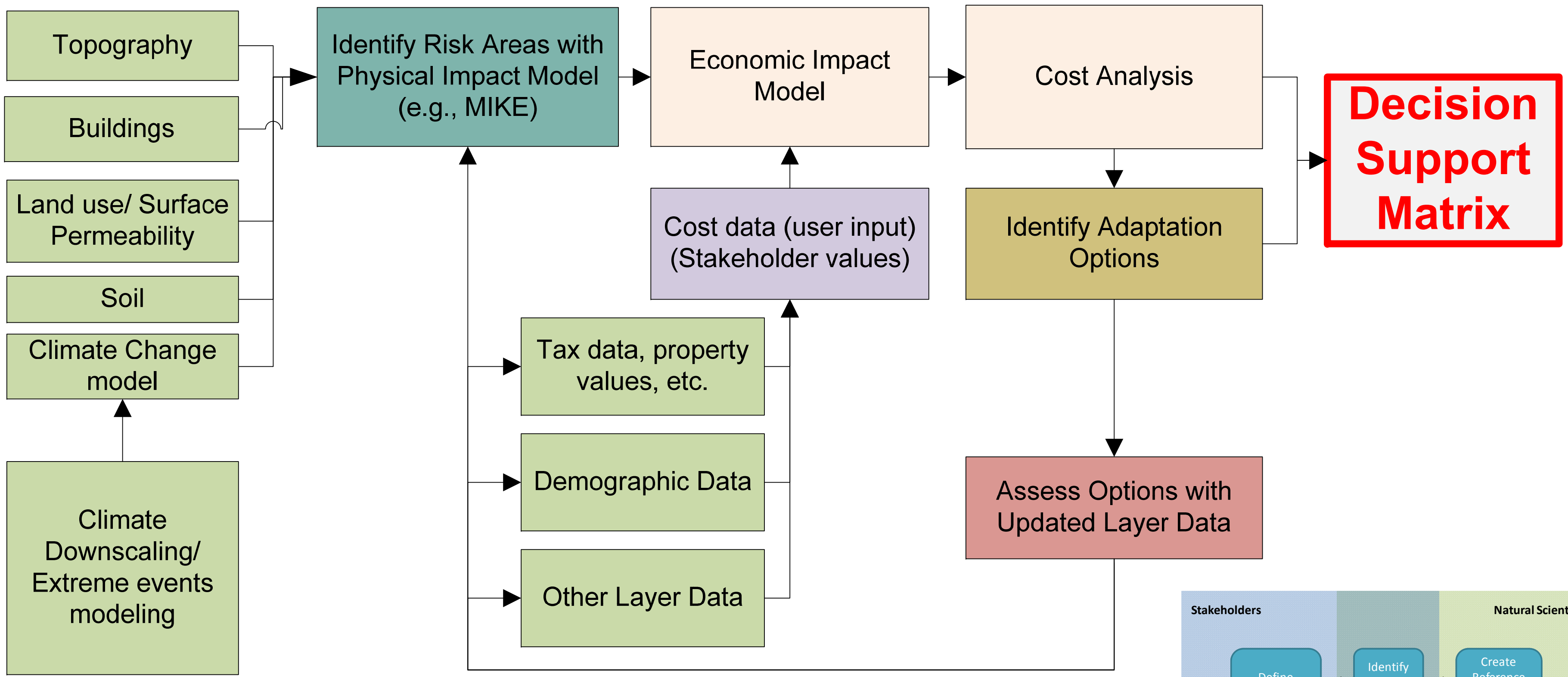
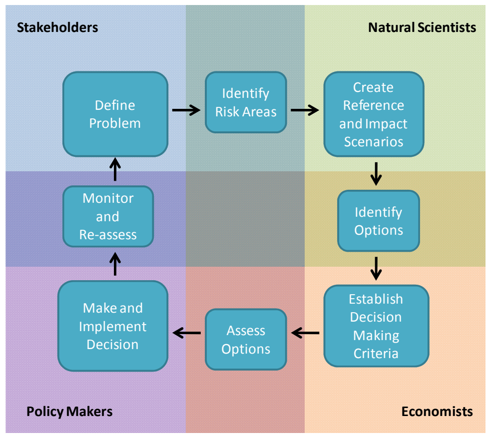
Assessing Adaptation Options





Decision Support Matrix

- ***Goal-*** Define a tool that can:
  - clarify the decision making process
  - highlight key uncertainties
  - identify critical assumptions
  - determine how different a priori values can influence the decision outcome

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Building a Decision Support Matrix

Decision Support Matrix: A systematic way of comparing available choices and options (*rows*) on the basis of a set of criteria (*columns*) associated with each hypothetical outcome

Options	Criterion a	Probability (a)	Criterion b	Prob (b)	…	Risk/Expected Cost
Option 1	a_1	$p(a_1)$	b_1	$p(b_1)$	…	$a_1*p(a_1); b_1*p(b_1);$…
Option 2	a_2	$p(a_2)$	b_2	$p(b_2)$	…	$a_2*p(a_2); b_2*p(b_2);$…
Option 3	a_3	$p(a_3)$	b_3	$p(b_3)$	…	$a_3*p(a_3); b_3*p(b_3);$…
:	:	:	:	:	:	:
Option n	a_n	$p(a_n)$	b_n	$p(b_n)$	…	$a_n*p(a_n); b_n*p(b_n);$…

Building a Decision Support Matrix

Consider a simple case, with one impact, and one adaptation option with 3 different levels of deployment. E.g., cost of building damage due to flooding versus building a sea wall at different heights.

	Cost of implementation	Cost of climate event, given adaptation choice	p(extreme event)	Expected Cost
Nothing	0	500	.16	0+500*.16= 80
adaptation level 1	10	50	.16	10+50*.16= 18
adaptation level 2	20	20	.16	20+20*.16=23.2
adaptation level 3	100	10	.16	100+10*.16=101.6

Decision Maker: Can we provide more information on risk? How extreme is extreme?

Building a Decision Support Matrix

Now we add a more detailed description of risk, with a 10-year event, 20-year event and 100-year event.
In reality, this would be a continuous probability distribution, and we could integrate to find the expected cost.

	Cost of implementation	Cost of 10 year climate event, given adaptation choice	p(10 yr event)	Cost of 20 year climate event, given adaptation choice	p(20 yr event)	Cost of 100 year climate event, given adaptation choice	p(100 yr event)	Expected Cost
Nothing	0	500	.1	1000	.05	50000	.01	600
adaptation level 1	10	50	.1	500	.05	10000	.01	140
adaptation level 2	20	20	.1	200	.05	5000	.01	82
adaptation level 3	100	10	.1	100	.05	1000	.01	116

Decision Maker: What if I want to consider two different adaptation options?

Building a Decision Support Matrix

Now we add two different options, at 3 discrete levels, and all the permutations.
In reality, these would be a joint distribution.

	Cost of implementation	Cost of 10 year climate event, given adaptation choice	p(10 yr event)	Cost of 20 year climate event, given adaptation choice	p(20 yr event)	Cost of 100 year climate event, given adaptation choice	p(100 yr event)	Expected Cost
Nothing	0	500	0.1	1000	0.05	50000	0.01	600
Sea wall level 1	10	50	0.1	500	0.05	10000	0.01	140
Sea wall level 2	20	20	0.1	200	0.05	5000	0.01	82
Sea wall level 3	100	10	0.1	100	0.05	1000	0.01	116
Park level 1	1	400	0.1	900	0.05	40000	0.01	486
Park level 2	5	300	0.1	800	0.05	9000	0.01	165
Park level 3	10	200	0.1	700	0.05	4000	0.01	105
SW 1, park 1	11	40	0.1	400	0.05	4000	0.01	75
SW2, park 1	21	15	0.1	150	0.05	1500	0.01	45
SW 3, park 1	101	8	0.1	80	0.05	800	0.01	113.8
SW 1, park 2	5	30	0.1	300	0.05	3000	0.01	53
SW 2, park 2	25	12	0.1	120	0.05	1200	0.01	44.2
SW 3, park 2	105	5	0.1	50	0.05	500	0.01	113
SW 1, park 3	20	10	0.1	100	0.05	1000	0.01	36
SW 2, park 3	30	5	0.1	50	0.05	500	0.01	38
SW 3, park 3	110	2	0.1	20	0.05	200	0.01	113.2

Decision Maker: What if I want to consider more than one type of impact, each with different units?

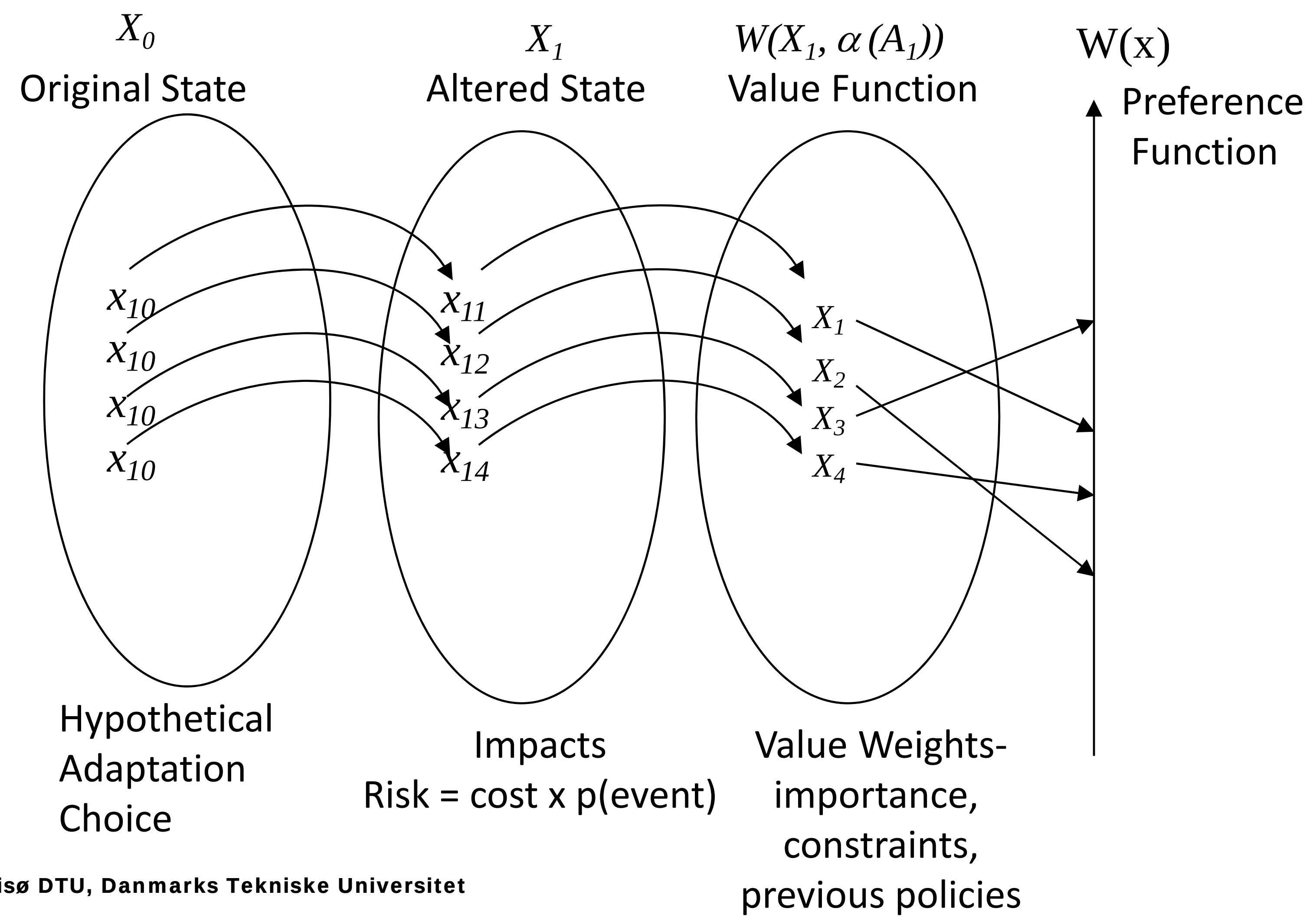
Building a Decision Support Matrix

Now we add two impacts, with different cost units (e.g., one monetary, one non-monetary)

	Cost of implement ation	Cost of 10 year climate event, given adaptation choice		p(10 yr event)	Cost of 20 year climate event, given adaptation choice		p(20 yr event)	Cost of 100 year climate event, given adaptation choice		p(100 yr event)	Expected Cost	
Nothing	0	500	30	0.1	1000	50	0.05	50000	100	0.01	600	6.5
Sea wall level 1	10	50	1	0.1	500	5	0.05	10000	15	0.01	140	10.5
Sea wall level 2	20	20	0	0.1	200	2	0.05	5000	10	0.01	82	20.2
Sea wall level 3	100	10	0	0.1	100	0	0.05	1000	5	0.01	116	100.1
Park level 1	1	400	1	0.1	900	5	0.05	40000	20	0.01	486	1.55
Park level 2	5	300	0	0.1	800	2	0.05	9000	10	0.01	165	5.2
Park level 3	10	200	0	0.1	700	0	0.05	4000	9	0.01	105	10.09
SW 1, park 1	11	40	0	0.1	400	3	0.05	4000	10	0.01	75	11.25
SW2, park 1	21	15	0	0.1	150	1	0.05	1500	6	0.01	45	21.11
SW 3, park 1	101	8	0	0.1	80	1	0.05	800	4	0.01	113.8	101.1
SW 1, park 2	5	30	0	0.1	300	1	0.05	3000	8	0.01	53	5.13
SW 2, park 2	25	12	0	0.1	120	0	0.05	1200	5	0.01	44.2	25.05
SW 3, park 2	105	5	0	0.1	50	0	0.05	500	3	0.01	113	105
SW 1, park 3	20	10	0	0.1	100	1	0.05	1000	6	0.01	36	20.11
SW 2, park 3	30	5	0	0.1	50	0	0.05	500	2	0.01	38	30.02
SW 3, park 3	110	2	0	0.1	20	0	0.05	200	1	0.01	113.2	110

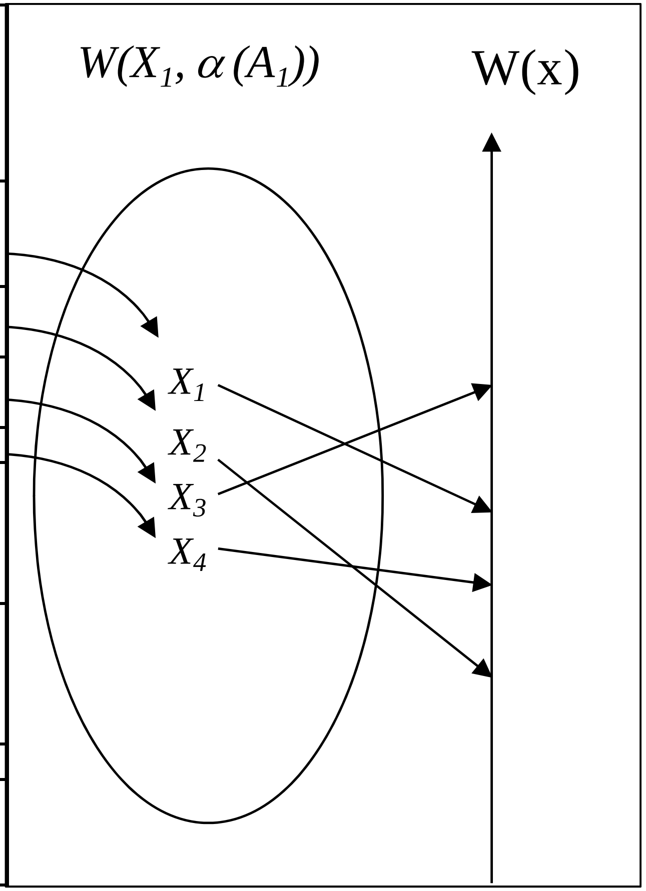
Decision Maker: How do I decide between the two expected costs? What level of risk is acceptable across all variables?

Building a Decision Support Matrix



Hypothetical Decision Support Matrix

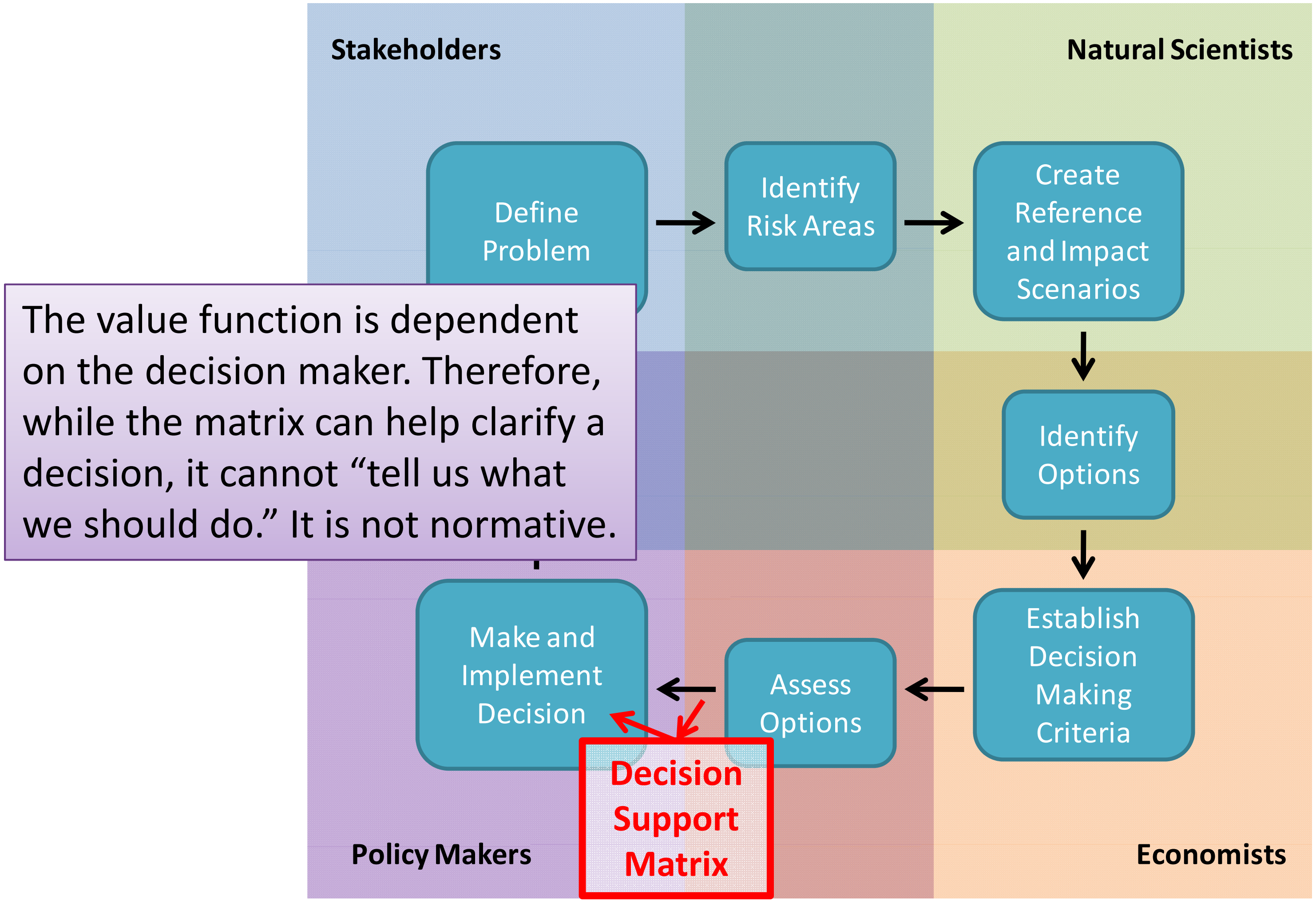
	Reference Outcome 1 (current state, no CC)	Reference Outcome 2 (current trend, no CC)	Impact 1 Outcome (with CC)	Impact 2 Outcome (with CC)	...	Impact *i* Outcome (with CC)
no adaptation	baseline reference scenario	projected reference scenario	scenario 0 outcome 1	Scenario 0 outcome 2	...	scenario 0 outcome *i*
Adaptation option 1	X	X	Scenario 1 outcome 1	Scenario 1 outcome 2	...	Scenario 1 outcome *i*
Adaptation option 2	X	X	Scenario 2 outcome 1	Scenario 2 outcome 2	...	Scenario 2 outcome *i*
:	:	:	:	:	:	:
multiple adaptation options (1,2, ...)	X	X	Scenario p1 outcome 1	Scenario p1 outcome 2	...	Scenario p1 outcome *i*
multiple adaptation options (1,2, ...)	X	X	Scenario p2 outcome 1	Scenario p2 outcome 2	...	Scenario p2 outcome *i*
:	:	:	:	:	:	:
all adaptation options	X	X	Scenario F outcome 1	Scenario F outcome 2	...	Scenario F outcome *i*



CC= Climate change

These scenarios are added to determine the severity of CC impacts and to give a framework for understanding costs and benefits of adaptation

Decision Support and the Decision Maker



Conclusions

- A Decision Support Matrix is a tool to aid in decision making, but not something that can make the decision itself
- It can become complex very quickly when considering adaptation planning: there are many possible options and timing
- One of the major challenges is to design a way to test different adaptation options iteratively and in multiple cost dimensions, and that represents plausible future scenarios
- The process of building the matrix can highlight sources of uncertainty and key assumptions
- The matrix can simplify the process of testing many different future scenarios