ROA and the value of improved climate information: an application to coastal transport infrastructure

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Workshop on Environmental Policy Options

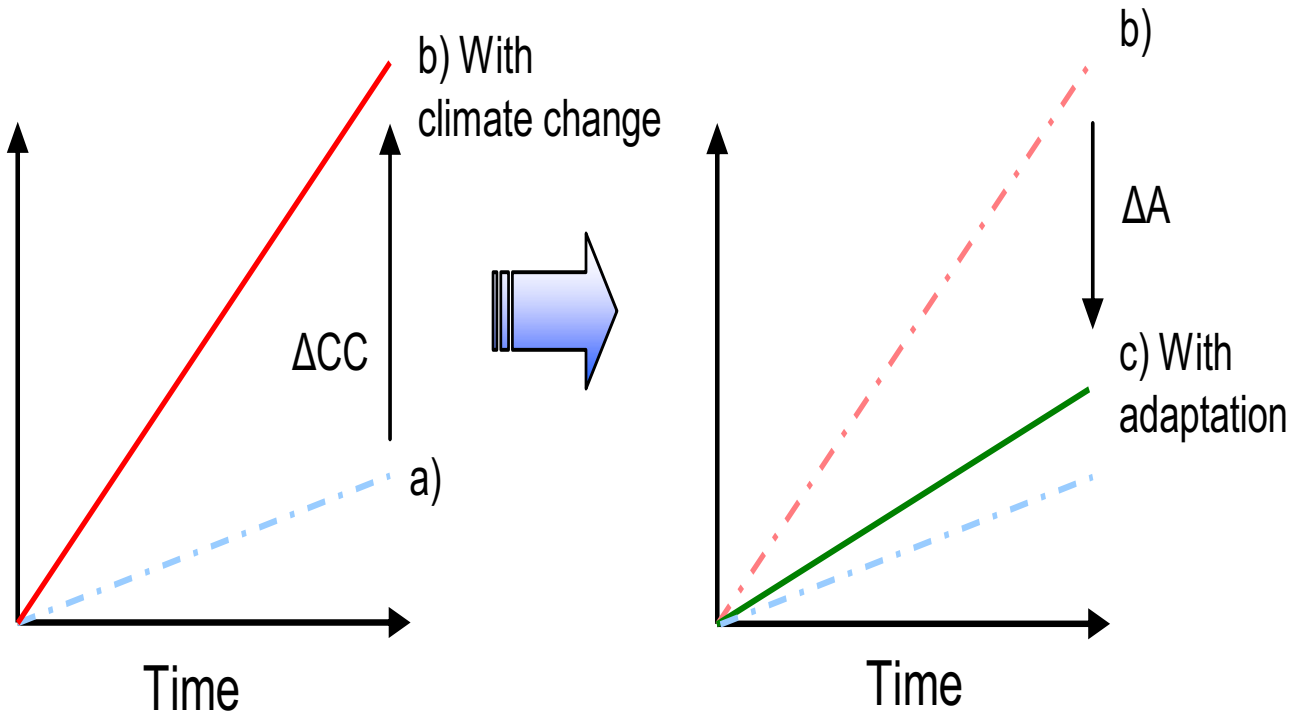
Durham, July 19th, 2023

UNIVERSITY OF BATH

Presentation Outline

- The research problem: Can we incorporate learning in economic analysis of climate adaptation decisions?
- Methodology: testing ROA in a coastal context
  - Economic decision support where:
    - New climate projections provide new information to be incorporated in decision-making process – ex post, rather than ex ante in previous literature
    - Probabilities about likelihood of projection occurrence do not exist (previous lit. assumes probabilities but with no basis)
- Results & Conclusions

Climate Change Adaptation: Economic Framework

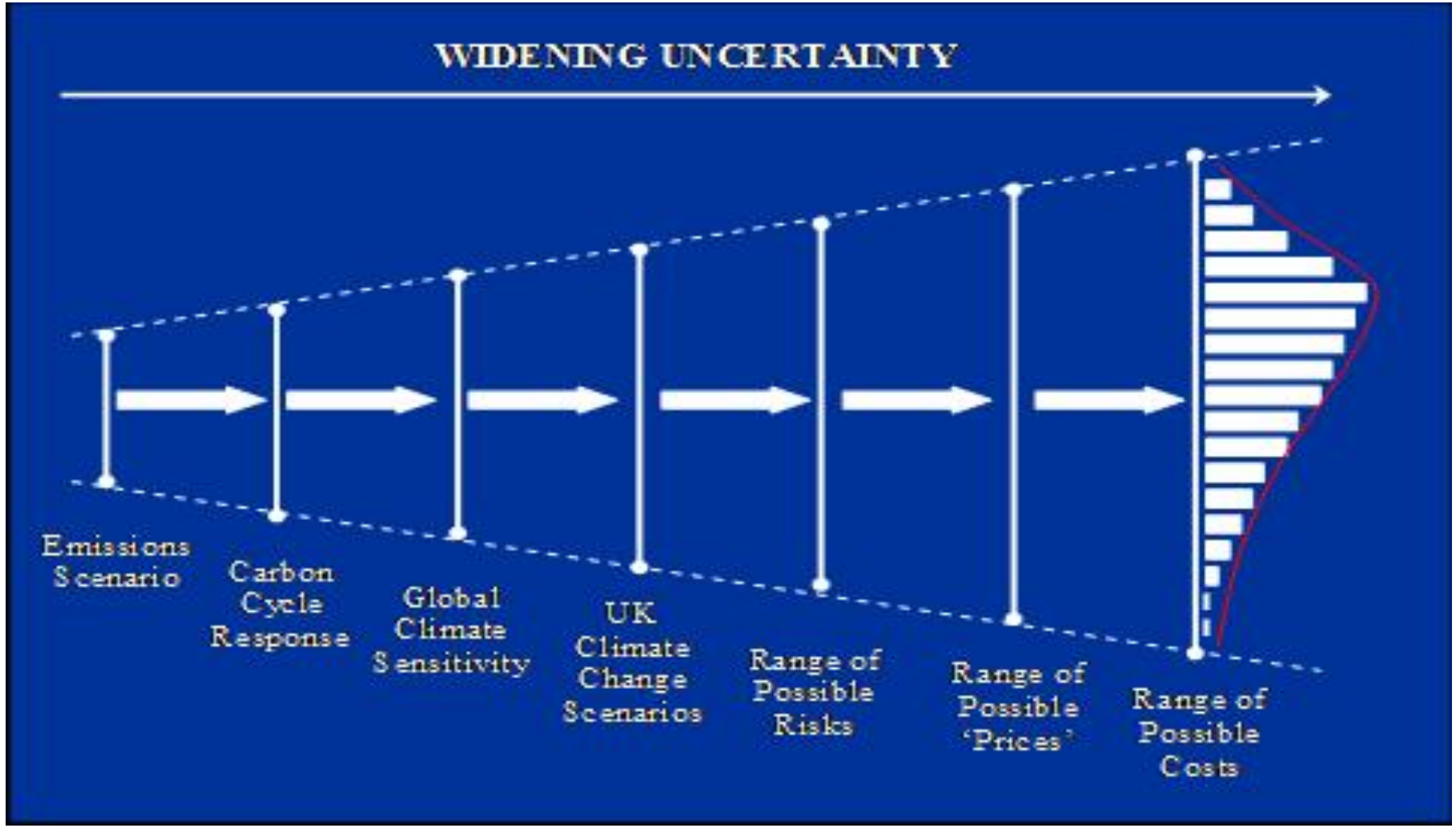


Definition: “actual adjustments, or changes in decision environments, which might ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate.” Adger et. al., (2007),

→ range of actions

- technical measures e.g. investment into flood defence wall,
- behavioural measures e.g. moving away from a flood plain,
- incentive-based measures such as higher insurance premia for houses situated in a flood risk area.
- Iv in adaptive capacity - potential or ability to adapt

Uncertainties in climate impacts

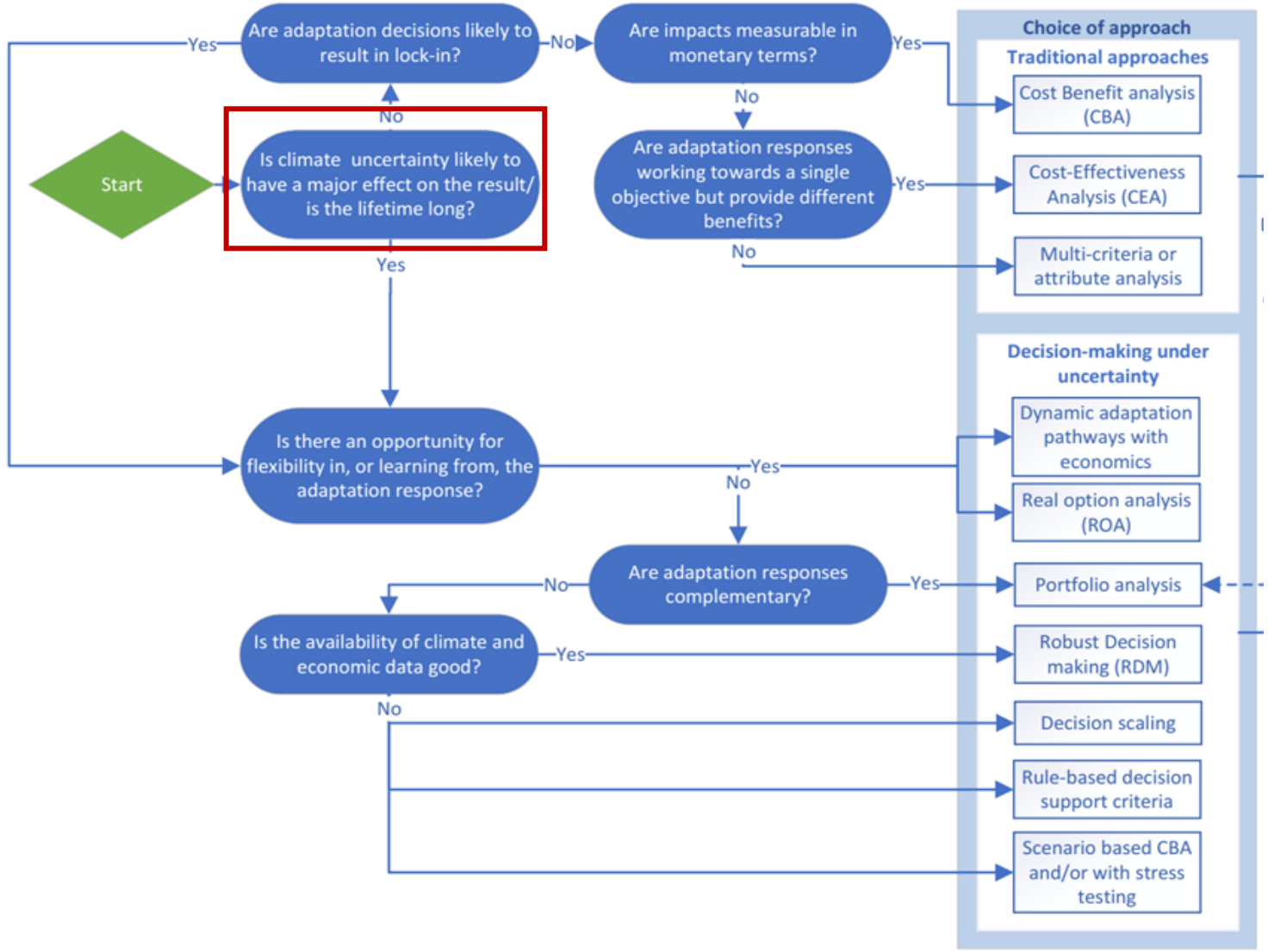


Uncertainties rather than risks since non-probabilistic.

No prior experience of climate change → Terra Incognita (Nordhaus, 1990)

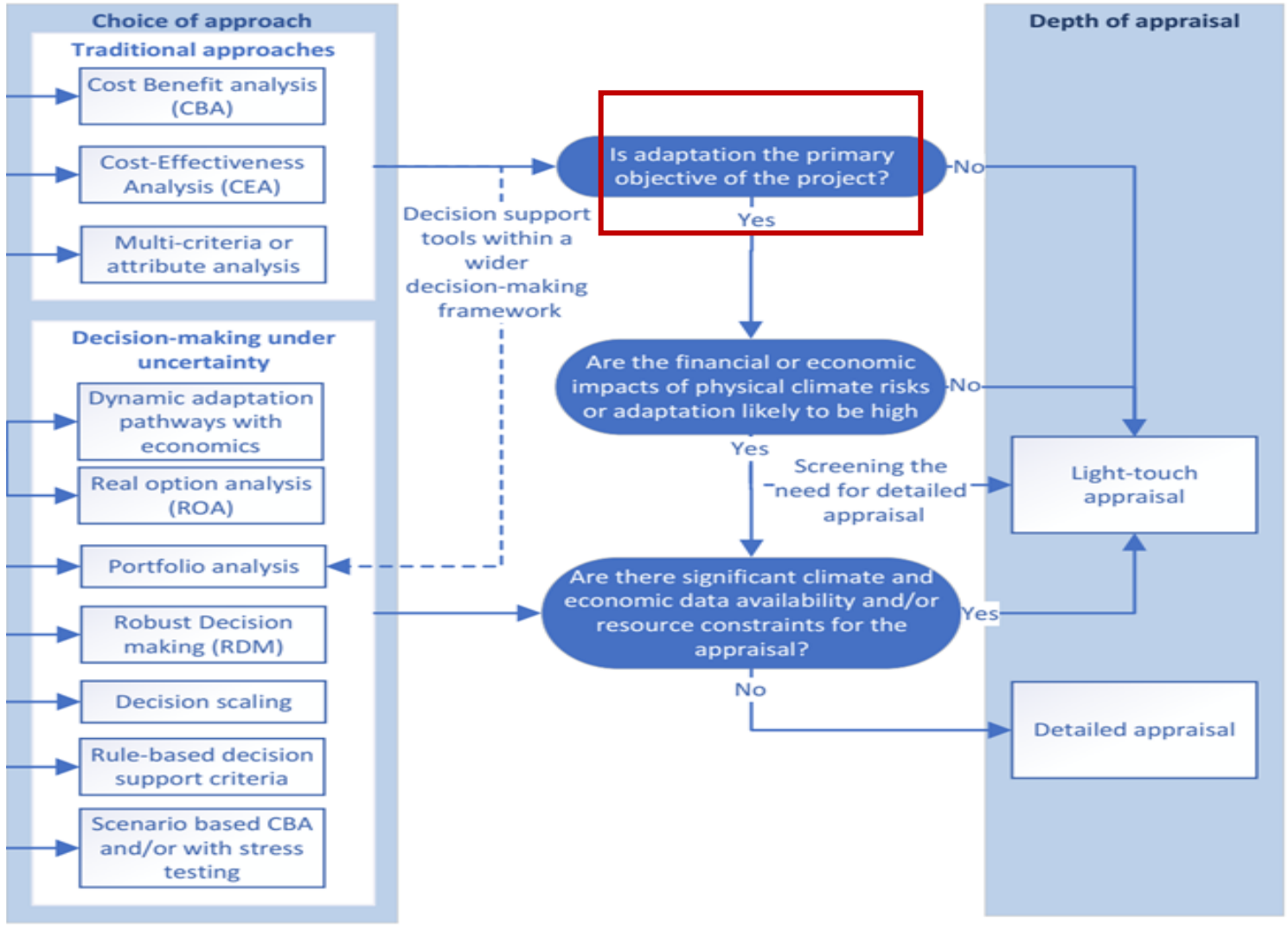
Guidance for the use of adaptation economics in urban investment decision-making

Adaptation Economic Appraisal Selection Decision-Tree (Part 1)



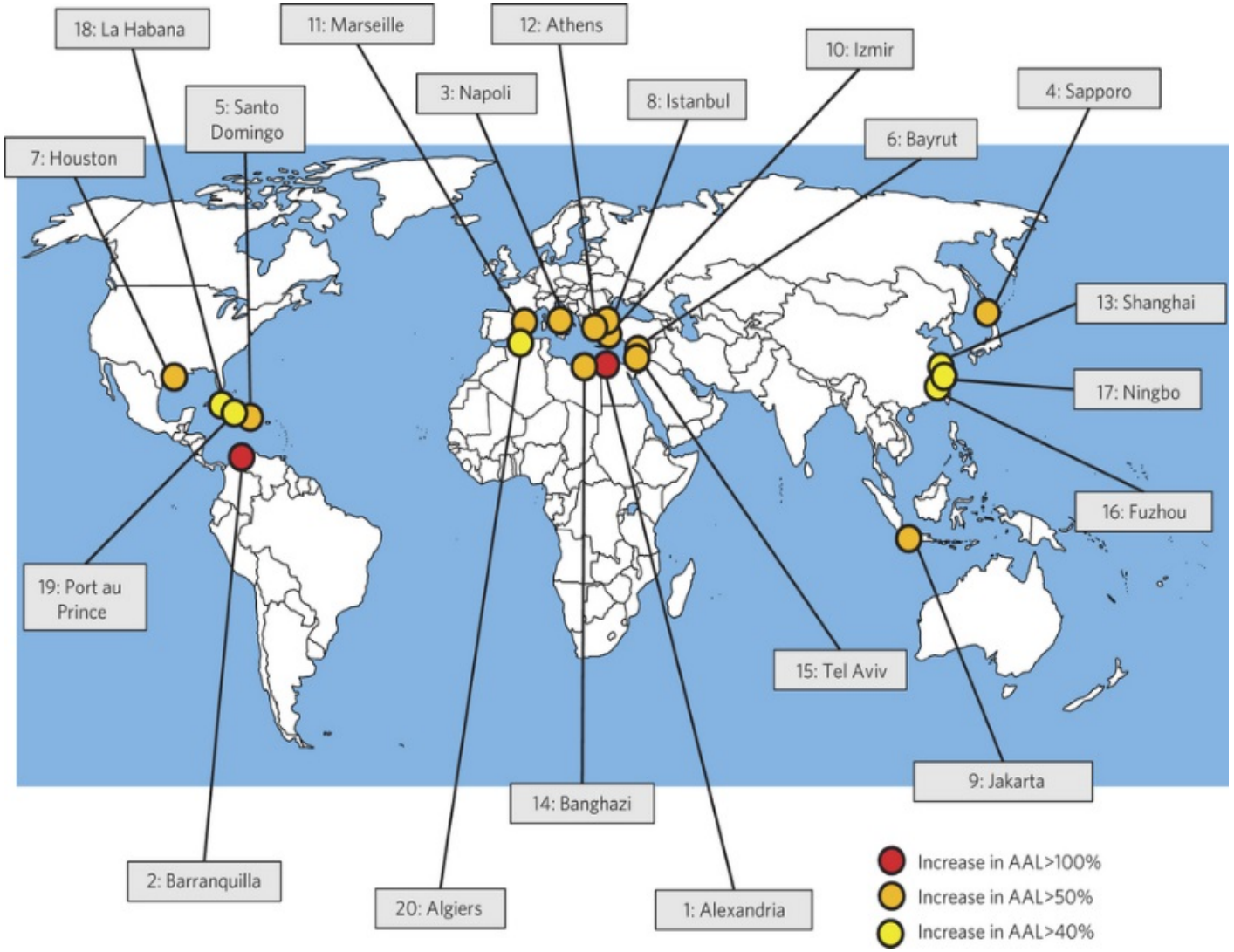
Guidance for the use of adaptation economics in urban investment decision-making

Adaptation Economic Appraisal Selection Decision-Tree (Part 2)



The problem: Incorporating learning in climate adaptation decisions

The 20 cities where AAL increase most - 2050



Source: Hallegatte et. al. (2013)

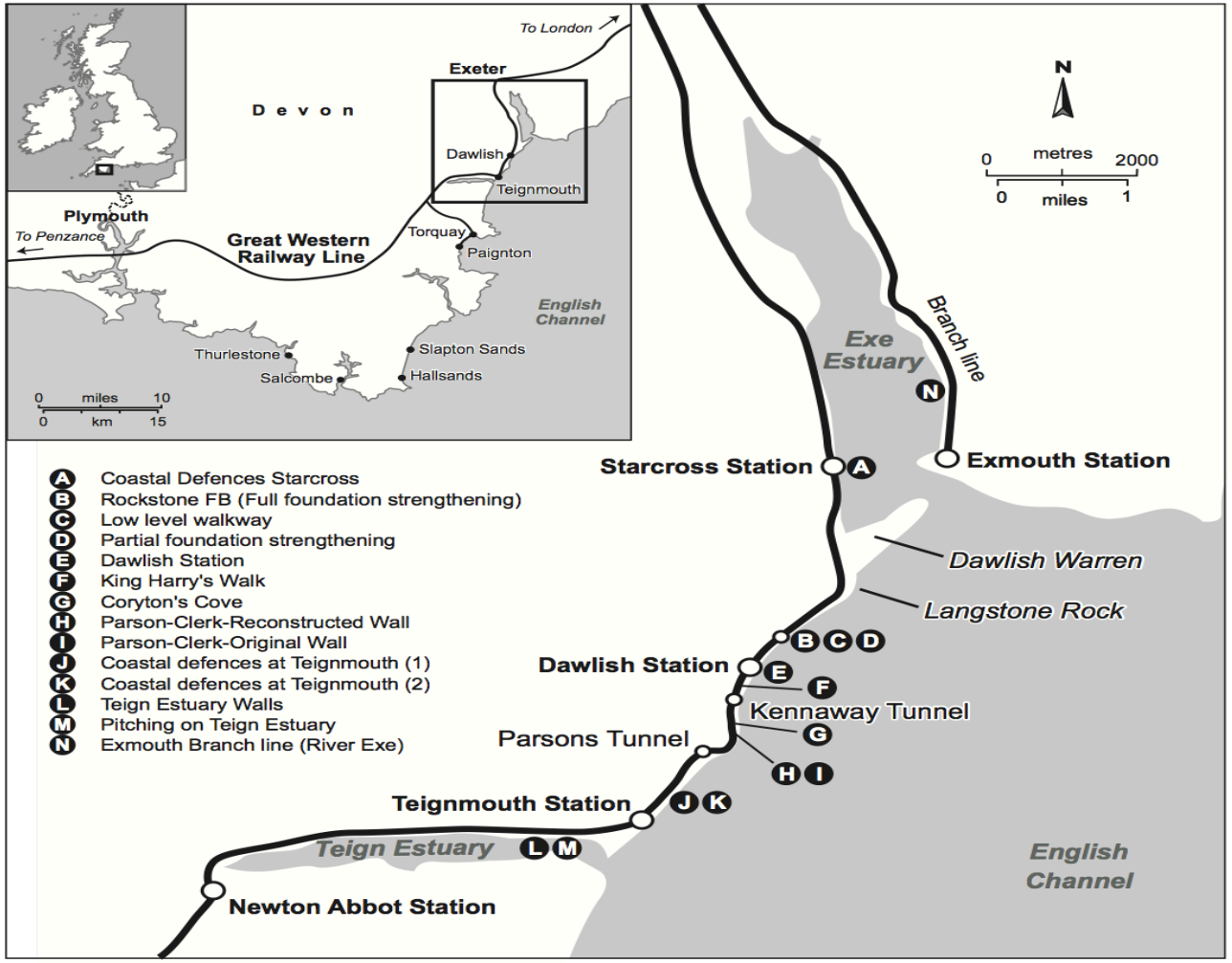
Economic efficiency-based rationale for resource allocation has to be considered in context of **uncertainty**:
Where climate is uncertain but significant to an investment

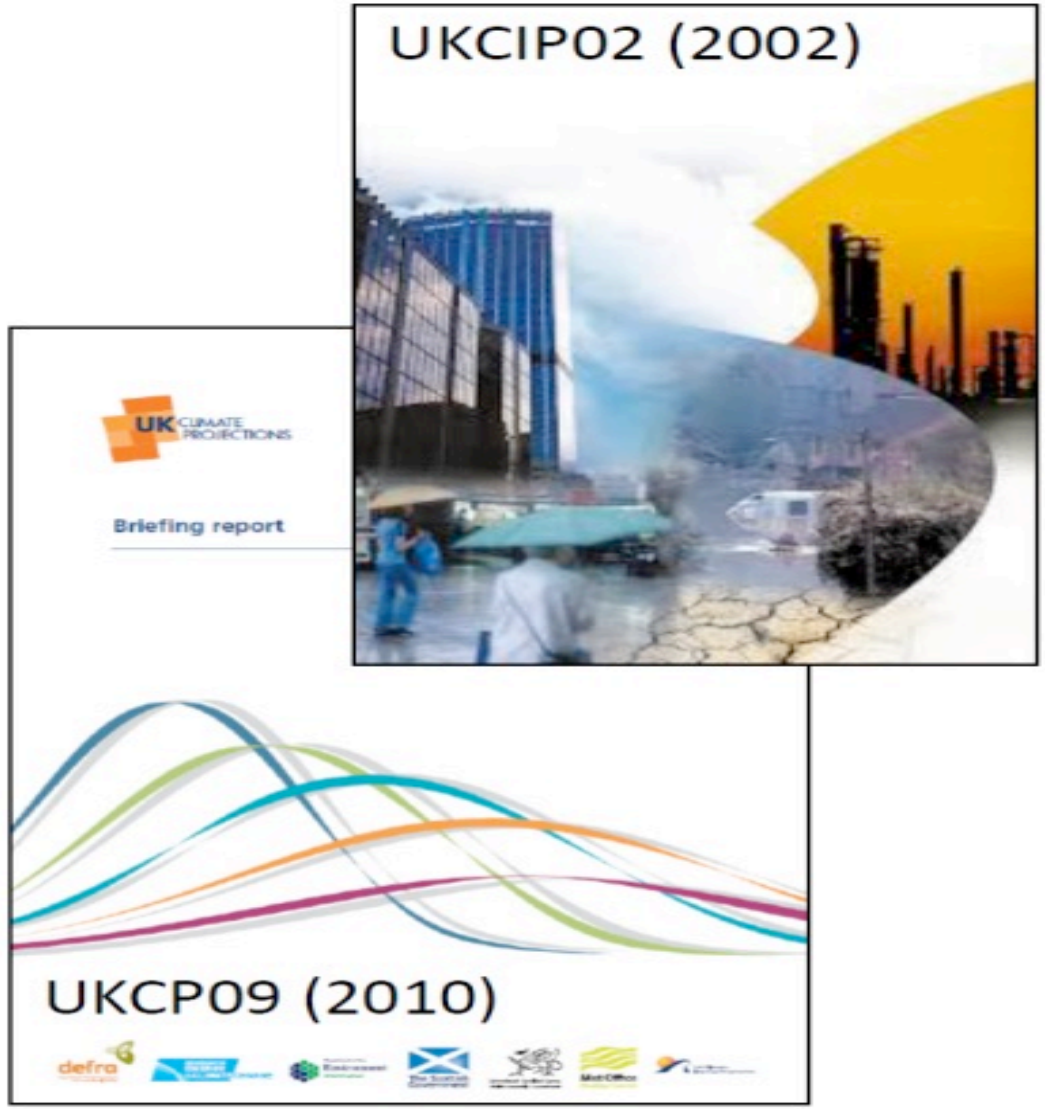
→ possibility of learning that reduces uncertainty

→ need for project appraisal to incorporate dynamic component

ROA Application: Case study context

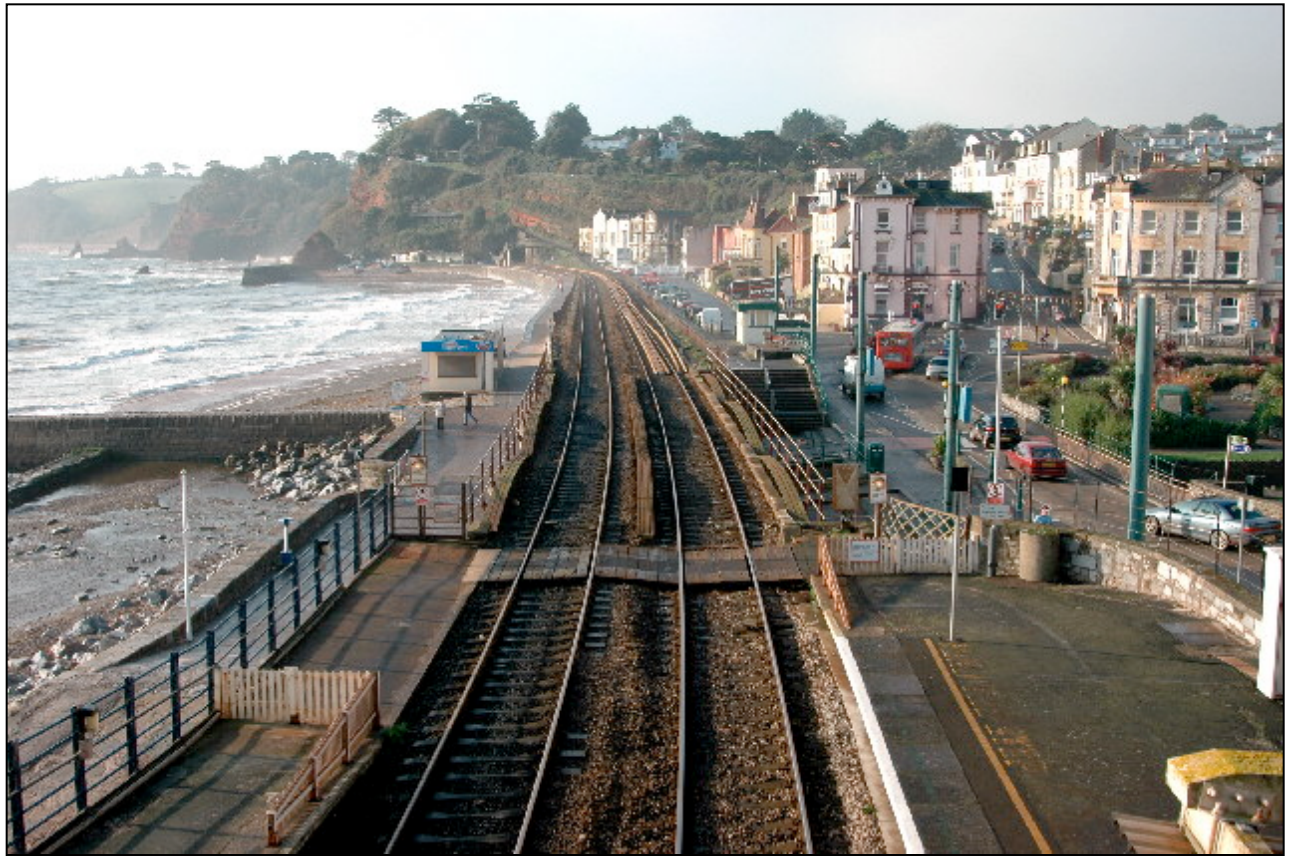
London-Penzance route: Section of coastal rail infrastructure in SW England threatened by climate change-induced sea-level rise: Storm surges, erosion

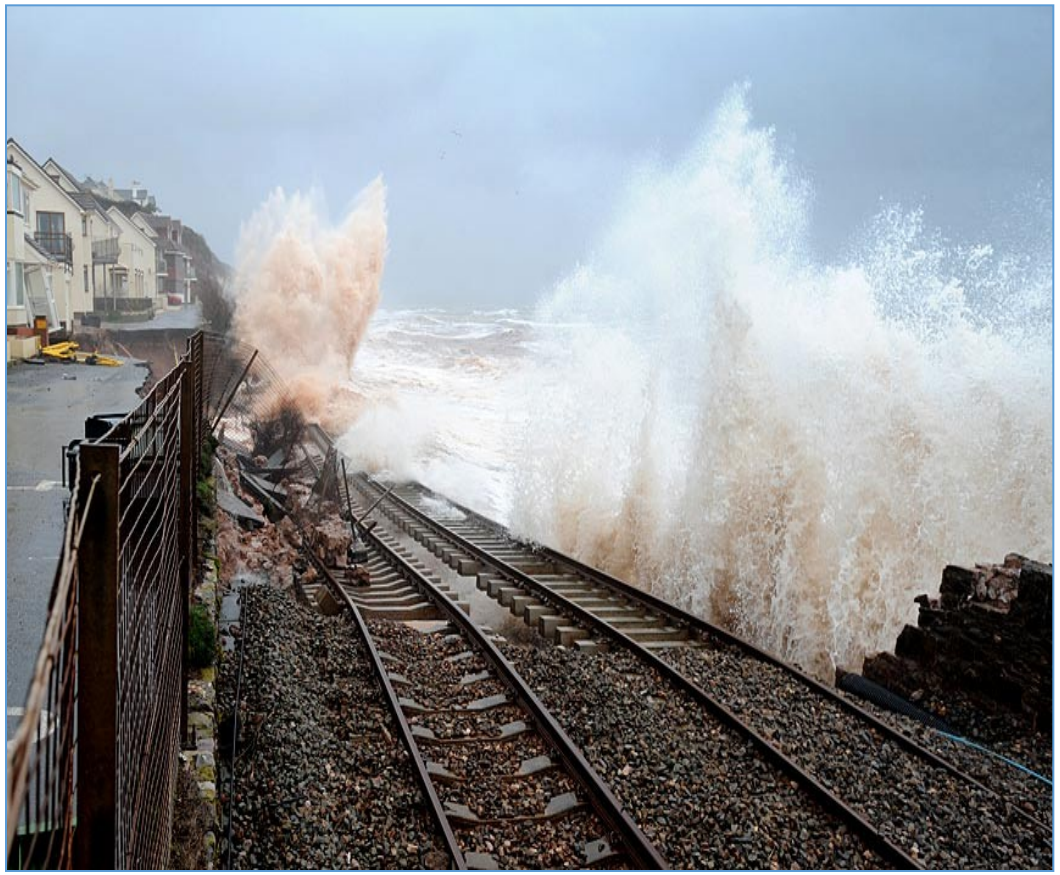




Storms: Passenger disruption – time delay costs

Historical analogues, e.g. Winter storms of 2013/2014 provide risk cost/benefit data for ROA application





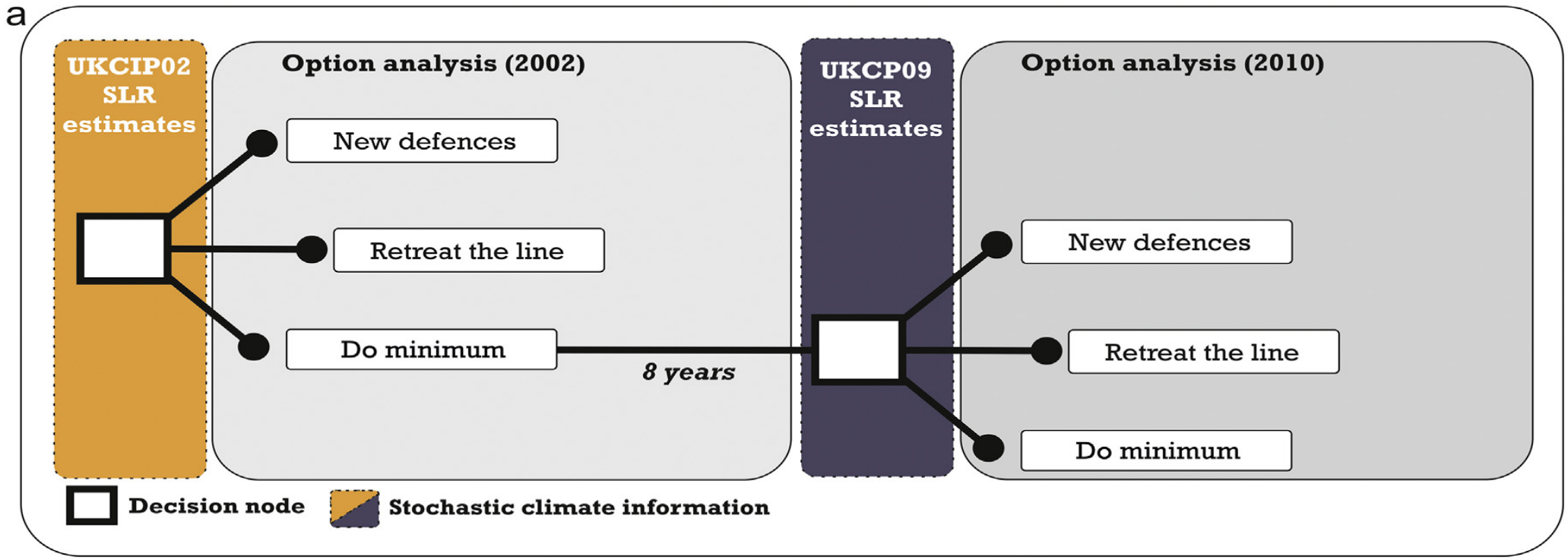
Summary of ‘real options’ for the London-Penzance railway line used in this study

Adaptation	Description	Length of vulnerable route remaining (km)	Capital cost (£m)*	Estimated maintenance costs incl. SLR (£m/yr)	Resilience level	Assumptions
Base case: do minimum	Continue to hold the line – repair & reopen	4.6	Nil	1.8 + low/high scenario impacts	Low	Continuation of historical overtopping trend and no complete breach in the next 60 years.
One: Further re-strengthening of existing	Build new defences over a 20-year period. Existing railway used by all trains	4.6	528	1.8 + gradual defence costs	Medium	The line will be built to a new 1 in 100 year design standard (20 year construction phase), from which the historical trend will continue. No complete breach during the remainder of the assessment period.
Two: New inland route	All trains use the new route. Old line abandoned.	Nil	2182	2.7	High	Coastal line abandoned, defences ownership transferred to relevant authority to maintain protection for coastal populations (e.g. Dawlish, Starcross, Teignmouth)

Baseline conditions taken from (Dawson et al., 2016). Adaptations One and Two costs’ constructed from Network Rail, (2014) and O’Breasail et al. (2007)

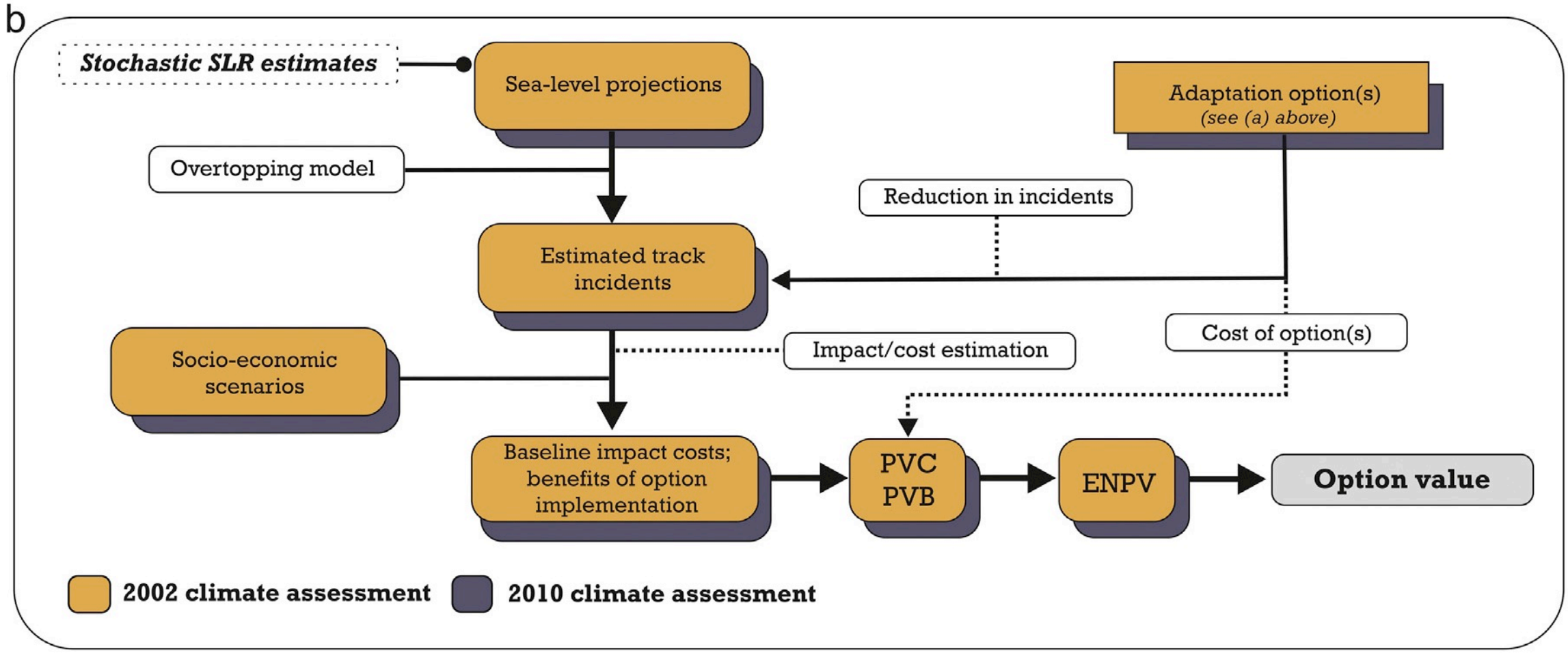
ROA Application Framework

Adaptation decisions in 2002 (UKCIP02) and 2010 (UKCP09)



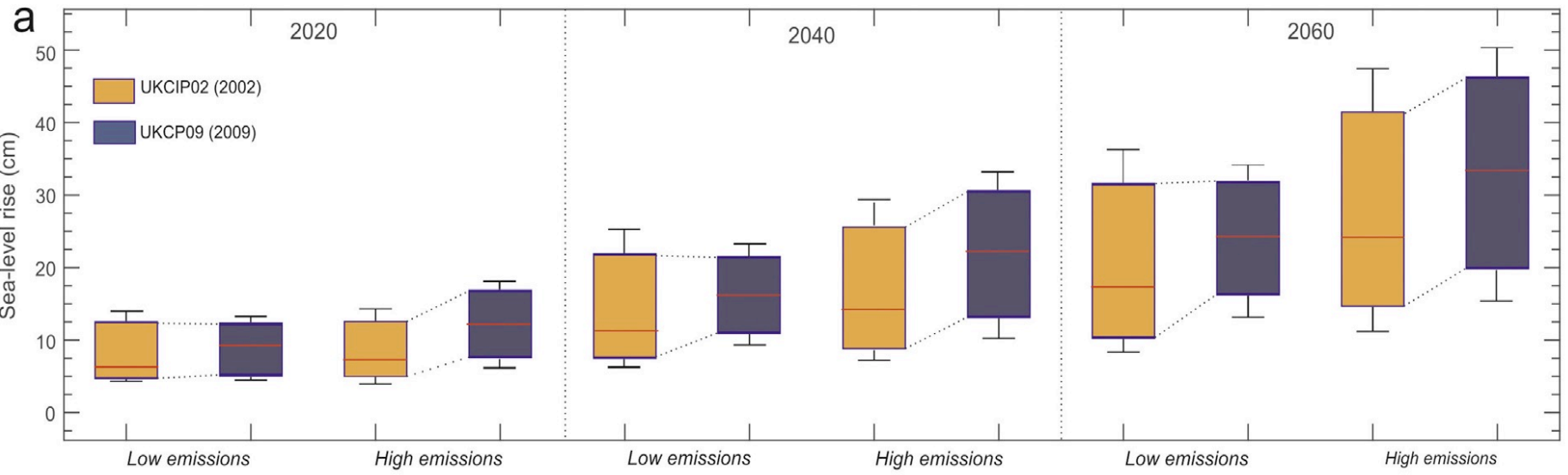
- Baseline + 2 options
- Real option analysis: 8 years apart using updated climate projections - sea level rise
- Ex post analysis
- What is the value of new 'improved' projections? Better decision?

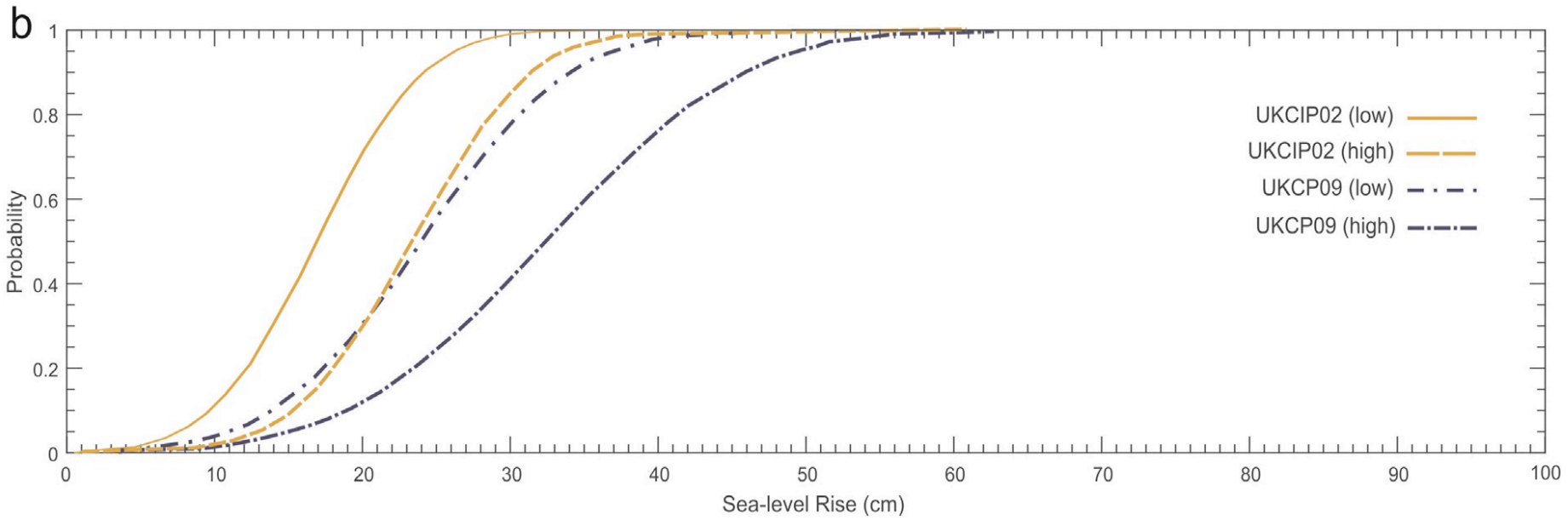
Schematic: economic analysis of rail infrastructure



- Difference between 2002 & 2010 **Expected Net Present Values** (ENPV) = option value of updated sea-level & socio-economic data.

Data – Stochastic climate projections



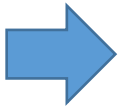


Two consecutive sets of low & high climate projections show:

- Uncertainties are slightly reduced: 2002 → 2010
- 2010 projections higher than 2002

Conversion of Non-probabilistic decision rules to probabilistic scenarios

Decision Rule	Climate Change Scenario
Maximax	Optimist - Allocates more weight to outcome that gives the best pay-off. Our decision context: equivalent to assuming relatively low levels of SLR.
Maximin	Pessimist - Allocates more weight to the outcome that gives the least worst pay-off. Our decision context: equivalent to assuming relatively high levels of SLR.
Laplace	Neutralist - Assumes all outcomes are equally probable. Our decision context: assume each of six SLR scenario points are given the same weight.



Scenario/percentile	Optimist	Pessimist	Neutralist
Low – 5th	0.90	0.02	0.16
Low – 50th	0.02	0.02	0.16
Low – 95th	0.02	0.02	0.16
High – 5th	0.02	0.02	0.16
High – 50th	0.02	0.02	0.16
High – 95th	0.02	0.90	0.16

ROA Estimation Procedure

- Calculate NPVs with probabilities → Expected values
  - $ENPV^{2002} = \left(EPVB^{2002} - EPVC^{2002}\right)^{t}$
  - $ENPV^{2010} = (EPVB^{2010} - EPVC^{2010})^{t}$

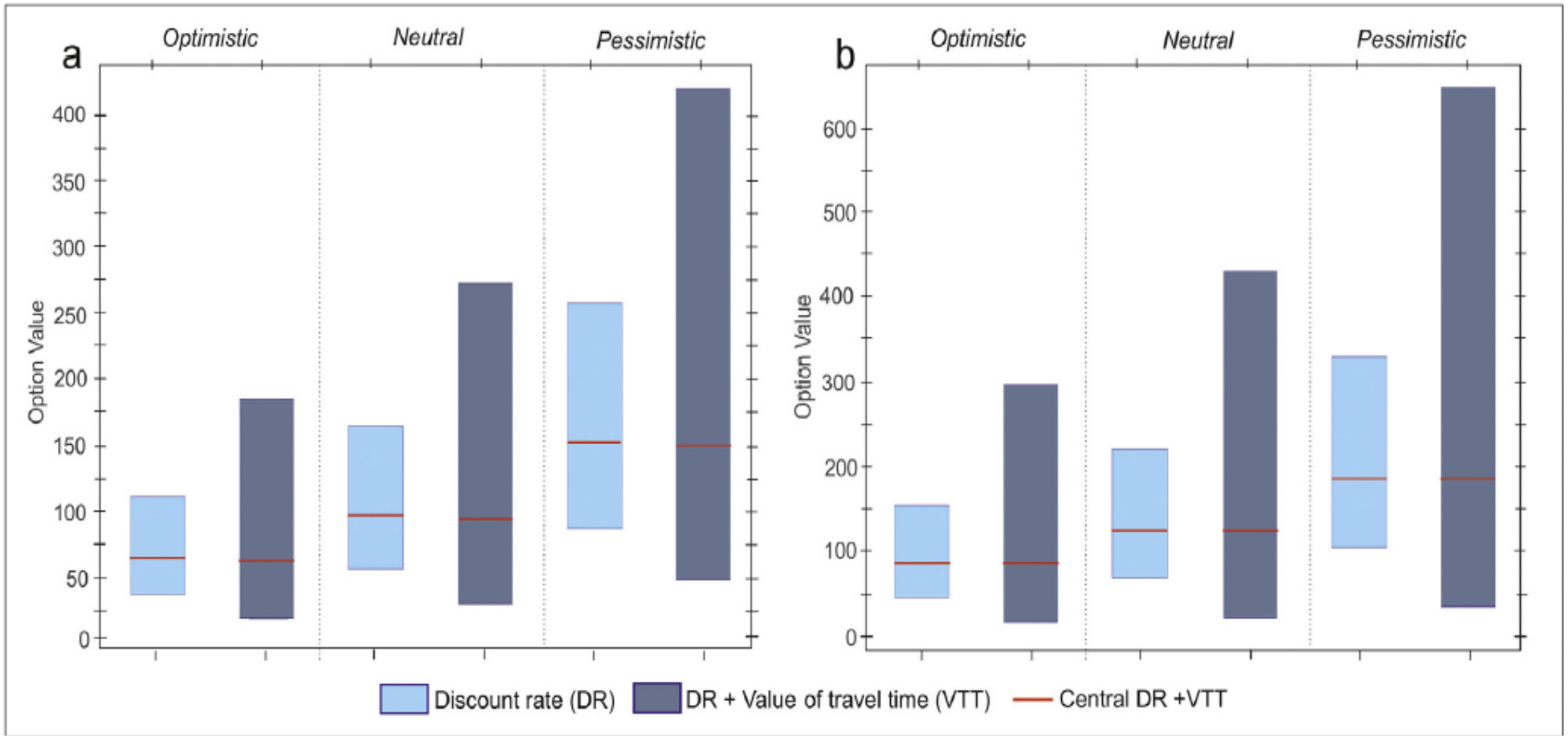
- Comparison yields option value
  - $\left(ENPV^{2002} - ENPV^{2010}\right) = \left(\left(EPVB^{2002} - EPVC^{2002}\right) - \left(EPVB^{2010} - EPVC^{2010}\right)\right)^{t}$

Results: Option values

Attitude	Adaptation/ Scenario	ENPV (£m)	Option Value (£m)	EBCR
Optimist	Increase defence			
	UKCIP02	-334	108	0.14
	UKCP09	-227		0.42
	Inland route			
	UKCIP02	-924	104	0.10
	UKCP09	-820		0.20
Pessimist	Increase defence			
	UKCIP02	-261	242	0.33
	UKCP09	-19		0.95
	Inland route			
	UKCIP02	-792	228	0.23
	UKCP09	-564		0.45
Neutralist	Increase defence			
	UKCIP02	-290	157	0.21
	UKCP09	-133		0.62
	Inland route			
	UKCIP02	-831		0.15

Sensitivity analysis of option value to discount rates (DR) and value of travel time (VTT) values

	Lower	Central	High
Discount rate (%)	1.4	3.5*	6
Value of Travel Time (£/minute)	10.78	13.48	16.85



(a) Adaptation One option value. (b): Adaptation Two option value.

Boxes: data limits, and red line represents central values used in the study

Results & Conclusions

- Option values sizeable but do not change appraisal outcomes
- Option values largest for Pessimist since residual damages highest in this weighting regime
- Real Options Analysis workable for climate change adaptation economic analysis if non-probabilistic decision rules can be “converted” to probabilities
- Ex post analysis shows investment in climate projections valuable to investment planner – as long as they resolve some uncertainty and are believed
- How to apply ROA to transformational adaptation?

Thank you!

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