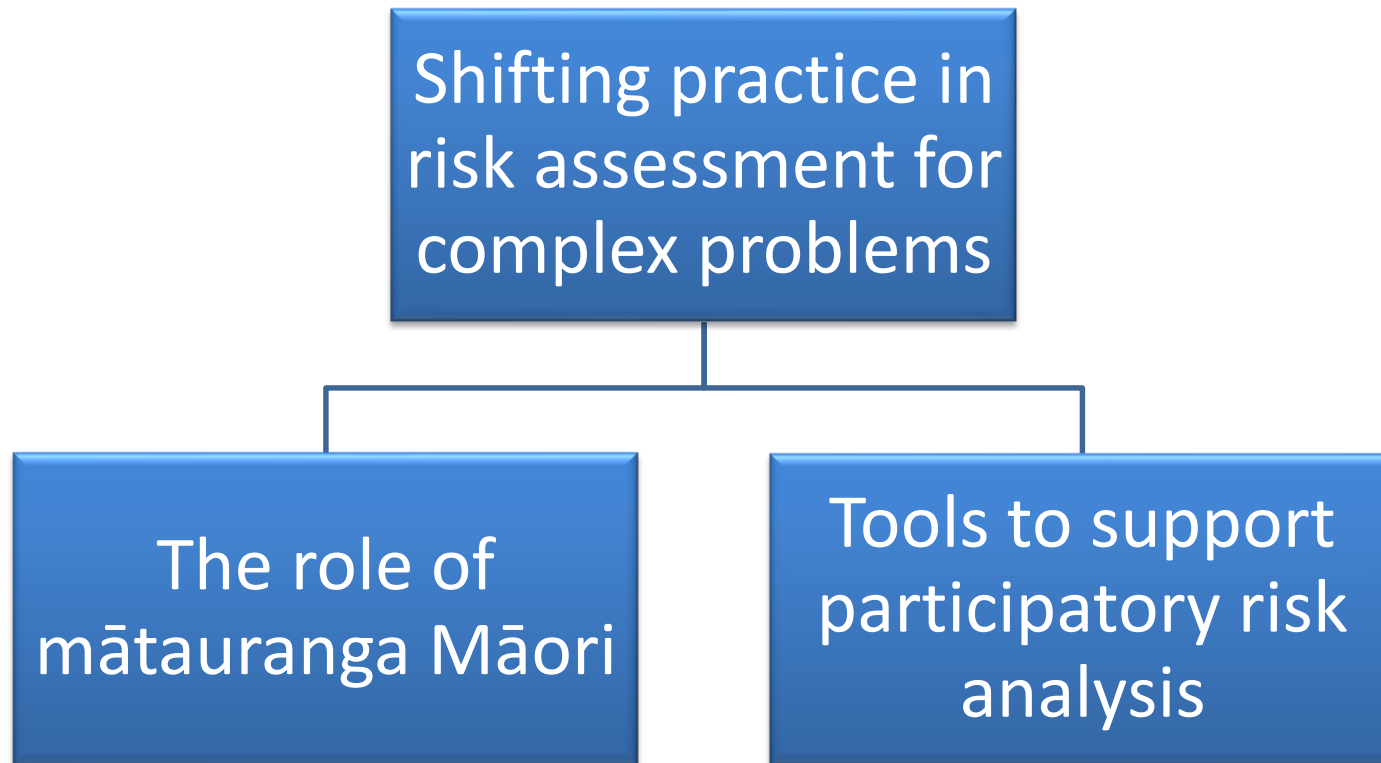


5.1.3 Decision-making under uncertainty

Tools and approaches for assessing risk in complex problems

Graeme Inglis, Kelly May, Tarek Soliman, Utkur Djanibekov, Kelly Ratana

Talk outline



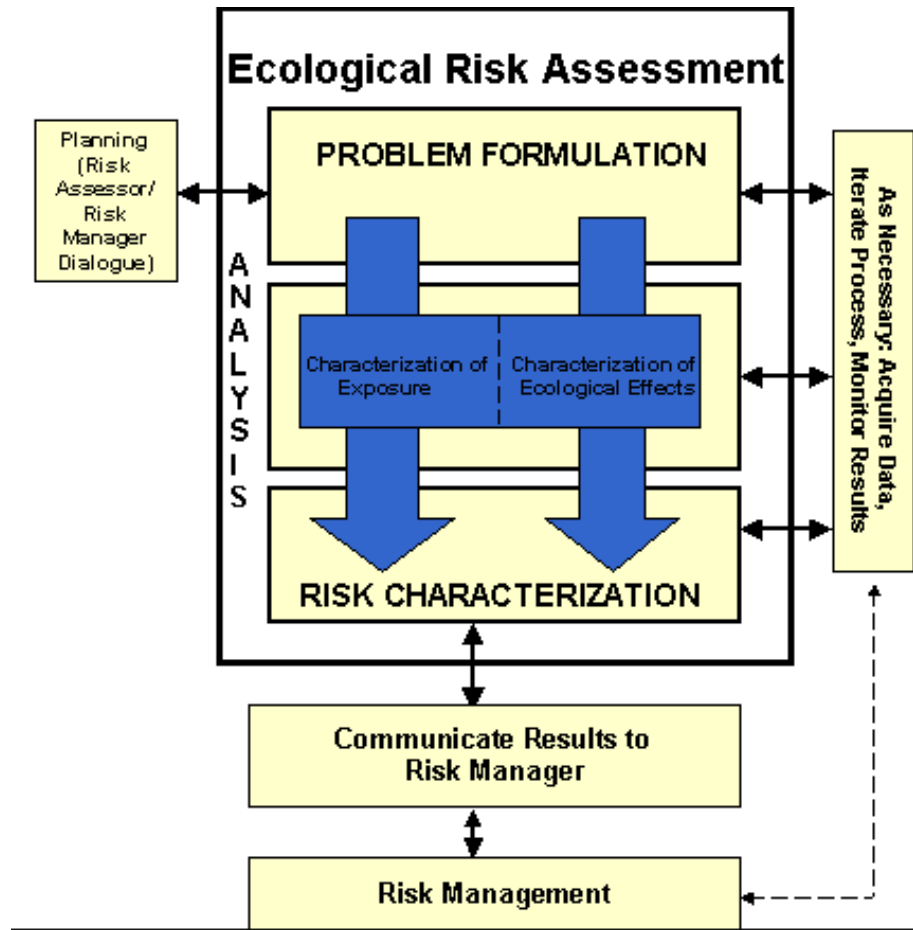
A definition

- Risk[†]

“A combination of the likelihood of occurrence and the magnitude of impact (consequences) of a hazard event on people or things that they value (assets)”

[†] Office of the Prime Minister’s Chief Science Advisor. 2016. *Making decisions in the face of uncertainty: Understanding risk. Part 1.* Office of the Prime Minister’s Chief Science Advisor, Auckland.

Conventional risk analysis



Source: US-EPA Guidelines for Ecological Risk Assessment, April 1998.
(Order 630R95002F (EPA/630/R-95/002F) from the National Service Center for Environmental Publications)

US National Research Council (1982)

“.....science and professional analysis cannot resolve many disputes about risk and decision making.....The committee rejects such a model of policy making as both unattainable and incompatible with democratic principles. We do so for several reasons.”

- Multiple objectives
- Diversity of stakeholders – and values
- Complexity - diversity of consequences
- High stakes – and inequitable outcomes
- Uncertainty - & fallibility of a single technical analysis

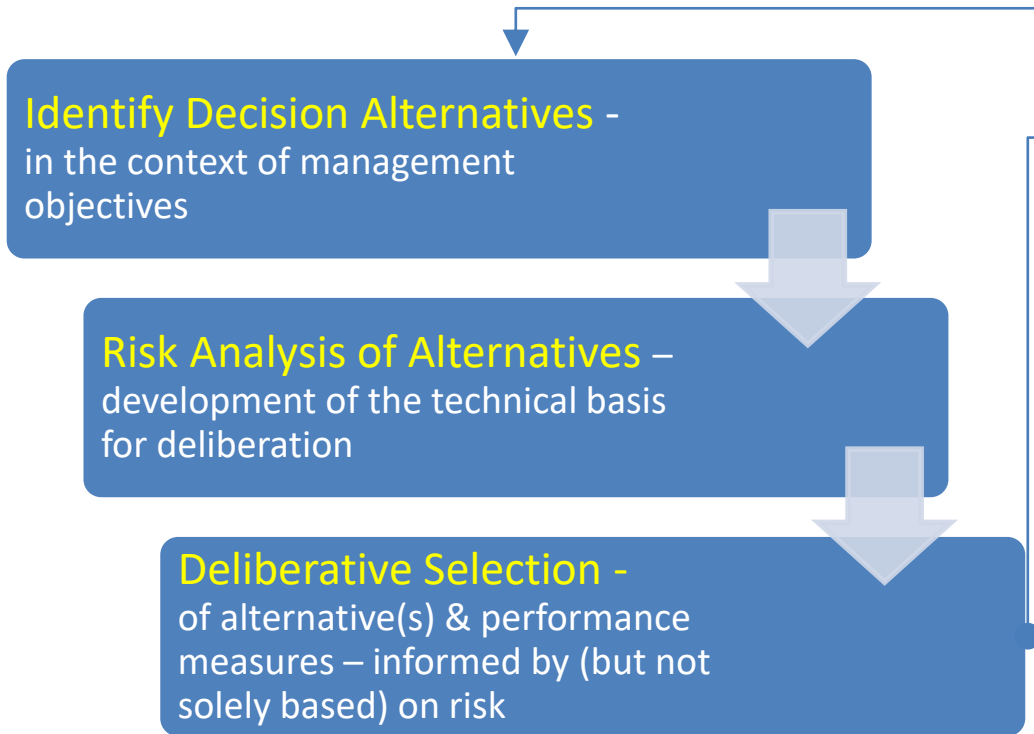
Shifting practice – Risk Informed Decision Making

“A deliberative process that uses a diverse set of performance measures, along with other considerations, to inform decision making.”

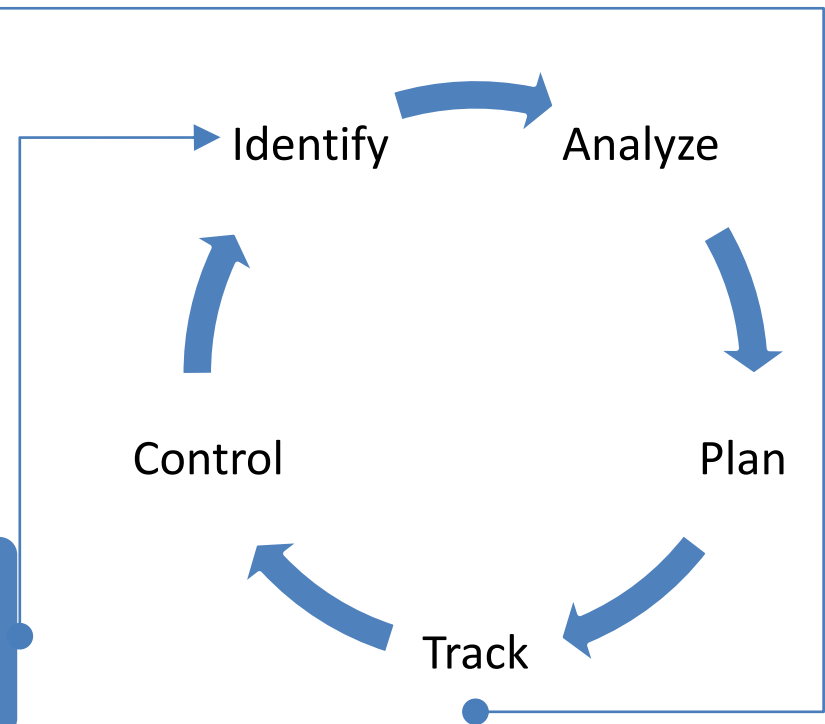
The RIDM process acknowledges the role that human judgment plays in decisions, and that technical information cannot be the sole basis for decision making.”

The decision context

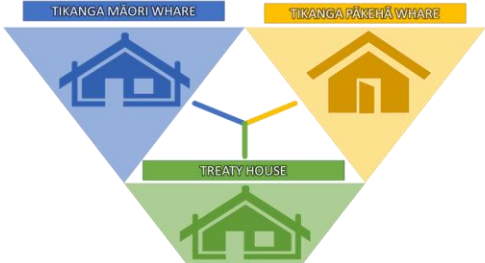
Risk-Informed Decision-Making



Continuous Risk Management



Whakaaro behind the kupu Māori used in the (DRAFT) diagram



Tau utu utu – cyclical/reciprocity.
Whakahāngai – Is a word that indicates implementing, updating and making things relevant

Mea Whakaara – what is the thing that “wakes us up” or “gets us moving”?

Ngā Whāinga – what are we seeking, goal or objective

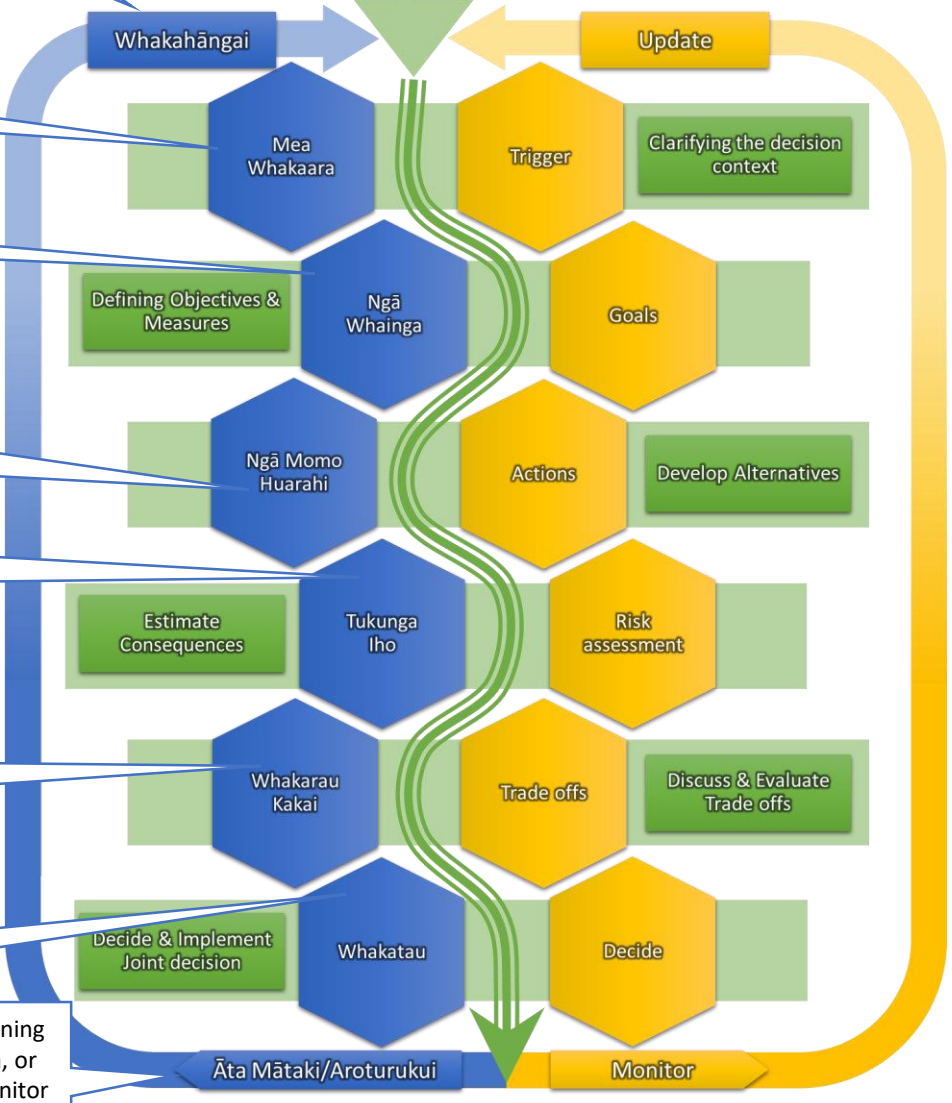
Ngā Momo Huarahi – what are the pathways forward?

Tukunga Iho – what are the outcomes / consequences?

Whakarau Kakai - debating fully and deliberating.

Whakatau – refers to making a decision, to settle or determine what to do.

Āta Mātaki – meaning to intently watch, or Aroturuki – to monitor



Whakahāngai

Update

Mea Whakaara

Trigger

Clarifying the decision context

Defining Objectives & Measures

Ngā Whāinga

Goals

Ngā Momo Huarahi

Actions

Develop Alternatives

Estimate Consequences

Tukunga Iho

Risk assessment

Whakarau Kakai

Trade offs

Discuss & Evaluate Trade offs

Decide & Implement Joint decision

Whakatau

Decide

Āta Mātaki/Aroturuki

Monitor

Tools to Support RIDM

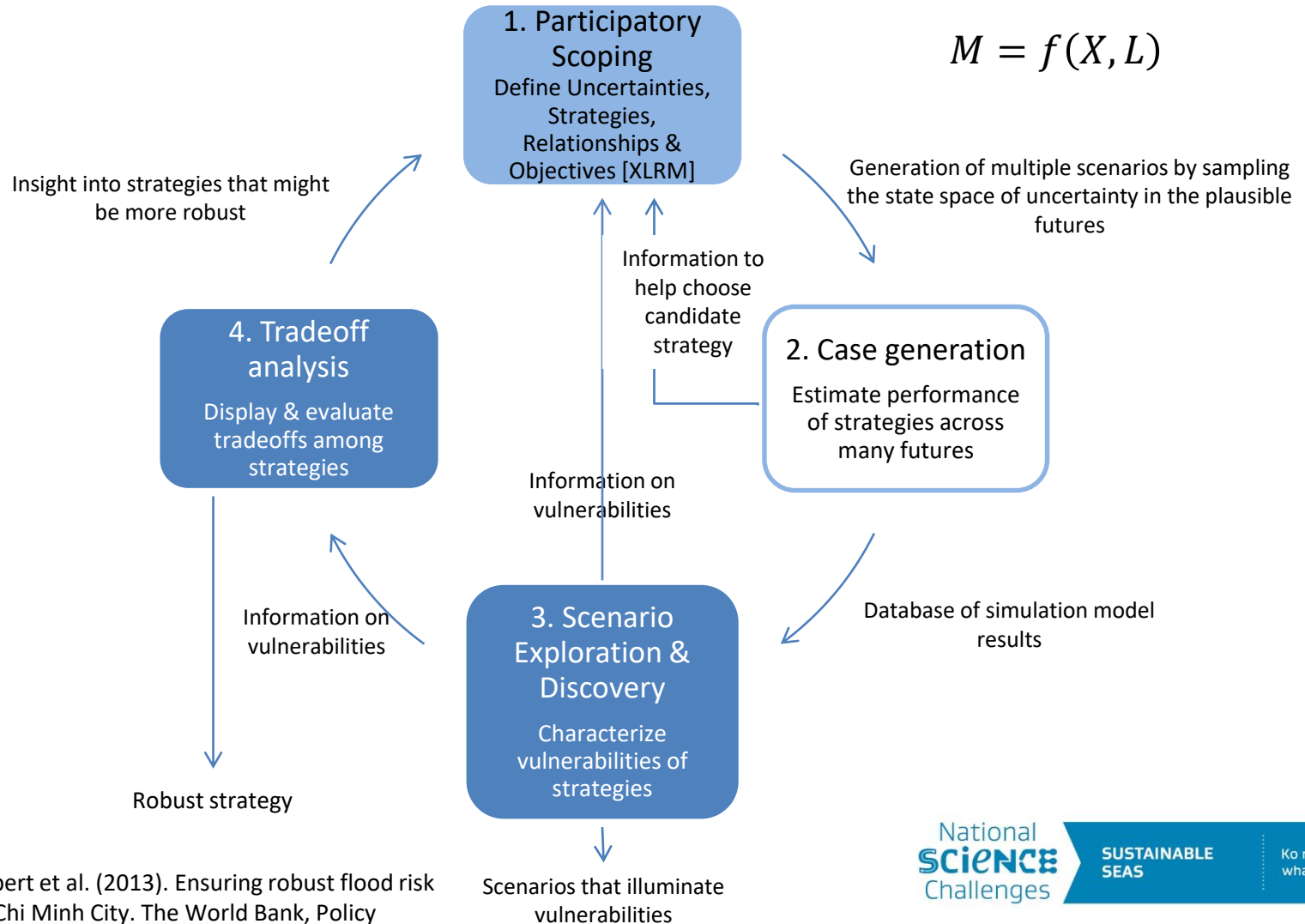
- Robust Decision-Making (Groves and Lempert, 2007)
- Many Objective Robust Decision-Making (Hadka et al., 2015)
- Info-Gap Decision Theory (Ben Haim, 2006)
- Decision Scaling (Brown et al., 2012)
- Dynamic Adaptive Policy Pathways (Haasnoot et al., 2013)*
- Adaptive Policy-Making (Kwakkel et al., 2010)
- Real Options Analysis (de Neufville and Scholtes, 2011)*

*Projects in the Deep South National Science Challenge

Some common threads

- Goal is a robust solution – not an optimal one
- Deliberative processes describe
 - the state of the system, long-term goals, functional relationships, uncertainties and the decision alternatives
- Use computational tools to:
 - explore a large ensemble of plausible future states within the dimensions of system uncertainty
 - stress-test performance of the decision alternatives against the goals across the future states
- Visualizations allow
 - participatory selection and evaluation of scenarios

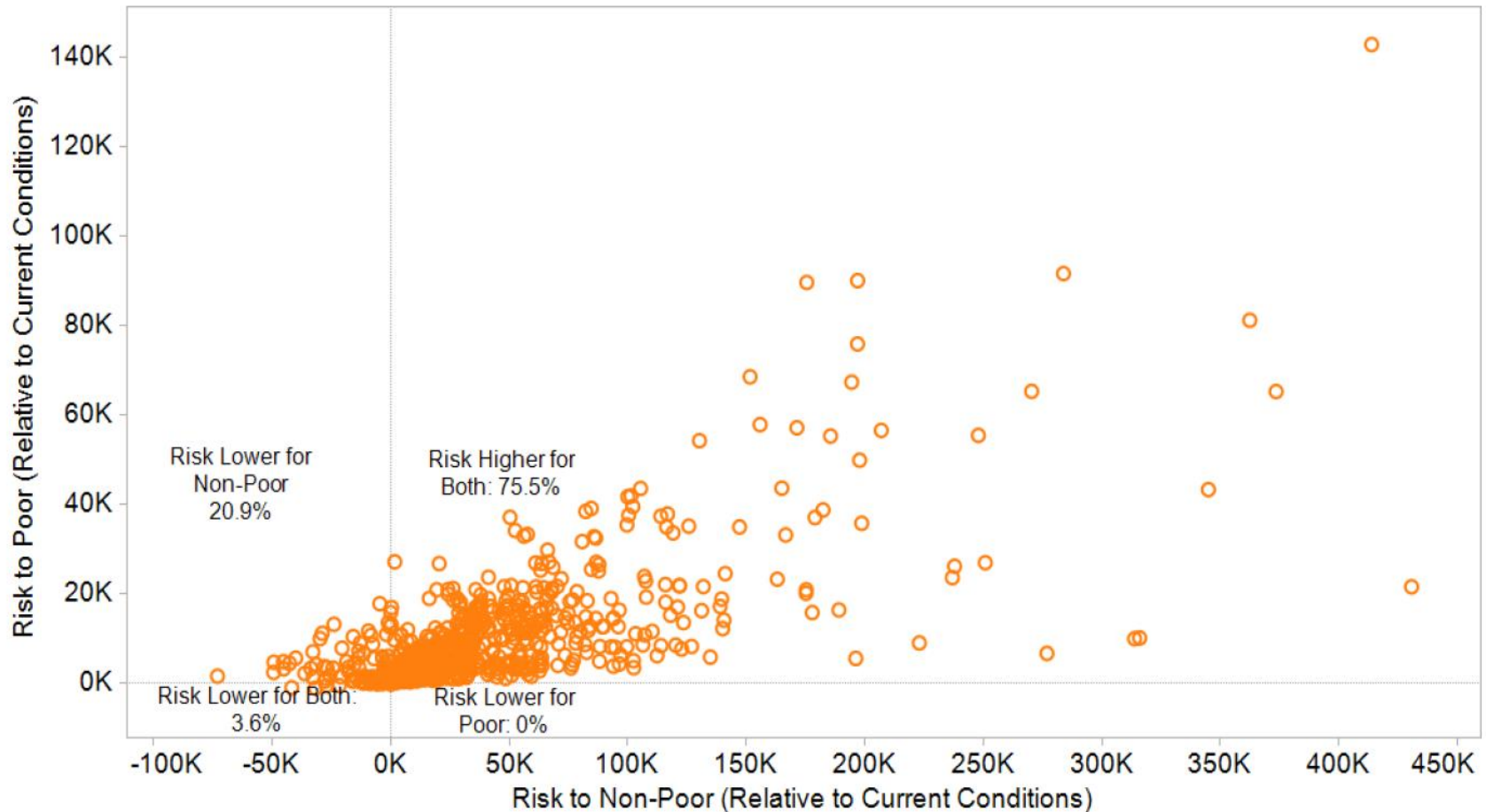
Robust Decision Making



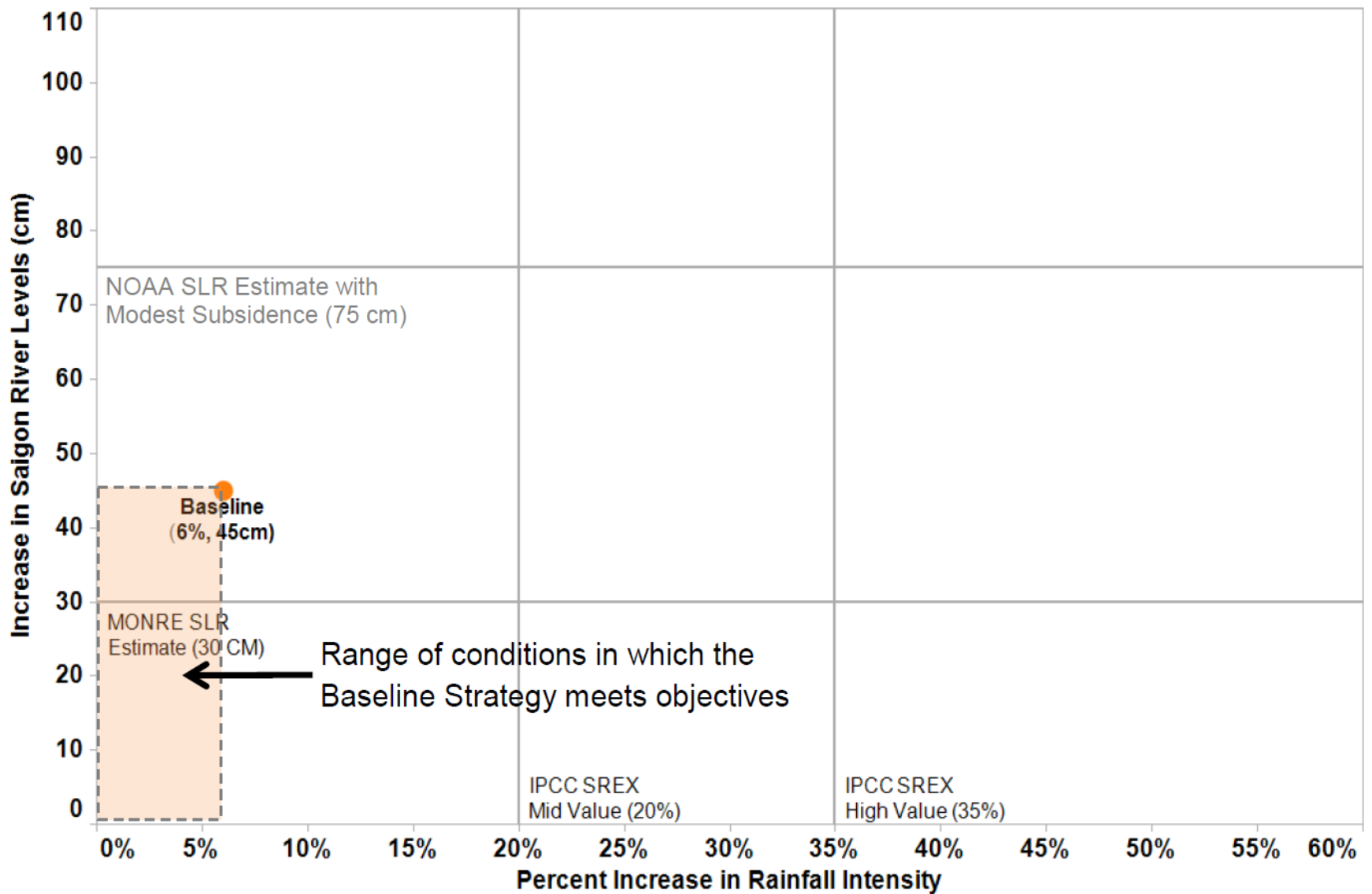
Adapted from: Lempert et al. (2013). Ensuring robust flood risk management in Ho Chi Minh City. The World Bank, Policy Research Working Paper 6465, 63 p.

An Example

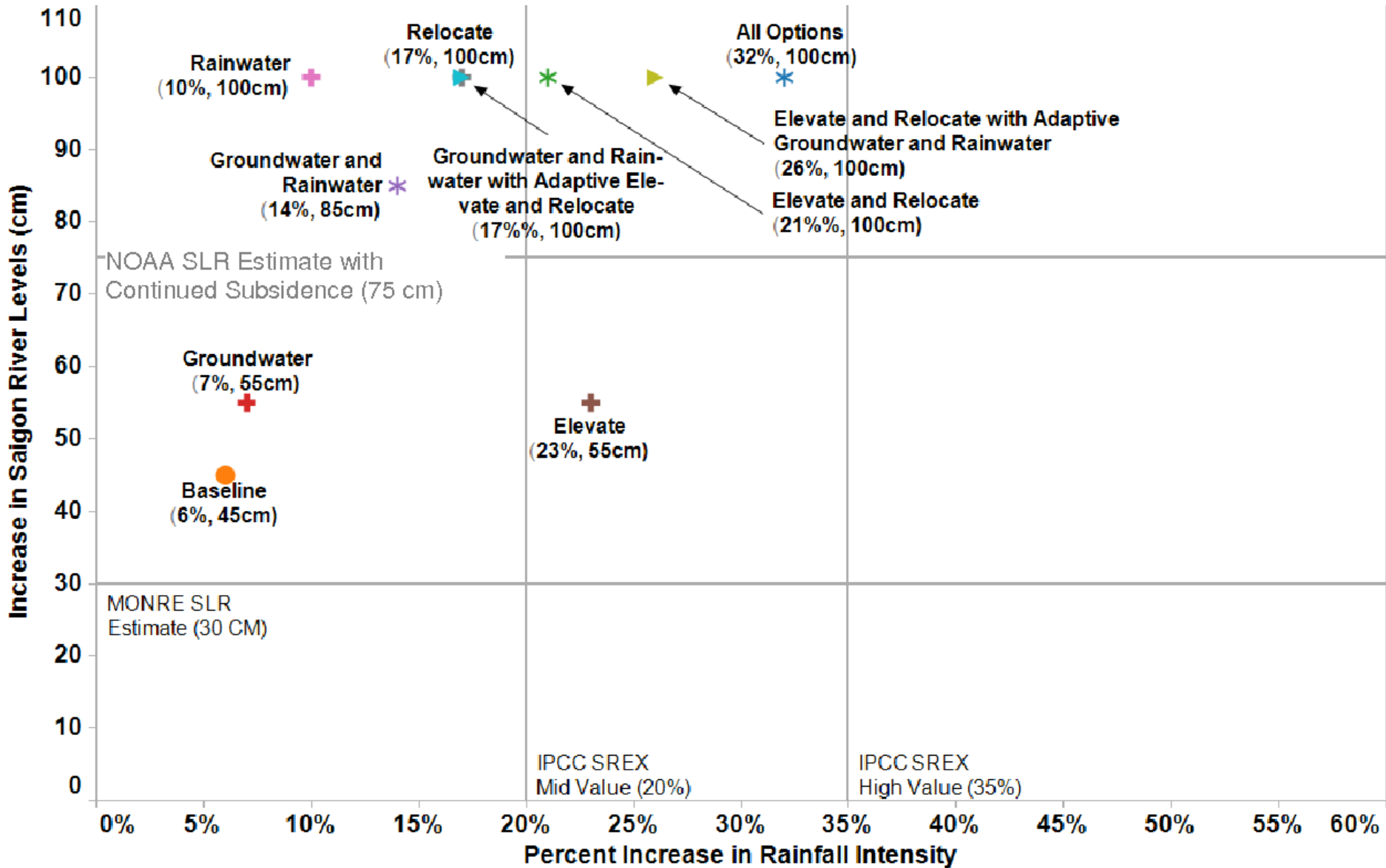
Flood mitigation options in Ho Chi Minh City



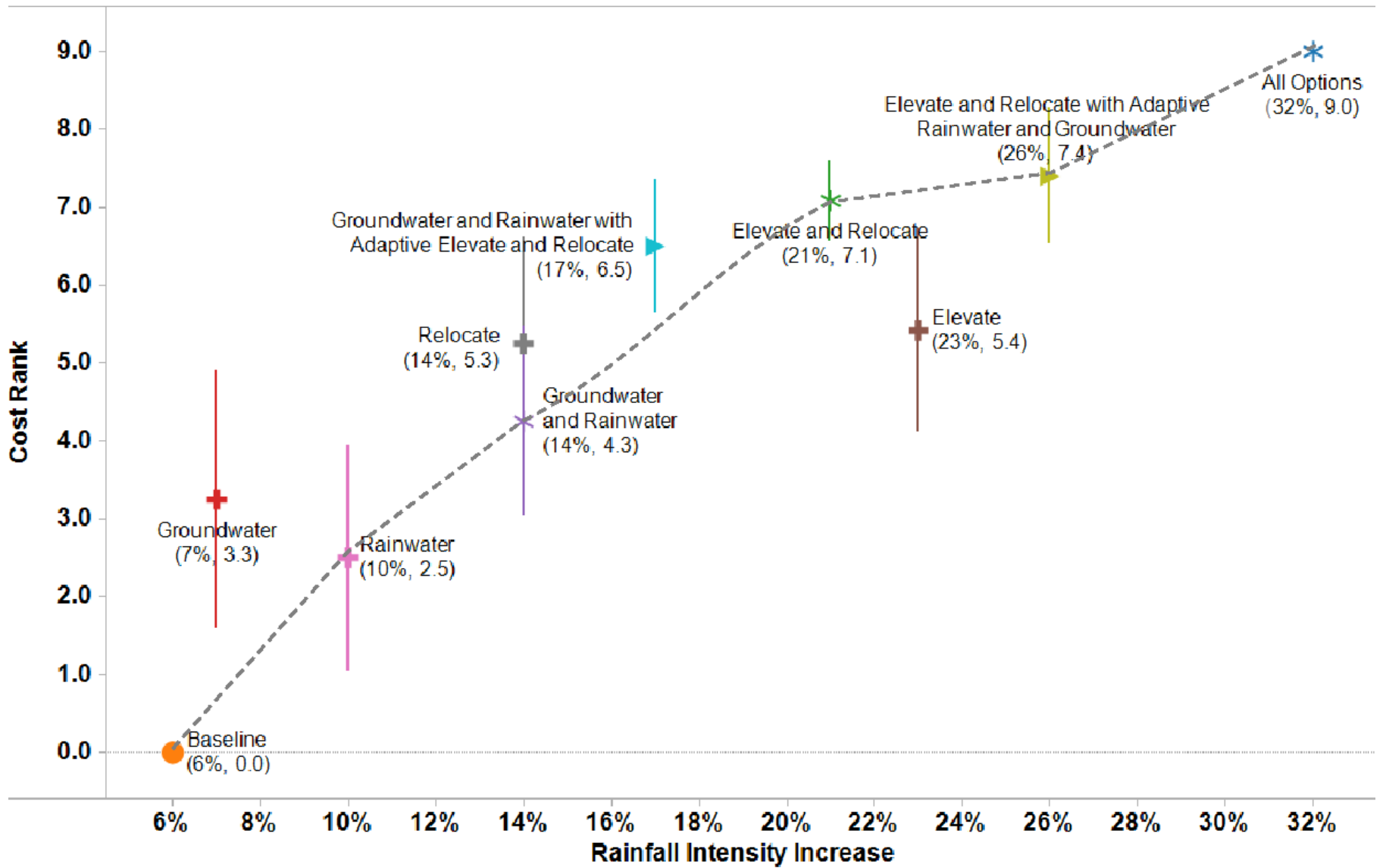
Source: Lempert et al. (2013). *Ensuring robust flood risk management in Ho Chi Minh City*. The World Bank, Policy Research Working Paper 6465, 63 p.



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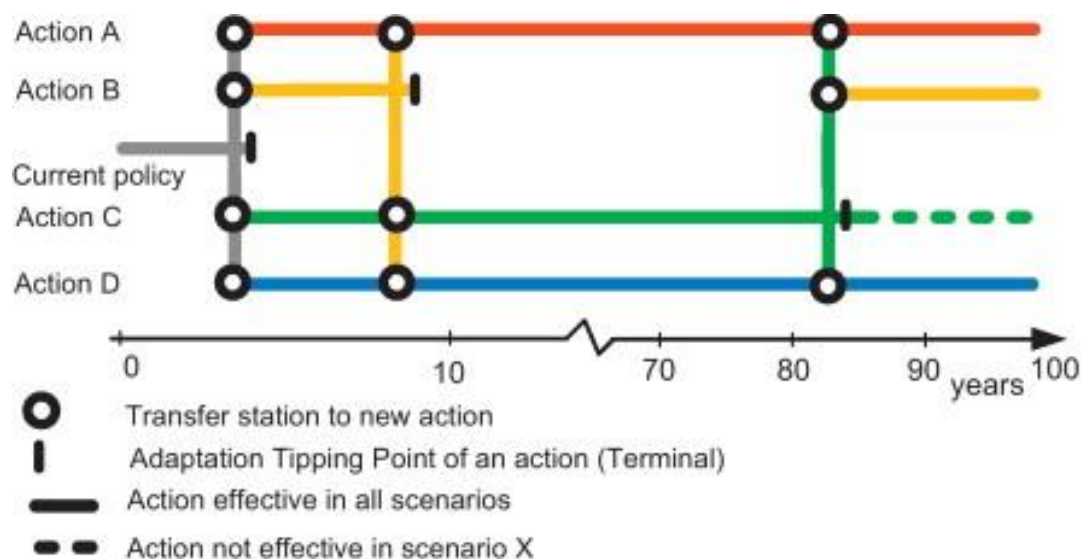


Source: Lempert et al. (2013). Ensuring robust flood risk management in Ho Chi Minh City. The World Bank, Policy Research Working Paper 6465, 63 p.

Dynamic Adaptive Policy Pathways

- Combines *Adaptive Policy Making* and *Adaptive Pathways*
- Explicitly incorporate adaptation ‘tipping points’
- Use near-term scenarios that represent a variety of uncertainties and their development over time
- Evolution / adaptation of policy actions
- Can incorporate computational evaluation of robustness for a large number of pathway scenarios (e.g., multi-objective robust optimization)

Dynamic Adaptive Policy Pathways



Adaptation Pathways Map

Path	actions	Relative Costs	Target effects	Side effects
1	○	+++	+	0
2	○	+++++	0	0
3	○	+++	0	0
4	○	+++	0	0
5	○	0	0	-
6	○	++++	0	-
7	○	+++	0	-
8	○	+	+	---
9	○	++	+	---

Scorecard pathways

Opensource software toolkit

Scenario Discovery Toolkit	<ul style="list-style-type: none"> • Scenario generation & discovery • Diagnostics toolkit • Visualization tools 	https://cran.r-project.org/web/packages/sdtoolkit/index.html	Bryant, B.P. & Lempert, R.J. (2010) <i>Technological Forecasting and Social Change</i> , 77, 34-49
Exploratory Modelling Workbench	<ul style="list-style-type: none"> • Generation of policy options • Scenario discovery • Vulnerability analysis • Robustness Optimization 	https://github.com/quaquel/EMAWorkbench	Kwakkel, J.H. (2017) <i>Environmental Modelling & Software</i> , 96, 239-250
Multi-Objective Robust Decision Making (MORDM).	<ul style="list-style-type: none"> • Scenario generation • Multi-Objective Evolutionary Algorithms 	https://github.com/sibeleker/MORDM---Multi-scenario-search	Eker S, Kwakkel JH. 2018.. <i>Environmental Modelling & Software</i> 105:201-216.
Project Platypus	<ul style="list-style-type: none"> • Rhodium – tool for RDM • Platypus – library of Multi-Objective Evolutionary Algorithms • OpenMODRM – Multi-objective Robust Decision Making • PRIM – Scenario discovery • J3 – Platform for visualizing and analyzing multi-objective tradeoffs 	https://github.com/Project-Platypus	Hadka D, Herman J, Reed P, Keller K. 2015. <i>Environmental Modelling & Software</i> 74:114-129.

Some reflections

- Tools based on plausible scenarios rather than probabilistic outcomes
- Facilitate participatory design and evaluation of options
- Flexible & Adaptive
 - Can incorporate:
 - Qualitative & quantitative models
 - Surprises
 - Threshold transitions
 - Dynamic decisions & conditions
- Require expert facilitation
- Computationally intensive

Collaborative decision-making

Collaborative, co-designed and participatory decision-making processes involving all interested parties.



Tailored

Place and time specific, recognising all ecological complexities and connectedness, and addressing cumulative and multiple stressors.



Co-governance

Governance structures that provide for Treaty of Waitangi partnership, tikanga and mātauranga Māori.



EBM

Ecosystem-based management for Aotearoa

A holistic and inclusive way to manage marine environments and the competing uses for, demands on, and ways New Zealanders value them.



Human activities

Humans, along with their multiple uses and values for the marine environment, are part of the ecosystem.



Sustainability

Marine environments, and their values and uses, are safeguarded for future generations.



Knowledge-based

Based on science and mātauranga Māori, and informed by community values and priorities.



Adapts

Flexible, adaptive management, promoting appropriate monitoring, and acknowledging uncertainty.

Utility – (draft)

	RDM	DAPP	Info-Gap	ROA
Ease of implementation	**	**	*	**
Data requirements	**	**	**	****
Computational Demands	**	***	*	**
Mutiple stressors / uncertainties	++++	++++	++	++
Dynamic risk management?	+++	++++	++	+
Can incorporate threshold transitions?	+++	++++	++	+
Can incorporate surprises?	+++	+++	+	+