

Sea Level Rise Primer

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هيئة البيئة - أبوظبي
Environment Agency - ABU DHABI

OUTLINE

- **Background**
- **Understanding sea level rise**
- **Coastal context in the UAE**
- **Framework for decision-making**

BACKGROUND

RESEARCH TEAM



- Jochen Hinkel, Global Climate Forum (Framework for decision-making)



- Daniel Lincke, Global Climate Forum (Framework for decision-making)



- Robert Arthur, American University of Ras Al Khaimah (coastal environment in UAE)



- Ze Edson, Oceanography Institute, University of Sao Paulo (understanding sea level rise)



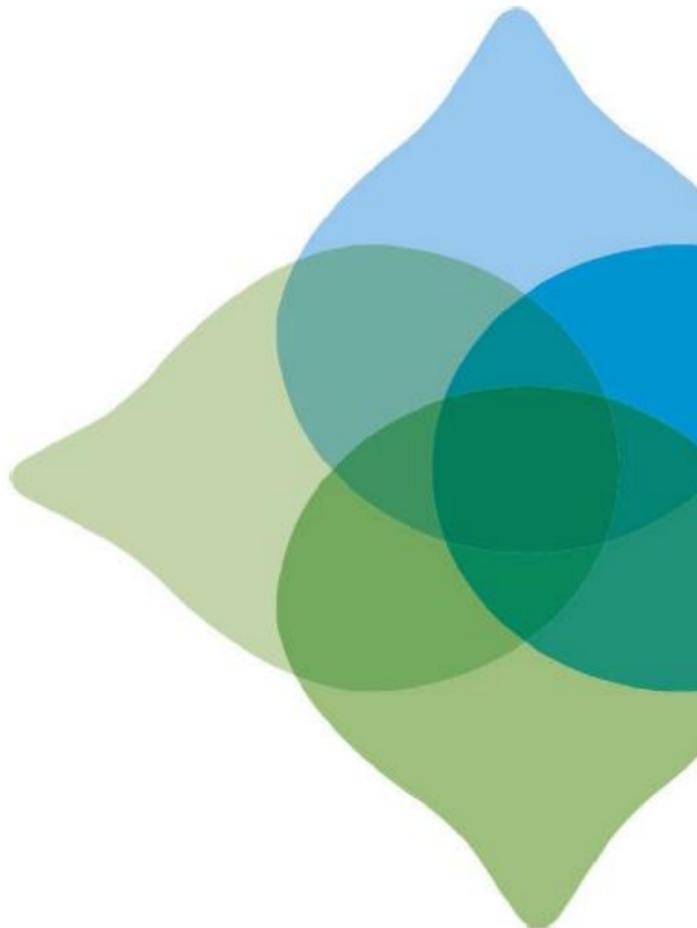
- Bill Dougherty, Climate Change Research Group, (understanding sea level rise)

PRIMER REPORT & CONTENTS



AGEDI- ABU DHABI GLOBAL ENVIRONMENTAL DATA INITIATIVE
CLIMATE CHANGE PROGRAMME

SOCIOECONOMIC SYSTEMS: SEA LEVEL RISE PRIMER



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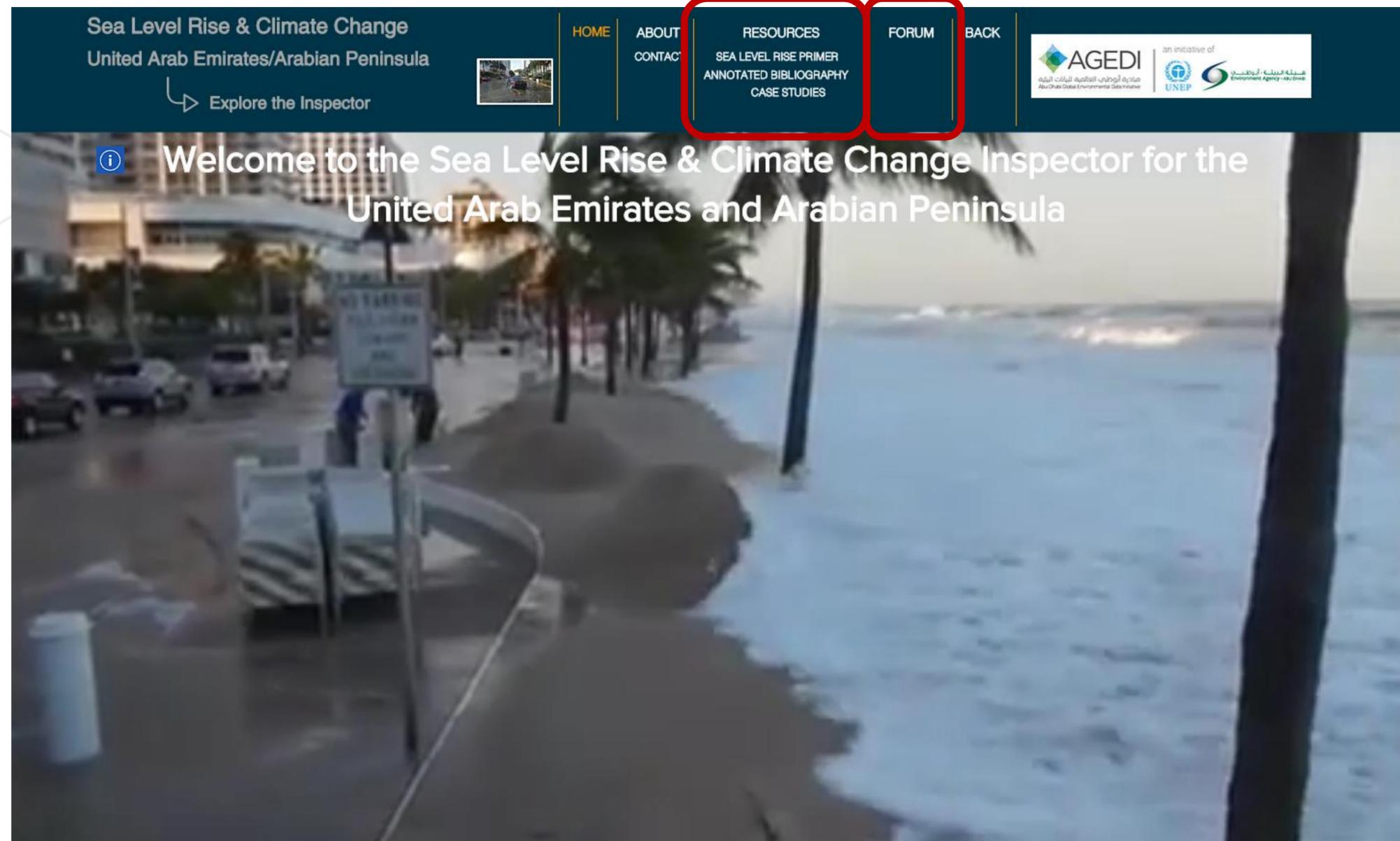


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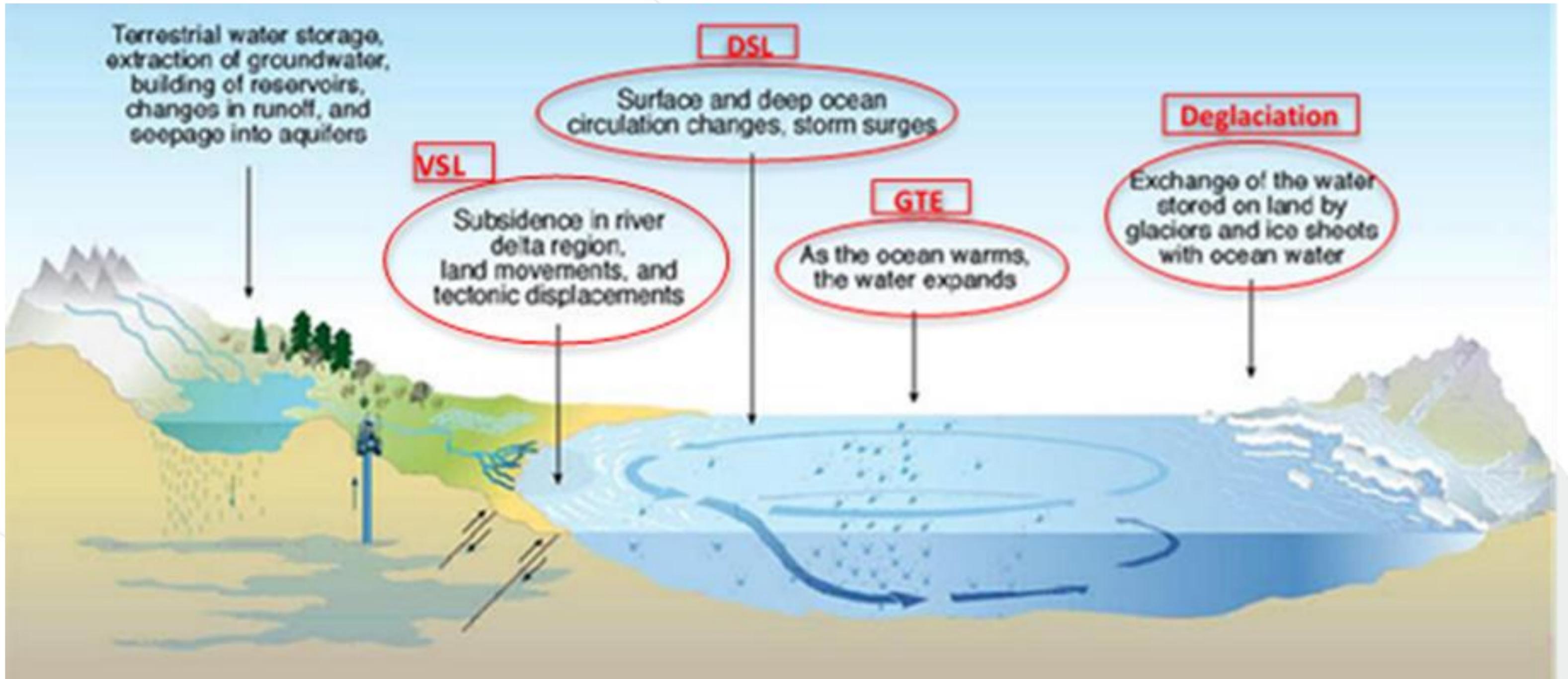
SEA LEVEL RISE INSPECTOR

- **One of 12 Inspectors**
- **Background; links to online resources**
- **Explore the Inspector**
 - **Inspector tools**
 - **Discussion forum**



UNDERSTANDING SEA LEVEL RISE

MAJOR CAUSES OF SEA LEVEL RISE

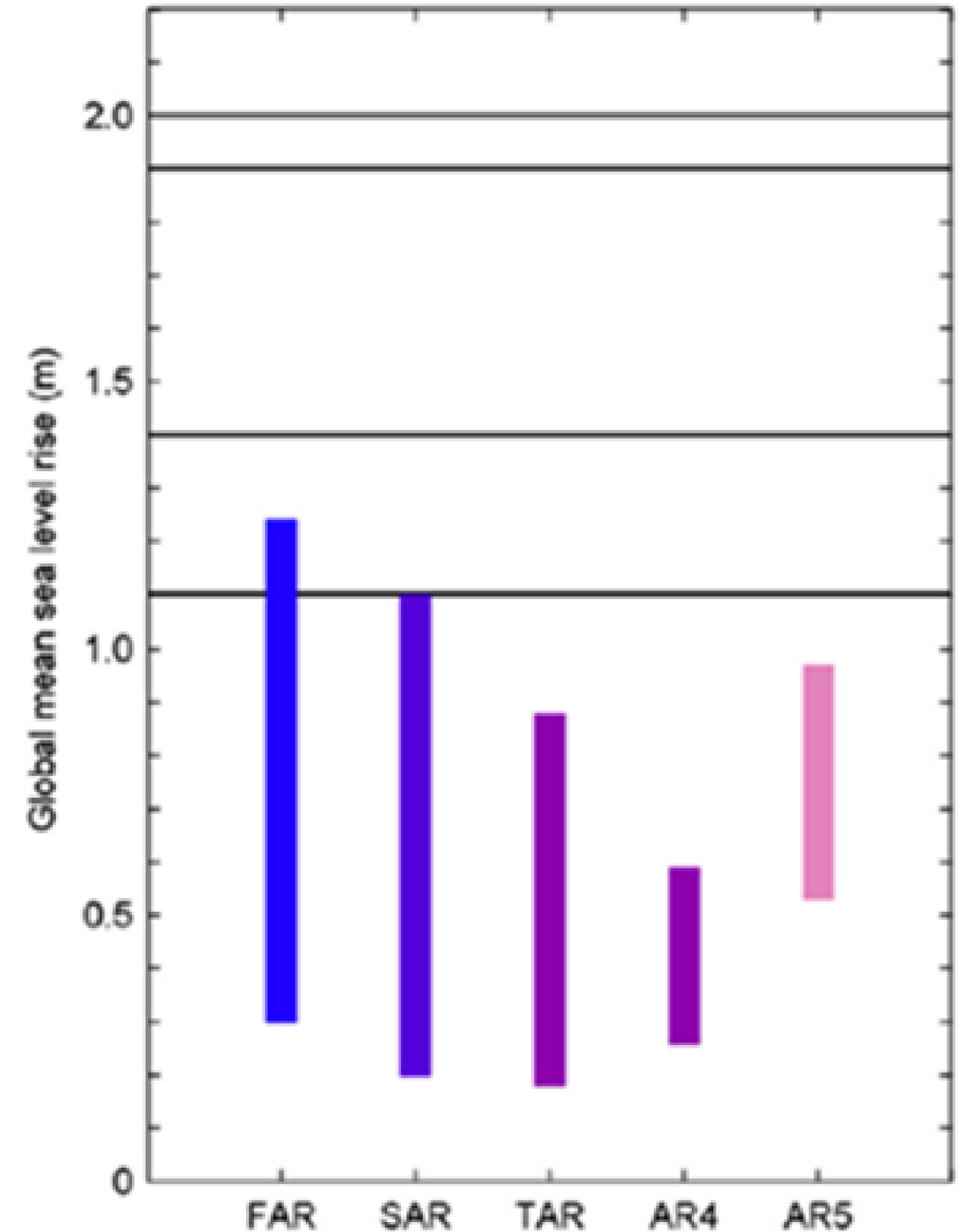


SEA LEVEL RISE CONTRIBUTOR SHARES

Contributor to sea level rise	Sea level rise (mm/year)	Share (%)
Thermal effects	1.1	34%
Deglaciation effects (Antarctica, Greenland)	0.6	19%
Deglaciation effects (other glaciers)	0.9	27%
Gravity and other effects	0.6	12%
“Unexplained”	0.3	8%
Observed global mean sea level rise	3.2	100%

IPCC PROJECTIONS

- **Wide range of estimates**
- **IPCC acknowledges uncertainty due to modeling limitations**
- **Highlights importance of obtaining better estimate of ice-air-ocean interactions**



ONGOING EFFORTS TO IMPROVE MODELING

- **Coupled Model Intercomparison Project (CMIP-6) process currently underway.**
- **Within CMIP-6, there is the Sea-Ice Model Intercomparison Project (SIMIP)**
- **2020 – 2021 timeframe for release of findings**

COASTAL CONTEXT IN UAE

INTRODUCTION



- UAE Coastline: ~2,750 kms, excluding off shore islands & built offshore developments
- This presentation will concentrate on endangered built environments and infrastructure
- Cautionary Principle
- Ramsdorf et al, 2007: 2m rise by 2099
- Combined effects – high tide, storm surge will add to this
- 6m heights in sheltered areas, 10m in open areas



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- As with most Emirates on the Arabian Gulf, the coastline is dominated by sandy beaches and sabkha plains.
- 214 islands – some inhabited, many low-lying and subject to erosion and inundation
- E11 runs close to the coast, especially in the Western Region
- Ruwais – one of the largest petroleum refineries and production facilities in the world
- Abu Dhabi – 20m above sea level with developments on other islands
- Hospitals, Gov't Buildings, Schools, Desalination & Electrical Generation
- Resort Hotels, Airports, Recreation, Culture, Shopping
- Fortunately, much is partially protected by the Qatar peninsula

DUBAI

- Financial hub of the UAE
- One of the busiest airports in the world - DBX
- One of the busiest sea ports in the world – Jebel Ali
- Many famous offshore developments: The World, The Palms, the Burj Al Arab as well as numerous resorts
- Sea walls protecting offshore developments only 3 to 4.25m
- The Khor and its extension will expose more of Dubai to inundation
- So many developments in this amazing city that they can not all be mentioned
- Of note is the Dubai Federal Hospital, just across the E11 from the coast



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Sharjah

- Only Emirate with coastline on both sides
- Surrounds Ajman
- South of Ajman heavily developed
- North of Ajman, less developed, Al Hamriyah
- Built around three Lagoons and Khor Khail
- Al Hamriyah built around a lagoon



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- Sharjah has many cultural sites
- the Central Souq, Sharjah Art Museum and Heritage Area, the Islamic Arts and Culture building and Crystal Plaza.
- Port Khalid and the E11
- Corniche flooded with 3km waves



AJMAN

- Built around Khor Ajman
- Smallest of the emirates
- Many world class resort Hotels
- High rise buildings: office and residential
- Warehousing and Industry
- Ajman drydocks and Ajman Free Trade Zone



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UMM AL QAWAIN



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- Least Developed
- 25kms of sandy beaches and sabkha plain
- Umm Al Qawain located on a peninsula
- Near shore low lying sandy islands
- Residential, tourist and commercial properties at risk
- E 11 runs close to the shore, less than 1 km.



RAS AL KHAIMAH

- Alluvial plains
- Khor Ras Al Khaimah
- Rocky coast to the north
- Coastline fully developed
- Reclaimed land:
 - Marjan Island And Al Hamra Al Jazirat
 - Many Resorts including the Waldorf Astoria
 - Saqr Port: largest bulk port in the region
 - Maritime Free Trade Zone



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مبادرة أبوظبي العالمية للبيانات البيئية
Abu Dhabi Global Environmental Data Initiative



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FUJAIRAH & THE GULF OF OMAN

- Hajar Mountains
- Rocky coast
- Narrow coastal plains
- Gulf of Oman open to the Indian Ocean
- Dibba: many resorts
- Fujairah Port
- Power plants
- Khor Kalba & Khor Fakkan, Sharjah



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- Cyclone Gonu



CONCLUSION

- Worldwide attraction of coastal locations
- Tremendous and rapid development along the coast since 1971
- With beautiful winter weather the UAE has become a tourist hotspot
- Development will continue, however will require future planning
- Protection of future and existing features



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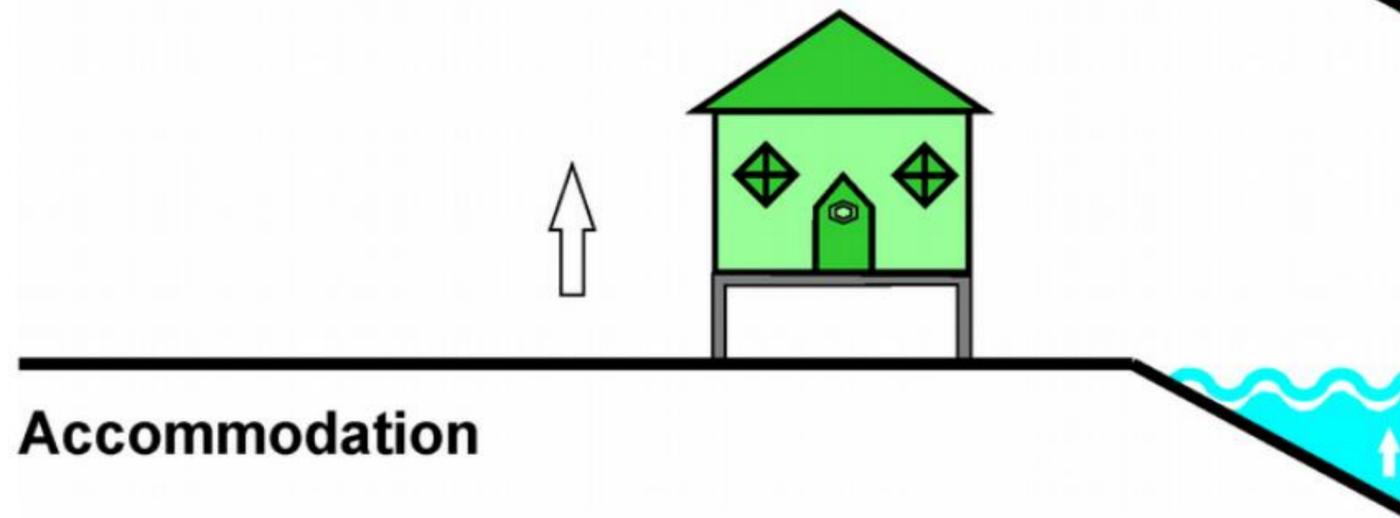
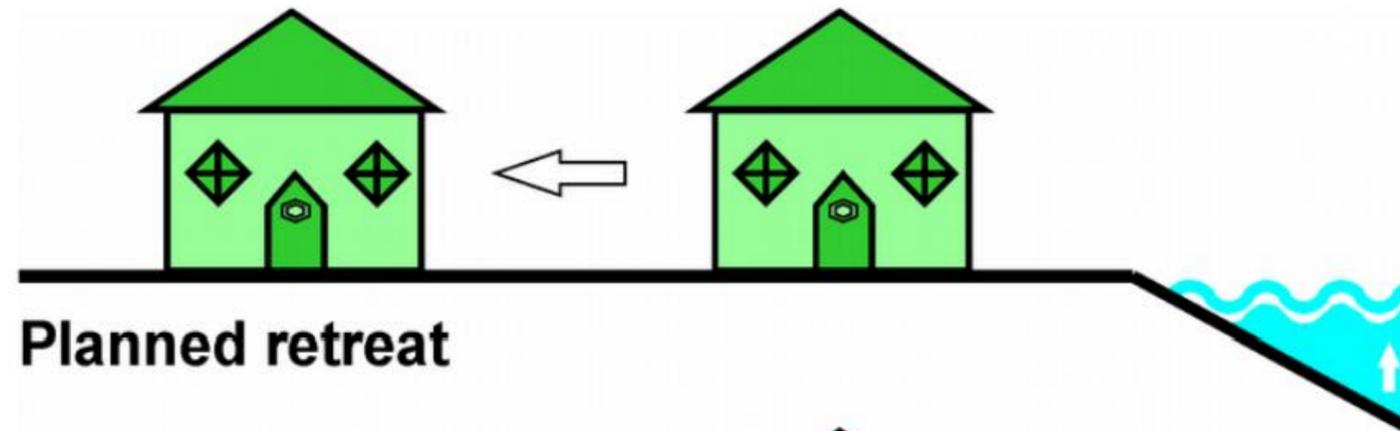
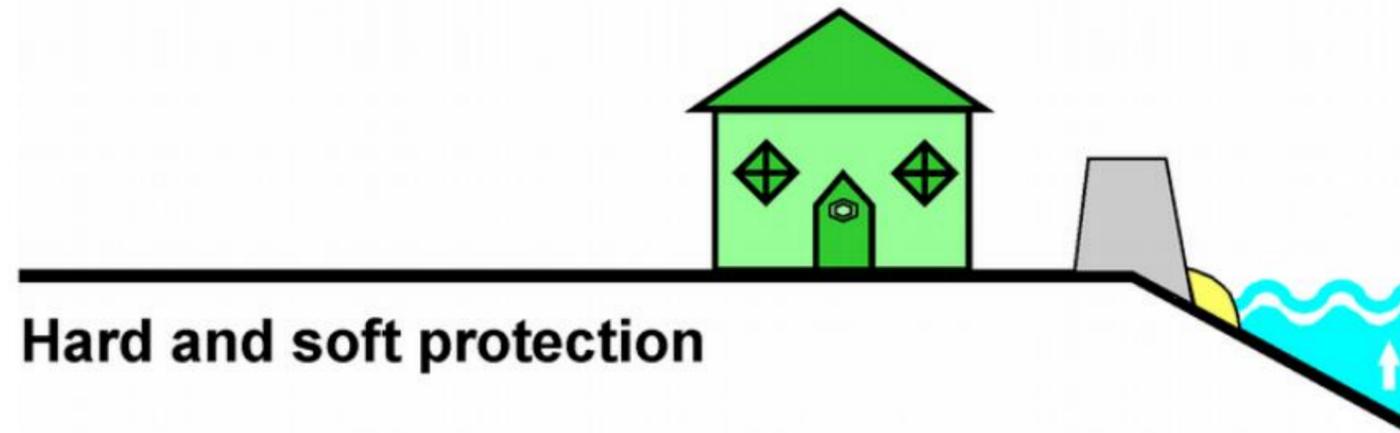


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FRAMEWORK FOR DECISION-MAKING

Responses to SLR

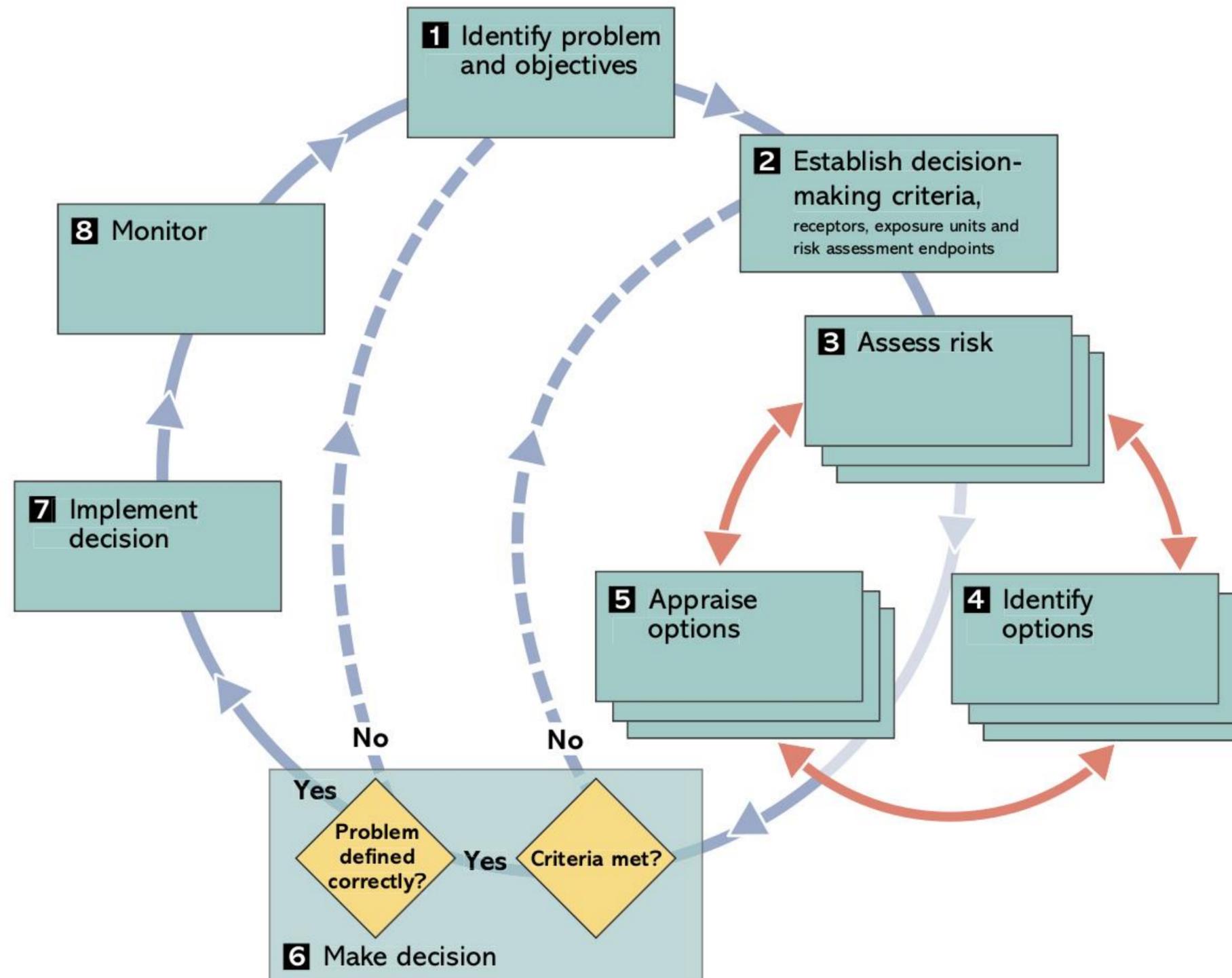


Adaptation frameworks

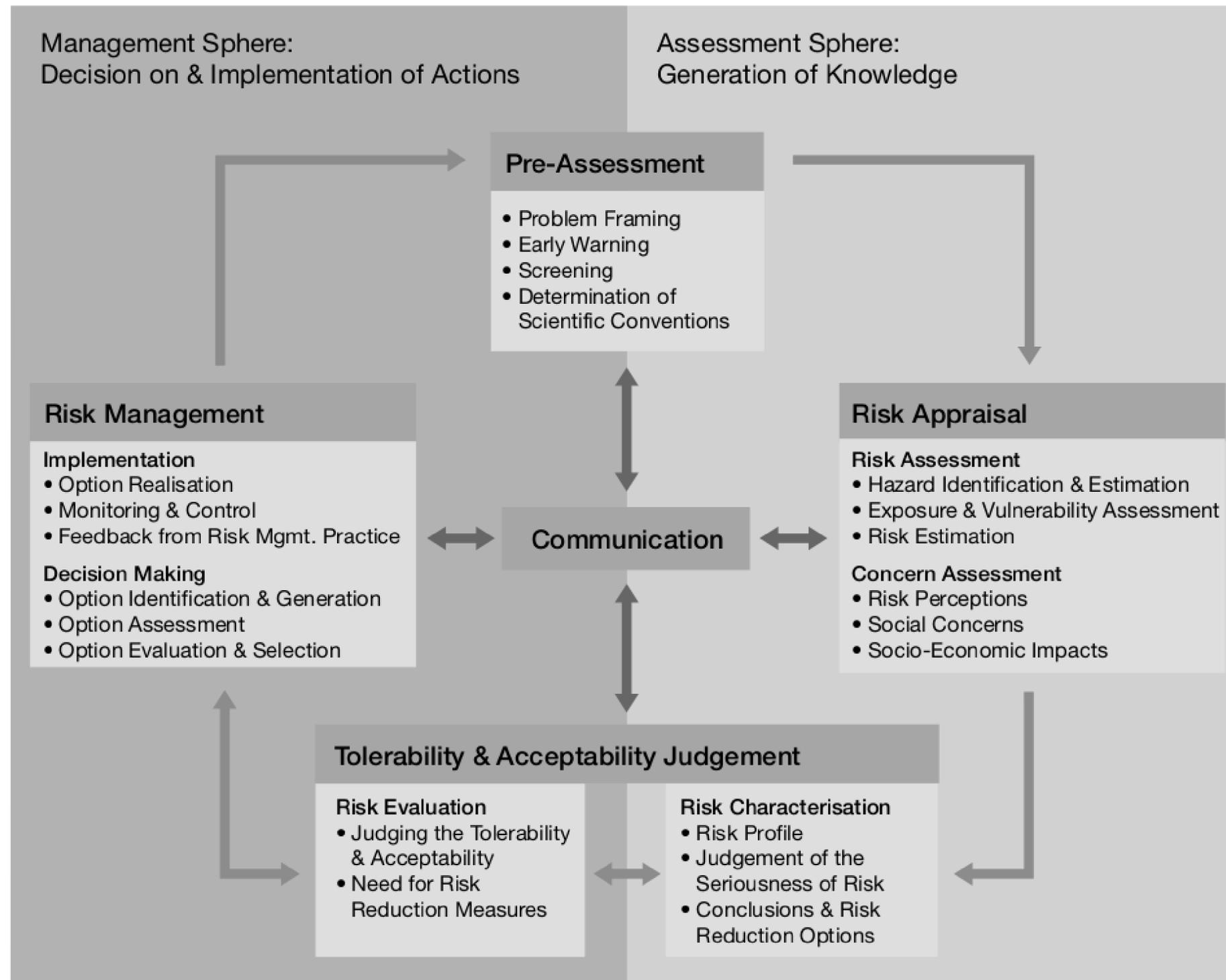
A wide variety of frameworks for the adaptation process are available. However, there is wide agreement that the adaptation process is an iterative learning process involving a number of generic stages:

1. Identifying adaptation needs.
2. Identifying adaptation measures.
3. Appraising adaptation options.
4. Planning and implementing adaptation options.
5. Monitoring and evaluation.

Adaptation frameworks - UKCIP



Adaptation frameworks - IRGC



Decision making frameworks

Risk management or decision making frameworks:

- zoom in the step of appraising adaptation options
- asses adaptation options against all available knowledge including uncertainties
- appropriate for decisions in the coastal domain

Decisions in the coastal adaptation face two main uncertainty Dimensions:

- Uncertainty in mean and extreme sea-levels changes.
- Uncertainty in socio-economic development, including population development, economic growth, price of capital for investments.

Decision making frameworks

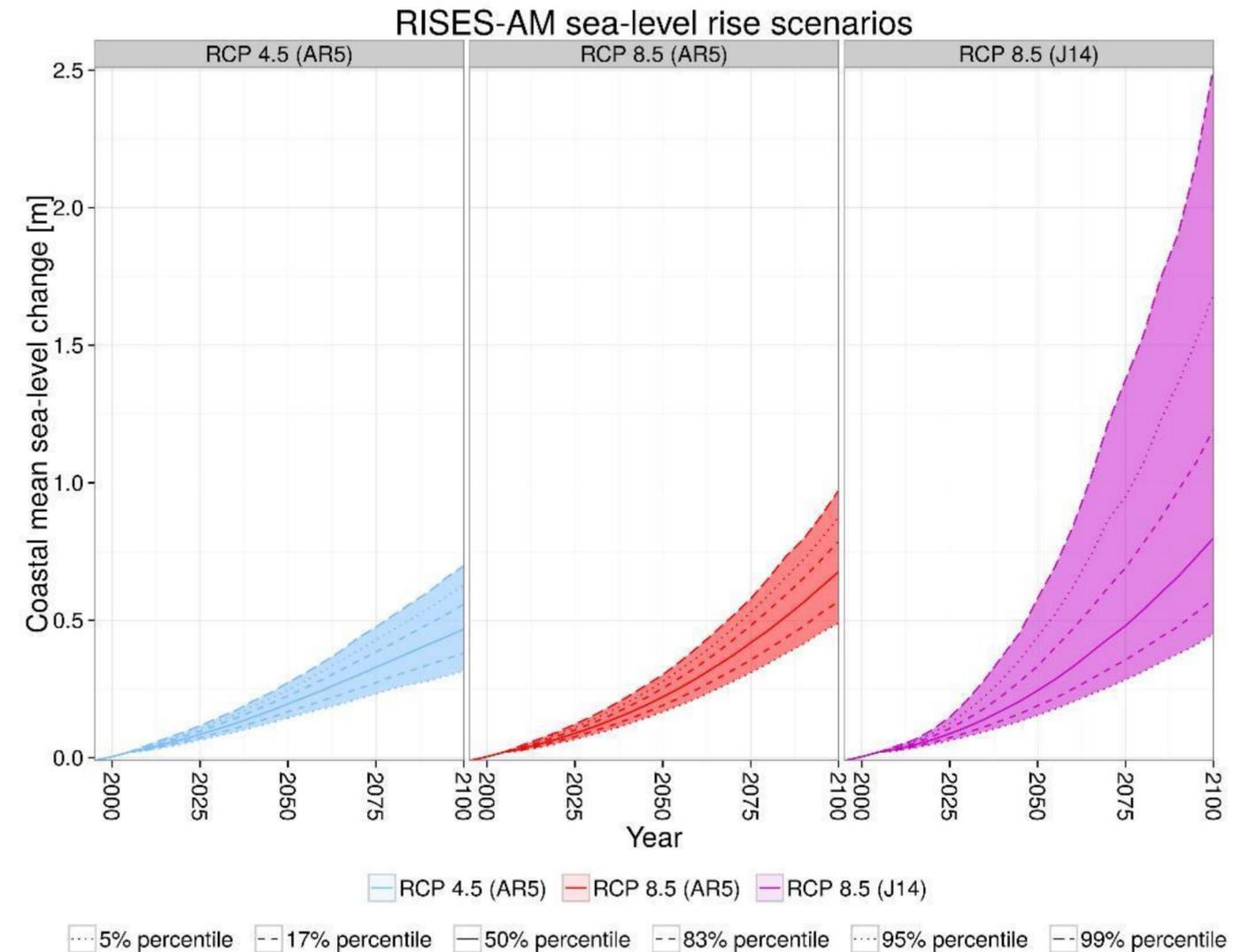
- **No general recipe can be given on which decision making framework to use for coastal adaptation.**
- Choice of decision making framework depends on the specific adaptation decision confronted with.
- For selecting an appropriate decisions making framework, two criteria need to be considered.

Risk preferences

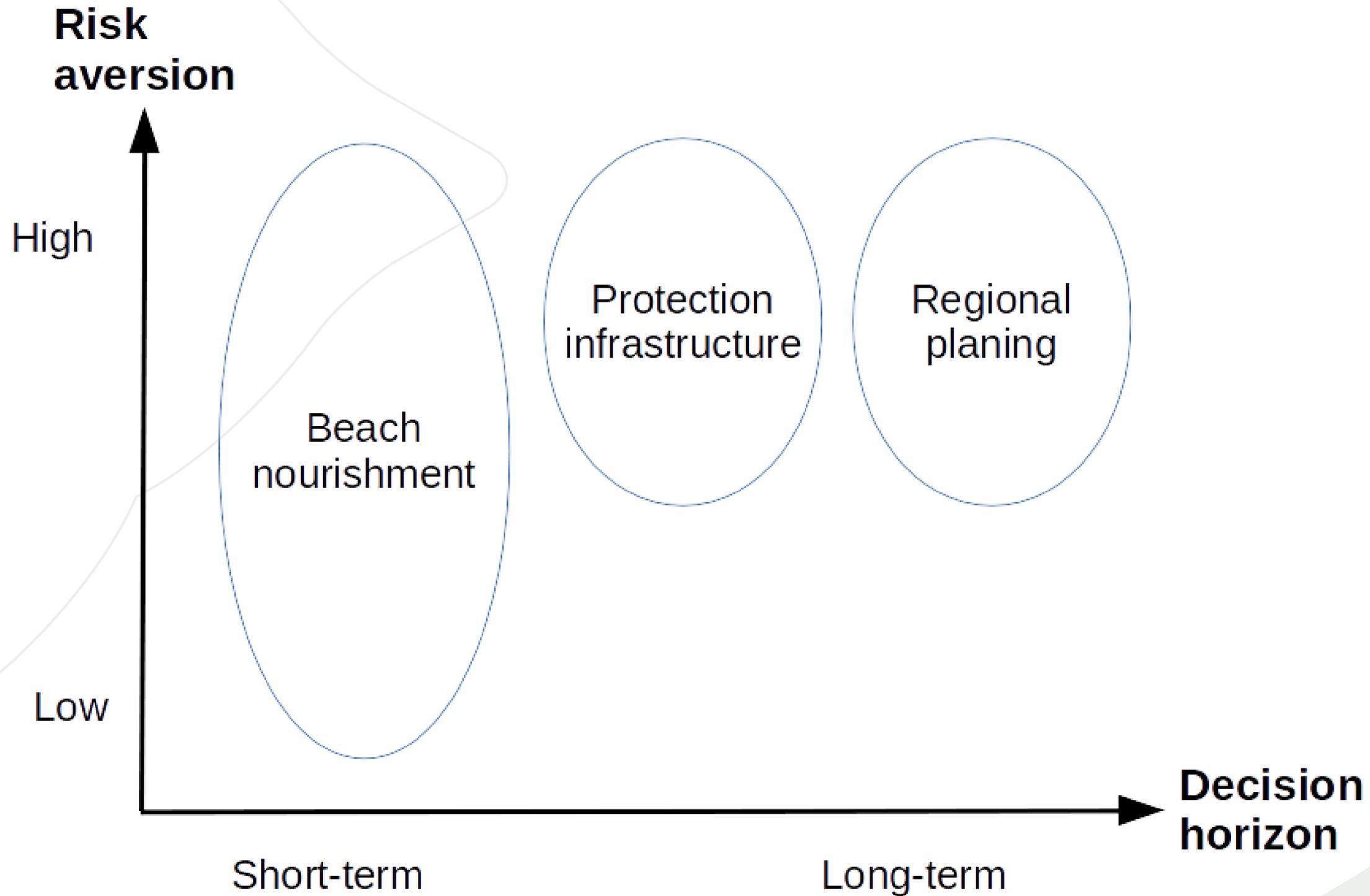
- Those who decide and those affected by the decision may have different preferences towards risks.
- Societies have different risk aversion.
- Needs to be taken into account when selecting decision making frameworks and relevant scenarios.
- The more risk-averse people are the more extreme and unlikely scenarios (high-end sea-level rise) need to be considered.

Decision horizon

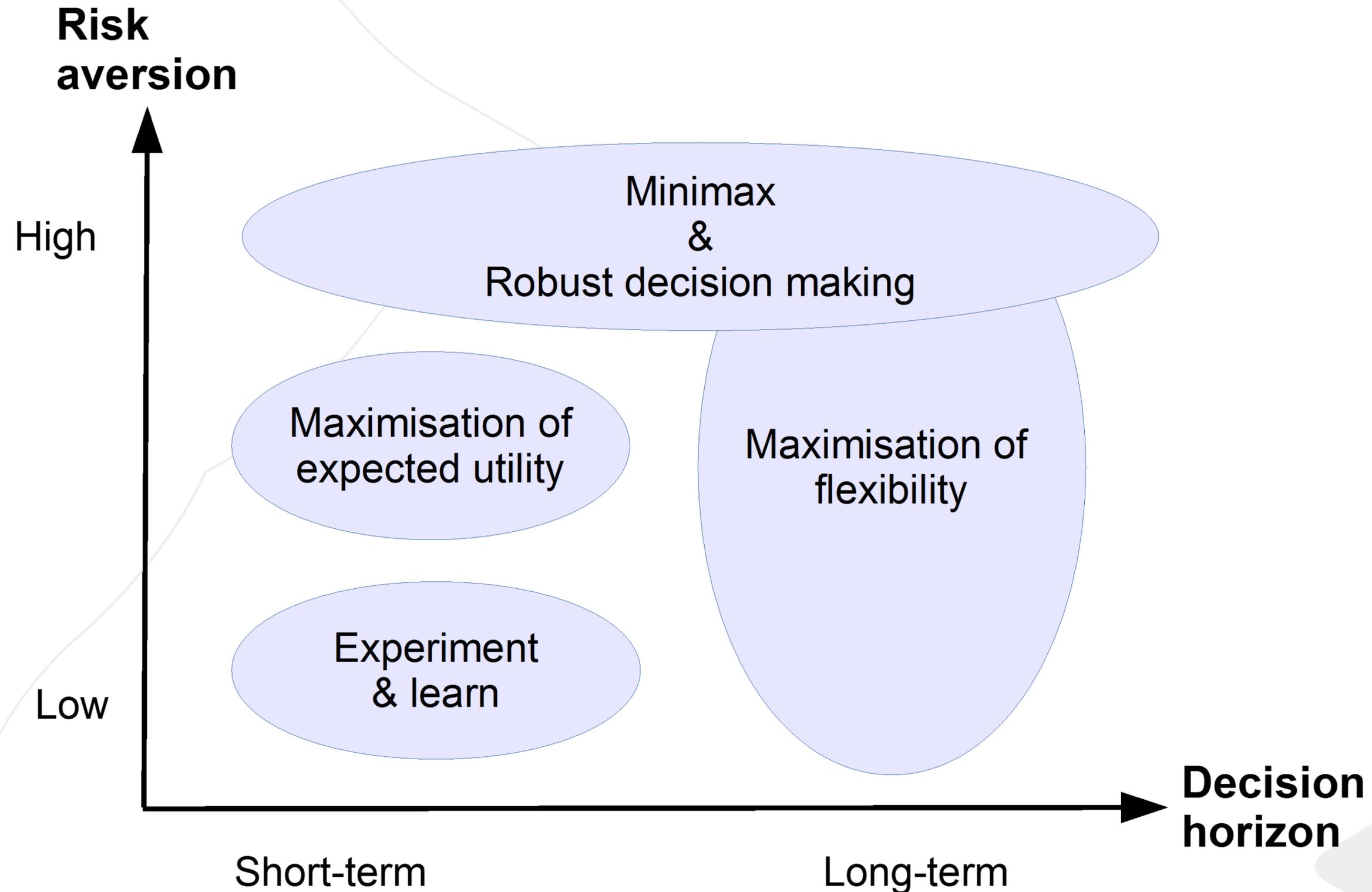
- The choice of scenarios and decision-making frameworks also depends on the length of the decision horizon.
- Long-term decisions: full range of scenarios.
- Shorter-term decisions: May ignore high-end SLR scenarios.



Coastal decisions



Decision making frameworks



Decision making frameworks

Maximisation of expected utility:

- Widespread approaches for decision-making under uncertainty
- Based on the maximisation of expected utility of some sort.
- These include cost-benefit analysis (CBA), cost-effectiveness analysis (CEA) and minimization of net present value etc.
- Calculation of the mathematical expectation of the effects of the adaptation options.
- Requires the availability of a probability distribution over all possible outcomes of a chosen option, either monetary (for CBA) or otherwise (for CEA).

Decision making frameworks

Minimization of impacts under the worst case scenario (Minimax):

- Minimize (or avoid all) losses or impacts under the worst case scenario that could possibly happen.
- All adaptation options are assessed against the worst case scenario, instead of against an average case attained by computing the expected utility as done in the former approach.

Decision making frameworks

Robustness of options under all scenarios:

- Further alternative framework for decision making under deep uncertainty (i.e. without probabilities)
- Aims at finding adaptation options that are robust against all (or most) scenarios.
- Each option is evaluated against each scenario
- The evaluation may use a variety of criterion including cost-benefit ratio or cost-effectiveness ratio

Decision making frameworks

Flexibility of options under all scenarios:

- Relevant for decision making under deep uncertainty.
- Aims at keeping future options open by favouring flexible options over non flexible ones.
- An option is said to be flexible if it allows to switch, at low cost, to other options that might be preferable in the future once more information is available about the changing climate.
- Example: beach nourishment is a flexible option to reduce flood risk, because it can be abandoned, without much cost, at any point in the future.
- Example: building dikes is less flexible because of large upfront investment costs.

Decision making frameworks

Adaptation pathways:

- combines both the criteria of robustness and flexibility.
- It does so by characterizing options in terms of two attributes:
 - 1) adaptation turning points (ATP), which are points beyond which options are no longer effective.
 - 2) what alternative options are available once a turning point has been reached.
- The exact time when an ATP is reached does not matter, it is rather the flexibility of having alternative options available.

Example: Thames barrier



Example: Robust protection analysis with the DIVA model

We developed the DIVA model to assess the impact of and adaptation to sea-level rise. We are:

- Daniel Lincke, Jochen Hinkel (Global Climate Forum, Berlin)
- Robert Nicholls, Sally Brown (University of Southampton)
- Nassos Vafeidis, Claudia Wolff, Jan Merkens (CAU)
- Tom Spencer, Mark Schuerch (University of Cambridge)
- Richard Tol (University of Sussex)
- Jiayi Fang (Beijing Normal University)



Christian-Albrechts-Universität zu Kiel



Example: Robust protection analysis with the DIVA model



Example: Robust protection analysis with the DIVA model

DIVA coastline	Global	Downscaled
Number of segments	13	1558
Coastline length	1850 km	5821 km
Segments that represent erodible beaches	0	189
Length of erodible segments	0	80.9 km



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