Kiel University
Christian-Albrechts-Universität zu Kiel

CRSLR Research Group

Sea-level rise impacts on the Mediterranean UNESCO World Heritage Sites

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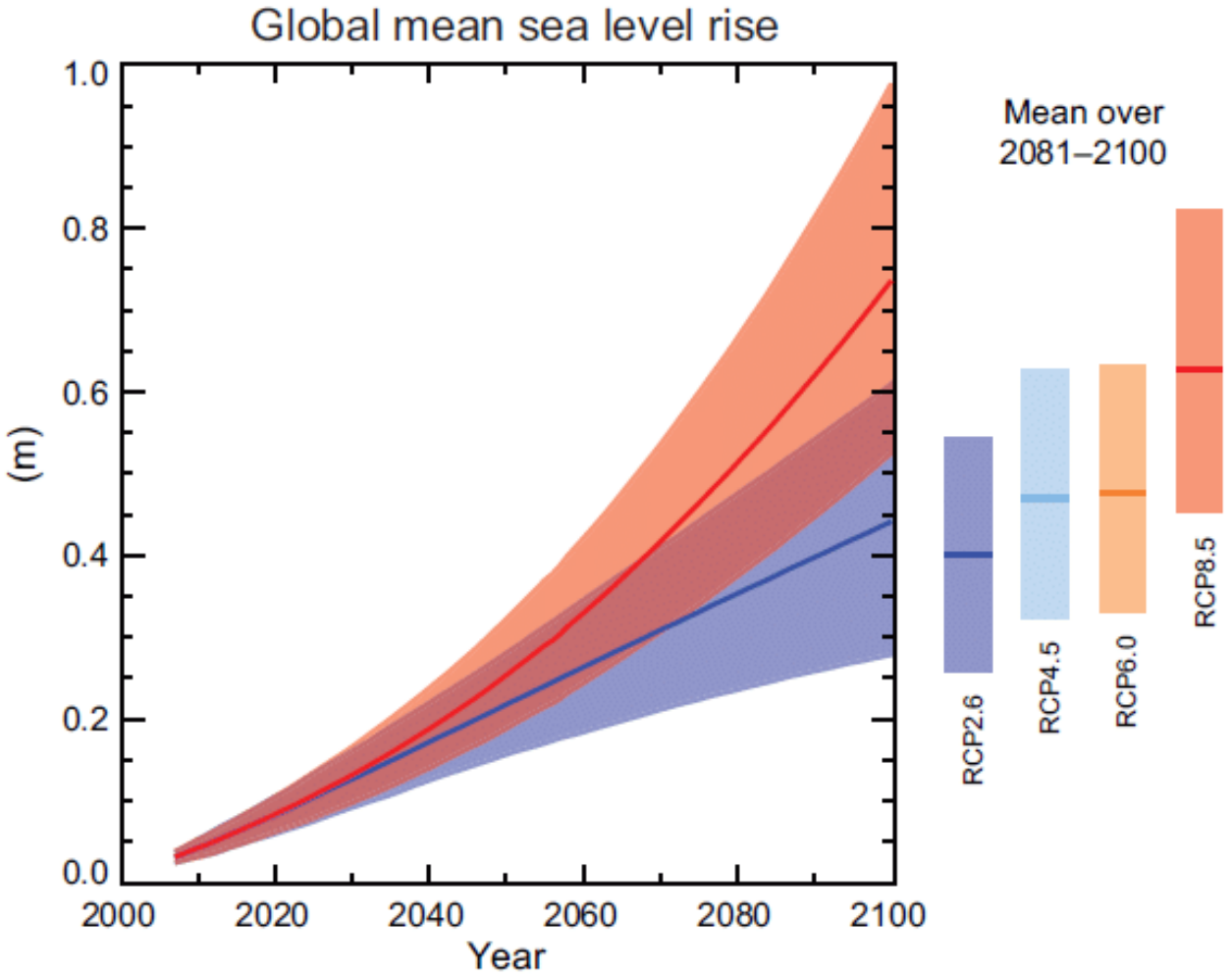
Overview

- Sea-level Rise (SLR) – How much, how soon, potential impacts
- Coastal World Heritage Sites (WHS) in the Mediterranean
- Assessing risk of coastal WHS to flooding and erosion
- Adaptation and barriers
- Conclusions

Sea-level rise projections



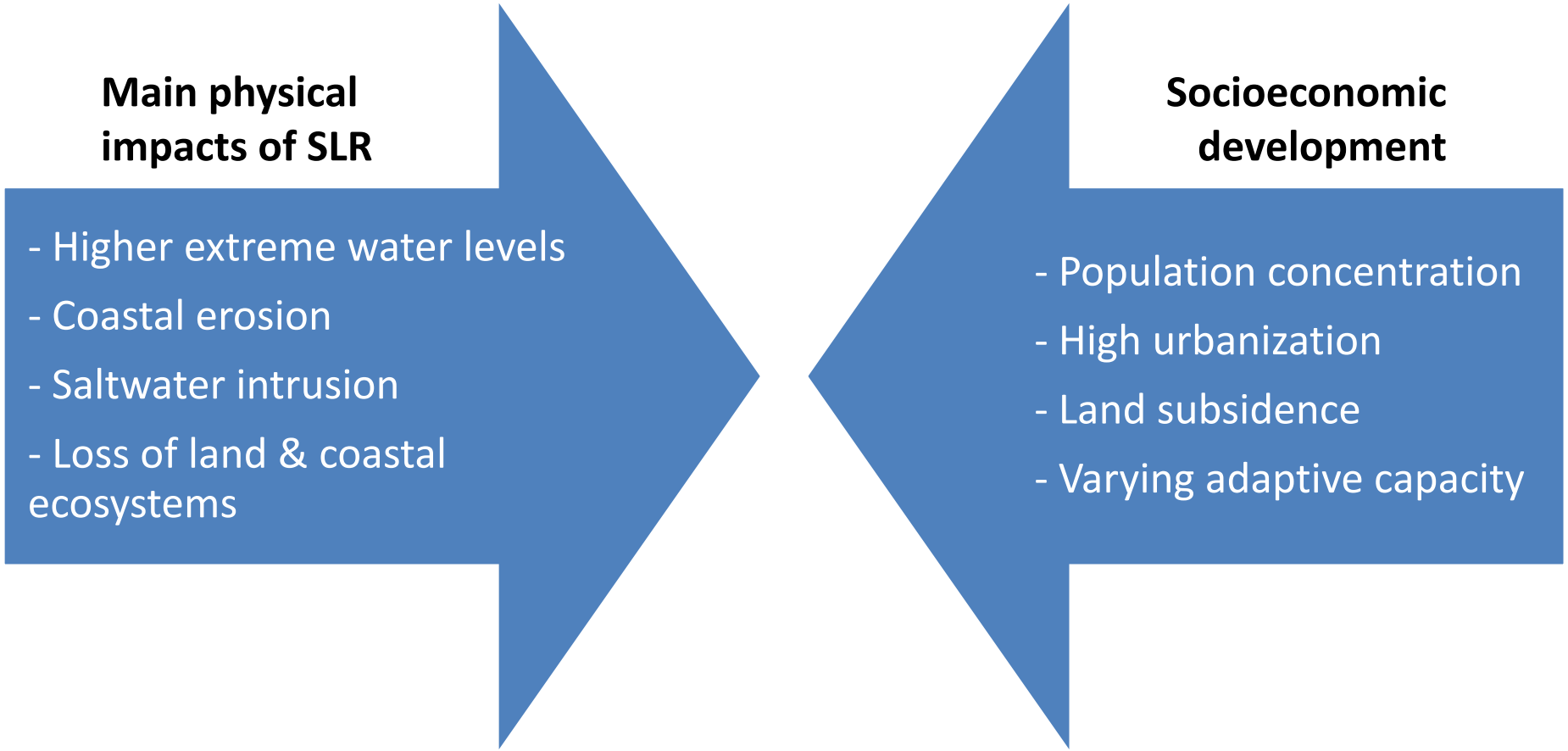
IPCC (2014), Synthesis Report, SPM

Mediterranean

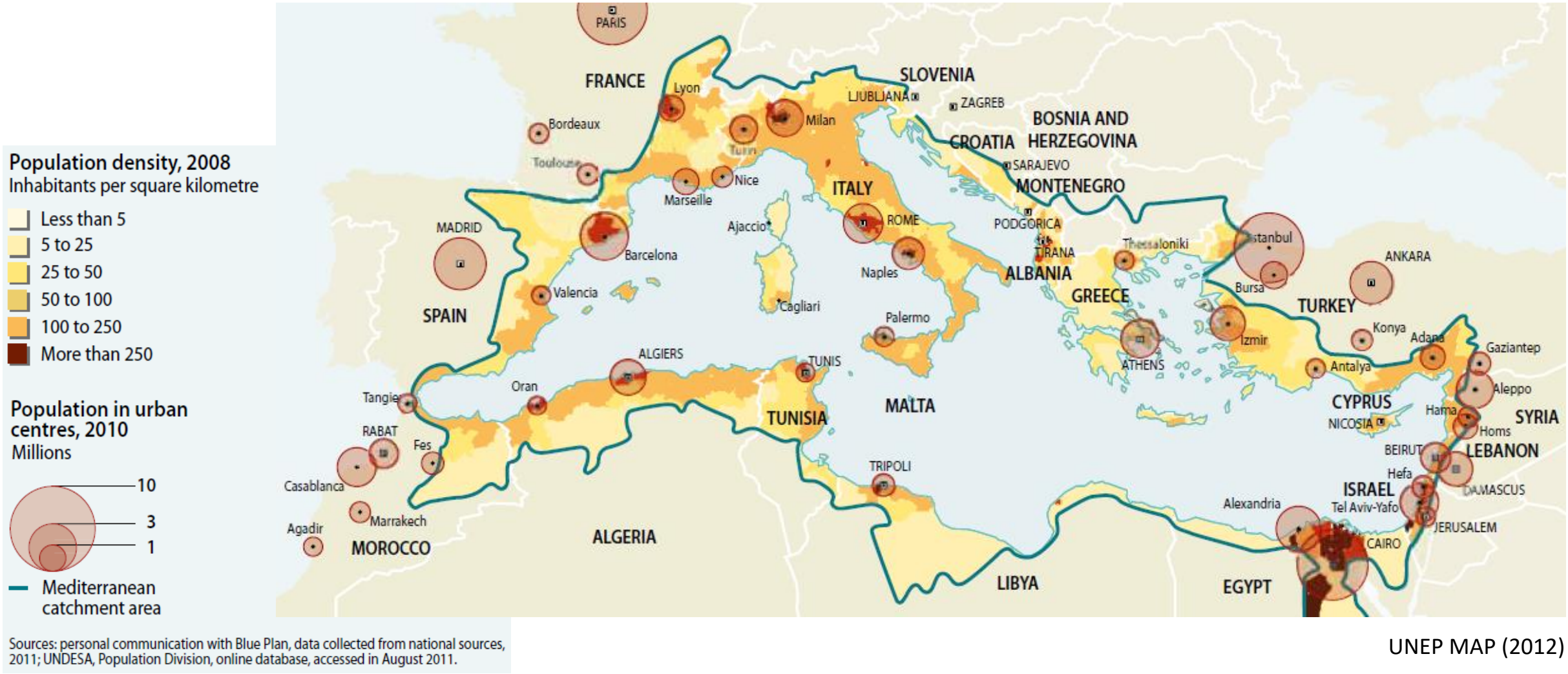
Scenario	in 2100 (m)
RCP2.6	0.36
RCP4.5	0.47
RCP8.5	0.62
High-end (RCP8.5, 95th p)	1.46

Based on Kopp et al. 2017

SLR and Socioeconomic Development



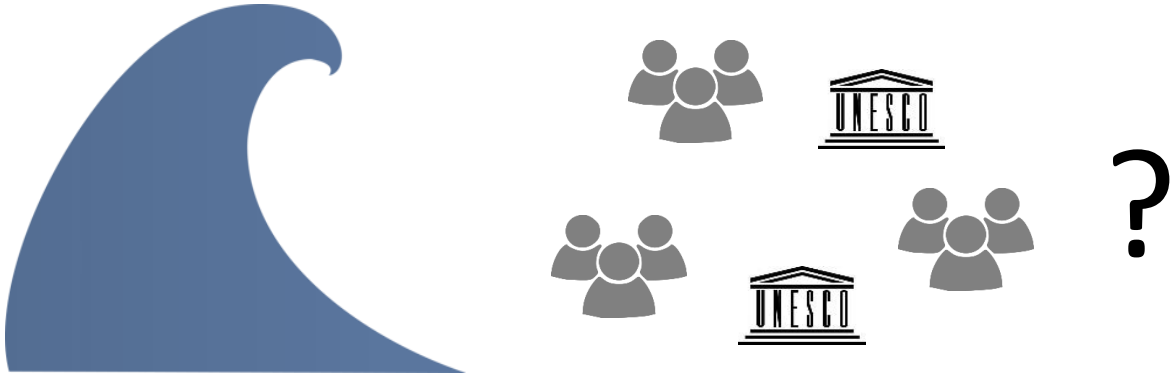
The Mediterranean



UNEP MAP (2012)

2) CULTURAL HERITAGE AT RISK

Starting point



- UNESCO World Heritage Sites (WHS) can be highly vulnerable
  - High intangible value
  - May lose Outstanding Universal Value (OUV)
  - Special adaptation needs

Regional Assessment

1) Assess WHS at risk from coastal flooding and erosion under four SLR scenarios until 2100
    - 1,092 natural and cultural WHS (2018)
    - We focused on cultural WHS (*Reimann et al., Nat. Comms.*)

2) Support adaptation planning
    - Identify WHS most at risk
    - Basis for local-scale assessments
    - Raise awareness

Analysis

- WHS data processing – lack of a coherent and consistent database
- Estimate 100-yr extreme water level and local SLR (for 4 scenarios)
- Model flood extent and depth
- Assess flood & erosion risk

Old City of Dubrovnik, Croatia

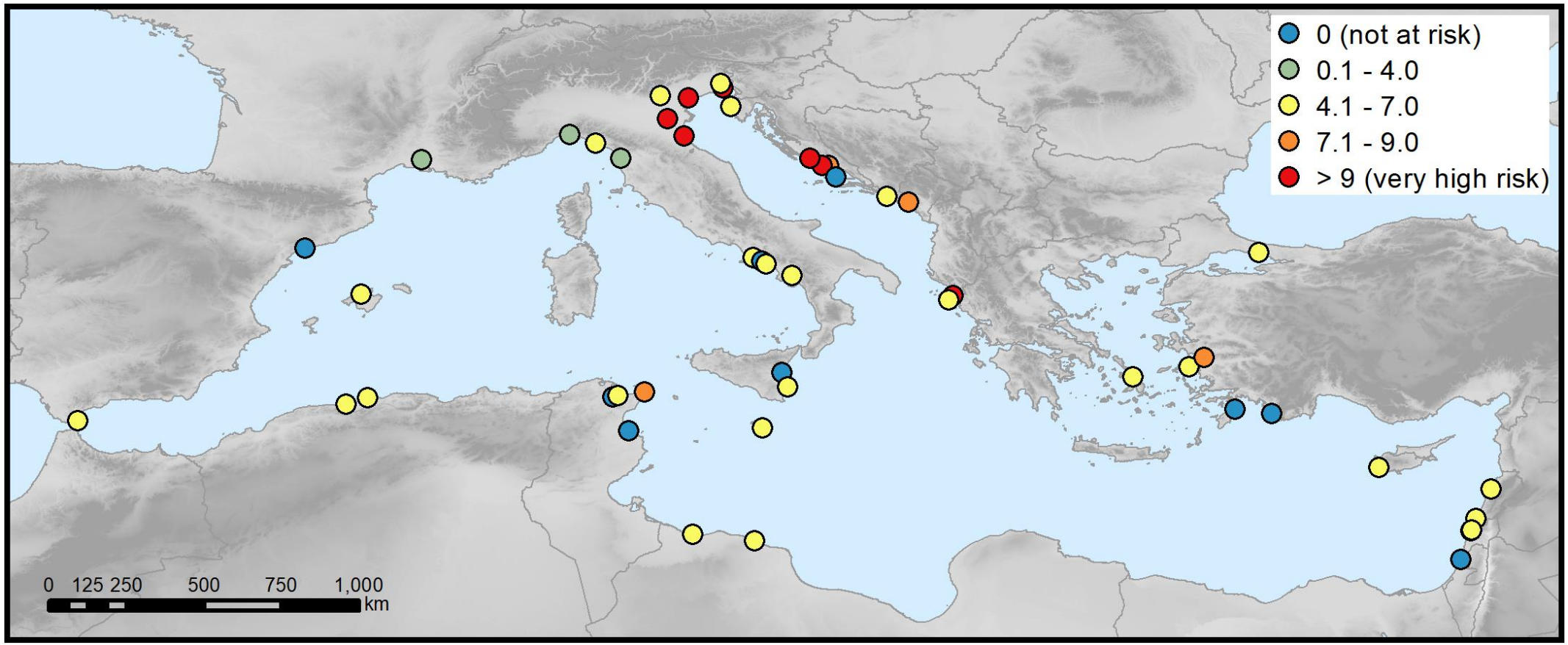
Risk analysis

INDEX / Indicator	0 not at risk	1 very low	2 low	3 moderate	4 high	5 very high	
FLOOD RISK							
Flood area [%]	0	> 0	→	→	→	≥ 50	**Flood risk index**
Flood depth [m]	0	> 0	→	→	→	≥ 1	
EROSION RISK							
Distance [m]	> 500	500	→	→	→	< 10	**Erosion risk index**
Coastal material		rocky	-	muddy; rocky with pocket beaches	-	sandy	
Mean wave height [m]		0.1	→	→	→	> 0.8	
Sediment supply [mg/l]		11.5	→	→	→	< 0.5	

Flood risk in 2100 (high-end)

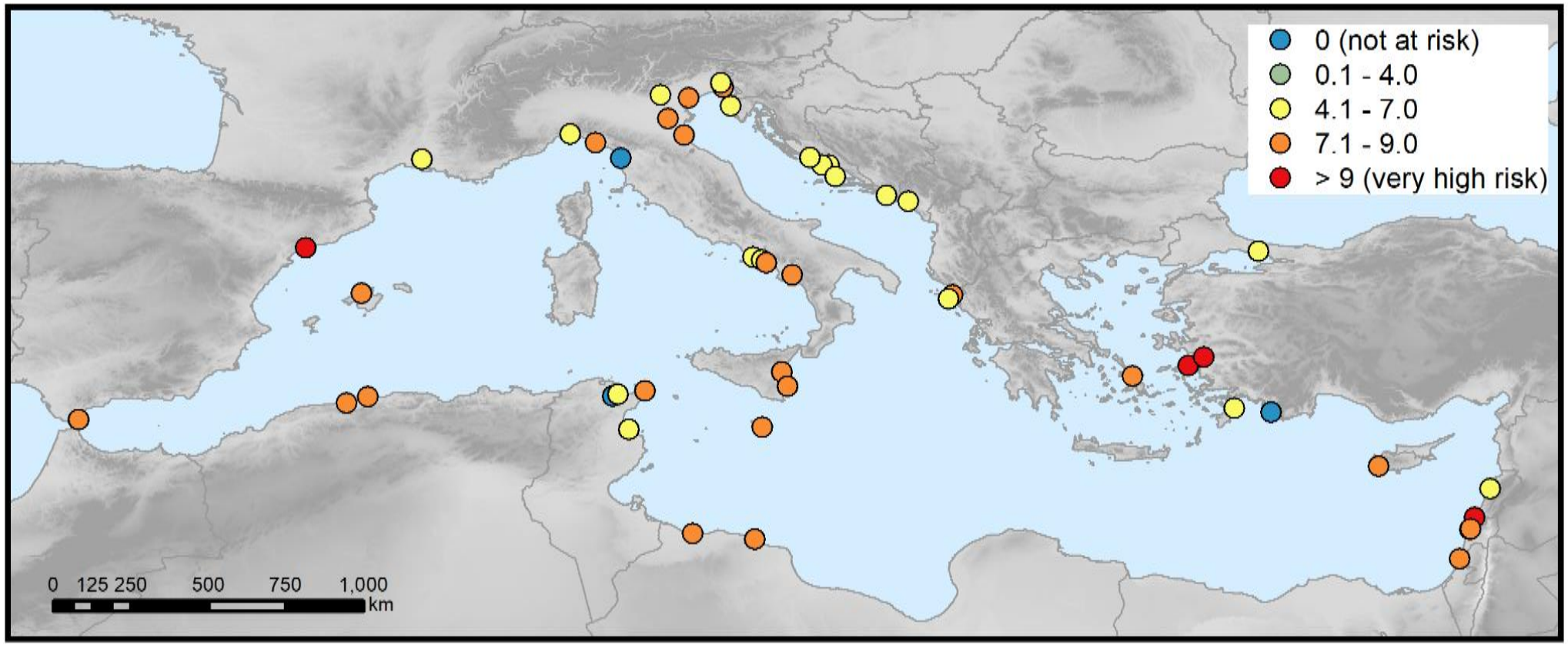
- 40 WHS at risk (82 %)
- Italy (13), Croatia (6), Greece (3)

- Venice: Flood area 98 %
  Flood depth 2.5 m



Erosion risk in 2100 (high-end)

- 46 WHS at risk (94 %)
- Highest risk: Tyre, Lebanon
- Italy (14), Croatia (7), Greece (4)



Implications for adaptation

Relocation

Accommodation

Protection

- **Must not compromise the site‘s OUV**
- ***Should account for multiple risks and long-term change***
- ***Need for innovative adaptation strategies***

La Stampa (Oct 12, 2017)

Barriers to Adaptation

General Adaptation Barriers to SLR (Hinkel et al., 2018, *Nat. Clim.*)

Technological limits

Social Conflict

Economic

Institutional

Finance

Barriers to WHS Adaptation to SLR

Social Conflict

Institutional

Economic

Technological limits

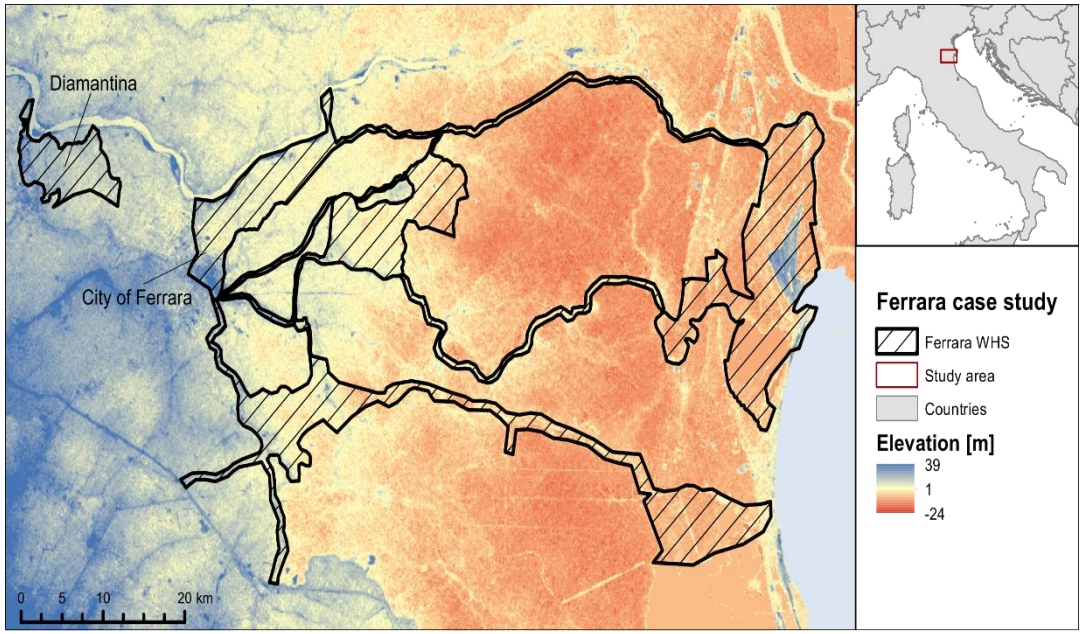
Finance

Research Gaps and Needs

- Consistent database on WHS characteristics
- Case-specific detailed studies of vulnerability to multiple hazards
- Interdisciplinary teams of experts

(e.g. engineers, architects, climatologists, chemists, archaelogists, geologists and others)

- Strong institutional framework



Conclusions – Key Messages

- Coastal WHS are, or will be, threatened by SLR (*virtually certain*)
- In the Mediterranean alone, 40+ sites will be at high risk by the end of the century (*likely*)
- Adaptation will be essential for preserving WHS (*virtually certain*)
- Conventional adaptation will NOT be adequate for preserving WHS
- Innovative adaptation, driven by case-specific interdisciplinary analysis will be essential in maintaining the OUV of WHS
- Early adaptation is necessary

Key Messages

- A large number of coastal WHS are, or will be, threatened by SLR (*virtually certain*)
- In the Mediterranean alone, 40+ sites are expected be at high risk by the end of the century (*likely*)
- Adaptation will be essential for preserving WHS (*virtually certain*)
- Conventional adaptation will NOT be adequate for preserving WHS
- Innovative adaptation, driven by case-specific interdisciplinary analysis will be essential in maintaining the UOV of WHS
- Early adaptation is necessary

Thank you for your attention!

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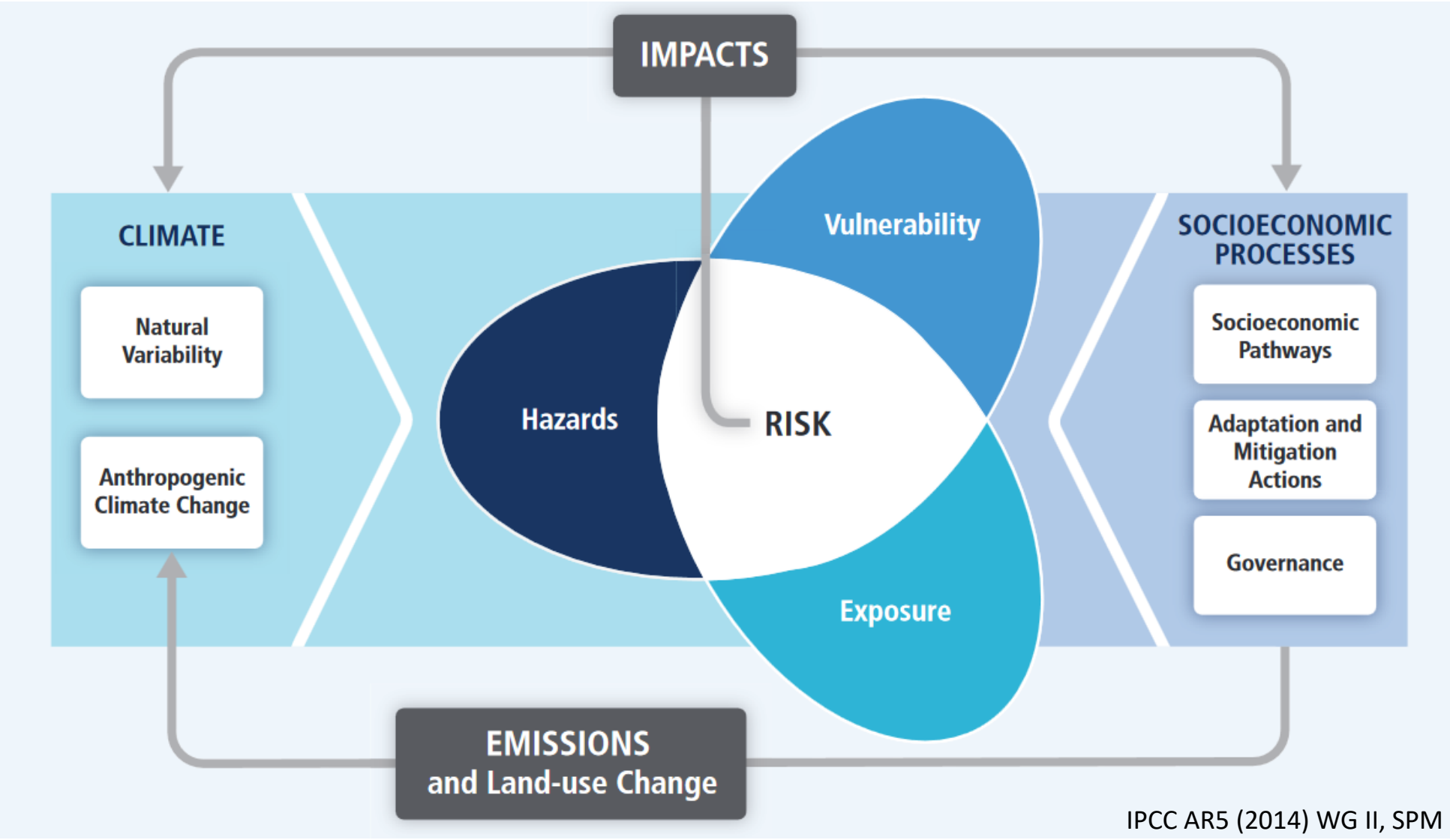
Risk framework



IPCC AR5 (2014) WG II, SPM

World Heritage data processing

- Correct downloaded point coordinate data
  - Add data entry of each serial site
  - Relocate misplaced points
- Manually digitize polygon of each site

Old City of Dubrovnik, Croatia

Risk analysis – Flood Risk

FLOOD RISK

100-yr floodplain

- Storm surge
- Regional sea-level rise

- Flood area
- Flood depth

Risk analysis – Erosion Risk

EROSION RISK

Sea-level rise

- Distance from the coast
- Coastal material
- Mean wave height
- Sediment supply