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Incorporation of multiple disaster risk reduction strategies into a global coastal flood risk assessment framework

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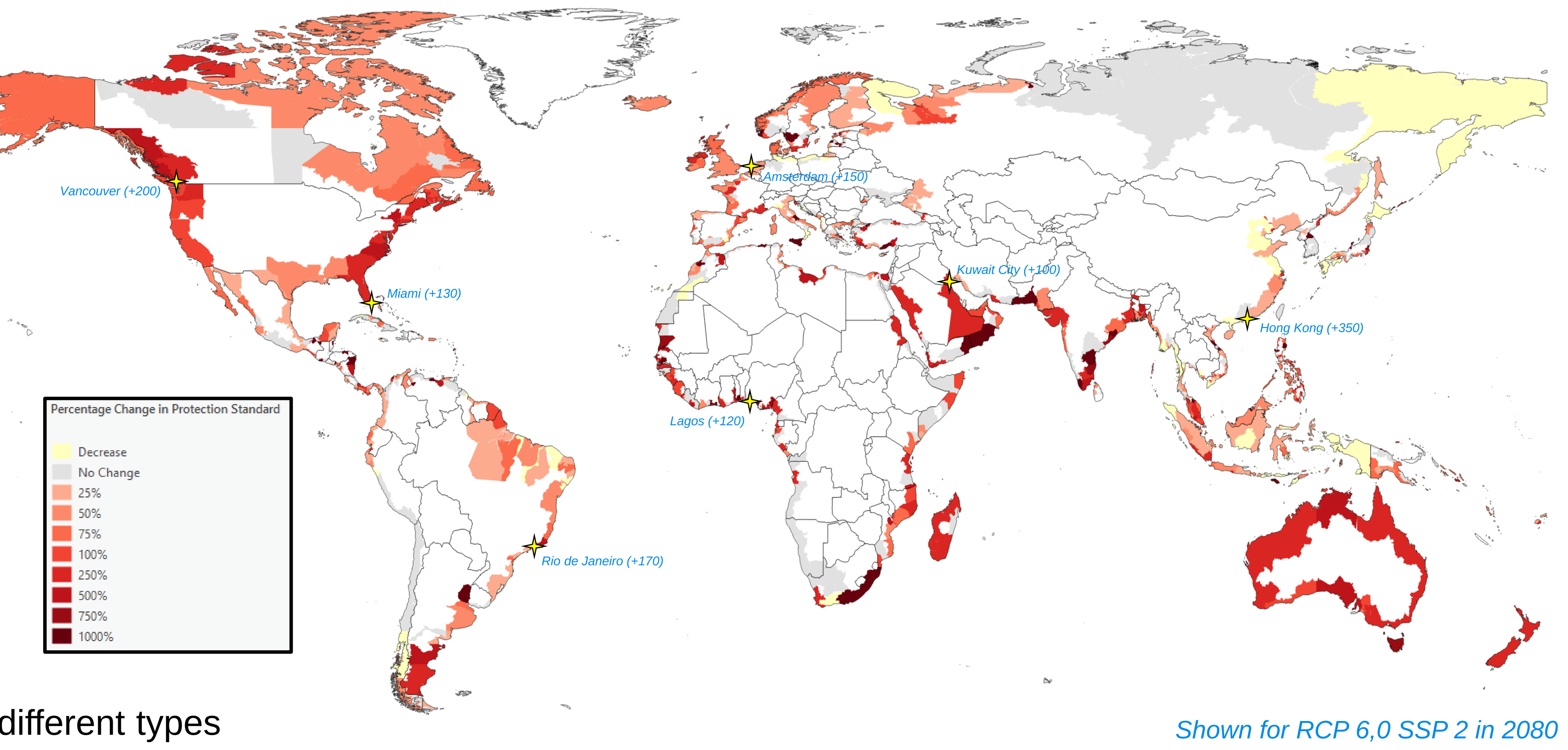
Abstract

Coastal flood risk is a major global challenge, and this risk is only expected to increase over the next several decades. Several disaster risk reduction (DRR[1]) strategies have been posited as methods of mitigating the deleterious impacts of coastal flooding and have been demonstrated in several small- to regional-scale applications around the world. These include structural measures, nature-based solutions, floodproofing of existing assets, land use planning, etc. **Unfortunately, the ability to model such strategies on the global scale is rather limited.** Most efforts undertaken typically examine potential risk reductions of structural measures alone (e.g., dikes and levees), and none have ever determined the reductions to be expected from employing multiple strategies at once. **The best solution for any given location may be a non-structural strategy, or a combination of strategies**.

This work looks to examine this potential by 1) modeling several different types of DRR strategies within the same global flood risk modeling framework (GLOFRIS[2]) and 2) determining what risk reductions are possible via (combinations of) these disaster risk reduction strategies. By using a disaster risk framework (i.e., **risk defined as a product of hazard, exposure, and vulnerability**[3]), benefit-cost analysis, and a baseline for reductions that should be achieved in the future, we determine expected levels of risk for different regions of the globe for various scenarios. In forthcoming work, we will further demonstrate which (combinations of) strategies may achieve similar levels of overall risk reduction that would be anticipated with solely structural measures.

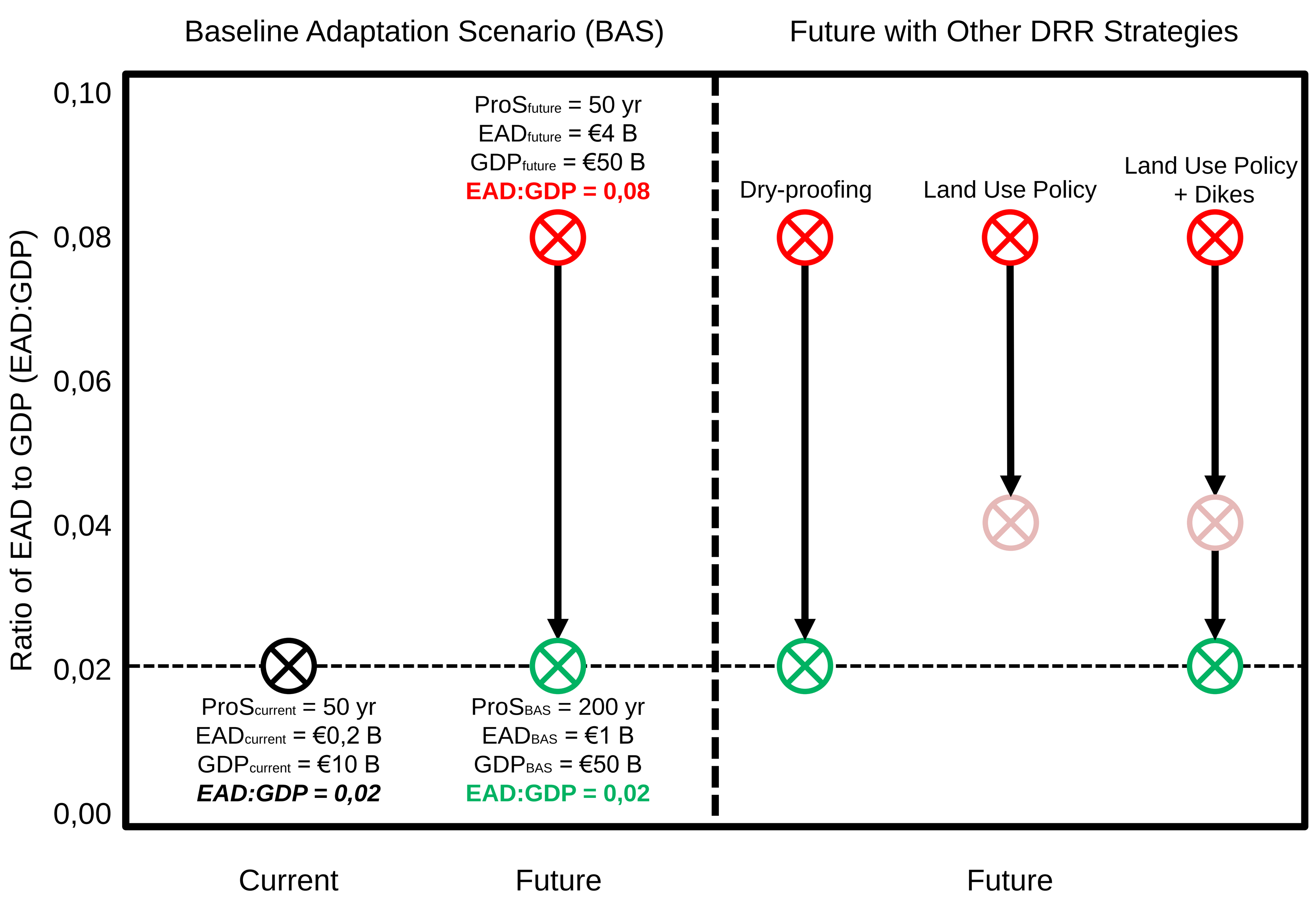
Required Changes to Flood Protection Standards (Current to 2080)



Shown for RCP 6,0 SSP 2 in 2080

This figure depicts the estimated necessary increases to current protection standards to maintain the current EAD:GDP ratio per global subunit. Certain locales require no changes. Most coastal regions, however, will require at least a **protection standard increase of almost 70%** to ensure a 2080 EAD that does not exceed current levels relatively. Major urban areas affected by the largest absolute increases of protection standard are marked for reference.

Conceptual Framework



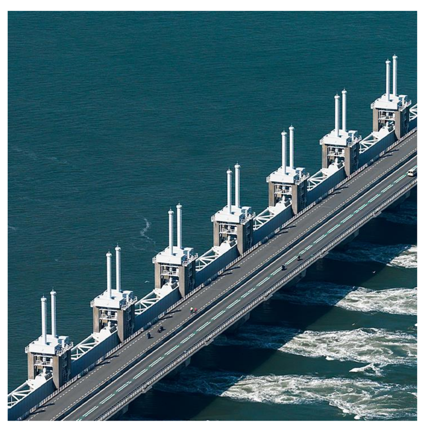
A **baseline adaptation scenario (BAS)** is established to guide risk reduction modelling in this research. For each global subunit, the ratio of current expected annual damages (EAD) caused by coastal flooding to current gross domestic product (GDP) is calculated and set as a threshold. This threshold is not to be exceeded in the future, meaning in most cases current protection standards (ProS, as determined through FLOPROS[4]) must be increased. BAS establishes what increase of protection standard (using structural measures) would be needed to reduce future damages to a level at which the EAD:GDP ratio would be achieved. Other DRR strategies are modelled and assessed **to determine how much risk reduction can be achieved relative to the BAS.**

SELECT REFERENCES

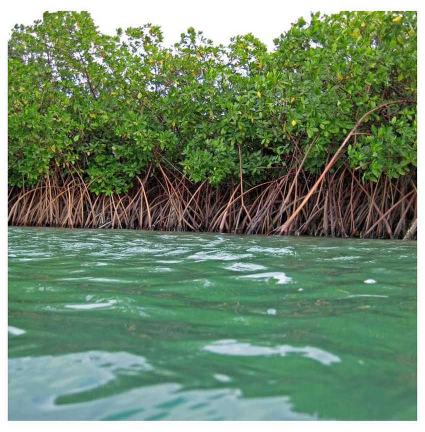
1. United Nations Office for Disaster Risk Reduction (2020) www.undrr.org
2. Winsemius et al. (2013) https://doi.org/10.5194/hess-17-1871-2013
3. Kron (2005) https://doi.org/10.1080/02508060508691837
4. Scussolini et al. (2016) https://doi.org/10.5194/nhess-16-1049-2016
5. Haasnoot et al. (2013) https://doi.org/10.1016/j.gloenvcha.2012.12.006

Modelled DRR Strategies

Reducing…	Hazard		Vulnerability	Exposure
	Dikes/levees (BAS)	Mangroves	Dry-proofing	Land Use Policy



Structures built to protection standard required to maintain EAD:GDP ratio



Extent of mangrove and other foreshore vegetation expanded in future

All urban assets within 100-year flood zone protected up to 1 meter

Future urban development prohibited in 1000-year flood zone

Preliminary Results

After small-scale site studies, global trial runs, and preliminary analysis, the following general points can be inferred:

- For areas with low levels of protection that need only marginal increases (e.g., remote areas), **dikes and levees tend to be cost prohibitive**
- Dry-proofing of assets in existing urban areas with low projected future growth seems to show **most potential as the alternative** of BAS
- Areas which already have major structural measures in place will struggle to find additional substantial risk reductions from other strategies
- Land use policy alone **cannot be leveraged** as a feasible strategy
- Most potential for hybridization is in areas of **high projected future growth** and **in climate regions which support** mangrove ecosystems

Moving Forward

In coming months, this analysis will be finalized and extended to…

- include **fully-hybridized** results of these and additional DRR strategies
- examine risk reduction potentials for **riverine flood hazard**
- consider the impact of **dynamic adaptive policy pathways** (DAPP[5])

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This poster was created by Eric Scott Mortensen for the Second International Conference on Natural Hazards and Risks in a Changing World 2021, hosted by the University of Potsdam on 5-6 October 2021 in Potsdam, Germany.