Nature-based and hybrid solutions to reduce coastal flood risk: A global perspective

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Introduction

Coastal floods are one of the deadliest and costliest natural hazards, triggering or contributing to property damages, loss of life and livelihood, economic disruption, displacement, and poverty traps. In the coming century, coastal communities are projected to face increases in coastal flood risk as coastal areas are experiencing increases in urban development, sea-level rise, and degradation of foreshore vegetation.

Flood risk can be reduced by implementing **adaptation measures** such as grey and structural measures (e.g., dikes and levees), Nature-based Solutions (Restoration of foreshore vegetation) or a combination of both (hybrid). Nature-based Solutions protect against coastal flood risks and provide other benefits as well, such as improved water quality, recreational opportunities, fisheries support and enhanced carbon sequestration.

The importance of climate change adaptation and disaster risk reduction is recognized in several global agreements, such as the Paris Agreement and the Sendai Framework for Disaster Risk Reduction. However, relevant national and regional decision makers face difficulties in aligning their planning and risk reduction objectives with these global agreements, partly due to a poor understanding of the effectiveness of potential adaptation measures.

To better understand the potential posed by Nature-based Solutions and hybrid strategies on coastal flood risk reduction, we conduct several assessments of feasibility and aftereffects. Further, we assess the spatial pattern of vulnerability indicators (poverty and regional wealth index) to assess where the benefits could amplify when looking into non-monetary indicators.

Effectiveness of Nature-based Solutions alone

To assess the effectiveness of any DRR measure, a baseline of desired risk reductions must be established. As outlined by the Sendai Framework, an equitable target of risk reduction needs to be established to ensure a realistic pathway forward for all regions of the world, regardless of development state or socioeconomic status. Arguably, **the relative-risk constant** option for a future risk reduction pathway is most equitable, and therefore can be used to establish a desired target for risk reduction.

If foreshore restoration alone is considered as an option for future flood risk adaptation, we see that many regions of the world are only able to achieve limited reductions to EAD (**by 2080, roughly 15% on average of total needed reductions to achieve relative-risk constant status globally**). The most notable potentials for reductions to EAD are seen in along the Indian Ocean and well as in southeast Asia, where many existing stocks of mangrove exist.

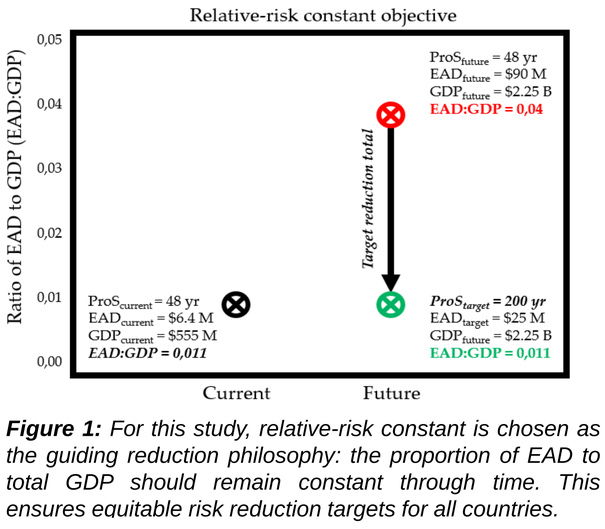
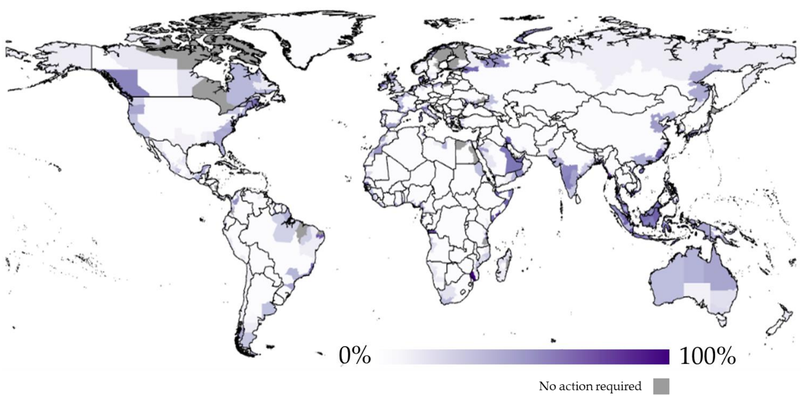


Figure 1: *For this study, relative-risk constant is chosen as the guiding reduction philosophy: the proportion of EAD to total GDP should remain constant through time. This ensures equitable risk reduction targets for all countries.*



This work shows that while some regions show promise in achieving considerable to significant reductions to EAD via Nature-based Solutions alone, hybridized solutions also must be considered as an option on the global scale moving forward.

Figure 2: *On the global scale, conserving and expanding existing foreshore vegetation results in notable risk reductions in certain cases (for example, most Indonesian provinces, much of Australia, Persian Gulf, etc.). In general, though, Nature-based Solutions alone are only able to contribute approximately 15% of total desired EAD reductions on the global scale.*

The effectiveness of hybrid strategies

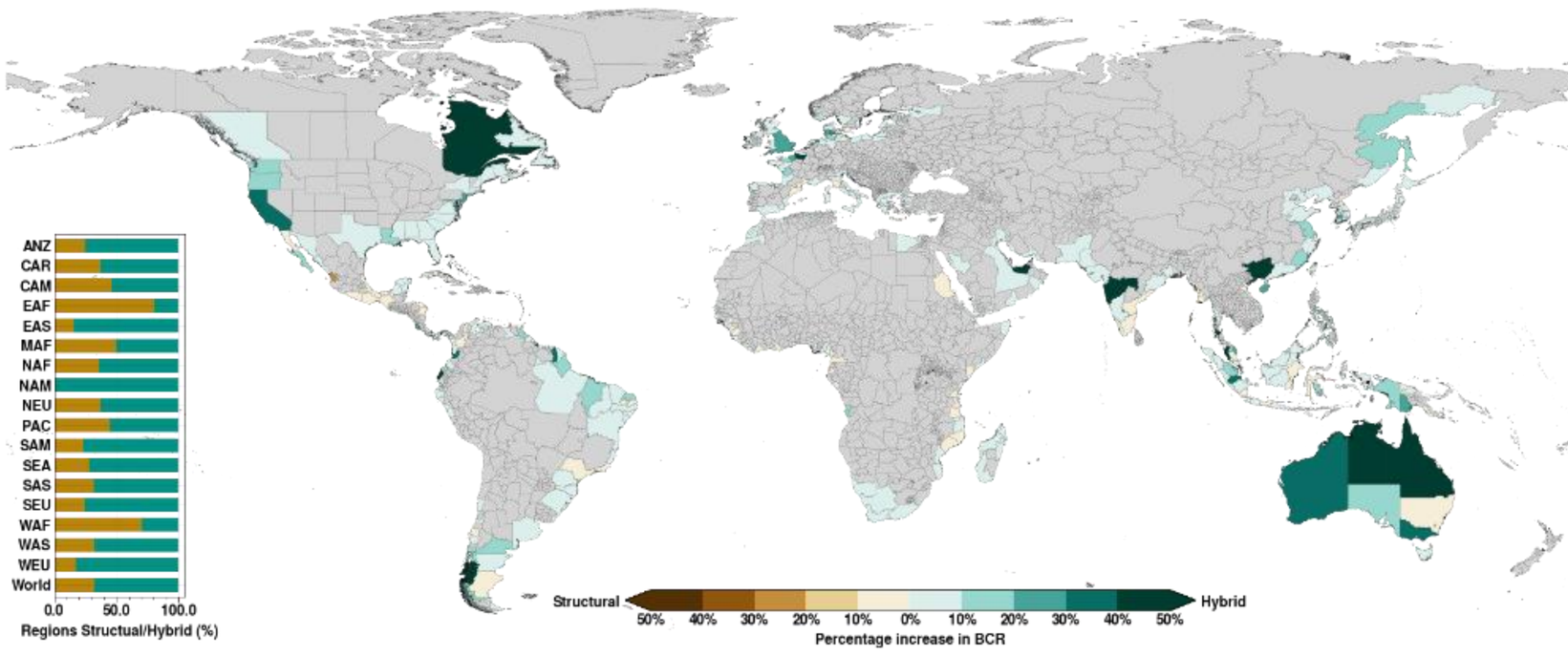


Figure 3: *Percentage increase in BCR for implementing solely structural measures versus hybrid strategies. Percentage sub-national regions favouring structural/hybrid strategies per subcontinental region are shown in the panel on the left side.*

To show the effectiveness of combining measures, we estimate the increase or decrease in cost-effectiveness in terms of change in BCR between structural measures only and hybrid strategies. **Our analysis shows that there is value gained in using hybrid strategies compared to structural measures only for two-thirds (68%) of the regions assessed** for the scenario RCP4.5/SSP2 as is shown in the left panel of Figure 1.

Social vulnerability: Poverty indicator

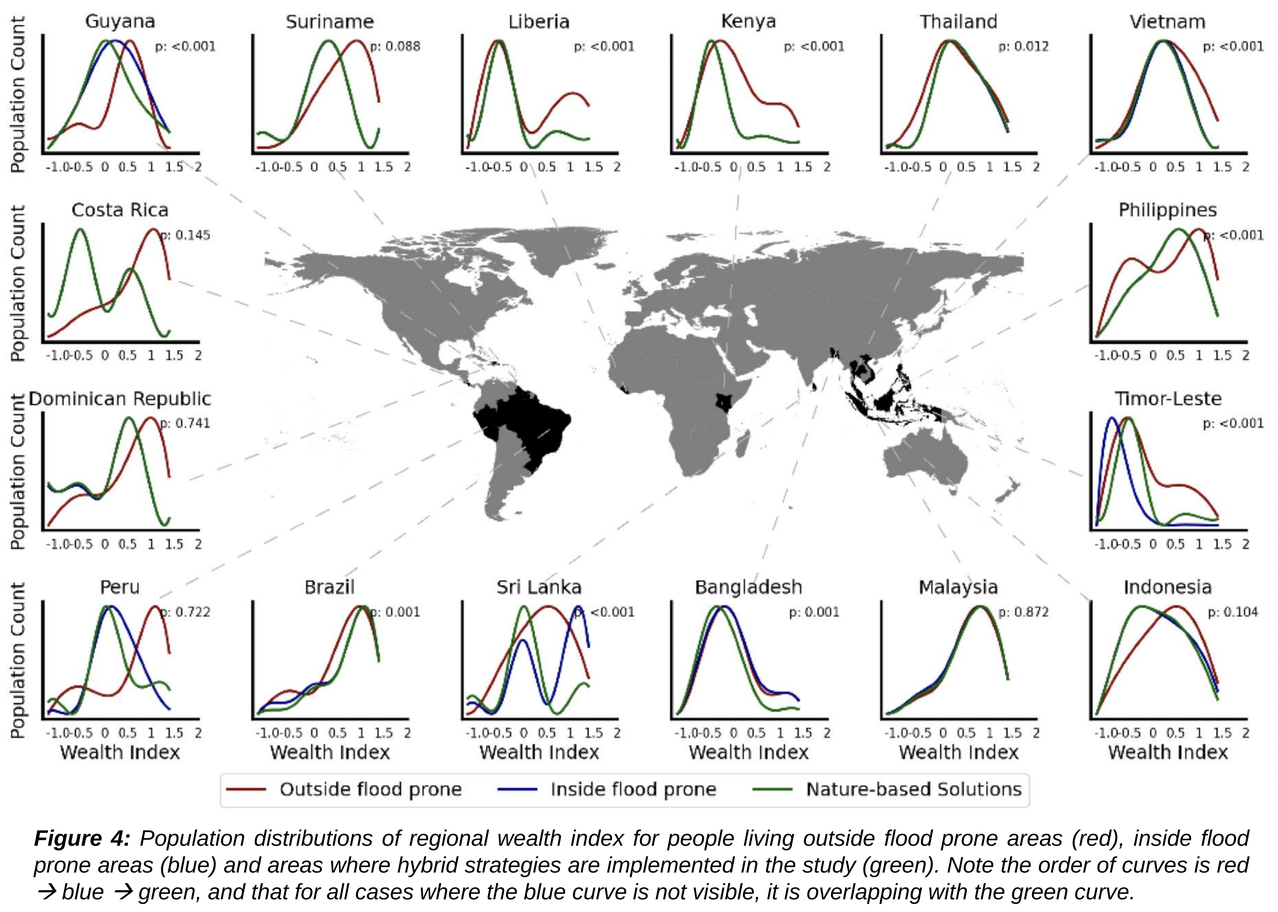


Figure 4: *Population distributions of regional wealth index for people living outside flood prone areas (red), inside flood prone areas (blue) and areas where hybrid strategies are implemented in the study (green). Note the order of curves is red → blue → green, and that for all cases where the blue curve is not visible, it is overlapping with the green curve.*

We find that in most countries people living in flood prone areas where Nature-based Solutions can be implemented tend to have low values of the wealth index, indicating that **if these measures would be implemented, they could contribute to the reduction of climate shocks to people with low wealth index**. This is particularly remarkable in the face of the escalating climate crisis.

Outlook

The results of the studies presented show that Nature-based Solutions are an effective measure in combination with structural measures to contribute to future flood risk mitigation. Further, future benefits from implementing Nature-based Solutions will amplify when looking into non-monetary indicators such as social vulnerability indicators (poverty) and Nature Contributions to People.

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