SHOULD WE ADAPT OR RETREAT FROM THE WORLD'S COASTS?

Manufacturing, oil and gas, mining, all have needs that require waterfront venues, however, direct water access introduces the risk of coastal hazards such as flooding and erosion. These hazards can pose a significant threat to the development and sustainability of coastal communities and infrastructure. In particular, major destructive coastal events can result in staggering loss of life and property damages. For example, the Indian Ocean tsunami of 2004 cost approximately 130,000 lives and resulted in losses of $4.5-8.7B USD, and Hurricane Katrina (2005) cost approximately 1,200 lives and $108B USD in property damage.

As sea levels rise and major destructive coastal events increase is it better to stay the course and pay increasing expenses to mitigate and address coastal hazards and face increasing risk of life loss, or is it better to plan to retreat from the coast?

Although simply stated, the answer is often not straightforward. Flooding and erosion hazards are driven by several interacting mechanisms, including the action of tides, waves, storm surges, and tsunami. These interacting mechanisms are complicated by long term climate effects, especially when considering the range of possible future conditions.

Let's highlight some of the interacting mechanisms, starting with tide. Tides are well understood and directly predictable with a high degree of certainty. It's also relatively straightforward to predict site specific wave actions through deterministic modelling (wave actions are determined by the selected initial conditions and model inputs). The complexity begins when you introduce additional mechanisms into the situation through storm surge or tsunami conditions. The way that individual processes, or combinations thereof (e.g., tide and either storm surge or tsunami), contribute to overall coastal hazards for a site is far less simple. Event based data for large combination events are relatively rare. To add to this complexity, our understanding of future conditions is still evolving. Climate change is anticipated to contribute to sea level rise, changes in the intensity and distribution of storms (e.g., hurricanes are expected to become more extreme), and changes in ice cover at northern latitudes, resulting in increased exposure to flooding and erosion hazards.

To understand and mitigate the risk posed by multiple coastal hazards, now and into the future, requires understanding the likelihood of coastal water levels reaching a given height or exerting a given amount of force that may cause damage. As global sea level rises, the action of tides, waves, storm surges and tsunamis increase the likelihood of extensive coastal flooding and erosion. Our simple coastal question just became a lot more complex, requiring detailed technical knowledge to answer.

Answering the coastal question requires a multi-step approach with a long term (life of project) perspective to support decision making around reducing the risk of coastal hazards (Figure 1).

Key to this multi-step approach is the ability to represent the complex interactions through probabilistic modelling. Probabilistic modelling introduces randomness in the model inputs to capture a broad range of potential outcomes. The randomness represents unknowns in the interacting mechanisms and the uncertainty of future climate conditions. Due to the complexity of coastal hazards, it is unreasonable to expect that the likelihood of all possible outcomes can be estimated. However, probabilistic modelling can improve decision making by improving understanding of the key drivers of risk but more importantly the relative importance of the uncertainties involved.

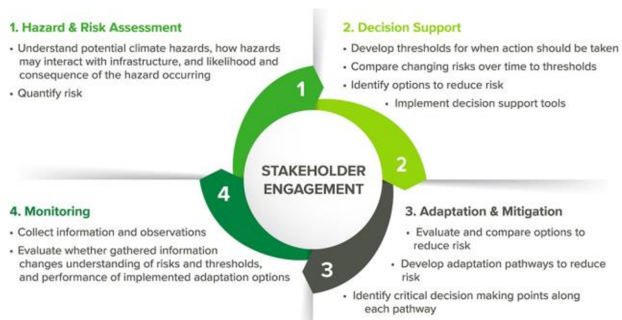

Figure 1: Multi-step approach to address coastal risk

1. Hazard and Risk Assessment

The first step in the approach, Hazard and Risk Assessment, identifies the potential hazards and quantifies the associated risk. This stage focuses on applying detailed technical knowledge to inform and support the risk assessment. Deterministic and probabilistic modelling is used to represent the impact of coastal hazards under current and future climate conditions.

2. Decision Support

The second step, Decision Support, begins to transform the technical information into a decision-making framework to support the stakeholders impacted by the coastal hazards. Technical expertise is matched by practical experience when identifying potential options to reduce risks and all potential options are considered at this stage. Key to this step is development of thresholds to signal when action should be taken because the risks are no longer manageable. For simpler projects, the thresholds may act directly as the decision support tools, but for more complex projects, more complex tools (e.g., multi-criteria analysis) can support decision making.

3. Adaptation and Mitigation

At the beginning of the third step, Adaptation and Mitigation, the necessary pieces of information around coastal risk (including uncertainty and potential data gaps) have been identified and the planning of practical actions begins. Practical actions may include gathering more information to better understand coastal hazards and their risks or implementing options to reduce the risk of coastal hazards. Before options can be implemented, they should be evaluated and compared to identify the best solutions to meet the needs and concerns of the stakeholders. Adaptation pathways document how and when these options will be implemented, including any critical points where decisions need to be (e.g., where the original path forks and can follow multiple paths pending additional input available at that time).

4. Monitoring

The final step, Monitoring, supports the outcomes of the previous three steps. In this stage, the understanding of the coastal risks and how they have been represented in the previous three stages is monitored through collecting additional information, incorporating this information into the adaptation pathways and evaluating the performance of any implemented options in reducing risk. This final step is focused on practical actions to support continuous improvement. Understanding coastal risk is not a static process. The approach to address coastal risk requires continuous improvement to monitor whether implemented options to reduce risk are performing as planned and to monitor for any changes in the understanding of the coastal risk.

Finally, stakeholder engagement is central to this approach to addressing coastal risk. Without meaningful engagement, the transition from technical knowledge to practical solutions is challenging. Stakeholder engagement needs to be incorporated into every step outlined above, with the amount of engagement increasing with each step. This will best capture the needs and concerns of the stakeholders involved. The adaptation pathways and practical actions are unlikely to be successfully implemented without ownership from stakeholders. The approach to address coastal risk captures complex concerns with meaningful actions, empowering stakeholders to confidently make decisions into the future. With the transition of solution ownership from technical experts to the stakeholders, this approach also supports stakeholder's sustainability goals by documenting climate resilience of coastal structures. The multi-step approach transparently documents the consideration of climate change in risk management. Demonstration of climate resilience and climate risk management are increasingly being requested by stakeholders, active investors, and climate disclosure programs.

Is it better to stay the course and adapt to changing coastal hazards or is it better to plan to retreat from the coast? The answer depends on the needs and concerns of the stakeholders involved. Our scalable approach is focused on stakeholder engagement and continuous improvement, to support long term climate resilience and sustainability.

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