Coastal Hazard and Risk Mitigation

Taking an integrated approach to protect people and places

Context and Importance of the Problem

The coast is a dynamic and constantly-changing environment that is incredibly productive both ecologically and economically. Forty percent of the world's population lives within 100 km of the coastline (UN 2017) and the trend of population migration to urban coastal areas is increasing. Living in this region brings its own set of hazards and mitigating the risk of impact from these hazards requires a dynamic and multisectoral approach. Such an approach must plan for future population growth and encourage preparedness for disasters. Hazards can be natural such as tsunamis, cyclones/hurricanes, earthquakes, storms and storm surges, as well as human-induced for example oil and chemical spills, environmental destruction and habitat removal, algae blooms, and invasive species introduction. Further, climate change is an anthropogenic impact that exacerbates natural hazards due to higher global mean sea level and the increased frequency and intensity of tropical storms (Figure 1).

Figure 1:
Cyclone damage in Barbuda that suffered back to back category 5 hurricanes in 2017 (UN Photo/Rick Bajornas)

Irrespective of the contribution of climate change, uncertainty exists in the coastal zone about the magnitude, frequency and extent of impact from both natural and human-induced hazards. Preparedness and investment are key to mitigating the risks and a coordinated and planned investment provides benefits for both short-term damage and long-term development efforts. Years of observation on the impacts of coastal hazards, in developed and developing countries alike, has shown that inadequate preparation for, and response to, emergency situations have contributed to widespread damage and the avoidable loss of lives and livelihoods (IOC 2009). In some instances these shortcomings have been due to a lack of warning through poor regional detection and communication systems. But in many cases, they have reflected inadequate awareness, planning and coordination on the part of national and local authorities and agencies.

Furthermore, long-term development that considers prevention and awareness of disasters builds resilience in the coastal communities and environment. Where the link between environmental management and disaster reduction and mitigation is strengthened, both short term and long term benefits are seen. Preserving and regenerating mangrove forests, for example, provides physical coastal protection benefits in few short years as well as longer-term fisheries benefits through critical fish habitat.

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In order to take a long-term investment view and calculate such benefits the local measures are best considered at national or regional level. This allows a coordinated approach of local and on-the-ground efforts to produce an outcome that is greater than the sum of its parts. For example, ensuring the spatial proximity of each local mangrove restoration effort takes into account migration patterns of targeted fisheries species. The coordinated approach should also be considered across multisectoral stakeholders. How are the interests of the environment, fishery industries, tourism, local landholders, all considered? It is this integration of risk assessment and mitigation into coastal area use and planning that is key.

*"**Hazards** can be natural or anthropogenic processes, phenomena or events that may cause loss of life, injury or detriment to health, property damage, social and economic disruption or environmental degradation.*

***Risk** is the potential of the hazard causing these harms while taking into account our capacity to mitigate the impact of the hazard" (UNDRR 2015)*

Resilience can be strengthened when coordination occurs over large spatial areas, such as the Large Marine Ecosystem (LME) level. This provides a clearly-defined understanding of the boundary in which coordination is to occur. The environmental services and regional interconnectivity within the LME are measurable above just the local level and therefore become manageable. This regional approach offers benefits from coordinated early-warning systems to regional management of fisheries through networks of refugia and protected areas.

Critique of Policy Options

Vulnerability Assessment

Consideration of coastal hazards and the adaptation of appropriate planning responses can provide economic, environmental and social benefits. In order to assess a hazard and its magnitude, the vulnerability of the coastal system and its components (population, infrastructure, ecosystems, livelihoods) must be assessed.

Determining vulnerability using the three components of exposure, sensitivity and adaptive capacity (Figure 2), provides an approach that considers both the threat and existing resilience in the coastal system. Both resilience and weakness can be in the form of both physical and procedural structures and the vulnerability assessment must reflect this. Such an assessment should therefore be conducted by a combination of multidisciplinary expert input and participatory actions.
For instance, measuring changes in coastal erosion rates or pollution spill pathways requires specialised skills while surveys and data collection, such as monitoring invasive species or reporting fish catch, can engage a mix of experts, organisations, local/provincial/national government and community members. By conducting a vulnerability assessment, the magnitude of hazards in the coastal zone can be determined and prioritised accordingly in coastal planning and investment decisions.

*"**Vulnerability** is usually defined as the capacity of a system to be wounded from a stress or perturbation. It is a function of the probability of occurrence of the perturbation and its magnitude, as well as of the ability of the system to absorb and recover from such perturbation." (Suarez 2002)*

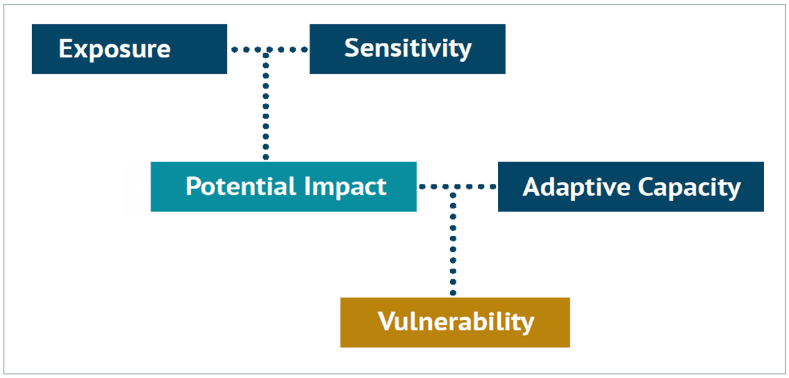

Figure 2:
Vulnerability is a function of exposure, sensitivity and adaptive capacity (MERF 2013).

Tools exist to conduct vulnerability assessment. They form an important part of effective Integrated Coastal Management (ICM). Undertaking an assessment of vulnerability to determine hazards strengthens the ICM framework and process at the LME-scale, where many coastal and marine processes are interlinked. Hazard mitigation efforts, such as contingency planning and integration of land and marine resource planning, increases the economic, environmental and social resilience in the coastal zone. Further, planning for identified risks and probable future events allows natural and human-induced disasters to better prepare for. This preparedness is true in terms of both physical investments in infrastructure, equipment and spatial planning as well as in education, training and awareness with the public, managers and emergency responders.

Risk Mitigation

There are ways of reducing risk which are sustainable and can be embedded in the culture of those communities, irrespective of the coastal communities' physical or developmental situation (IOC 2009). Essential to this is the need to achieve coordination of effort among the many stakeholders, whether in the assessment of risk, the planning and implementation of mitigation measures, or the emergency response. The successful application of these processes, whether in planning or in emergency response, will depend above all on the effective operational coordination and cooperation of the many parties involved. This adaptive capacity (see Figure 2) determines the overall coastal vulnerability and is where most improvements can be made to reduce the negative impact of coastal hazards.

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__Risk__ is the potential of the hazard causing these harms while taking into account our capacity to mitigate the impact of the hazard.

To be successful, sustained levels of cooperation and coordination are required between all the involved agencies which are difficult to achieve, even in developed countries (IOC 2009). Coordination among national and local authorities as well as regionally between countries and international agencies ensures effective identification, management and response to risks. Mechanisms of coordination among the authorities, communities and agencies must be adaptive and involve hazard-related risk assessment and management processes, both for potentially catastrophic events and long-term progressive hazard reduction and preparation.

Policy makers should consider the cumulative risks of all coastal hazards and distinguish the different types of risks associated with individual hazards and events. This facilitates the prioritisation of the hazard-prone areas and hazards that have a higher likelihood or occurring, or higher risk of catastrophic damage when they do. Using this prioritisation approach then provides policy makers and planners with a basis for developing a management strategy to reduce the community's exposure and vulnerability to these hazards. Such a strategy will need to be developed under an ICM, or similar multisectoral, approach. Decisions must be made that take into account the wide range of stakeholder interests and impacts on other coastal management pressures. The management strategy will also need to identify responsibilities, both operational and financial. The assurance of adequate funding, whether national or local, is an important consideration in the successful execution of the plan and sustaining the cooperative approach.

Integrated Coastal Management

Figure 3:
Fisheries are an essential part of coastal communities and economies (UN Photo / Evan Schneider)

Links between environmental management and disaster reduction and mitigation requires strengthening in both policy and practice. The integration of vulnerability assessment and risk mitigation into coastal area planning is key. Strengthening the ICM framework and process, through risk assessment, contingency planning and integrated land-based activities and marine-use planning ensures that local governments are able to respond to disasters by instituting the culture of safety before hazards wreak havoc (IOC 2009). ICM has been successfully used at the regional-scale by the partnerships in Environmental Management for the Seas of East Asia (PEMSEA), an intergovernmental organization operating in East Asia to foster and sustain healthy and resilient oceans, coasts, communities and economies across the region. ICM provides a framework to assess the vulnerability of the coastal zone to physical processes, such as erosion, flooding, land-based activities, as well as management gaps, such as disjointed spatial planning and communication between ministries and agencies. ICM efforts must not only assess the natural hazards to a coastal area, but also consider how human activities and development may both rely on and affect the coast's vulnerability (Figure 3).

Disasters and Development

Management of coastal hazards and risks at the LME level allows for regional preparedness and coordination for disasters. The UN Office for Disaster Risk Reduction (UNDRR) is responsible for implementing a voluntary, non-binding agreement which recognizes that the primary role to reduce disaster risk is at the national level but that responsibility should be shared with other stakeholders including local government, the private sector and other stakeholders. This agreement, the Sendai Framework (2015-2030), aligns with ICM taking a multisectoral approach to disaster management, with the desired outcome of a substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries (UNDRR 2015). This shared-responsibility approach towards disaster risk management should be based on a broad understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure, hazard characteristics and the environment. Such

Figure 4:
Aftermath of Hurricane Matthew, Haiti (UN Photo/Logan Abassi)

knowledge can be used for risk assessment, prevention, mitigation, preparedness and response. Strengthening the response requires collaboration and partnership of governance at the national, regional and international level. This is important across the entire timeline of disaster in prevention, mitigation, preparedness, response, recovery, and rehabilitation efforts. Lastly, the recovery, rehabilitation and reconstruction phase is a critical opportunity to build back better, including through integrating disaster risk reduction into development measures (UNDRR 2015).

Considering a multi-pronged approach

Policy makers will usually have to take a multi-pronged approach to risk mitigation and incorporate a variety of the protection, development and management options available to be most effective. No single approach by itself will be able to address vulnerability to coastal hazards. Once an overall strategy is identified, policy makers must choose specific measures to implement the selected strategy. These measures could protect against, accommodate to, or retreat from the identified hazard. Examples of protective measures are the building of physical infrastructure or restoration of mangrove habitat to combat coastal storm surge damage. An accommodating measure would modify behaviour to protect against the hazard, such as training and testing of tsunami early warning evacuation systems or proper waste oil containment and disposal procedures. An example of a retreat measure would be adapting land and marine spatial planning regulations to identify public open space areas where protection of infrastructure and lives is financially or physically feasible. Often, a combination of these measures will be needed and to be implemented at different time scales and in consideration of the political, legal and socio-economic context.

When selecting management measures, policy makers should consider the management of risk as well as the potential effects of those measures on coastal resources, public access, recreational space and the environment. The whole coastal management system needs to be taken into account in deciding on the mitigation approach. For example, policy makers might focus on a retreat strategy with some protection elements such as the development of a special zoning overlay district that establishes a setback for structures along a shoreline. Such an approach might also achieve the benefits of protecting riparian habitat, providing public lateral access and establishing a vegetated zone to protect and potentially improve coastal water quality (IOC 2009). Alternatively, for a highly developed area, a protection response should include warnings and evacuation elements to manage residual risk. Further, if the protection degrades coastal ecosystems, habitat creation could also be considered in appropriate locations. This is much more feasible and effective when operating at a cooperative regional scale and using the LME to set the geographical and ecological boundaries.

The application of decision-analysis tools

Making decisions and designing policy to manage hazards and mitigate risk involves multiple decision-makers and multiple stakeholders. At the LME or regional level these decision-makers and stakeholders become even more numerous and diverse in their immediate priorities. Managing conflicting needs and interests between stakeholder groups is a key challenge. With so many variables to consider, policy makers can find it very challenging to decide which strategy and measures would be best. Decision analysis tools can be very helpful in evaluating the various benefits and drawbacks of each option. Two examples of decision-analysis tools are cost-benefit analysis and multi-criteria analysis. Cost-benefit analysis involves comparing the total cost of one or more strategies with the total benefits it would provide. When the benefits outweigh the costs, the approach would be effective and have an overall benefit to the community. In order to perform a cost-benefit analysis, all costs and benefits must be translated into a common denominator – typically monetary. Ecosystem services must be included in the analysis, for instance, the monetary benefits of protection afforded by coral reefs and mangroves or industry benefits of tourism and fisheries. Multi-criteria analysis can be helpful for analysing complex, multi-disciplinary strategies with multiple criteria and objectives. Multi-criteria analysis does not require that all alternatives be placed in monetary terms, but can incorporate both quantitative and qualitative data, including value judgements (IOC 2009). While there are many different types of decision analysis tools to select from, policy makers should be sure the analysis will provide a reasonable comparison of the short- and long-term costs of protection, accommodation and retreat, and account for the major socio-economic and environmental costs of the alternatives as well.

Public involvement

Public opinion and wide stakeholder involvement are valuable tools that should be included in the decision-making process as the risk management strategy is developed. Public support and buy-in is important for the success of the hazard and risk mitigation as it is for ICM in general. To engage the public, policy makers should educate them about the risks, benefits and drawbacks of various management options. The public should have the opportunity to provide input on the level of risk that is acceptable or needs to be managed. Local communities may also have their own measures and contributions in place such as coastal vegetation rehabilitation groups and pollution awareness campaigns.

Policy Recommendations

Preparedness and investment are key to identifying hazards, assessing vulnerabilities and mitigating risks. This needs to be undertaken in an approach that supports sustained coordination to provide benefits for both short-term protection and long-term resilience. ICM offers the multisectoral and regional cooperation framework to achieve this, facilitating involvement at the community level as well as regional partnership. Policy recommendations that will assist with coastal hazard identification and mitigation of identified risks are:

- Determine the geographical extent of the coastal management areas, such as at the LME level, to then bring together the partner countries, institutions, industries at national and local levels. Regional coordination offers great benefit for early warning systems and management of the marine resources.
- Integrate hazard assessment and risk mitigation into coastal area planning as part of an ICM framework and process.
- Undertake a vulnerability assessment that considers existing adaptive capacity as part of a broader ICM approach to hazards and risk mitigation.
- Consider the cumulative risks of all coastal hazards and use a prioritisation approach to develop a risk management strategy that reduces the community's exposure and vulnerability to these hazards.
- Recovery, rehabilitation and reconstruction after natural disasters is a critical opportunity to build back better and integrate disaster risk reduction into sustainable coastal development measures.
- Take a multi-pronged approach to risk mitigation and incorporate a variety of the protection, development and management measures.
- Use decision support tools such as cost-benefit or multi-criteria analyses to better identify trade-offs and opportunities.
- Work with a breadth of experts in coastal processes and human activities, both land-based and marine, as well as participatory engagement with local institutions and populations.

Case Study: PEMSEA

Partnerships for Environmental Management for the Seas of East Asia (PEMSEA) is an intergovernmental organisation facilitating regional cooperation to sustain resilient coastlines and healthy seas across six LMEs of South East Asia including the South China Sea, the Gulf of Thailand, the East China Sea, the Yellow Sea, the Sulu-Celebes Sea, and the Indonesian Sea (Figure 5). One of PEMSEA's three focal areas is Disaster Risk Reduction. This covers human and natural disasters including harmful algal blooms, sea level rise, flooding, landslides, extreme weather events and oil and chemical spills. Support is provided at the regional level to partner countries in producing vulnerability assessments, risk mitigations, and resilience and preparedness systems. Adaptation and response are core mandates at the regional level and this has been successful in part due to ICM, which was pioneered in East Asia by PEMSEA. This offered a holistic approach for addressing complex coastal issues by combining governance, management, economics and cross-cutting scientific solutions. ICM provided a proven, practical tool for operationalizing sustainable development and the principles of ecosystem- based management (EBM) of coasts and oceans.

Figure 5:
PEMSEA has facilitated ICM coverage over 17% of the region's coastline, across 12 countries (PEMSEA)

> *"PEMSEA has applied integrated coastal management in dozens of sites across the region, impacting more than 42,000 km, or 17%, of the region's coastline and over 146 million people living in coastal and watershed areas." (PEMSEA 2018)*

At the regional level, the 14 PEMSEA Partner Countries recognised numerous coastal and ocean-related challenges in the region and have adopted an integrated development and disaster management package of principles, strategies and objectives. This Sustainable Development Strategy for the Seas of East Asia (SDS-SEA) takes account of global agreements and targets, including the UN Sustainable Development Goals, the UNFCCC Paris Climate Agreement, the Convention on Biological Diversity-Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets, and the Sendai Framework for Action on Disaster Risk Reduction and Management. This allows regional adoption of global efforts to improve livelihoods and the environment while incorporating hazard identification and risk mitigation of both disaster and human-induced origin.

Hazard and risk mitigation is also supported at the national and local level. One such example is the Manila Bay Oil Spill Contingency Plan. This was developed by local government units and national government agencies in partnership with oil and shipping companies and other stakeholders with technical assistance from PEMSEA. The plan delineates roles and responsibilities among the various agencies and stakeholders, identifies response mechanisms, and establishes institutional arrangements to strengthen coordination and better integrate resources and ultimately build capacity in the area to efficiently cope with and reduce damage to the marine environment. Local communities have also successfully implemented initiatives of their own to deal with various hazards. One example of this is in Sriracha Municipality, in Chonburi, Thailand, where fishers, youths and local communities organized a Marine Environmental Protection Volunteer group in partnership with the private and government sectors. The group assists in oil and chemical spill monitoring and reporting and other coastal management activities. The Marine Department and private oil companies provided free training on basic oil spill clean-up techniques to the group and other government officers.

ICM integration of land-based activities in hazard identification and mitigation has been seen in the Bohai Sea, Xiamen, Manila Bay, and Bataan. This saw the integration of Red Tides/Harmful Algal Blooms Response Plans into the strategic action plans of ICM demonstration sites. This resulted in a significant decrease in red tide frequency in Xiamen that has been attributed to government efforts in reducing the level of nutrient inputs into the sea. In contrast, the frequency and geographical coverage of red tide occurrence in the Bohai Sea are increasing, indicating the need for continued effort and enhanced measures to combat this problem.

Natural and man-made hazard prevention and management was implemented in Danang, Vietnam. Coastal communities were faced with increasing impacts from floods, typhoons and coastal erosion. Through an ICM approach to hazard and risk mitigation Danang focused on measures to strengthen the community's resilience including natural buffers against storm surges; improved forecasting, early warning, response and recovery systems; and the construction of multipurpose shelters and model houses designed to withstand typhoon damage. Over 6,500 meters of dike system were strengthened as a barrier against saltwater intrusion from sea level rise, saving more than 400 hectares of agricultural land and doubling its productivity.

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GEF LME:LEARN

GEF LME: LEARN is a program to improve global ecosystem-based governance of Large Marine

Ecosystems and their coasts by generating knowledge, building capacity, harnessing public and private partners and supporting south-to-south learning and north-to-south learning. A key element of this improved governance is main-streaming cooperation between LME, MPA, and ICM projects in overlapping areas, both for GEF projects and for non-GEF projects. This Full-scale project plans to achieve a multiplier effect using demonstrations of learning tools and toolboxes, to aid practitioners and other key stakeholders, in conducting and learning from GEF projects. This global project is funded by the Global Environmental Facility (GEF), implemented by the United Nations Development Programme (UNDP), and executed by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization. The GEF LME: LEARN's Project Coordination Unit (PCU) is headquartered at UNESCO-IOC's offices in Paris.

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