

# Ecosystem-based Adaptation in Marine and Coastal Ecosystems

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*Climate change is already impacting the ability of marine and coastal ecosystems to provide food, income, protection, cultural identity, and recreation to coastal residents, especially vulnerable communities in tropical areas. These impacts will continue and increase over the short to medium term, even as the community of nations works to reduce its greenhouse gas emissions. There is an urgent need to develop, implement, and fund ecosystem-based adaptation strategies in coasts and oceans as a central part of the global response to climate change. Coastal and marine ecosystem protection and restoration is the foundation for ecosystem-based adaptation, and strong and specific provisions for the development, implementation and funding coastal and marine ecosystem-based adaptation need be a central part of a Post-2012 Climate Agreement.*

## Human Societies Depend on Marine and Coastal Ecosystems

The ocean is a unique, extraordinary and vital element of our planet, covering more than 70 per cent of its surface. It sustains life by generating oxygen, absorbing carbon dioxide from the atmosphere, and regulating climate and temperature. Marine fisheries and aquaculture provide more than 15% of global protein in people's diets and directly support more than 43 million jobs. Fish provide more than 50% of dietary protein for people in many small island developing states and coastal countries like Bangladesh, Cambodia, Ghana, and Sierra Leone (FAO, 2008). In addition, marine and coastal ecosystems provide a wide range of other important services to human society, including medicines, natural shoreline protection against storms and floods, water quality maintenance, and other cultural and spiritual benefits (UNEP, 2006). Marine and coastal ecosystems have long been under severe stress from habitat degradation, overexploitation and pollution (Millennium Ecosystem Assessment, 2005).

## Climate change is already impacting the 50% of humanity that lives along coasts

Population densities in coastal regions are about three times higher than the global average, with **23 per cent of the world's population living both within 100 kilometer distance of the coast and less than 100 meters above sea level**. Sixty percent of the world's cities with a population of over 5 million are located within 100 kilometers of the coast. Many of the world's poorest communities also live along the coast and rely on mangrove and reef-based fisheries for food security and on tourism for foreign exchange, particularly in small islands and tropical developing countries. This, coupled with poor adaptive capacity of the local populations and the governments, makes these areas highly vulnerable.

Climate change is affecting marine and coastal ecosystems through various ways (IPCC, 2007; Griffis *et al.*, 2008):

- Sea level rise - impacts the condition and distribution of coastal habitats and human infrastructure.
- Ocean physical changes (e.g. changes in water temperature, stratification, and currents) - affects species survival and distributions, ocean productivity, and the timing of biological events.
- Loss of sea ice - leads to reduced habitat for ice-dependent species in the Arctic and Antarctic and changes the habitat and productivity for other species. It also decreases the storm resiliency of coastal Arctic communities.
- Ocean acidification - impacts the growth and viability of sensitive marine organisms such as corals, bivalves, crustaceans, and plankton.
- Altered freshwater supply and quality - impacts coastal habitats, spawning migrations, and survival of anadromous species.

These impacts on marine and coastal ecosystems and biodiversity are affecting their ability to provide critical ecosystem services, directly impacting on livelihoods of ocean dependant communities and threatening those most vulnerable.

### **The Global Response to Climate Change – Mitigation and Adaptation**

There is an immediate need for a significant reduction in greenhouse gas emissions to reduce the impacts of climate change and avoid catastrophic consequences in the long term. In the absence of such strong mitigation action, it is possible that the most vulnerable ecosystems, such as coral reefs, will cease to function in their current forms within a few decades (Hoegh-Guldberg *et al.*, 2007).

Even if mitigation measures aimed at reducing greenhouse gases and slowing climate change are implemented now, the earth's climate will continue changing over the short to medium term, due to lag effects of temperature in response to the build-up of CO<sup>2</sup> already in the atmosphere. This will result in significant impacts, particularly in the marine and coastal environments. Measures to increase resilience in the face of these changes are a necessary complement to mitigation actions.

**There is a need for comprehensive adaptation strategies to consider not only “hard solutions,” but also ecosystem-based adaptation.**

So far, existing and proposed adaptive responses to climate change in coastal areas have focused on using “hard” engineering solutions to try to build our way out of the problem. These approaches include reinforcing seawalls, building dams, levees and channels to control flooding, and repairing or relocating infrastructure and even whole settlements. Such expensive infrastructure responses, though in some cases necessary, will not be sufficient to address the full scope of climate change impacts, and can exacerbate the destruction of fragile ecosystems, further reducing their ability to adapt. For example, seawalls and jetties that are built to protect stretches of shoreline often result in increased erosion and further loss of habitat on directly adjacent or downstream shorelines.

Integrating “soft” and “hard” engineering approaches to adaptation would also allow for the development of structural measures targeted at protecting the natural ecosystems themselves, in cases where climate impacts extend beyond their natural resilience. In the

Mississippi Delta for example, plans are being developed for the construction of small dikes that protect salt marshes and coastal peatlands against erosion and allow them to naturally regenerate. Subsequently, the regenerated coastal ecosystems contribute to the resilience of the Delta as a whole and are able to provide their full range of services.

## **Ecosystem-Based Adaptation**

Ecosystem-based adaptation aims to:

- Preserve and restore natural ecosystems that can provide cost-effective protection against some of the threats that result from climate change. For example, coastal ecosystems like wetlands, mangroves, coral reefs, oyster reefs, and barrier beaches all provide natural shoreline protection from storms and flooding in addition to their many other services (CBD, 2009).
- Conserve biodiversity and make ecosystems more resistant and resilient in the face of climate change so that they can continue to provide the full suite of natural services. This is particularly important for sustaining natural resources (e.g., fish stocks, fuel, clean water) on which vulnerable communities depend for their subsistence and livelihoods.

Ecosystem-based adaptation requires collective action among governments, communities, conservation and development organizations, and other stakeholders to plan and empower action that will enhance environmental and community resilience to climate change impacts. In addition, it can be a major opportunity for community-based adaptation. Vulnerable coastal communities can be engaged, employ local knowledge and participate directly in developing and applying ecosystem-based solutions.

## **Benefits of Ecosystem-based Adaptation**

Ecosystem-based adaptation strategies provide a cost-effective way to reduce vulnerability to climate change and have multiple benefits to people and local communities. Some of these benefits in the marine and coastal environment are:

***Shoreline protection.*** Across the globe, there are numerous examples of the important role that coastal ecosystems such as mangroves, wetlands, and coral reefs play in coastal protection as they dissipate wave energy. Mangrove restoration in Vietnam has been shown to attenuate wave height and thus reduce wave damage and erosion (Mazda *et al.*, 1997). Sri Lanka's Muthurajawela marsh, a coastal peat bog covering some 3,100 hectares, is an important part of local flood control. In Malaysia, the value of intact mangrove swamps for storm protection and flood control has been estimated at US\$ 300,000 per km, which is the cost of replacing them with rock walls (Ramsar Convention on Wetlands, 2005). Analysis of recent disasters — such as the December 2004 Indian Ocean tsunami and the hurricanes that struck North and Central America in September and October 2005 — demonstrates the importance of habitat protection and natural resource management in decreasing vulnerability to extreme events (Sudmeier-Rieux *et al.*, 2006). It is important to note that progressive members of the insurance industry, a primary driver in where and how coastal development occurs, are now recommending that a strong risk mitigation strategy should recognize the enormous protective value of ecosystems and other natural infrastructure, such as coastal wetlands, barrier islands,

trees, mangroves and other vegetation. This reflects the industry's understanding that natural infrastructure is essential to society's efforts to address climate change, and that these systems must be included as part of any adaptation strategy (Heinz Center and Ceres, 2009).

***Sustenance of local livelihoods.*** The World Bank's Climate Change Framework Strategy (2008) warns that the disproportionate impacts of climate change on the poorest and most vulnerable communities could set back much of the development progress of the past decades and plunge communities back into poverty. Ecosystem-based adaptation helps maintain ecosystem productivity and supports sustainable income-generating activities in the face of climate change. For example, in Kimbe Bay, Papua New Guinea, coral reef resilience principles were applied to design a network of marine protected areas to help the Bay's ecosystems withstand the impacts of a warming ocean and continue to provide food and other resources to local communities (Green et al., 2009). In Samoa, mangroves are being planted as part of a larger restoration project to enhance food security and protect local communities from storm surges which are expected to increase as a result of climate change (UNDP, 2008), and in Myanmar, communities are replanting mangroves in the Ayerwaddy Delta following the destructive impact of Cyclone Nargis, which devastated life and property in the absence of mangrove forests, cleared over time for paddy cultivation. (Tripartite Core Group, 2008)

***Re-enforce mitigation efforts.*** Coastal wetlands, including marshes and mangroves, sequester substantial amounts of carbon (Pritchard, 2009), so also play a crucial and incremental role in reducing the pace and scale of climate change itself. For example, a conservative estimate is that mangroves sequester an estimated  $112 \pm 85$  Tg C per acre, which is mostly an underestimation due to the lack of information about fine root activities. This amount of carbon sequestration is comparable with that for tropical terrestrial forests (Alongi, 2008; Bouillon *et al.*, 2007).

## **Guiding Principles for Ecosystem-based Adaptation**

Guiding principles for developing effective ecosystem-based adaptation strategies include:

- ***Use nature's infrastructure first.*** Natural ecosystems provide valuable protection and other services for free, and we should take advantage of them. Maintaining and restoring "nature's infrastructure" should be a priority for reducing vulnerability to climate change impacts. As the effects of climate change become more severe, there will be, however, situations where engineering and hard structures may be necessary, such structures need be built in sync with nature and its changing patterns.
- ***Healthy ecosystems will be more resilient to climate changes.*** Ecosystem-based adaptation strategies should include a focus on minimizing other anthropogenic stresses that have degraded the condition of critical ecosystems. It is also important to take into account the full range of impacts, as one environmental change may have cascading effects.
- ***Make use of existing management practices and governance infrastructure.*** The most effective ecosystem-based strategies currently available apply

established best practices in land, water, and natural resource management to confront the new challenges posed by climate change. **Effective integrated coastal management programs** are central to adaptation planning; and **marine protected area networks** can make an enormous contribution to maintaining natural connections across seascapes so that ecosystems can continue to function and to provide services to dependent communities (Smith *et al.*, 2009).

- ***Involve diverse stakeholders in strategy development.*** Ecosystem-based adaptation presents a tangible opportunity to solve climate change problems by aligning conservation, development, and poverty alleviation interests. Such synergies benefit from government collaboration with indigenous and local communities, conservationists, relevant private sector stakeholders, development specialists, and humanitarian aid specialists.
- ***Work with government and the private sector to provide incentives for “climate smart” development and discourage development in vulnerable and sensitive habitats.*** The financial and insurance sectors can and need to play a positive role in ecosystem-based adaptation by fully recognizing and accounting for risks associated with development in vulnerable areas and providing incentives for maintaining “nature’s infrastructure.”
- ***Adaptive management is imperative.*** While the general trends in climate change are well-documented, the timing and magnitude of local changes remain difficult to predict accurately. Ecosystem-based adaptation strategies should include monitoring so that management actions can be quickly adjusted in response to changing conditions. Management objectives may need to be revised and geographic priorities may need to be reconsidered to protect natural climate change “refugia”, or to triage places suffering severe climate change impacts.
- ***Be prepared for the unimaginable.*** In preparing for climate change, we need to keep in mind the possibility of non-linear, abrupt changes or step functions which can alter the state of an ecosystem or biome quickly once a threshold has been reached. These uncertain but high consequence events (such as de-glaciation or alteration of oceanic currents) need to be acknowledged and social resilience to cope with such changes developed.
- ***A regional approach is needed.*** Ecosystems stretch beyond political and geographical boundaries, and this is particularly true for the marine environment. Therefore, efforts need to be made to design adaptation measures that are not limited by these boundaries. Adaptation measures for a resource shared by multiple states can succeed only through integration of a regional or transboundary dimension.

### ***Effective Ecosystem-based Adaptation Requires Enhanced Assessment Methods and Decision-Support Tools***

Ecosystem-based adaptation is a new endeavor that needs to be quickly mainstreamed. It is therefore urgent that the emerging body of research and experience be made widely available and that new information be rapidly disseminated. There are a number of useful tools that are now available to help managers, communities and decision makers

undertake ecosystem-based adaptation. These tools include guides for mainstreaming ecosystem-based adaptation in coastal development and management (CRC, URI, 2009); enhancing reef resilience to climate change ([www.reefresilience.org](http://www.reefresilience.org)) and implementing Integrated Ecosystem Assessments (IEAs) which allow managers to simultaneously track multiple ecosystem indicators relative to climate change and to develop more comprehensive management responses (Levin *et al.*, 2009). There is a need for additional development of such tools and to transfer technology and build capacity for their use.

### **Coastal and Marine Ecosystem-based Adaptation Resources**

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Reef Resilience Toolkit: [www.reefresilience.org](http://www.reefresilience.org)

### **Ecosystem-based Adaptation and a Post-2012 Climate Agreement**

In the run-up to the UNFCCC COP15 in Copenhagen in December 2009, the Parties to the convention are considering how to implement each aspect of the Bali Action Plan, including a shared vision, enhanced action on adaptation, and a financial mechanism. Preparatory discussions prior to and during COP14 began to focus attention on adaptation, in particular addressing the needs of the most vulnerable countries, communities, ecosystems, and related livelihoods. There are calls for adaptation to be given at least the same level of priority as mitigation, to be contextual, and build on local knowledge. Many developing countries are also calling for adaptation to be community-driven and ecosystem-based, reflecting the dependence of communities on natural resources for their livelihoods.

### **Recommendations**

**1. Protect and restore coastal and marine ecosystems as a foundation for ecosystem-based adaptation in coastal areas.** Wetlands, beaches, and reefs--both coral and shellfish--provide not only valuable biodiversity and habitat benefits; they are also nature's shoreline defense system. These habitats need increased protection. Action also

needs to be taken to conserve areas behind today's estuaries, beaches, and wetlands so that as sea level rises, landward migration can occur.

## **2. Fully incorporate ecosystem-based adaptation strategies in National Adaptation**

**Programs of Action:** Currently, only 25 countries (eight of which are small island developing states) refer to ecosystem-based adaptation in their National Adaptation Programs of Action (NAPA). NAPAs of all coastal countries would benefit from vulnerability assessments of their marine and coastal ecosystems and tailored ecosystem-based adaptation responses such as restoration of coastal ecosystems and the establishment of marine protected areas

## **3. Include ecosystem-based adaptation in the decisions of the Parties to the UNFCCC at COP15 in accordance with the outline provided in the Bali Action Plan.**

In particular:

- (i) **Ecosystem-based adaptation should be part of the adaptation component of the shared vision for long-term cooperative action currently being discussed by the AWG-LCA.** The full scope of actions for implementation of adaptation measures, including ecosystem-based adaptation, should be included in a framework that is consistent with the principles of common but differentiated responsibilities and in accordance with national capacities, and the social and economic conditions in countries.
- (ii) **Ecosystem-based adaptation should be one of the concepts underpinning the program for Enhanced Action on Adaptation in the post-2012 climate agreement.** There is a need for integration of ecosystem-based adaptation into sectoral, national and regional planning. Emphasis should be placed on marine and coastal ecosystems, especially in the least developed countries and small island developing states, where economies are highly dependent on the resilience and productivity of natural ecosystems.
- (iii) **Coastal and marine ecosystem-based adaptation should be a focus of new technology development and transfer.** Effective methods for implementing coastal and marine ecosystem-based approaches to adaptation should be collated, compiled, and made available through professional development and other capacity-building programs such as those designed to share knowledge and develop expertise at community and seascape scales. The development of the Reef Resilience Network, Ecosystems and Livelihoods Adaptation Network (ELAN) and other efforts to build capacity, share lessons learned, and link the science and practice of ecosystem-based adaptation should be encouraged.
- (iv) **Increase financial resources and investment to support action on ecosystem-based adaptation in coastal and marine ecosystems.** There needs to be improved access to adequate, predictable, and sustainable financial resources that can enable the successful design, implementation, monitoring, and adaptive management of coastal and marine ecosystem-based adaptation strategies. In addition, when hard infrastructure projects are built, mitigation funding to offset losses to natural systems should be included in their

financing. Finally, development assistance for adaptation should be provided in a coherent and coordinated way to ensure that ecosystem-based adaptation is considered and funded as an integral part of any adaptation project.

**4. Recognize the urgent need for specific attention and increased funding for marine and coastal ecosystems.** Because of their critical importance in providing coastal protection, reducing the impacts of natural disasters, and sustaining the livelihoods of hundreds of millions of vulnerable people, marine and coastal ecosystems should be one of the highest priorities for ecosystem-based adaptation intervention and support, particularly in small island developing states and least developed coastal nations. There is an urgent need for an immediate halt of the continuing degradation of marine and coastal ecosystems to allow them to help support coastal communities in the face of climate change.



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