chapter 1

INTRODUCTION

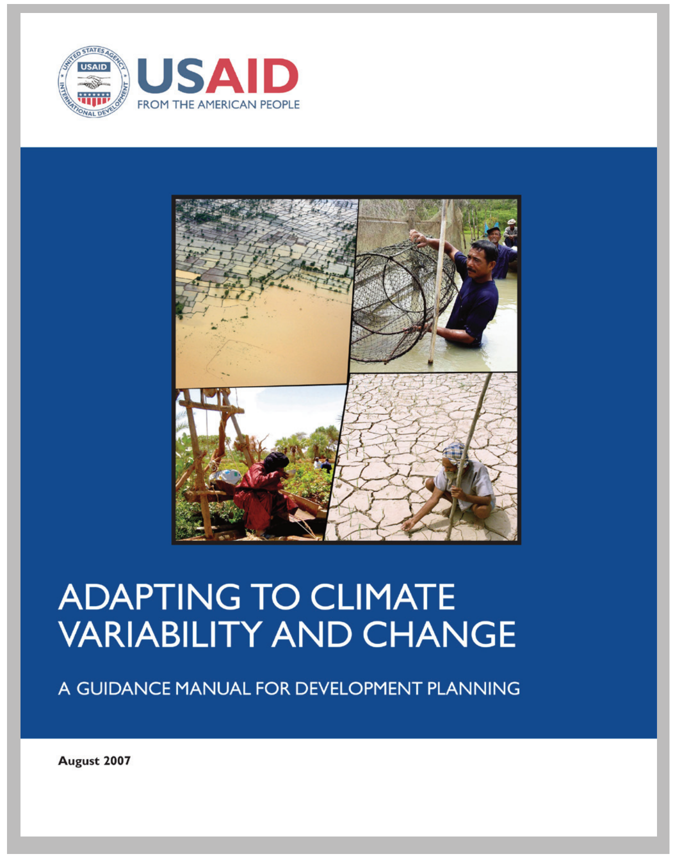
1.1 BACKGROUND

Coasts and the world's oceans are crucial to life on Earth, they support livelihoods, and are vital to the global economy in many ways. Coastal ecosystems exist at the interface between terrestrial and marine environments. They include some of the most diverse and dynamic environments on earth. This narrow band of the earth's surface attracts human populations because it is a focal point for economic growth—accounting for a majority share of humanity's infrastructure, transportation and trade, energy processing, tourism, and recreation. Coastal ecosystems provide a myriad of ecological goods and services. They provide habitat and nurseries for the majority of commercially important marine fish and shellfish species, and provide food security and livelihoods for over 1 billion people. They offer storm surge protection, erosion control, and flood mitigation. They also help retain nutrients and sediments and filter pollutants. Thus, the socioeconomic and ecological importance of the coastal zone is virtually unparalleled.

> Considering that the majority of humans reside along coasts, coastal regions have become uniquely important to the well-being of society and the need for proactive action to adapt to climate changes is ever more pressing.

Global climate change already impacts and will continue to impact coastal communities, ecosystems, and many facets of people's lives in the coastal zone where approximately 2.7 billion people—over 40% of the world's population—live. Even without climate change, coastal areas face a litany of problems associated with population growth, habitat change, resource over-exploitation and degradation, water pollution, and changes in freshwater flows. Climate change is expected to amplify many of these and other stresses on coastal areas. This in turn increases the need and urgency to include coastal adaptation as part of effective coastal management. As a consequence of these realities, climate change is considered by many to be one of the most important challenges of the 21st century and a priority for immediate action for coastal areas.

In 2007, the Global Climate Change Team in the United States Agency for International Development (USAID) Bureau for Economic Growth, Agriculture



USAID
FROM THE AMERICAN PEOPLE

ADAPTING TO CLIMATE VARIABILITY AND CHANGE

A GUIDANCE MANUAL FOR DEVELOPMENT PLANNING

August 2007

and Trade developed guidance to help USAID Missions and partners account for and address vulnerabilities to climate variability and change in their projects and programs. The document, *Adapting to Climate Variability and Change – A Guidance Manual for Development Planning* (USAID, 2008), is structured around a six-step vulnerability and adaptation (V&A) process[1]. This process helps planners and stakeholders to assess vulnerability to climate variability and change, and to identify, assess, select, implement, and evaluate adaptation options that reduce climate impacts.

The V&A Manual was intended as general guidance on the full range of climate concerns and impacted sectors. It provides links to important sources of information and tools and offers a broad overview of methods and best practices for conducting vulnerability assessments and evaluating adaptation measures. The V&A Manual includes case studies illustrating some of these best practices.

This coastal adaptation Guidebook is a companion document to the V&A Manual and provides the practitioner with more detailed and sector-specific

1 The six steps are: 1) Screen for vulnerability; 2) Identify adaptations; 3) Conduct analysis; 4) Select course of action; 5)Implement adaptations; and 6) Evaluate adaptations

guidance for responding to climate variability and change impacts on coastal areas. The emphasis is on developing country contexts.

The Guidebook's primary goals are to:

- Advance understanding of climate change impacts along coasts, vulnerability, and approaches for mainstreaming coastal adaptation measures into development policies, plans, and programs
- Provide practical adaptation options for responding to the impacts of climate variability and change on the coast
- Draw lessons from experience on how to overcome implementation barriers and utilize an adaptive management approach to coastal climate adaptation

1.2 ROADMAP TO THE GUIDEBOOK

The Guidebook follows a common approach, or cycle, to program development as shown in Figure 1.1. The approach is similar to the Integrated Coastal Management (ICM) policy cycle often used by coastal practitioners and includes the following steps: vulnerability assessment (Step 1), planning and selection of a course of action (Step 2), formal adoption or mainstreaming of adaptation actions (Step 3), implementation (Step 4), and evaluation (Step 5). This highlights a central message of the Guidebook: the process of coastal planning and action is not radically changed by applying a climate lens. While the process and good practices of planning and program management apply equally to climate change as they do to other coastal issues, the Guidebook will show that some of the strategies of coastal management are influenced by climate change considerations. For example, there will be greater emphasis on nature-based adaptations and a longer planning horizon must be taken into account.

Each chapter of the Guidebook refers to one of the five steps of the program cycle. Chapter 2 focuses on diagnosis of coastal climate change impacts, trends, and vulnerability. Chapter 2 also summarizes current stresses and threats to coastal areas from development pressures and weaknesses in management.

Coastal communities are likely to face a number of climate-impacted issues and challenges—some in the near term and others within the next several years or decades. Chapter 3 provides guidance on setting priorities and formulating adaptation goals. It also provides a list of 17 adaptation measures and summarizes the criteria for evaluating and selecting adaptations.

TERMINOLOGY

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic changes or their impacts, so as to reduce harm or exploit beneficial opportunities.

Climate change: Any change in weather averaged over time due to natural variability or because of human activity.

Climate variability: Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Examples of climate variability include extended droughts, floods, and conditions that result from periodic El Niño and La Niña events.

Hazard Mitigation: Sustained action taken to reduce or eliminate long-term risk to life and property from a hazard event. Considered as one of four phases of emergency management, together with preparedness, response, and recovery.

Mitigation: Within a climate change context, mitigation is a human intervention to actively reduce the production of greenhouse gas emissions (reducing energy consumption in transport, construction, at home, at work etc.), or to remove the gases from the atmosphere (sequestration)

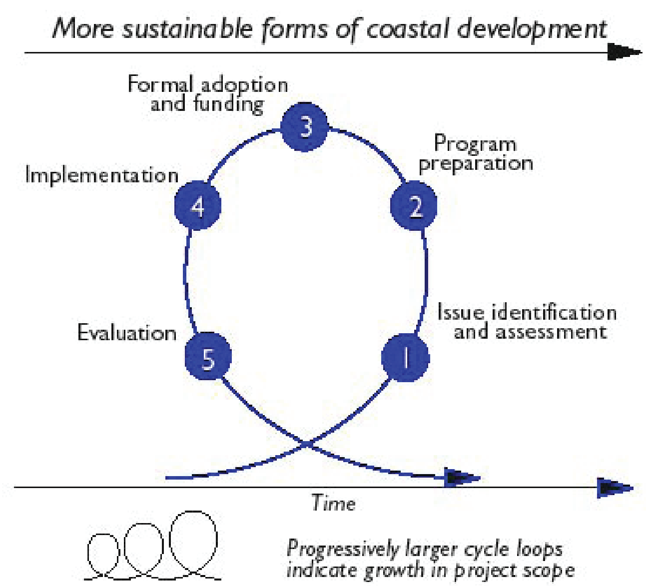
Vulnerability: The degree to which a human or natural system is susceptible to, or unable to cope with, adverse effects of climate change. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

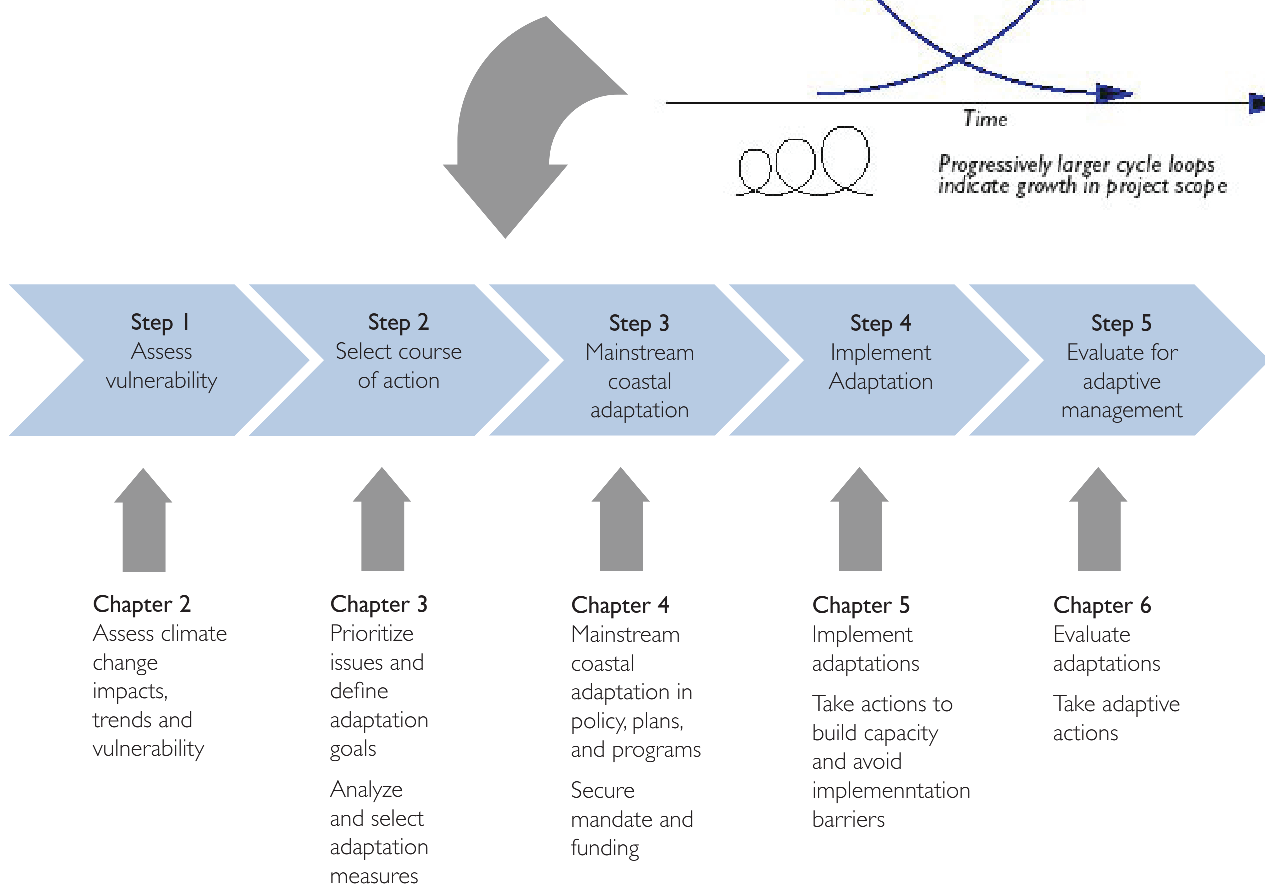
Coastal adaptation requires a mandate and funding. Chapter 4 describes how coastal V&A can be mainstreamed into public planning and budgeting processes and policies at national, sub-national, and local scales. ICM experience has taught us that the list of potential obstacles to successful mainstreaming is long. This chapter presents lessons learned on overcoming these obstacles and offers strategies and preconditions for sustained mainstreaming of coastal adaptation.

After the adaptation options have been evaluated and selected and once there is a formal mandate and funding to proceed, you are ready to take action. Chapter 5 focuses on making adaptation plans operational and overcoming typical obstacles to successful implementation.

Coastal adaptation is not a one-time event. It is an adaptive and iterative process. Chapter 6 focuses on evaluating the progress of the actions that are undertaken and adapting to changing conditions based on valid reasons and circumstances.

Figure 1.1 A coastal adaptation roadmap applies a climate lens to the ICM policy cycle often used by coastal practitioners





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chapter 2

ASSESS VULNERABILITY

This chapter first provides an overview of climate change observations and trends in the coastal zone, their impacts on coastal sectors, and the panoply of existing threats to human and natural ecosystems in the coastal zone. Climate change only amplifies these threats and further increases the challenges of strategically managing the coasts and seas and their extraordinary but shrinking resources. The chapter then explores four critical factors: climate change projections, exposure to climate change, sensitivity to climate change, and the capacity of society to cope with actual or expected climate changes (adaptive capacity and resiliency of coastal ecosystems). Coastal vulnerability hot-spots are also highlighted.

VULNERABILITY ASSESSMENT

- ☑ Assess climate change projections
- ☑ Assess exposure to climate change
- ☑ Assess sensitivity to climate change
- ☑ Assess health of coastal habitats and ecosystems
- ☑ Assess adaptive capacity

2.1 GLOBAL CLIMATE CHANGE AND THREATS TO THE WORLD'S COASTS

There is scientific consensus that increases in greenhouse gases in the atmosphere drive the warming of air and sea temperatures and cause the world's oceans to acidify from the carbon dioxide they absorb. Even if greenhouse gases were capped today, air and sea temperatures will continue to rise as a result of past emissions—as greenhouse gases in the atmosphere have a lifetime of between 10 and several thousand years. Warming of air and sea induces precipitation change, sea level rise, and more extreme weather events (e.g., storms and sea surge). The most significant and immediate consequences of these climate changes for the world's coasts include coastal erosion, flooding, drought, saltwater intrusion, and ecosystem change. There are also other health, economic and social impacts.

These climate changes and impacts are already affecting coastal areas and ecosystems and projections for the coming decades paint a somber picture. Table 2.1 summarizes observations and trends of the effects of increased greenhouse gases on coastal and ocean systems.

Rising sea-level poses a severe threat to countries where their coastal regions have heavy concentrations of population and economic activity. Through the 20th century, global rise of sea level contributed to increased coastal inundation, erosion and ecosystem loss (IPCC, 2007a). Until recently, studies of sea level rise typically predicted a 0-1 meter rise during the 21st century. For example, the Intergovernmental Panel on Climate Change (IPCC) anticipates that sea level will rise by 0.6 m or more by 2100 (IPCC, 2007c). Ocean thermal expansion was expected to be the dominating factor behind this rise. However, new data on rates of deglaciation (the uncovering of land previously covered by a glacier) in Greenland and Antarctica suggest that glacial melt may play a significant role in creating an even greater rise in sea level—i.e., 1-3 meters in this century (Dasgupta et al., 2007). A rise of this amount would displace hundreds of millions of people in the developing world.

> "A 0.5 °C increase in sea surface temperature is associated with a 40 percent increase in hurricane frequency and activity." Saunders and Lea, Nature, January 29, 2008

Sea level rise and other changes brought on by climate change can affect land-based activities (see Figure 2.1) and coastal ecosystems, especially wetlands and coral reefs, and have serious implications for the well-being of societies dependent on coastal ecosystems for goods and services. Rises in marine/coastal water surface temperatures lead to the bleaching and widespread mortality of coral reefs. Further, saltwater will displace or at least intrude coastal aquifers; and estuarine systems will likely become more brackish. Alterations to estuarine and marine ecosystems will have potentially severe impacts on fisheries and the goods and services provided by marine and coastal biodiversity.

As more carbon dioxide (CO_2) dissolves in the oceans, they become more acidic (decreased seawater pH). This creates the potential for widespread effects on marine ecosystems. It may inhibit calcification, which will threaten the survival of coral-reef ecosystems. It will inhibit the growth of calcareous algae at the base of the food web and of shell-forming marine organisms (such

Table 2.1 A Summary of climate change observations and trends in the coastal zone

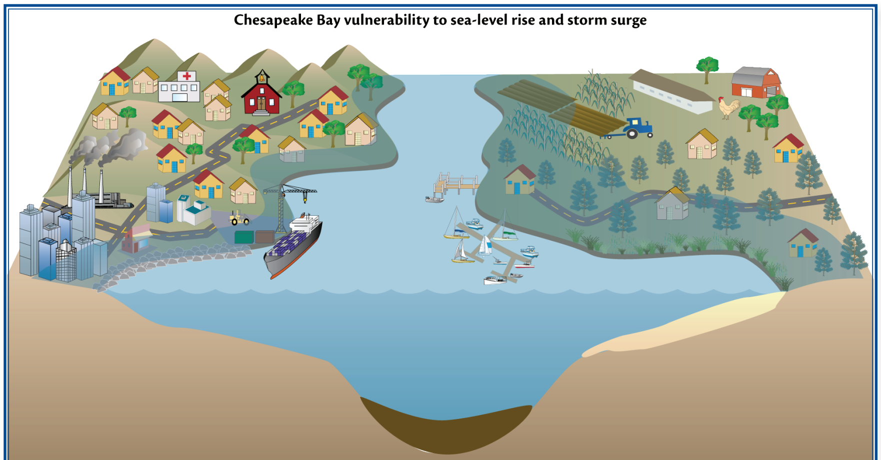
Coastal Impact	Observations	Projected Trends
Sea Level Rise	• For the 20th century, sea levels rose at a rate of 1.7 to 1.8 mm/yr • In the last decade, the worldwide average rate was measured to be 3.0 mm/yr • Coastal erosion is increasingly observed around the world; it can be related to either sea level rise or subsidence, or both	• Sea levels are expected to rise by at least 0.6 meters by the century's end; glacial melt is expected to increase this rise • Coastal flooding could grow tenfold or more by the 2080s, affecting more than 100 million people per year due to sea-level rise, especially in Southeast Asia • It is projected that seawater intrusion due to sea-level rise could severely affect aquaculture in heavily-populated mega-deltas, such as in Southeast Asia • A one-meter rise in sea level could inundate 17% of Bangladesh and completely flood the Republic of Maldives, reduce Bangladesh's rice farming land by half and affect millions of livelihoods • A 2°C increase in temperature could result in the loss of a number of island states
Sea Surface Temperature Change	• Between 1970 and 2004, sea surface temperatures around the planet rose between 0.2-1.0°C, with a mean increase of 0.6°C • The Caribbean Sea has warmed by 1.5°C in the last 100 years • Observations since 1961 show that the ocean has been absorbing more than 80% of the heat added to the climate system • Changes in water temperature caused wide scale coral bleaching in the Asia region, damaging as much as 75-100% of coral in the Philippines in 1998	• By 2100, temperatures are projected to rise in the tropical Atlantic (2-4°C), Pacific (1.5-3.5°C) and Indian (3°C) Oceans • Increases in sea surface temperature of about 1-3°C are projected to result in more frequent coral bleaching events and widespread mortality • Studies project that with a 1°C increase in sea surface temperatures, all coral reefs in the Great Barrier Reef, Southeast Asia and the Caribbean could be bleached
Increased Frequency of Extreme Weather Events	• Increases in category 4 and 5 tropical cyclones, hurricanes and typhoons during the 20th century have been reported • Tropical cyclone activity has increased since 1970, with a trend towards longer lived storms and storms of greater intensity • Mass mortality of mangrove species in the Caribbean has been attributed to the increased frequencies of hurricanes in the region • El Niño events have become more frequent, persistent and intense during the last 20 years compared to the previous 100	• Models project a likely increase of peak wind intensities and increased mean and peak near-storm precipitation in future tropical cyclones • The population exposed to flooding by storm surges will increase over the 21st century, especially in South, Southeast and East Asia
Precipitation Change	• Precipitation has increased by up to 10% in the Northern Hemisphere and decreased in other regions (e.g., North and West Africa, parts of the Mediterranean and the Caribbean) • The frequency and severity of drought has increased in some regions, such as parts of Asia and Africa • Very dry areas have more than doubled since the 1970s • Australia incurred over US$13 billion in drought damage between 1982-2003	• Projections for Latin America show a general year round drop in seasonal precipitation of up to 60% with the greatest effects felt in Mexico and Central America • Precipitation change is very likely to increase the frequency of flash floods and large-area floods in many regions • In Tarawa, Kiribati, it is projected that drought damages could to reach 18% of the gross domestic product by 2050
Ocean Acidification	• Since 1750, an average decrease in pH of 0.1 units has been observed	• It is projected that the pH of the world's oceans could fall by up to a further 0.3 – 0.4 units by 2100, resulting in the lowest ocean pH levels in 20 million years

Sources: IPCC, 2007a, b; IUCN, 2007.

as scallops), and it will stunt the growth of calcified skeletons in many other marine organisms, including commercial fish species.

Rising sea-level coupled with increased sea surface temperatures is expected to contribute to more frequent and severe extreme weather events, such as coastal storms. These, in turn, will generate larger waves, storm surges, and increased coastal erosion. Annually, about 120 million people are exposed to tropical cyclone hazards alone; storms killed 250,000 people between 1980 and 2000 (IPCC, 2007a).

Figure 2.1 Vulnerability to sea level rise and storm surge



Chesapeake Bay is vulnerable to sea-level rise and storm surge. The western shore has a dense built environment , including industry and ports . The grade of slope affects shoreline movement, so areas with steep slopes, such as Calvert Cliffs, will have a slower rate of shoreline movement than flatter areas. The Eastern Shore's flat landscape contains low-lying roads , animal feeding and agricultural operations , marinas , marshes , and forests .

Source: Maryland Commission on Climate Change, Adaptation & Response Working Group. 2008

The recent human tragedies of the December 2004 Indian Ocean tsunami, Hurricane Katrina (United States, August 2005), Cyclone Sidr (Bangladesh, November 2007) and the Cyclone Nargis (Myanmar, May 2008) prove that coastal calamities can overwhelm resources and disaster responses of developed and less developed nations alike. Each coastal disaster provides tangible examples of the potential impacts that may unfold during the next century as a result of global warming and associated sea-level rise. As real disasters unfold around us, the need for global action today becomes ever more obvious and pressing.

Rainfall patterns are also changing and the effects of El Niño and La Niña episodes have worsened. This has resulted in increased cyclones, flooding and drought cycles. Runoff from more intense precipitation and changes in seasonal freshwater flows in many coastal environments can result in broad ecosystem changes. This includes changes in coastal erosion and sedimentation to which mangroves, estuaries, and coral reefs are particularly vulnerable. Meanwhile, nutrient-rich runoff under conditions of higher sea surface temperature will likely promote coastal hypoxia or seasonal hypoxic events. Changing weather patterns affect the distribution and range of species and disrupt the natural balance of many ecosystems and this has potential impacts on fisheries. When bacteria, viruses, mosquitoes or other disease vectors change their geographical range as a result of global warming, diseases also spread.

CORAL REEFS AND SEA SURFACE TEMPERATURE RISE

Scientists estimate the world has already lost 30% of its coral reefs, mostly from the effects of overfishing, nutrient pollution, and habitat conversion, but coral bleaching and increasingly acidic seas—both associated with climate change—are exacerbating these effects and pushing many coral reefs over the edge. With climate change, more than 80% of the world's coral reefs may die within decades.

Sources: Hoegh-Guldberg et al., 2007 and Nelleman, et al., 2008

Erosion impacts both public and private investments which are often built too close to the shore or do not consider appropriate building techniques for dynamic shorelines.

In short, climate change is increasing the frequency of natural disasters with overarching impacts on the health and resilience of coastal ecosystems and the global economy. Sea level rise; more frequent and severe extreme weather events; increased flooding; and the degradation of freshwater, fisheries and other coastal resources could impact hundreds of millions of people. The socioeconomic costs on coasts will escalate (IPCC, 2007a). This occurs at a time when there is an ever increasing human dependence on coastal resources and growing populations in the coastal zone. In some regions already stressed with overpopulation, poverty, internal conflict, resource overuse and the spread of disease, these impacts from climate change can be devastating.

Table 2.2 lists the many impacts of climate change on coastal sectors and concerns. It highlights that the world's coastal regions are already under assault as a result of coastal development patterns and habitat loss, over-fishing, pollution, and other environmentally-damaging activities. Climatic changes combine with and amplify existing non-climate stressors to make such coastal communities even more vulnerable.

Mangroves, coral reefs, estuaries, seagrass beds, dune communities—and the rich biodiversity provided by these and other systems on or near shorelines— serve critical ecological functions that are important to human society in the face of climate change. For example, they serve as vital nurseries and habitat for fisheries, and provide food security and livelihoods for over one billion people; provide protection from storms and wave surges; reduce impacts from flooding; provide shoreline natural defenses; control erosion; provide water storage and groundwater recharge; retain nutrients and sediments; and filter pollutants. When these critical resources are compromised, coastal ecosystems become weakened and unhealthy and are less resilient to the effects of climate change and variability. Hence, an important element of any adaptation strategy is to identify and reduce those human-based stresses on coastal ecosystems that can be controlled. By doing this, we can work with nature to increase ecosystem resilience and thereby increase the ability of coasts to cope with climate change.

Table 2.2 Threats to the coastal environment

Sector	Climate Change Threats	Other Human Threats
Coral Reefs, Coastal Wetlands and Ecosystems	• Loss of coral reefs from **coral bleaching** and **ocean acidification** • **Loss or migration of coastal wetland ecosystems,** including salt marshes and mangroves • Runoff from more intense **precipitation** causing coastal erosion, and sedimentation adversely affecting estuaries and coral reefs • Nutrient rich runoff under conditions of higher **sea surface temperature** promoting coastal hypoxia and marine **dead zones** • Change in the distribution and **abundance** of commercially valuable marine species • Increased spread of **exotic** and **invasive species**	• 30 percent of the world's **coral reefs** have been lost as a consequence of overfishing, pollution, and habitat destruction • Intense coastal development and **habitat loss** • Pollution and marine **dead zones** • **Conversion of mangroves** and wetlands for mariculture • Disruption of the quantity, quality, and timing of **freshwater inflows** to estuaries • Damage to **seagrass beds** from sedimentation, recreational boating, fishing and tourism • **Coral mining** for construction and lime making • **Oil spills** from shipping • Spread of **invasive species** • Coastal reinforcement disrupts natural **shoreline processes** • Sand and gravel **mining** of riverbeds and beaches
Capture Fisheries	• Overall decline in ocean productivity • **Eutrophication** and coral mortality leading to reduced fish catch • **Loss or shifts in critical fish habitat** • **Temperature shifts** causing migration of fishes • Extreme events, temperature increases and oxygen depletion reducing spawning areas in some regions • **Temperature changes** affecting the abundance and distribution of marine pathogens • **Ocean acidification** and increases in temperature damaging coral reefs	• **Over-harvesting** • **Destructive fishing** practices (e.g., bottom trawling, dynamite fishing, beach seining) • Land-based sources of **pollution** (sewage, industrial waste, nutrient runoff, etc.) • **Sedimentation** of coastal systems from land-based sources

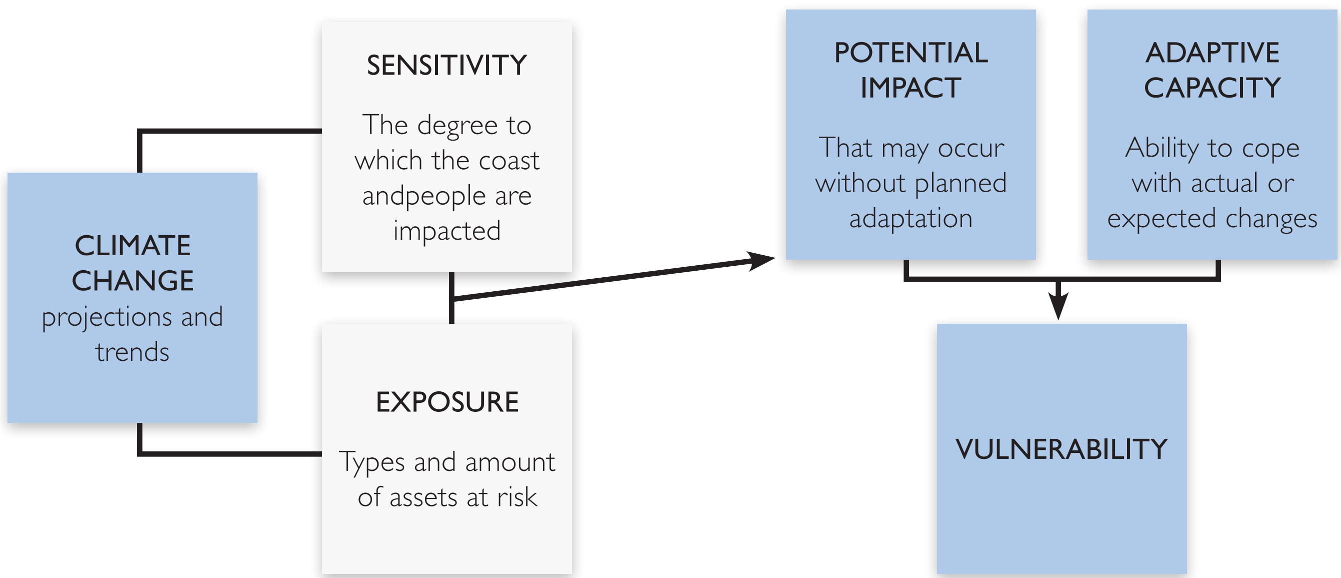
Sector	Climate Change Threats	Other Human Threats
Mariculture	• Increases in water temperature could result in **unpredictable changes** in culture productivity • Environmental changes could increase stress and vulnerability to **pathogens** and parasites in cultured organisms • Overall decline in **ocean productivity** reduces supplies of wild fish used for fish meal for mariculture sector • Changes in weather patterns and extreme weather events reduce **productivity** and damage operations (loss of infrastructure and stock)	• **Overexploitation** of juveniles and larvae seed stock for fish farms • Release of chemicals, nutrients and sediment in pond effluents • **Spreading of pathogens** and disease to local ecosystems and neighboring culture operations • **Loss of protective habitats** from improper siting of mariculture facilities
Recreation and Tourism	• **Storms, erosion, and precipitation** damaging infrastructure and causing losses to beaches • Compromised **water quality** and increasing beach closures • Increases in tourism **insurance costs** on high-risk coasts	• **Improper siting** of tourist facilities • **Alteration** of the shoreline, coastal processes and habitat • Strain on **freshwater resources** for tourist facilities • **Marine pollution** and habitat disruption from recreational boating
Freshwater Resources	• **Saltwater intrusion** of freshwater sources • Encroachment of saltwater into estuaries and coastal rivers • Waves and **storm surges** reaching further inland, increasing coastal inundation and **flooding** • **Decreased precipitation,** enhancing saltwater intrusion, and exacerbating water supply problems	• Discharge of untreated sewage and chemical **contamination** of coastal waters • Unregulated **freshwater extraction** and withdrawal of groundwater • Upstream **dams** • Enlargement and **dredging** of waterways
Human Settlements	• Coastal **inundation** causing relocation inland • Building and infrastructure damage from increasing coastal **storm intensity** and flood exposure • **Sea level rise** raising water levels during storm surge • Reduced clearance under bridges • Overtopping of coastal defense structures • **Sea level rise,** erosion, and extreme weather events leading to degradation of natural coastal defense structures	• Rapid increase in **coastal development** projected to impact 91% of all inhabited coasts by 2050 • Inappropriate **siting** of infrastructure • Shoreline **armoring** • **Habitat conversion and biodiversity los**s
Human Health	• **Heat stress** from extremely hot periods • Injuries, illness, and loss of lives due to **extreme weather events** • **Malnutrition** and food shortages during extreme events • Increased spread of vector-borne **disease** (dengue fever and malaria), waterborne diseases (diarrhea) and toxic algae (ciguatera)	• **Pollution** and water contamination
Conflict	• **Coastal land loss** leading to coastal land and resource scarcity or loss, and human migration • **Water use** conflicts due to scarcity • Population **migration** to urban areas as ocean productivity and food availability declines and fishers are displaced	• **Displacement** and loss of shore access resulting from tourism and coastal development

Sources: IPCC, 2007a, b; IUCN, 2007

2.2 VULNERABILITY ASSESSMENT

Assessing a coastal area's vulnerability to the impacts of climate change involves understanding: 1) the climate projections for a given region or locale, 2) what is at risk (climate change exposure and sensitivity), and 3) the capacity of society to cope with the expected or actual climate changes (adaptive capacity). Combined, these three factors define the vulnerability of people in a place to climate change. Figure 2.1 illustrates this relationship, which is described in the subsequent four sub-sections.

Figure 2.2 Vulnerability framework



Source: Adapted from Allison, 2007.

2.2.1 ASSESSING CLIMATE PROJECTIONS FOR A COASTAL AREA

Tailoring adaptation measures to climate change requires information on climate processes and impacts for specific coastal areas over a timeframe much longer than the typical 5-10 years used for planning and policy. When assessing vulnerability and what to do about it, it is reasonable to use a 100 year timeframe—since we know climate change impacts will grow stronger with time.

Successful adaptation requires setting clear geographic boundaries within which to focus the assessment and actions. This is especially difficult in coastal areas, but it is important. Here, the interconnectedness of issues is amplified by the flows of water from rivers and ocean currents. A tendency is to incorporate too many adaptation elements. Good practices in coastal climate change adaptation include:

- Match boundaries to issues of concern
- If issues are rooted in the larger watershed, the analysis and possibly the implementation must be broader, but avoid overextending the scope of the effort
- Differentiate between boundaries for analysis and those for policymaking and action (the latter must remain focused and is narrower) and work across political boundaries when necessary
- Understand inshore ocean currents so that, for example, an analysis of biological vulnerability includes consideration of the dispersal patterns of important larvae in the assessment areas and actions
- Recognize the temporal and spatial scope of populations—e.g., coastal populations frequently engage in seasonal employment as fishers, farmers, crew on ships; and the number of people in seaside resorts changes dramatically between high and low seasons
- Recognize the inherent dynamics of the natural environment, such as seasonal and inter-annual variations in beach sand movement, and fish stock abundance and structure

Larger scale climate change models and projections, such as those of the IPCC, as well as on-line regional mapping tools and downscaling models (e.g., the SERVIR Climate Mapper http://www.iagt.org/downloads.aspx#sv or http://www.servir.net/ and the PRECIS Regional Climate Modeling System http://precis.metoffice.com/) provide a starting point to understand an overall context, but lack the resolution and specificity needed to assess the vulnerability of specific coastal areas.

They can, however, provide a starting point from which to overlay local knowledge on past and current climate trends for the specific place. For example, local knowledge can help answer the basic question: "Has

USE BEST AVAILABLE INFORMATION AND TRADITIONAL KNOWLEDGE

By integrating the best available knowledge and involving local communities, it is possible to take responsible action in situations where there are uncertainties and imperfect information. Following the *precautionary approach*, actions should not be impeded by an absence of full scientific certainty. A skillful adaptation approach is to look at the trends suggested by existing models along with the trends that are beginning to show themselves in the region in question and to plan accordingly. Trends will continue to change and emerge for generations to come—even should mitigation efforts greatly reduce global greenhouse gas emissions.

the frequency, magnitude, or timing of precipitation, extreme weather events and other climate impacts changed in the last several decades?" A review of historic records for climate variability and hazard events in a specific area can also help validate the projections. Spatial data and maps to visualize biophysical impacts (e.g., shoreline, storm surge, and flooding maps) also aid in this exercise.

To develop climate change projections for a coastal area, assess available information and formulate assumptions to create scenarios that reflect a range of low to high degrees of change. Stakeholders can use these scenarios to assess vulnerabilities and identify issues and adaptation measures. Scenarios can also help move dialogue from a debate about exactly *how* the climate will change to a discussion among key stakeholders, experts and project staff on the *implications* of the different scenarios (high, medium, low change). Projections should include changes in temperature, precipitation, sea level rise and severe storm events along the coastal watershed (bays, estuaries, nearshore currents and rivers).

At the end of this assessment phase, there should be two or more projections of climate change and the potential impacts of each to the environment. There should also be a constituency of stakeholders who understand the context of the place relative to climate change.

At this point, it is useful to prepare an **issue statement** that provides a concise and factual description of the climate change challenges that affect the community. All stakeholders should contribute to the statement to ensure there is shared understanding of the problem. An example might look like:

"Greater frequency and intensity of storms on the island of Antigua puts at risk the health and safety of the population and infrastructure. It is in the long-term interest of the community to take measures to increase storm hazard preparedness and resilience."

2.2.2 ASSESSING EXPOSURE TO CLIMATE CHANGES

Exposure is defined as the types of valued assets that are at risk of being impacted by changes in the climate system as well as by ocean acidification. These assets include social assets (people, health, education), economic assets (property, infrastructure, and income), and ecological assets (natural resources and ecological services).

To select a course of action for adapting to climate change, communities need to answer several questions, such as: "What are the most important assets that are at risk?" "What is the threshold at which impacts will occur?" For example, in Tamboko, the Solomon Islands—where coastal communities are exposed to seasonal flooding—community-level assessments identified drinking water as the most valued asset (IFRC, 2005).

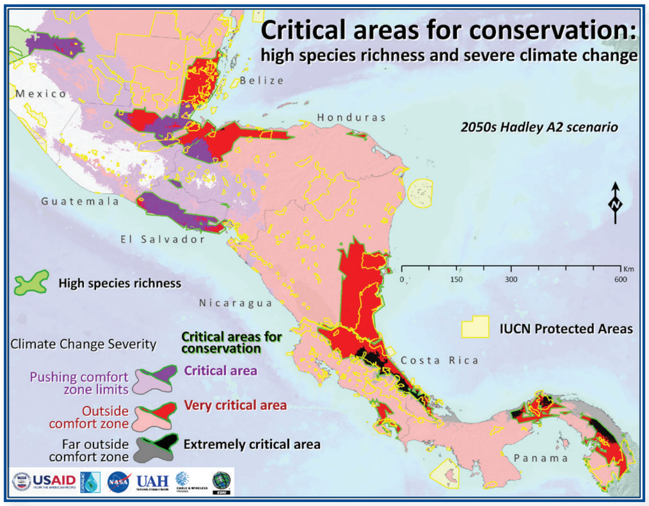
When determining the most important assets exposed to climate change risks consider:

- *Impact to critical systems:* Is a vital food (e.g., fishery), safety or economic asset at risk?

SPATIAL DATA

Maps and measurements of coastal areas are invaluable to understand how climate impacts will play out.

- Shoreline mapping—coastal elevation, sea level rise projections, erosion rates, storm surge inundation, land use and land cover
- Socioeconomic context—coastal resource uses, demographics, development density, and administrative boundaries



SERVIR can integrate and downscale global information, assess vulnerabilities from natural hazards in real time, and evaluate past and future climate trends, as seen here in this example of a CATHALAC/USAID study of regional biodiversity and climate change. For more information go to www.servir.net

- *Attitudes towards risk:* What is the community's level of risk perception and tolerance—e.g., coastal communities with tourism may perceive eroding beaches as a higher risk than those without tourism.
- *Impacts on current government/stakeholder priorities:* Does the potential impact put a major economic development priority at risk? Will there be an impact on a social problem for which significant resources have already been allocated?
- *Level of certainty about the projected consequence of climate change:* If there is high uncertainty about the likelihood of a potential risk, exposure to the risk may be considered a low priority.
- *Reversibility of changes that may occur in the absence of effective management response:* Can the asset be recovered after being impacted? If not, the issue might be a high priority. An example is a coral reef ecosystem. Once the coral animals die, the reef structure breaks down with no easy way to regain the ecological goods and services of habitat, fisheries, tourism, and storm protection.

2.2.3 ASSESSING SENSITIVITY TO CLIMATE CHANGE

The potential impact of climate change is determined by an asset's level of exposure and its sensitivity—i.e., the degree of likely damage—if exposed to climate change. For example, 100 houses along the coast may be exposed to flooding. However, the 60% that are built on raised foundations are less sensitive to damage from flood waters. Table 2.3 highlights assets and factors that can make them sensitive to the impacts of climate change.

Healthy ecosystems and social groups have significant ability to absorb impacts. An example of this is Vietnam, which experiences eight to 10 major coastal storms annually. Tidal flooding associated with these storms usually leads to the breaching of sea dykes and economic losses to the local population. To protect coastal assets and improve livelihoods, the Vietnam Red Cross has been planting and protecting thousands of hectares of mangrove forests along the northeast coast

Table 2.3 Examples of exposed coastal assets and factors of sensitivity

Groupings	Coastal Assets Exposed	Dimensions of Sensitivity
Social	People, health, education, sanitation, historic and cultural assets, social capital	Material assets and savings, secure land tenure, community cohesiveness, the state of public health, sanitation conditions in the community
Built environment	Property and coastal infrastructure, ports and shipping	Siting of buildings and coastal infrastructure and construction methods, availability of insurance systems and emergency funds
Ecological infrastructure	Natural resources, wildlife, coastal watersheds, ecological values, protected areas, unique ecosystems and landscape/seascape amenities	Existing condition and health of coastal ecosystems and natural barriers to coastal flooding, abundance and variety of natural resources and unique ecosystems, quality of coastal stewardship efforts

Source: Adapted from Kaiser, 2006

Swimming lessons for women in Zanzibar is important for their new mariculture livelihood venture. This also builds their adaptive capacity to survive if their community were to be hit by a large storm surge or tsunami.

of Vietnam since 1994. The mangroves have reduced the cost of dyke maintenance by millions of dollars annually and reduced damages from coastal storms. Similarly, after the Indian Ocean Tsunami, a regional effort was initiated to create coastal "Green Zones" and protect mangrove forests as buffers.

To assess the sensitivity of coastal assets exposed to climate change, it is useful to answer the following questions:

- How and to what degree were social, economic and ecological assets affected by past climate conditions and coastal hazard events?
- What specific characteristics make groups or systems sensitive?
- Was everyone equally impacted? If not, what were the differences between various individuals and groups?

Resilience to coastal hazards and **adaptive capacity** are linked. High levels of adaptive capacity lead to an increased likelihood of being able to absorb impacts of climate change and rebound. The Coastal Community Resilience Guidebook provides benchmarks and a methodology for conducting resilience assessments in the coastal context. (USAID, 2007)

- What is the sensitivity of "non-exposed" assets? For example, agriculture activities that take place away from the coast may rely on a highly exposed and sensitive coastal road or port for export. Losing this transportation asset could result in a loss in the value of the agricultural assets.

Answers to these types of questions help in estimating the likelihood and degree of potential impacts to systems and assets. They also help in identifying specific characteristics that make coastal assets vulnerable/ sensitive and the thresholds at which impacts will likely occur. For each projection, assess what is exposed and its sensitivity to various degrees of climate change. You can then estimate the impacts by collecting data on the costs of the assets, number of people or infrastructure that will be exposed.

2.2.4 ASSESSING ADAPTIVE CAPACITY

Adaptive capacity refers to the ability of society to change in a way that makes it better equipped to manage its exposure and/or sensitivity to climatic influences. A community with the capacities to adapt is likely to be more resilient or able to recover from stressful events and conditions (see text box). Referring back to Figure 2.1, it is the first two factors, exposure and sensitivity, that dictate the gross vulnerability of a coastal community and its potential susceptibility to adverse impacts. The third factor, adaptive capacity, reflects a community's ability to manage, and thereby reduce, gross vulnerability.

When you look at a community's exposure, sensitivity, and adaptive capacity as a whole, the result is net vulnerability. Net vulnerability is the ability of a community to manage risk and thus minimize or prevent potential impacts. For example, a coastal region could have high gross vulnerability, but relatively moderate net vulnerability as a result of its high adaptive capacity. The reverse is also possible—i.e., a coastal area with low gross vulnerability may be compromised by its limited degree of adaptive capacity, thereby increasing its net vulnerability.

A broad range of factors reflect adaptive capacity:

- Political leadership and commitment
- Resource availability (e.g., human, physical, technological, and financial)

In 2004 many communities in the Indian Ocean revealed a weakness in adaptive capacity due to the strong dependence on fisheries livelihoods, which was severely impacted by the tsunami.

- Institutional and governance networks and competence
- Social capital and equity
- Information technologies and communication systems
- Health of environment

There are many studies with lists of determinants of adaptive capacity. Most indicators are focused on national scale factors such as gross domestic product, poverty indices and demographics. These indicators are helpful for comparative purposes, but not very useful for local decision-making. On a practical level, the aim of assessing adaptive capacity is to answer questions such as:

- How well do community members work together on coastal development planning and coastal management, including coastal hazards?
- What practices are currently employed to cope with natural hazards? Who is responsible for developing and implementing such measures? How effective are they?
- Are the public and decision-makers informed and engaged?
- Do most people rely on the same activity for their livelihoods? For example, does everyone rely on fishing or agriculture, such that a single event could destroy the livelihoods of many in the community or country?
- In an emergency, are there multiple means of communicating or transporting people and supplies? Or will damage to a single road, bridge, or telecommunications hub isolate a community?
- How healthy are the ecosystems and how well are natural resources managed?
- Adaptive capacity is not evenly distributed across and within societies. Also, wealthy countries have greater adaptive capacity than poorer countries (Nichols et al., 2007). This reality of adaptive capacity has been termed the "climate divide" (see text box to the left). In this sense, climate change is very much a development issue. Also within countries, it is the case that women and poor socioeconomic groups have less adaptive capacity and are the most vulnerable (see text box on next page).

Assessing the adaptive capacity of a place or sector helps in understanding why vulnerability exists in the first place. To reduce vulnerability, stakeholders must understand its root causes. These are much deeper societal issues than, for example, poorly constructed houses being located in areas of coastal erosion. Root causes might include poverty, insecure property rights, natural resource dependency, degraded resources, and weaknesses in institutions and political assets (Adger, 1999). Adaptive capacity can be strengthened through policies that enhance social and economic equity, reduce poverty, improve natural resources and coastal management, increase public participation, generate useful and actionable information, and strengthen institutions.

THE "CLIMATE DIVIDE"… WHAT IS IT?

The "climate divide" is a term used to explain the inequities and differences in responsibility for, impact from, and the capacities needed to reduce the effects of climate change. These disparities influence the strategies people use to cope with stresses and changing environments. Disproportionate impacts of climate change will be felt by less developed countries and small island developing states. Within countries, internal disparities and inequities influence how coastal climate change impacts different socioeconomic groups.

GENDER DIMENSIONS OF VULNERABILITY TO COASTAL CLIMATE CHANGE

Men and women are affected differently by the impacts of climate change and climate vulnerability. Women tend to be poorer, more marginalized and much more likely to be afflicted by natural disasters. World-wide, women are more vulnerable because of their social roles, inequalities in the access and control of resources, lower education, poorer health, and their low participation in decision-making. Climate change magnifies existing inequities.

Women are not only the primary victims of climate change, but they can also be effective change agents, managing both mitigation and adaptation. Women have extensive knowledge and expertise that can be applied in assessing community risk, selecting adaptation measures and mobilizing communities to manage risk.

To mainstream gender into climate change adaptation, we need the following types of information:

- ☑ Women's and men's resource use patterns, access, and responsibilities (to include a discussion on how might these change with climate change, and how they would adapt)
- ☑ Women's and men's roles in decision-making
- ☑ Women's and men's vulnerability—the gender dimensions of different climate change impacts (e.g. droughts and flooding) and how they would affect women and men
- ☑ Understanding how men's and women's roles change and may complement each other when coping with climate change

Gender inequalities are deeply ingrained and difficult to change, but you can overcome obstacles by:

- ☑ Ensuring that participatory planning methods are inclusive and motivate, support, and encourage women and men to engage in the process
- ☑ Understanding practical barriers to women's participation in discussions, planning and decision-making, and in micro-enterprise
- ☑ Ensuring that issues identified and analyzed are relevant and of interest to both men and women—this will help both genders formulate ideas and engage in the adaptation process
- ☑ Learning to recognize and handle conflict—personal attitudes and feelings about equal participation and gender mainstreaming will vary and some may work against it
- ☑ Establishing gender focused and disaggregated monitoring

For more information see: Gender Equality and Adaptation, WEDO and IUCN (http://www.genderandenvironment.org/admin/admin_biblioteca/documentos/Factsheet%20Adaptation.pdf)

2.3 COASTAL VULNERABILITY HOT SPOTS

Low-lying coastal areas, deltas and countries—many of which are small island developing states—and less developed countries are especially vulnerable to climate change impacts. Each has social, economic and physical vulnerabilities that combine to increase likely impacts even further. Other vulnerability hot spots include areas with poor and insecure land tenure, and dense or urbanized populations that will have to migrate with sea level rise.

Small size and isolation mean that SIDS are more vulnerable because they have scarce natural resource supplies (e.g., water resources, construction materials and physical space) and limited and high cost transportation options. The primary climate change

Small island developing states such as the Federated States of Micronesia are especially vulnerable to climate change.

concerns for SIDS are exposure to sea level rise and more intense or frequent cyclones/hurricanes. Low-lying SIDS have even fewer options for adaptation and are particularly vulnerable. However, even in SIDS there are steps you can take to help reduce vulnerability. Examples include relocating buildings and infrastructure; using different styles of housing; and preserving coral reefs, mangroves, and wetlands that offer protection by buffering against storm surges.

SIDS and less developed countries share the same economic challenges—high dependency on climate-sensitive industries like tourism, agriculture and fisheries; a degraded natural resource base; rapid population growth; weak administration and infrastructure; and poor transportation and communication systems. These socioeconomic stressors tend to further increase the vulnerability of a place by compromising ecosystem functionality. An example of this is the case of the Cuvu and Tuva villages in Fiji where unsustainable fishing practices destroyed the coral reefs (UNFCCC, 2008).

Some of the deltas most vulnerable to climate change include the heavily populated Yangtze (China), Ganges (Bangladesh), Mekong (Cambodia), Niger (Nigeria), Irrawaddy (Myanmar), Nile (Egypt) and Mississippi (USA). Even in the absence of a changing climate, most deltas are deteriorating as a result of human activities (e.g., extraction of groundwater and construction of upriver dams, levees and channels, and destruction of coastal vegetation). These and other such activities have affected the deltas' natural flood pulses and sedimentary processes (Day et al., 1997). Climate change has the potential to amplify the further decline of deltaic systems through sea level rise, increased storm intensity, and changes in rainfall and runoff to the coast.

However, these difficulties can be overcome. In cyclone-prone Mauritius, precautionary measures have proved remarkably successful in reducing injuries and loss of life. These measure include creating a network of shelters, public education initiatives, early warning systems and the mandatory closing of schools and businesses in the case of a storm. Similarly, the result of Bangladesh's investment in warning systems, shelters, coastal housing standards and evacuation plans for its delta areas is a dramatic decline in deaths over the past 40 years—from a high of a million people in 1970 to 4,000 in 2007 (Revkin, 2008).

SOURCES FOR MORE INFORMATION

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Nellemann, C., Hain, S., and Alder, J. 2008, *In Dead Water: Merging of Climate Change with Pollution, Over-harvest and Infestations in the World's Fishing Grounds,* United Nations Environment Programme (UNEP).
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http://www.pacificrisa.org/cms/images/Nakalevu%202006%20CVA%20A%20Guide%20to%20community%20vulnerability%20and%20adpatation%20assessment%20and%20action%20(3).pdf

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USAID 2007, *How Resilient is your Coastal Community? A Guide for Evaluating Coastal Community Resilience to Tsunamis and other Hazards.* U.S. Indian Ocean Tsunami Warning System Program: Bangkok, Thailand.
http://www.crc.uri.edu/download/CCRGuide_lowres.pdf

Woman's Environment & Development Organization (WEDO) and International Union for Conservation of Nature (IUCN), 2007, *Gender Equality and Adaptation.* Fact Sheet.
http://www.genderandenvironment.org/admin/admin_biblioteca/documentos/Factsheet%20Adaptation.pdf

WEBSITES

Computer-based Decision Tools

Adaptation Wizard: Risk based analysis and decision-making, UK Climate Impacts Programme.
www.ukcip.org.uk

Assessment and Design for Adaptation to Climate Change (ADAPT): A Tool to Screen for Climate Risk, World Bank.
http://go.worldbank.org/AWJKT60300

Community-based Risk Screening Tool - Adaptation & Livelihoods (CRISTAL), International Institute for Sustainable Development.
www.iisd.org/security/es/resilience/climate_phase2.asp

Mapping and Modeling

Providing Regional Climates for Impact Studies (PRECIS) Regional Climate Modeling System. UK Met Office.
http://precis.metoffice.com

SERVIR Regional Modeling and Visualization System
http://www.servir.net
http://www.iagt.org/downloads.aspx#sv

Vulnerability Assessment Tutorial. U.S. National Oceanic and Atmospheric Administration
http://www.csc.noaa.gov/products/nchaz/htm/methov.htm

chapter 3

SELECT COURSE OF ACTION

Vulnerability assessment provides the basis for defining a strategic plan of action. This includes the selection of specific adaptation issues, management goals and objectives, and bundles of measures. This chapter offers guidance on these topics and Annex A provides guidance briefs for practitioners on 17 coastal adaptation measures.

SELECT A COURSE OF ACTION

- ☑ Identify priorities
- ☑ Define adaptation goals and objectives
- ☑ Assess adaptation measures
- ☑ Select measure or bundle of measures

3.1 IDENTIFY PRIORITIES

The vulnerability assessment identifies numerous climate change risks and potential impacts to different sectors. There will likely be more climate change risks than can be acted upon based on resource availability or institutional and technical capacity. Therefore, adaptation to climate change must be strategic. The first step is to clearly identify the priority climate change risks upon which to focus efforts and resources. These priorities then determine the choice of adaptation measures selected.

The information needed to set priorities comes from the vulnerability assessment: what assets are most *sensitive* and *exposed* to climate change, and what are the *adaptive capacities* to address climate change impacts?

Identify priorities. Given the scope and multi-faceted effects of climate change, coastal adaptation efforts need to choose an initial focus on a limited set of key climate threats and adaptation issues that capture the interest, imagination and commitment of local residents and the government departments most directly involved. A limited number of climate change issues should be selected strategically with attention to the complexity of the problems, political realities, and available resources to achieve goals.

Priorities should be selected through an *inclusive and ongoing process* that involves the major stakeholder groups and decision-makers. It is their perspectives and interests that will influence the criteria used for judging risk and prioritizing concerns. Encouraging broad collaboration and cooperation in the process ensures the salience and public and political support for coastal adaptation that are necessary for effective implementation in the short and long-term. This was the conclusion of Pacific Island countries (see text box below). While there is no formula for determining the most important climate change risks for a specific coastal area, it is possible to draw from the experience of integrated coastal management best practices.

- Identify and involve governmental agencies and other formal institutions—such as universities and user groups—that have an interest in the condition and use of the coastal ecosystems being considered
- Solicit the views of major stakeholder and other groups and, to the extent possible, the general public (e.g., through focus groups and surveys)
- Identify potential leaders and the stakeholder groups who will be involved in the implementation of the adaptation measures
- Ensure the scope and complexity of the climate change issues selected as priorities for adaptation measures are appropriate to the capacity of the institutions involved

LESSON FROM THE "CAPACITY BUILDING FOR THE DEVELOPMENT OF ADAPTATION MEASURES IN PACIFIC ISLAND COUNTRIES PROJECT"

"Implementation of climate change adaptation should utilize an open, transparent and highly-participatory process that engages the community in the exploration of options to reduce vulnerability and effectively balances the needs and interests of a variety of stakeholders."

Source: Taito Nakalevu, workshop presentation, 18 and 19 April 2006 in Pohnpei, FSM.

3.2 DEFINE ADAPTATION GOALS AND OBJECTIVES

The goal for addressing a climate change issue should state the desired changes in or the quality of ecological, economic and social conditions you hope to achieve. Ensure the goal reflects the principles that guide resolution of the issue. For instance, the goal to maintain a natural and functioning shoreline may be highly appropriate for a majority of coastal settings where a natural, functioning shoreline represents the most cost-effective and best option to simultaneously meet several objectives. Conversely, this goal eliminates adaptation measures that involve hard engineering practices such as seawalls and groins. Table 3.1 lists some of the major categories of management goals common to adaptation programs in coastal areas.

Goals identify the desired endpoint you want to reach. Objectives provide the specific achievements that must be met in order to reach the goals. The most successful long-term coastal management programs teach us the importance of setting objectives that are unambiguous and time-bounded for each issue the program chooses to address. Such objectives are best when they specify in *quantitative terms* what will be achieved *by a specified date.*

KEY TERMS THAT DEFINE A HIERARCHY OF OBJECTIVES

Goal: A general statement of the desired long-term outcome or impact of the coastal management project. A goal statement does not imply that the project, by itself, will be sufficient to attain this goal. Rather, coastal management may contribute to reaching goals such as sustainable forms of development, the improved adaptation capacity to climate change, or improved quality of life, in coastal communities.

Objectives: Specific statements of the desired accomplishments or outcomes of a project. Project objectives are quantifiable and time-limited. Achievement of all project objectives should lead to the fulfillment of its stated purpose or goal.

Table 3.1 Examples of adaptation goals for coastal climate change

Illustrative Goals and Objectives for Coastal Adaptation to Climate Change

1. Functioning and healthy coastal ecosystems
   - **The natural shoreline is ecologically sound and functioning as a dynamic system.** Strengthened natural defenses protect people and nature from future hazards. Sand dunes, sea grass, mangroves and beaches are physical buffers.
     - ✓ Mangrove forest area is expanded by 30% within 5 years in any given coastal lagoon through community-based replanting efforts
   - **Extraction and use of natural resources do not compromise the sustainability of vital coastal ecosystems.** Reducing or eliminating non-climate stresses and unfavorable trends helps achieve functional ecosystems that are more resilient to climate change and variability. Resilient, healthy systems can better withstand all types of perturbations than can systems that are unbalanced or at the edge of their survival.
     - ✓ Illegal sand and gravel mining in coastal riverbeds and beaches is stopped in one year's time
   - **Marine fisheries are healthy and resilient to climate change. Reducing overfishing and destructive fishing** will reduce or eliminate non-climate stresses and non-climate trends helps strengthen fish populations and restore fish habitat.
     - ✓ Use of destructive small-mesh nets is eliminated in a given marine protected area within 2 years
   - **Coastal and marine ecosystems are functioning and healthy.** Functional ecosystems provide goods and services that are important to human society in the face of climate change (storm protection, flood mitigation, shoreline stabilization, erosion control, water storage, groundwater recharge, and retention of nutrients, sediments and pollutants).
     - ✓ Mangrove replanting increases mangrove habitat by 30% in a given coastal district in 2 years
   - **Key climatic refugia that will likely experience less change are reserved to "bank" ecosystem services for future climate changes.** Identifying locations that are more stable during periods of global climate change can be useful for conservation. In the marine environment, for example, these sites may have strong currents, upwelling or other oceanographic features that make them less prone to thermal fluxes.
     - ✓ Coral reef areas that are more resilient to climate changes are identified within 1 year and management plans are completed within 2 years to protect climate change resilient reef systems
   - **Freshwater supplies and access to freshwater for human uses continue to be available.** Proactive adaptation measures can reduce or avoid the undesirable impacts of climate change on access to freshwater supplies for meeting both growing human demand and environmental flow requirements.
     - ✓ Water User Associations in three Districts prepare water management plans and approve the plans within 2 years

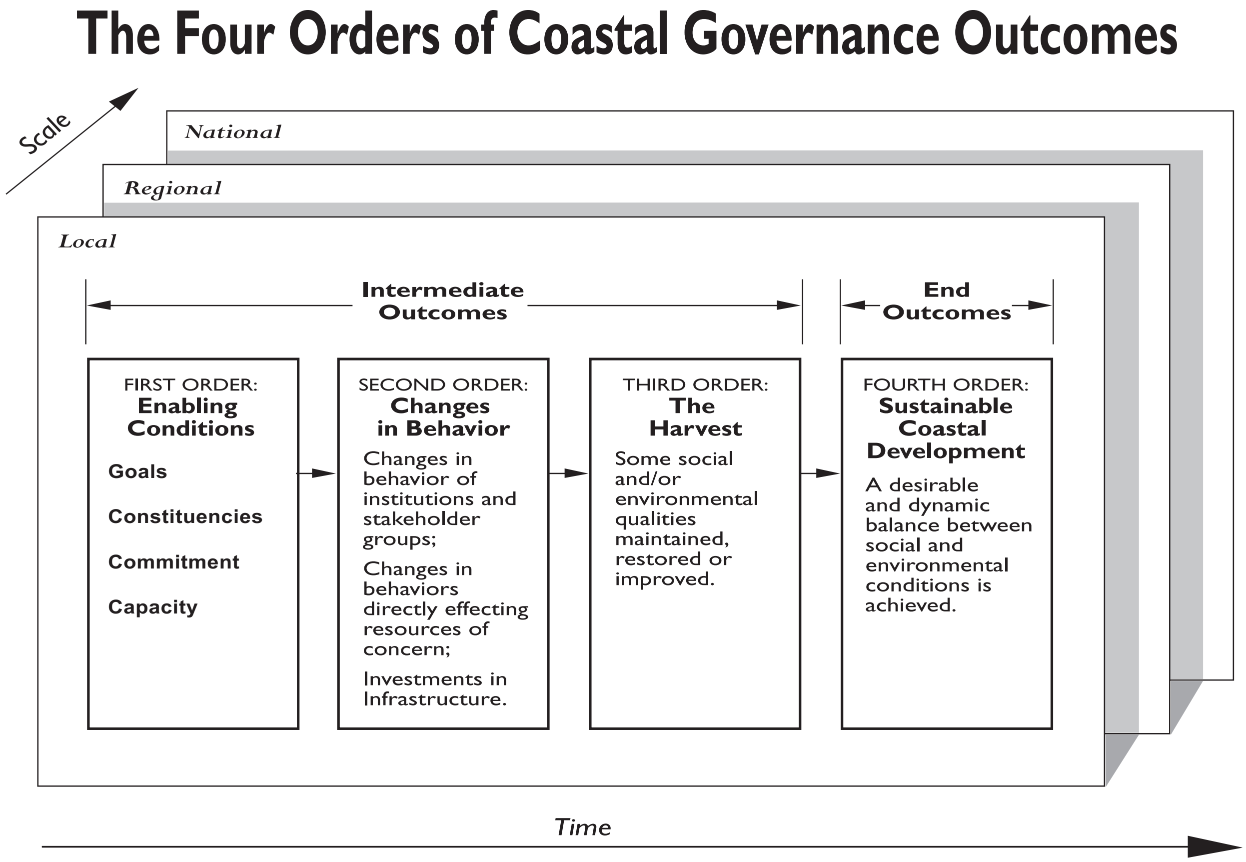
2. **The built environment is less exposed and less vulnerable to damages from natural hazards.** Reduce human injury, loss of life, and damage and loss to public and private infrastructure with measures that protect, accommodate or avoid the impacts of climate change on the built environment.
   - ✓ A District management plan in a given District that defines coastal development setback rules is completed and formally adopted by local government in a two year timeframe

3. **Livelihood opportunities are maintained or strengthened in the face of climate change impacts.**
   - ✓ Community savings and loan mechanisms are established in three coastal districts within 15 months to increase community resilience and opportunities for fishing households to diversify their livelihoods

4. **Impacts of climate change to human health and safety are minimized.** Disaster risk management and preparedness reduce the risks to human health and safety from natural hazards.
   - ✓ Flood hazard maps for all coastal provinces are completed in 1 year and at the same time pilot disaster risk management plans completed in 5 communities

5. **Governance, policy and planning capacities for planned adaptation are strengthened.** Vigilance, planning, and continually renewed political commitment improve adaptive capacity and reduce society's vulnerability to climate change impacts.
   - ✓ National Adaptation Plan of Action prepared by national working group within 12 months and recommended implementation actions initiated within 2 years

Figure 3.1 Ordering coastal adaptation outcomes



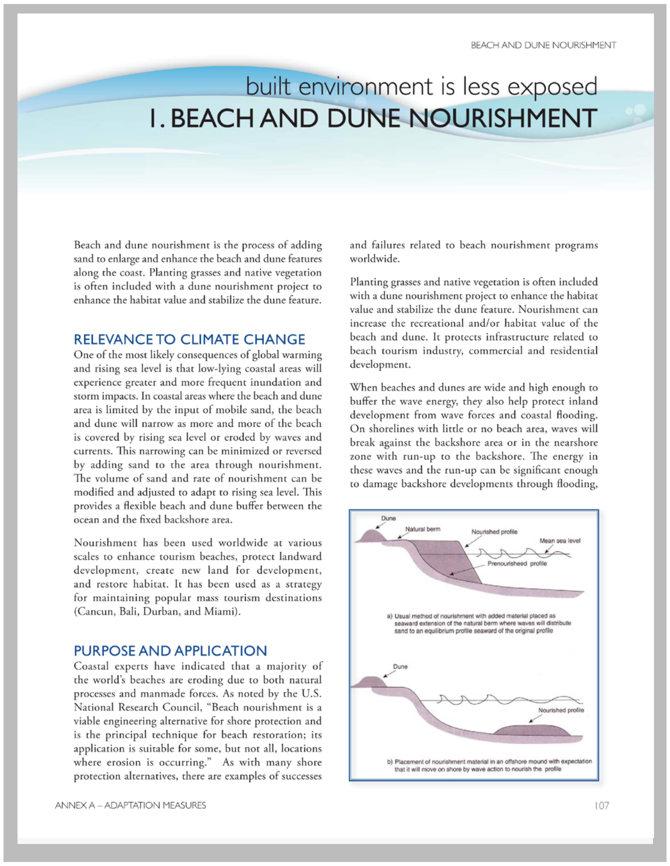
Source: Adapted from Oslen et al. 1998

Orders of Outcome framework helps to sort adaptation outcome goals and think strategically over the long term (see Figure 3.1). The **First Order** is achieved by assembling key enabling conditions for coastal adaptation including clear goals, engaged constituencies, formal commitment, and adequate institutional capacity. The third goal listed in Table 3.1 above (governance, policy, and planning capacities) is a First Order outcome. The **Second Order** marks changes in the behavior of institutions and relevant user groups. Change in coastal construction practices is a Second Order outcome. The **Third Order** marks the achievement of the specific societal and environmental quality goals such as healthy coastal ecosystems, improved human safety, sustainable fisheries, and food security. The **Fourth Order** adds the dimension of balance and asks whether the conditions achieved are sufficient to sustain a healthy, just, and equitable human society that is sustaining the qualities of the ecosystem of which it is a part.

3.3 ADAPTATION MEASURES

In general, there are two types of adaptation—"reactive" and "planned." Reactive adaptations are the changes in policy and behavior that people and organizations adopt after changes in climate and coastal risks are observed. For example, as the spatial and temporal distribution of fish stocks change with ocean warming, fishers will automatically change fishing practices. As property losses from coastal storms and sea-level rise increase, insurance companies will increase insurance rates, creating a disincentive to locate in hazard zones.

Planned Adaptation is the result of deliberate policy decisions on the part of pubic agencies vs. autonomous adaptations by private actors triggered by market or welfare changes



BEACH AND DUNE NOURISHMENT

built environment is less exposed

I. BEACH AND DUNE NOURISHMENT

Beach and dune nourishment is the process of adding sand to enlarge and enhance the beach and dune features along the coast. Planting grasses and native vegetation is often included with a dune nourishment project to enhance the habitat value and stabilize the dune feature.

RELEVANCE TO CLIMATE CHANGE

One of the most likely consequences of global warming and rising sea level is that low-lying coastal areas will experience greater and more frequent inundation and storm impacts. In coastal areas where the beach and dune area is limited by the input of mobile sand, the beach and dune will narrow as more and more of the beach is covered by rising sea level or eroded by waves and currents. This narrowing can be minimized or reversed by adding sand to the area through nourishment. The volume of sand and rate of nourishment can be modified and adjusted to adapt to rising sea level. This provides a flexible beach and dune buffer between the ocean and the fixed backshore area.

Nourishment has been used worldwide at various scales to enhance tourism beaches, protect landward development, create new land for development, and restore habitat. It has been used as a strategy for maintaining popular mass tourism destinations (Cancun, Bali, Durban, and Miami).

PURPOSE AND APPLICATION

Coastal experts have indicated that a majority of the world's beaches are eroding due to both natural processes and manmade forces. As noted by the U.S. National Research Council, "Beach nourishment is a viable engineering alternative for shore protection and is the principal technique for beach restoration; its application is suitable for some, but not all, locations where erosion is occurring." As with many shore protection alternatives, there are examples of successes and failures related to beach nourishment programs worldwide.

Planting grasses and native vegetation is often included with a dune nourishment project to enhance the habitat value and stabilize the dune feature. Nourishment can increase the recreational and/or habitat value of the beach and dune. It protects infrastructure related to beach tourism industry, commercial and residential development.

When beaches and dunes are wide and high enough to buffer the wave energy, they also help protect inland development from wave forces and coastal flooding. On shorelines with little or no beach area, waves will break against the backshore area or in the nearshore zone with run-up to the backshore. The energy in these waves and the run-up can be significant enough to damage backshore developments through flooding,

ANNEX A – ADAPTATION MEASURES 107

Adaptation measures are summarized as practitioner briefs in Annex A.

This Guidebook focuses on "planned adaptation." Planned adaptation is intentional, proactive, and occurs at the societal level. It is strategic and aims to address the full range of coastal climate change hazards in ways that meet societal objectives.

Seventeen practitioner briefs on coastal adaptation measures and strategies were developed with the assistance of coastal practitioners and are included in this Guidebook. The 17 briefs were chosen by coastal practitioners from an initial list of 50 adaptation measures. The term "measure" is used broadly and includes specific actions (e.g., a development setback) and management approaches (e.g., special area management planning) to address climate change adaptation. Table 3.2 lists these 17 measures and their relationship to the adaptation goals presented above, while Table 3.3 provides definitions. Annex A contains technical briefs on each measure, including information on:

- Relevance to climate change
- purpose/application
- Information and data requirements
- Design considerations for developing the measure
- Improving the likelihood of success in applying the measure as a climate change adaptation
- Sources for more information

Many of these adaptation measures are not "new" to those involved in managing coastal systems. They include strategies and actions familiar to coastal practitioners as part of responding to episodes of natural hazards and shocks. They are also familiar as part of everyday efforts to implement sustainable

USAID's Global Conservation Program is supporting the development and application of nature-based adaptation strategies to climate change in four large marine ecoregions—the Meso-American Reef in Central America, Wakatobi National Park and Raja Ampat in Indonesia, and Kimbe Bay in Papua New Guinea. Nature-based adaptation strategies can help people and communities deal with climate change impacts by protecting natural systems and the benefits they provide—shoreline protection, erosion control, as well as food from fisheries, jobs, and income. Solutions to address climate change impacts to the marine ecosystems rely on marine protected networks specifically designed for resilience (i.e. the ability to resist shock or recover quickly from stress) to climate change. Building resilience in coastal and marine ecosystems depends upon: (1) Spreading risk to manage for uncertainty by protecting replicates of critical habitats (i.e. mangrove forests) over a large geographic range; (2) Identifying and securing sources of "seed" or marine larvae which are critical for maintaining and restoring healthy populations; (3) Maintaining connectivity between habitats by creating refugia from other stresses, such as overfishing; and (4) Managing resources effectively by controlling other threats and pressures (i.e. sedimentation from land-based sources).

For more information: "Scientific Design of a Resilient Network of Marine Protected Areas: Kimbe Bay, West New Britain, Papua New Guinea." Source: http://conserveonline.org/workspaces/pacific.island.countries.publications development—including sound environmental management, planned development, wise resource use, and poverty reduction. Adopting these measures with a climate lens provides an opportunity to be strategic in the face of future changes.

There are also new approaches and tools being developed, such as nature-based approaches to coastal adaptation (see text box). Nature-based approaches include new tools for managing seascapes and approaches to conserve biodiversity in the face of shifting geographies. They focus on helping people and communities deal with climate change impacts by protecting mangroves, coral reefs, estuaries, seagrass beds, dune communities, and other systems on or near shorelines and the benefits they provide. As noted earlier in section 2.1, these benefits include protection from storms; mitigating floods; controlling erosion; providing water storage and groundwater recharge; and retaining and assimilating nutrients, sediments, and pollutants. In addition to these benefits, functional ecosystems are critical to maintaining biodiversity and to fishers and other resource users whose livelihoods rely on the condition of natural systems. These approaches provide a departure for the next generation of adaptation briefs, with subsequent versions of this Guidebook and associated tools.

Using a single, stand-alone measure is usually not the best approach. To respond effectively to a wide array of climate change impacts requires combining complementary measures. In selecting the best combination, it helps to look for measures that have interdependencies, contribute to good coastal management, and bring additional benefits in terms of climate change adaptation. For example, if the management goal is to maintain and restore coastal wetlands, a variety of adaptation measures can apply: coastal development setbacks, coastal zoning, protected area management, integrated coastal management, and actions to protect living shorelines. Table 3.2 lists other measures often undertaken as part of a suite of complementary adaptation actions for a particular climate change issue or adaptation goal.

Table 3.2 Adaptation measures, goals, and climate change impacts. Annex A contains technical briefs on each Adaptation Measure listed below.

Adaptation Measures	Description	Relevance to Climate Change
FUNCTIONING AND HEALTHY COASTAL ECOSYSTEMS AS A PRIMARY GOAL		
Coastal wetland protection and restoration	Provides nursery habitats for fisheries, ecosystems services for communities and their livelihoods; serves as a natural water filter, buffer against coastal ecosystems. Climate change mitigation and adaptation measure.	Acts as buffer against extreme weather events, storm surge, erosion, and floods; limits salt water intrusion.
Marine conservation agreements	Formal or informal agreements between parties to exchange benefits, take or refrain from certain actions, transfer certain rights and responsibilities in order to restore and protect fragile coastal and marine ecosystems.	Improves the resilience of coastal ecosystems to climate change and improves the economic and social conditions of coastal communities.
Marine protected areas	Intertidal or subtidal terrain areas, their waters, flora, fauna, and cultural and historical features, of which part or all is protected. An overarching management approach or strategy that can be used to bundle a series of measures.	Maintains healthy and resilient coastal habitats and fisheries productivity; acts as "refugia" and critical sources of new larval recruits.
Payment for environmental services	Financial instruments under which beneficiaries of ecosystem services compensate the suppliers as a means to fund sustainable environmental management policies and actions. No-regrets option.	Provides incentives to protect critical habitats that defend against damages from flooding and storm surges as well as coastal erosion.
BUILT ENVIRONMENT IS LESS EXPOSED AS A PRIMARY GOAL		
Beach and dune nourishment	Process of adding sand to enlarge and enhance coastal beach and dune features as well as, in many cases, planting grasses and native vegetation. Level and rate of nourishment can be adjusted to adapt to rising sea levels.	Protects shores and restores beaches; serves as a "soft" buffer against flooding, erosion, scour and water damage.
Building standards	Delineate the minimum technical and safety requirements for the design and construction of residential and commercial structures as a means to promote occupant health, welfare and safety. Can be prescriptive or objective-oriented.	By incorporating climate considerations (e.g. effects of flooding, waves and wind) in building design, it reduces damages and human safety risks from climate change impacts, including extreme events, sea level rise, and flooding.
Coastal development setbacks	Set distance from a coastal feature within which all or specific types of development are prohibited; often includes a buffer. Useful within an overarching coastal management program.	Reduces the infrastructure losses and human safety risks of sea level rise, storm surge, and erosion.
Living shorelines	Management practice involving strategic placement of plants, stones, sand fill and other materials to achieve the dual goal of long-term protection/restoration/enhancement of shoreline habitats and the maintenance of natural processes.	Mitigates erosion and protects people and ecosystems from climate change impacts and variability in low to medium energy areas along sheltered coastlines (e.g. estuarine and lagoon ecosystems).
Structural shoreline stabilization	Shoreline hardening or armoring; ranges from technically complex structures to the placement of construction debris serving as, for instance, bulkheads, revetments and seawalls. Not a long-term strategy, but option of last response.	Temporary buffer against the impacts of erosion and flooding caused by factors such as sea level rise, storm surge, and wave attacks.
DIVERSIFIED LIVELIHOODS AS A PRIMARY GOAL		
Fisheries sector good practices	Adapting fisheries management and strengthening capacity to deal with long-term climate-related effects on relevant habitats and ecosystems. Can apply to production, infrastructure, operations and/or ecosystem protection.	Contributes to the protection of rural livelihoods, food security and marine biodiversity against the impacts of extreme climate events, precipitation change, ocean acidification, sea level rise and sea surface warming.
Mariculture best management practices	Largely self-enforced measures to better efficiency and cost in the mariculture sector in order to increase the derived benefits and promote development.	Integration of climate change considerations helps safeguard against extreme climate events, precipitation change, ocean acidification, sea level rise and sea surface warming.
Tourism best management practices	Actions that enable the tourism sector to improve services and business while minimizing the adverse effects on the environment and local communities. Can serve as climate change mitigation and adaptation measure.	Integration of climate change concerns helps promote the sector's sustainability as well as safeguard against extreme climate events, precipitation change, sea level rise and sea surface warming.
HUMAN SAFETY AND SAFETY ENHANCED AS A PRIMARY GOAL		
Community-based disaster risk reduction	An overarching management approach or strategy consisting of structural and non-structural measures that prevent, mitigate and/or help prepare for the effects of natural hazards. Can be used to bundle a series of measures.	By proactive planning and capacity building that addresses the specific needs of local communities, increases their resilience and ability to respond to the effects of extreme climate events and flooding.
Flood hazard mapping	Conducted in areas adjacent to water bodies to ensure land owners, insurers and regulators have relevant information on flooding risks.	Informs coastal planning processes and policy, reducing the impact of flooding resulting from storm events, heavy rains, storm surges, and extreme tides.
OVERARCHING PLANNING AND GOVERNANCE AS A PRIMARY GOAL		
Coastal watershed management	Integrated water resources management (IWRM) in the coastal context, which takes into consideration watershed and estuary management. An overarching approach or strategy that can be used to bundle a series of measures.	Preserves estuaries, which act as storm buffers and protect against coastal groundwater salinization.
Integrated coastal management	An overarching management approach or strategy involving planning and decision-making geared to improve economic opportunities and environmental conditions for coastal people. Can be used to bundle a series of measures.	Provides a comprehensive process that defines goals, priorities, and actions to address coastal issues, including the effects of climate change.
Special area management planning	An overarching management approach or strategy for a geographic area of critical concern, usually within the context of a coastal resources management program. Can be used to bundle a series of measures.	Improves the management of discreet geographic areas where there are complex coastal management issues and conflicts, including issues related to extreme climate events, precipitation change, ocean acidification, sea level rise and temperature change.

3.4 SELECTING MEASURES

In selecting measures, it is important to acknowledge differences among countries. What is the pre-existing degree of awareness and salience of climate change impacts? What is the locus of decision-making power? What is the capacity to address coastal issues? What is the country's "readiness" to tackle accelerated climate change? How are present and future environmental goods and services maintained?

Different country contexts drive the need to tailor adaptation measures to local conditions (see text box). Adaptation measures need to be commensurate with the realities of time, funding, personnel, and institutional capacity. Capacity to respond to climate change issues will grow with time, experience, and the positive reinforcement that comes with success. Early successes of adaptation may begin with establishing setbacks and buffer areas, for example, in undeveloped areas or areas proposed for future development that are exposed to flooding and erosion. More complex adaptation measures might include those that involve infrastructure development and maintenance.

Population density and infrastructure are other key considerations in selecting measures. For example, in developed areas facing potential increases in erosion, sea level rise, or flooding, the favored adaptation option would be structural shore protection (to stabilize the shoreline) vs. retreat. In underdeveloped areas, the opposite would be likely—i.e., a strategy of retreat would be favored. Retreat refers to a series of measures that would remove the population and development by "retreating" landward—i.e., away from the potential risk.

Coastal managers, stakeholders and decision-makers can use a range of criteria in deciding the best adaptation option within a given local context. Criteria include:

- **Technical effectiveness:** How effective will the adaptation option be in solving problems arising from climate change, (i.e. might some measures be more beneficial than others)?
- **Costs:** What is the cost to implement the adaptation option and what are the benefits? Is one approach both cheaper and more effective? Is the measure a "no-regrets" measure—i.e., would it be worthwhile regardless of climate change (e.g., protecting/restoring coastal ecosystems that are already vulnerable or of urgent concern for other reasons)?
- **Benefits:** What are the direct climate change-related benefits? Does taking action avoid damages to human health, property, or livelihoods? Or, does it reduce insurance premiums? Are there any greenhouse gas reduction advantages that could be valued according to the market price for carbon credits? Other benefits include increased ecosystem goods and services and positive contributions to economic value chains.
- **Implementation considerations:** How easy is it to design and implement the option in terms of level of skill required, information needed, scale of implementation, and other barriers?
  - Some measures require sophisticated information and specialists that are not available
  - Flexible, adaptive approaches require more knowledge and judgment than a simpler, rule-based policy
  - A standardized setback for a shoreline area is simple compared to a detailed scientific study of oceanographic, geological or other landscape-scale parameters
  - Working with a resort developer in a particular case to make adjustments may be easier than creating a broad-reaching policy that deals with all business owners in a tourism district who unwittingly made investments and physical alterations to the shore that expose them to hazards and climate change

The Climate Ready Estuaries Program of the U.S. Environmental Protection Agency has initiated a review of on-the-ground adaptation strategies available to coastal managers, with a focus on the eight management

Tailor to local conditions. Countries or coastal areas may share the same climate change issues. Yet, each has different circumstances—climate, natural resources, infrastructure, technological state, economy, governance, etc.—so the responses to those climate change issues may vary. Coastal adaptations must be "tailored" to the local context through an inclusive process that matches the climate change issues with the technical capabilities and the capacity of the institutions and community stakeholders of the place.

goals critical to the National Estuary Program. Looking at the management goals (both primary and synergistic), together with the climate stressors, benefits, and constraints helps managers identify measures and bundles of measures that may be implemented to mainstream adaptation (see Figure 3.2).

Most adaptation measures can help in achieving multiple objectives and benefits. "No regrets" measures should be the priority. For example, wetlands protection and living shoreline strategies would be beneficial even in the absence of climate change. Living shorelines protect from erosion and at the same time can enhance vegetated shoreline habitats today and in the future as wetlands migrate landward (see Figure 3.3). This, in turn, can benefit natural resources-dependent livelihoods and increase community resilience. Compare this to the option of constructing a seawall—a strategy that also could protect against erosion in a specific location, but at the same time cause problems in the future (e.g., erosion of adjacent shoreline or preventing wetland migration), and bring little benefit to the larger community and natural ecosystem. Measures that provide few benefits other than protection require a high degree of certainty about the impact from climate change at a particular site.

As a procedure, conduct basic screening of adaptation measures on an individual basis. For options that are substitutes (beach nourishment vs. shoreline stabilization), select the best option to include in the overall adaptation strategy. Consider synergistic impacts. Some measures will yield better results when combined with others (e.g., combining construction setbacks together with building codes). Take into account budget constraints and try to consider all implementation costs as part of the package. Finally, be realistic about current organizational capacity to simultaneously manage multiple adaptation options.

When selecting measures, also consider how the measure may affect greenhouse gas emissions. Many measures can be designed in a way that reduces the production of greenhouse gases or removes the gases from the atmosphere (sequestration). For example, although wetlands cover 6% of Earth's land surface, they store 10-20% of its terrestrial carbon. Preserving or restoring wetlands helps protect the shoreline and the community from climate risks and also mitigates greenhouse gas concentrations. Similarly, building standards for the coast can serve as both an adaptation measure, and be designed to reduce energy use and greenhouse gas emissions.

Local stakeholders along with the socioeconomic and institutional context of the place will determine the relative importance of various criteria in selecting the most appropriate adaptation measures. The dynamics and processes for the coastline in question will also influence these criteria. As well, it is essential to match measures to the resources, the technical capabilities, and the capacity of the institutions and community stakeholders.

Cambodia's Tonle Sap has adapted to changes in water levels, where the lake can rise up to 10 meters. This floating school moves with the community as it migrates during these seasonal changes.

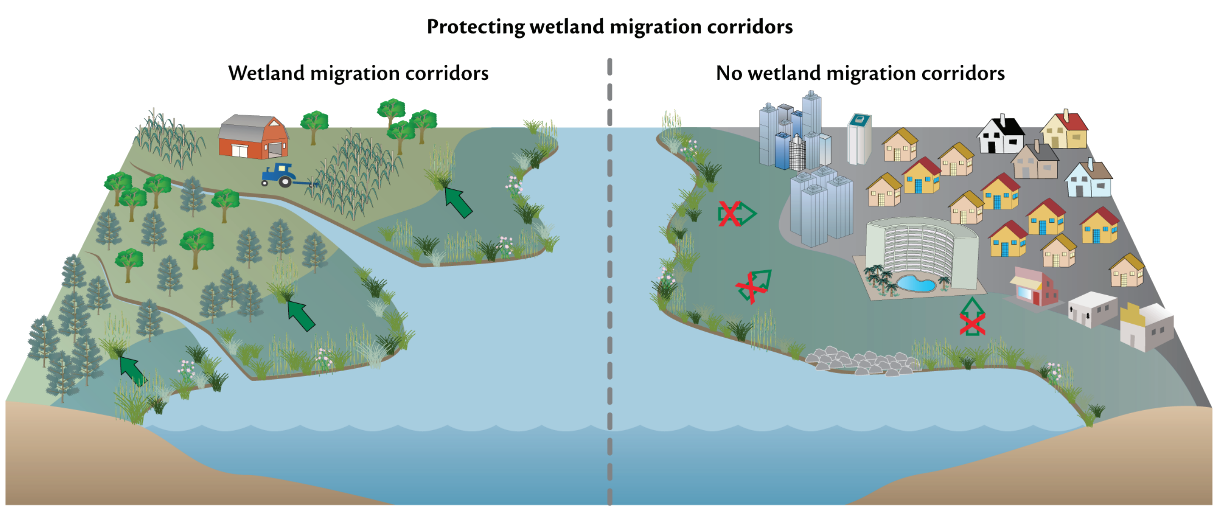
No-regrets. Many coastal adaptations yield benefits independent of climate change. These measures address current vulnerabilities and focus on increasing the ability of ecosystems and communities to cope with current environmental pressures and climate variability. They provide a benefit now, a benefit in the future, and potentially provide a benefit whether or not the projected climate changes become reality. These options are more likely to gain political support given that some climate impacts will only be felt over the medium term.

Figure 3.2 Adaptation options related to the goals of the U.S. National Estuary Program.

Adaptation Option	Climate Stressor Addressed	Additional Management Goals Addressed	Benefits	Constraints	Examples
Retreat from and abandonment of coastal barriers	Sea level rise	Maintain/restore wetlansd	May help protect estuaries, allowing them to return to their natural habitats	Not politically favored due to the high value of coastal property and infrastructure	
Purchase upland development rights or property rights	Changes in percipitation; Sea level rise	Maintain/restore wetland; Maintain water quality	Protects habitats downstream	Costly; uncertainty about sea level rise means uncertainty in the amount of property purchased	San Francisco Estuary Project (planned); Massachusetts Climate Protection Plan
Expand the planning horizons of land use planning to incorporate longer climate predictions	Changes in precipitation; Sea level rise	Preserve coastal land/development	Could inhibit risky development and provide protection for estuarine habitats	Land use plans rarely incorporate hard prohibitions against development close to sensitive habitats and have limited durability over time	San Francisco Bay Conversation and Development Commission (SFBCDC) has proposed recommendations

In evaluating each management goal within their program, managers identify an initial set of measures from which they can develop adaptation strategies to meet their management goals. Source: USEPA, 2008

Figure 3.3 Protecting wetland migration corridors will aid in sea level rise adaptation and provide mitigation to greenhouse gases.



As sea level rises, wetlands may migrate into open spaces such as forests and fields. However, wetlands cannot migrate into areas with man-made barriers such as hardened shorelines and heavy development such as urban, commercial, and residential areas.

Source: Maryland Commission on Climate Change, Adaptation & Response Working Group. 2008

SOURCES FOR MORE INFORMATION

Note: Sources for more information are also listed in each of the 17 adaptation technical briefs in Annex A

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San Francisco Bay Conservation and Development Commission, *Preparing for Sea Level Rise in the San Francisco Bay Area – A Local Government Forum.*
http://www.bcdc.ca.gov/planning/climate_change/2008-04-16_forum.shtml

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