

A TOOLKIT FOR

Integrating Disaster Risk Reduction and  
Climate Change Adaptation into

**ECOSYSTEM MANAGEMENT  
OF COASTAL AND MARINE AREAS  
IN SOUTH ASIA**



Outcome of the South Asian Consultative Workshop  
New Delhi, 6 and 7 March 2012



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## List of Acronyms

ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Centre
AIDS	Acquired immune deficiency syndrome
ARI	Acute respiratory infection
BOBLME	Bay of Bengal Large Marine Ecosystem
CBD	Convention on Biological Diversity
CBO	Community-based Organisation
CCA	Climate change adaptation
CCD	Coast Conservation Department
CH <sub>4</sub>	Methane
CIDA	Canadian International Development Agency
CO <sub>2</sub>	Carbon dioxide
COP	Conference of Parties
CRED	Centre for Research on Environmental Decisions
DDMA	District Disaster Management Authority
DM	Disaster management
DRR	Disaster risk reduction
EbA	Ecosystem-based adaptation
ECA	Ecologically Critical Area
EIA	Environmental impact assessment
EJF	Environmental Justice Foundation
ENSO	El Niño–Southern Oscillation
ENVIS	Environmental Information System for India
EPA	Environmental Protection Agency
EPI	Expanded Programme on Immunization
FFF	Forest, Fish, and Fruit
FMA	Fishery Managed Area
GBIF	Global Biodiversity Information Facility
GCRMN	Global Coral Reef Monitoring Network
GDP	Gross domestic product
GDRC	Global Runoff Data Centre
GEF	Global Environment Facility
GHG	Greenhouse gas
GIS	Geographic information system
GoI	Government of India
GOOS	Global Ocean Observing System
GOMBR	Gulf of Mannar Biosphere Reserve
GOMBRT	Gulf of Mannar Biosphere Reserve Trust
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Society for Technical Cooperation)
H <sub>2</sub> O	Water
HDI	Human Development Index
HDR	Human Development Report
HFA	Hyogo Framework for Action
HFC	Hydrofluorocarbons
IDRC	International Development Research Centre
INCOIS	The Indian National Centre for Oceanic Information Systems
IPCC	Intergovernmental Panel for Climate Change
ISDR	International Strategy for Disaster Reduction
IUCN	International Union for Conservation of Nature

KSNDMC	Karnataka State Natural Disaster Monitoring Centre
LDCs	Least developed countries
LOICZ	Land and Ocean Interaction in the Coastal Zone
MA	Millennium Ecosystem Assessment
MDG	Millennium Development Goals
MCPA	Marine and coastal protected area
MoEF	Ministry of Environment and Forests
MPA	Marine protected area
MSP	Multi-stakeholder platform
NAQDA	National Aquaculture Development Authority
NAPA	National Action Plan of Adaptation
NARA	National Aquatic Resources Development Agency
NASA	National Aeronautics and Space Administration
NCCAS	National Climate Change Adaptation Strategy
NCSCM	National Centre for Sustainable Coastal Management
NDMA	National Disaster Management Authority
NDRF	National Disaster Response Force
NGO	Non-governmental organization
NIDM	National Institute of Disaster Management
NO <sub>2</sub>	Nitrous oxide
NOAA	National Oceanic and Atmospheric Administration
O <sub>3</sub>	Ozone
OECD	Organisation for Economic Co-operation and Development
OHCA	Office for the Coordination of Humanitarian Affairs
PFC	Perfluorocarbons
PPP	Purchasing power parity
RAMSAR	Convention on Wetlands of International Importance
REDD	Reducing Emissions from Deforestation and Forest Degradation
RRDA	Regional Resource Development Authority
SAARC	South Asian Association for Regional Cooperation
SACEP	South Asia Co-operative Environment Programme
SAM	Special area management
SDMAs	State Disaster Management Authorities
SEIAA	State Environmental Impact Assessment Authority
SEDAC	Socio-economic Data and Applications Center
SER	Society for Ecological Restoration
SF <sub>6</sub>	Sulphur hexafluoride
SWoT	State of the World's Sea Turtles
TB	Tuberculosis
TCM	Traditional Chinese medicine
UN	United Nations
UNDP	United Nations Development Programme
UNESCAP	United Nations Economic and Social Commission
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations Office for Disaster Risk Reduction
UNITAR	United Nations Institute for Training and Research
US\$	United States dollars
VOC	Volatile organic chemical
WCMC	World Conservation Monitoring Centre
WHO	World Health Organization
WMO	World Meteorological Organization
WWF	World Wildlife Fund

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## Foreword

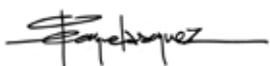
Five countries in South Asia - Bangladesh, India, the Maldives, Pakistan and Sri Lanka have extensive mangroves, coral reefs, and sand dunes that harbor some of the world's most significant coastal and marine biodiversity. The coastal sub-region of South Asia is home to about 400 million people, many are poor and vulnerable. The sub-region also faces increasing occurrence of natural hazards such as cyclones, floods and tidal surges; rapid changes in land-use; and climate variability. Integrated management of coastal and marine environment is crucial to ensure the long-term sustainability of this sub-region.

Against this backdrop, we are delighted to introduce two publications that promote ecosystem approach for effective disaster and climate risk management by strengthening the inter-linkages between Disaster Risk Reduction, Climate Change Adaptation and coastal ecosystems management. These are '*A Toolkit for Integrating Disaster Risk Reduction and Climate Change Adaptation into Ecosystem Management of Coastal and Marine Areas in South Asia*'; and '*Status of Coastal and Marine Ecosystem Management in South Asia*'.

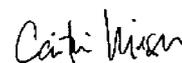
The Toolkit offers a step-by-step guide for integrating Disaster Risk Reduction and Climate Change Adaptation into the coastal and marine ecosystem management that will be quite useful for the field practitioners of coastal areas in the sub-region. The toolkit is accompanied with the publication on current status, providing the context of coastal and marine ecosystem management in South Asia. Both these publications build on UNDP's new Biodiversity and Ecosystems Global Framework, titled *The Future We Want: Biodiversity and Ecosystems – Driving Sustainable Development* that calls for a shift in focus towards the positive opportunities provided by biodiversity and natural ecosystems, in terms of harnessing their potential for sustainable development.

These publications are outcomes of a South Asian Regional Consultation of Experts held in New Delhi in March 2012 organized jointly by the United Nations Development Programme (UNDP) India, and the United Nations Office for Disaster Risk Reduction (UNISDR), Asia and the Pacific Secretariat.

It is our intention that these publications serve as valuable source material for taking an integrated approach to ecosystem management for effective risk reduction. Equally we hope that they will inform the ongoing consultations on the Post-2015 Development Agenda and Disaster Risk Reduction frameworks. We believe this is an important step towards building resilience of nations and communities in the South Asian sub-continent to shocks and natural disasters.



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# 1. Introduction

## Background

The Coastal and marine environment plays a vital role in supporting human welfare by virtue of its immense biological and mineral resources and the life-supporting systems it provides. Production operations and economic installations along the coast, such as marine fishing, aquaculture, agriculture, oil and gas exploration, ports and harbours, and tourism, contribute significantly to the global gross domestic product (GDP).<sup>1</sup> For instance, nearly 500 million people (including nearly 30 million poor people) depend directly and indirectly on coral reefs for their livelihoods, food and other resources (Wilkinson, 2004). Further, it is estimated that up to 80 percent of the global fish catch is directly or indirectly dependent on mangroves (Sullivan, 2005).

The five coastal countries of South Asia, namely Bangladesh, India, the Maldives, Pakistan and Sri Lanka, have extensive coastal and marine ecosystems (see Figure 1.1). The coastal region of South Asia is also one of the most populous in the world and is home to around 400 million people who are critically dependent on coastal and marine ecosystems for their livelihoods. Some of the world's largest urban agglomerations that are located along the coast in the region include Mumbai, Kolkata, Colombo, Chennai, Chittagong, Karachi and Male.

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<sup>1</sup> For instance, production activities in the coastal region constitute around 10 percent of India's national GDP (UNDP, 2011b, India: Coastal and Marine Programme document).

**Figure 1.1. Map of South Asia**



(Source: [http://www.unisdr.org/files/18873\\_southasiadisasterriskassessmentstud.pdf](http://www.unisdr.org/files/18873_southasiadisasterriskassessmentstud.pdf))

The coastal and marine environment in South Asia faces threats ranging from mega-development, excessive harvesting of resources, an increasing occurrence of disasters and, of late, climate change. There is conclusive evidence to prove that there are critical linkages between ecosystems, climate change and disasters. The vicious cycle of ‘climate change–ecosystem degradation–accelerated disasters’ causes severe economic and ecological disruptions including the loss of lives, property and biodiversity. Effective management of the coastal and marine environment is thus critical in our pursuit of achieving sustainable development and particularly the Millennium Development Goals (MDGs).

One of the central facets in developing a pragmatic strategy for the effective management of coastal and marine areas in South Asia involves integrating disaster risk reduction (DRR) and climate change adaptation (CCA)<sup>2</sup> into ecosystem management. These need to be integrated into the relevant policy and programme imperatives at the regional, national and subnational levels keeping in mind the contexts, specificities, needs and aspirations of human, natural and geophysical systems.

<sup>2</sup> This acronym is commonly used for ‘Common Country Assessment’. In this document, ‘CCA’ refers to climate change adaptation.

This publication is aimed at broadening our understanding of the possibilities of integrating DRR and CCA into ecosystem management of coastal and marine ecosystems in the South Asian region. This document is a product of a consultative workshop held in New Delhi on 6 and 7 March 2012, “Integration of Disaster Risk Reduction and Climate Change Adaptation into Biodiversity and Ecosystem Management of Coastal and Marine Areas in South Asia”. It is expected that coastal and marine environment practitioners will draw hands-on tools and practical examples on incorporating DRR and CCA into ecosystem management in their respective areas from this publication.

## Threats to the coastal and marine environment

At a global level, the threats faced by the coastal and marine ecosystems originate from various factors. The UNDP Global Human Development Report 2011 (UNDP, 2011a) notes that the current annual fish catch of 145 million tonnes far exceeds the maximum annual sustainable yield of 80–100 million tonnes. About 10 percent of the fishing activities alone accounts for an estimated 90 percent of the total catch—mostly fishers from industrialized countries using capital-intensive methods such as the deployment of technologically advanced fishing vessels with long-term storage facilities and mechanized trawls suitable for fishing in deep waters. Around 45 million (including 6 million women) fisherfolk face lower catches as coastal and marine ecosystems degrade.

Indiscriminate use of resources, reclamation for urban and agricultural expansion, pollution from urban and industrial effluents, and offshore oil and gas exploration have taken a heavy toll on coastal and marine resources in the recent past. For instance, in India, an estimated 18,240 million litres of domestic sewage is discharged into rivers each day that ultimately finds its way into oceans. In the Sundarbans, the largest delta of the world, situated in India and Bangladesh, 150,000 hectares of mangroves has been destroyed in the last century and converted to agriculture (Kathiresan, undated b). Much of the coastal region of South Asia is being sought increasingly for massive infrastructure development, for industrial or infrastructural installations in India and for ports and development of the leisure sector in Sri Lanka. For instance, beach sand mining on the east coast of Sri Lanka is estimated at 500–1,000 cubic metres per kilometre each year (CCD, 2004). In addition, coastal cities are growing rapidly, causing widespread degradation of coastal and marine habitats. Climate change and an increasing frequency of disasters exacerbate the already existing vulnerabilities of the coastal and marine environment.

According to the Millennium Ecosystem Assessment (2005), climate change is likely to become one of the most significant drivers of biodiversity loss by 2100. The Third Assessment Report of the IPCC states that coastal and marine areas are most vulnerable to climate variability and the long-term impacts of climate change. The UNDP Global Human Development Report (2011a) estimates that by 2100, about 90 percent of the coral reefs that protect oceanic islands from waves and storms could disappear, adding to the vulnerabilities of coastal populations. Further, the 2009 Global Assessment Report on Disaster Risk Reduction has identified ecosystem decline as one of the four major drivers of risks and called for greater protection and enhancement of ecosystem services. The United Nations Framework Convention on Climate Change (UNFCCC) negotiations have also recognized that ecosystems are vital in adapting to climate change. Sustainable ecosystem management is, therefore, increasingly viewed as an effective approach for achieving both CCA and DRR (Krishnan and Soni, 2011).

## Climate change and the coastal and marine environment

Increased exposure to extreme weather events and natural disasters, and their impacts on ecosystems are cited among the five tipping points through which climate change impacts human development (UNDP, 2007). With the current trends, the average global temperature could rise by 2°–3°C within the next 50 years or so, leading to many severe impacts, often mediated by water. These impacts will be manifested in the coastal and marine environment as a rise in the sea level, violent storm surges, ocean acidification, coral bleaching and heat stress. Crippled functionality of ecosystems, declining crop yields, floods during the wet season and a reduction in the off-season water supply are other possible impacts.

Fluctuating weather patterns are inducing changes in the distributions and ranges of species and are disrupting the natural balance of many ecosystems. As a result, the goods and services they provide to humans will be affected drastically. Invasive species, with shorter life cycles and higher reproductive capacities, are more likely to survive climate change, leading to their proliferation, often at the cost of native species. Changes in the distribution of species can also expand the ranges of disease vectors, such as mosquitoes, that can have insidious implications for human health.

Countries in the South Asian region face the challenge of sustaining their economic growth while dealing with climate change. They have solid reasons to be concerned about climate change as several million people directly rely on climate-sensitive sectors (agriculture, forests and fisheries) and natural resources for their subsistence and livelihoods. Besides, South Asia is home to nearly 40 percent of the world's poorest people (Dorward et al., 2002). Tragically, at the forefront of all these events are the poor who are critically dependent on coastal and marine ecosystems for their livelihoods.

## Disasters and the coastal and marine environment

Asia is the world's most disaster-prone region, having suffered about half of the world's major disasters over the past 50 years, 67 percent of the casualties and 28 percent of the economic losses (Reid and Simms, 2007). It is estimated that 1 in every 19 persons in Asia is affected by natural disasters, compared with 1 in every 1,500 persons in the Organisation for Economic Co-operation and Development (OECD) countries: This represents a risk differential of about 79 (UNDP, 2007).

The region's geo-climatic circumstances and its relatively poor socio-economic conditions make it extremely vulnerable to devastating disasters. Among the disasters that strike the region frequently are floods, droughts, cyclones and landslides, affecting both natural and human systems (see Boxes 1.1 and 1.2). Simulation models predict an increase in the frequency of tropical cyclones in the Bay of Bengal and a sea level rise in coastal zones, displacing populations, increasing flooding in low-lying areas and reducing crop yields due to inundation and salinization.

Over the years, there has been a paradigm shift in the disaster management strategy, with a greater emphasis being given to DRR. There is also a sustained emphasis on reducing the vulnerabilities and increasing the coping capacities of populations at risk. DRR is being carried out by systematically analysing the underlying risks and formulating institutional mechanisms and frameworks to address these risks.

## The resilience of coastal and marine ecosystems: Its bearing on DRR and CCA

There is a growing recognition of the role healthy ecosystems play in adapting to climate change and disasters. They have the capacity to recover naturally from environmental perturbations. Resilient ecosystems also provide an array of goods (water, shelter, food, fuel, fibre, raw materials, genetic materials) and a multitude of services (such as acting as a barrier against disasters) that people critically depend on for survival and existence (Krishnan and Soni, 2011).

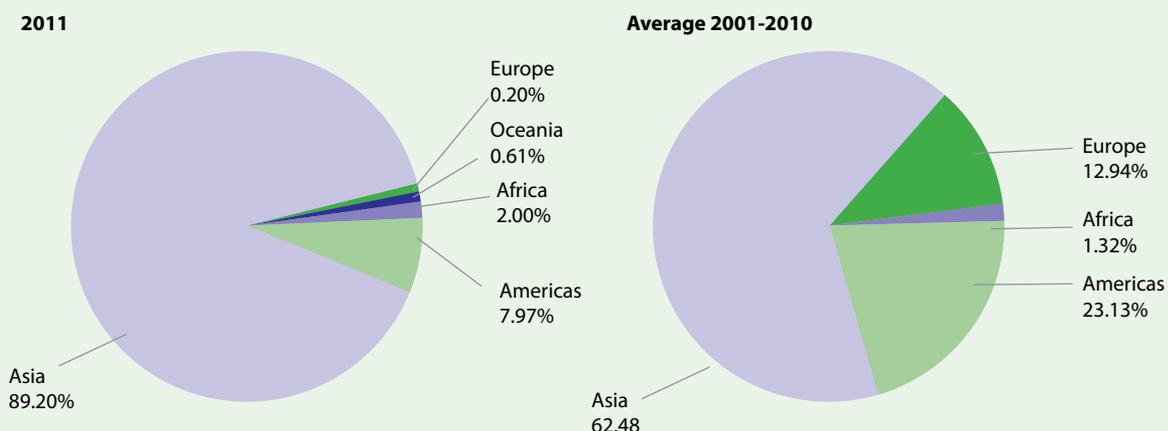
### **Box 1.1 The effect of disasters on Olive Ridley Turtles**

Olive Ridley Turtles (*Lepidochelys olivacea*) are among the highly endangered oceanic species. The Odisha coast in India is known for the mass nesting sites of this species (Rout and Behera, 2006). These nesting sites in Odisha are considered to represent 50 percent of the world population of Olive Ridelies and 90 percent of India's population of sea turtles (<http://www.wildlifeorissa.in/seaturtleproject.html>). An increasing frequency of cyclones in the Bay of Bengal is a major threat to this already beleaguered species.

### Box 1.2. Asia: A snapshot of natural disasters in 2011

In 2011, Asia was the continent hit worst by natural disasters, particularly in terms of lives lost. In terms of economic losses, these disasters incurred a cost of over 260 billion dollars (SwissRe, 2011).

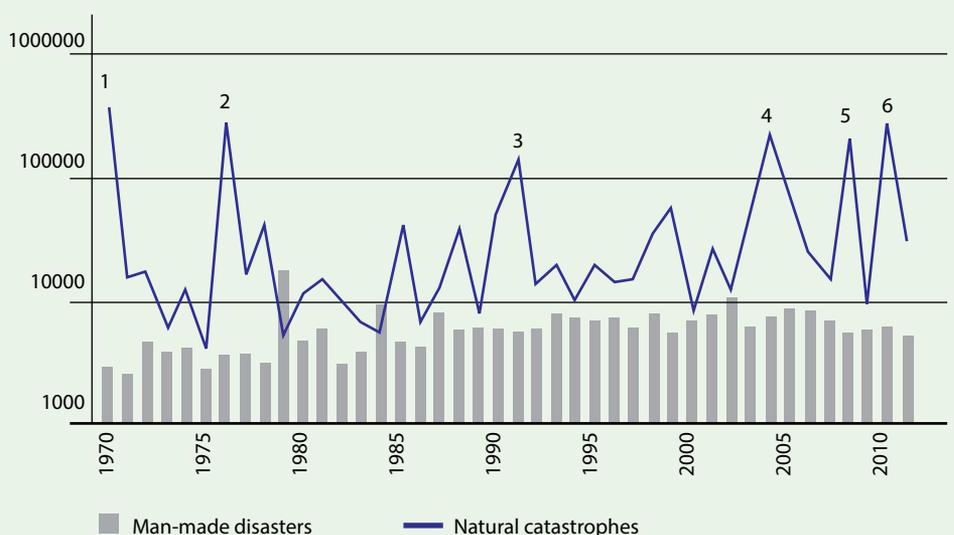
#### Percentage of people killed by natural disasters by region



Source: International Disaster Database [www.emdat.be](http://www.emdat.be)

In the last three decades (from the 1970s to 2010), five of every six natural disasters in the world occurred in Asia.

#### Number of victims 1970-2011



- |   |   |
|---|---|
| 1 1970: Bangladesh storm, Peru earthquake | 2 1976: Tangshan earthquake, China          |
| 3 1991: Cyclone Gorky, Bangladesh         | 4 2004: Indian Ocean earthquake and tsunami |
| 5 2008: Cyclone Nargis, Myanmar           | 6 2010: Haiti earthquake                    |

Note: The scale is logarithmic – the number of victims increases tenfold per band.

Source: Swiss Re Economic Research & Consulting

### **Box 1.3. DRR and CCA services provided by coastal and marine ecosystems**

#### **Reducing the effects of natural disasters**

- Coral reefs, mangroves and sand dunes provide **shoreline protection**. Mangroves, sand dunes, coral reefs and other coastal ecosystems create physical barriers between communities and against coastal hazards such as storm surges. Various studies have shown empirically that these coastal ecosystems reduce the force of events such as tidal surges (Dahdouh-Guebas et al., 2005; Kathiresan and Rajendran, 2005; Ranasinghe and Kallesoe, 2006).
- Mangroves, salt marshes and coastal wetlands **attenuate floods**, acting as gigantic sponges to trap and slowly release surface water. A one-acre wetland can typically store about three acre-feet<sup>3</sup> of water, or 1 million gallons (EPA, 2006). Muthurajawala Marsh, in northwestern Sri Lanka, provides flood and storm protection valued at US\$5.75 million per year (Emerton and Bos, 2004).

#### **Carbon sequestration**

- Coastal ecosystems **sequester carbon**, i.e., they are carbon sinks. If there are natural coastal habitats, then loss of the carbon that is present in vegetation and soils is already being prevented. By conserving these ecosystems, there is continued sequestration of carbon dioxide from the atmosphere.
- Although the geographic extent of coastal ecosystems is limited, the absolute value of the carbon sequestered per unit area compared with terrestrial systems could well be greater (Laffoley and Grimsditch, 2009).
- The global **carbon burial in mangroves** is estimated to be about 18,400,000 metric tonnes of carbon per year (Laffoley and Grimsditch, 2009). A 20-year-old plantation of mangroves has a carbon burial rate of 580 grams per square metre per year (Fujimoto, 2000).
- At least 430 million metric tonnes of carbon is stored in the upper 50 centimetres of **salt marsh** soils worldwide (Laffoley and Grimsditch, 2009).
- **Seagrass meadows** are estimated to store between 27 million metric tonnes and 40 million metric tonnes of carbon per year.
- The enormous difference between the storage of carbon in coastal ecosystems and that in terrestrial ecosystems is the vast amount of carbon trapped in sediments and mud in the former.

Ecosystems act as natural buffers against the impacts of extreme weather events. They protect physical infrastructure and increase the resilience of human systems to disasters. Coastal and marine ecosystems also play a crucial role in mitigating climate change through carbon sequestration. (See Box 1.3 for details of DRR and CCA services provided by coastal and marine ecosystems.) Besides, natural ecosystems offer a cost-effective way of DRR and CCA and form an integral part of the overall sustainable development strategy.

Disasters are essentially a product of the hazards and the vulnerability faced by the 'at-risk' population minus the coping capacity. The current approach to dealing with disasters includes DRR initiatives coupled with a sustained focus on reducing the vulnerabilities and increasing the coping capacities of the at-risk population. In addition to 'hard' engineering solutions (use of technologies and the design of climate-resilient infrastructure), 'soft' nature-based solutions are becoming an integral part of the overall DRR and CCA strategies in the region. For example, dunes, barrier islands, mangroves and coastal wetlands are natural shock absorbers against violent coastal storms. The sand dunes of Vadakku Poigainallur village, in Nagapattinam District of peninsular India, which acted as an effective barrier against the devastating Indian Ocean tsunami of 2004 are a standing illustration in this context.

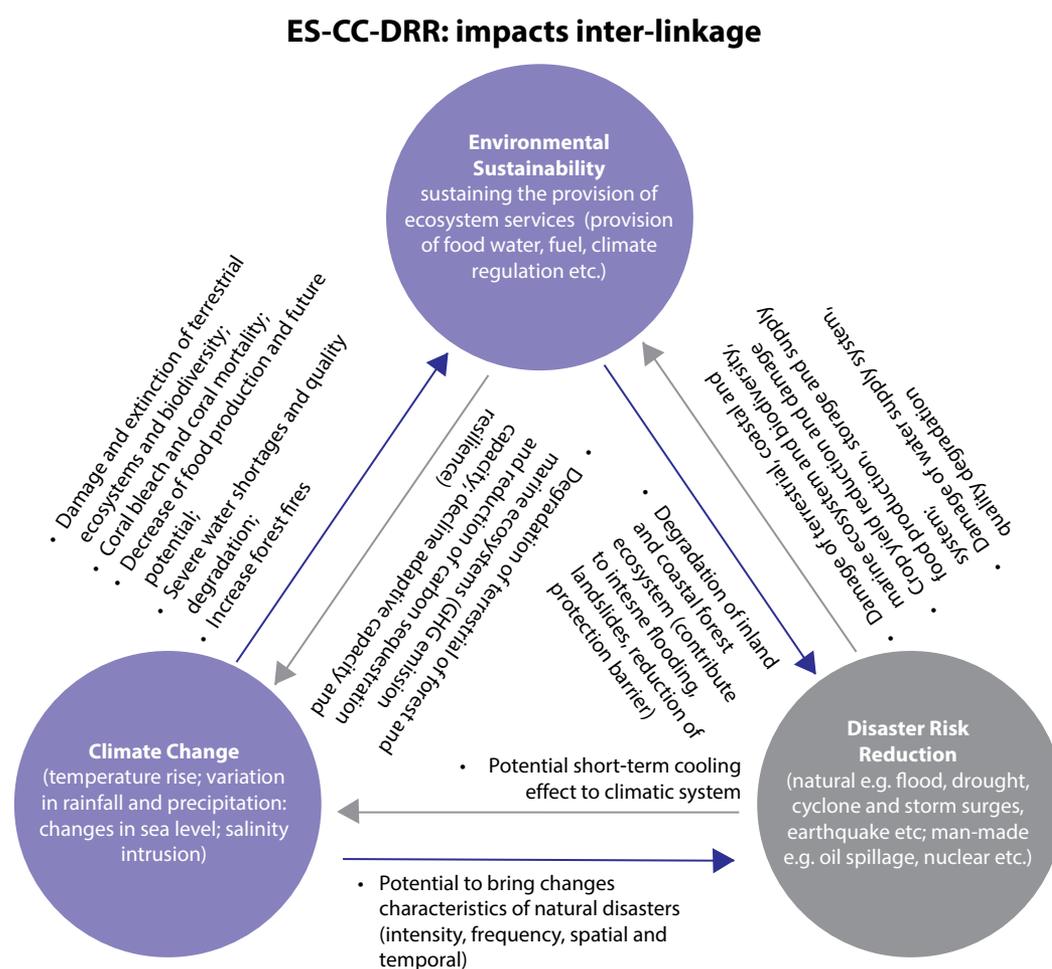
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<sup>3</sup> An acre-foot is one acre of land, covered one foot deep in water.

## Integrating DRR and CCA into ecosystem management<sup>4</sup>

The foregoing account clearly shows the critical linkages among ecosystem management, DRR and CCA. Integrated ecological approaches that link ecosystems to disaster and climate risk management may be broadly considered as part of 'ecosystem-based adaptation' (EbA). EbA can integrate the use of ecosystem services into an overall strategy to help people adapt to the adverse impacts of climate change and to reduce the risks of climate-induced disasters. According to the Convention on Biological Diversity (CBD), EbA generates significant socio-economic benefits along with ecological gains. EbA approaches include sustainable management, conservation, maintenance and restoration of ecosystems to provide services that help people adapt to both current climate variability and climate change. It is quite apt that the Stern Review on the Economics of Climate Change recommended that governments develop policies for "climate sensitive public goods including natural resource protection, coastal protection and emergency preparedness". Figure 1.2 depicts the linkages among CCA, DRR and ecosystem management.

**Figure 1.2. Linkages among DRR, CCA and ecosystem management**



Source: Alam, undated

<sup>4</sup>The text on EbAs used here is consistent with *Connecting Biodiversity and Climate Change Adaptation*. Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change under the Convention on Biological Diversity (CBD), and Wiesen, C (2012).

Managing natural ecosystems, as carbon sinks and as a strategy for adaptation, is increasingly being recognized as necessary, efficient and relatively cost-effective. As natural buffers, ecosystems are often cheaper to maintain, and are often more effective, than physical engineered structures, such as dykes or concrete walls (<http://climatechange.worldbank.org/natural-solutions-protected-areas-helping-people-cope-with-climate-change>). EbA approaches can, therefore, be readily integrated into community-based adaptation and address many of the concerns and priorities identified by the most vulnerable countries and people. In addition, healthy ecosystems, such as forests, wetlands, mangroves and coral reefs, have greater potential to adapt to climate change and recover more easily from extreme weather events (Dudley et al., 2010). For instance, degradation of mangrove ecosystems in the Sundarbans increased the exposure to Cyclone Aila. The local communities in Paschim Midnapur, West Bengal, are now planting a mangrove sea wall as an adaptation strategy to withstand cyclones and violent storms.

As already mentioned, in this publication, we are attempting to synthesize a knowledge base on the potential for integrating DRR and CCA into ecosystem management. It is hoped that this will provide guidance to coastal and marine resource managers in South Asia on integrating these three elements into an overall strategy for effective management of the coastal and marine environment. We focus our efforts on five South Asian countries: Bangladesh, India, Maldives, Pakistan and Sri Lanka. It is expected that such an approach will stimulate a series of interconnected responses and will trigger a process of holistic management of the coastal and marine environment of this region.



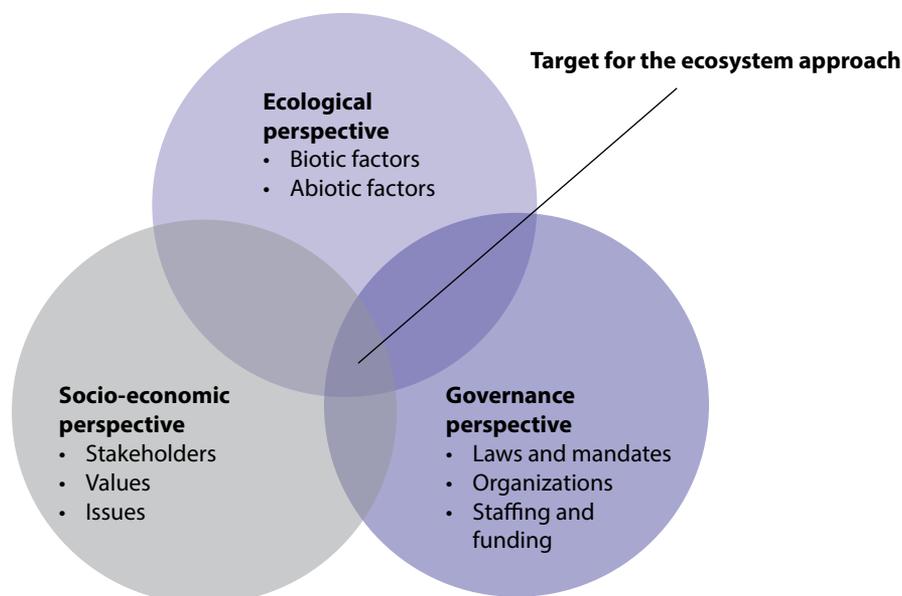
## 2. The Ecosystem Approach

### Background

An ecosystem is a dynamic complex of plant, animal and micro-organism communities and their nonliving environment interacting as a functional unit. Like an ecosystem, the ecosystem approach integrates ecological, socio-economic and institutional perspectives in a collaboratively developed vision of desired future conditions, with the ultimate goal of long-term sustainability (Meffe et al., 1997). The ecosystem approach is a strategy for integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It is based on the application of appropriate scientific methodologies focused on levels of biological organization that encompass the essential processes, functions and interactions among organisms and their environment. It recognizes the fact that humans, with their cultural diversity, are an integral component of ecosystems (CBD, 2012) (see Annexure 3 and 4). Figure 2.1 depicts the three key elements of the ecosystem approach.

The ecosystem approach recognizes the full array of interactions taking place within an ecosystem. It considers humans as an integral part of ecosystems and recognizes the fact that dealing with the underlying causes of anthropogenic pressures is essential for holistic management of natural resources. It promotes a multi-species, multiple-issue approach and moves managers from a single-species, single-issue approach to a holistic approach that promotes conservation and sustainable use in an equitable way. The ecosystem approach is

Figure 2.1. Diagram showing the three elements of the ecosystem approach



Source: Meffe et al., 1997

also characterized by the practice of ‘adaptive management’ to deal with the complexity of ecosystems and the lack of complete knowledge of their forms and functions. Rather than manage different resources and multiple threats to resources independently, an ecosystem approach focuses on the collective management of all resources—maintaining ecological integrity while allowing resource extraction. This approach ensures the “co-existence of healthy, fully functioning ecosystems and human communities and development” (Leech et al., 2009).

The ecosystem approach is the primary approach used in the Convention on Biological Diversity (CBD). The Conference of the Parties, at its Fifth Meeting, endorsed the description of the ecosystem approach and recommended the application of the principles and provided other guidance on the ecosystem approach (Decision V/6). The Seventh Meeting of the Conference of the Parties agreed that the priority at this time should be on facilitating implementation of the ecosystem approach and welcomed additional guidelines to this effect (Decision VII/11) (CBD, 2012).

## EbA: Practical application of the ecosystem approach

EbA can be considered as the practical application of the ecosystem approach that is very relevant to the theme of this publication, namely, integrating DRR and CCA into ecosystem management. EbA not only reduces vulnerability to climate change by decreasing disaster risks and enhancing carbon sequestration but also reduces non-climate risks. Thus, it provides multiple economic, social, environmental and cultural benefits (CBD, 2012; Sudmeier-Rieux and Ash, 2009). It will be worthwhile to look at the benefits of adopting EbA that, *inter alia*, can be summarized as follows<sup>5</sup>.

### 1. First line of defence against climate change and disasters

EbA is our primary defence mechanism against climate change and disasters. They are more easily accessible to the poor than the adaptation interventions based on hard infrastructure and engineering solutions and can

<sup>5</sup> The text in this section is adapted from a variety of sources that include UNDP, IUCN, UNEP and World Bank.

effectively build on local knowledge and needs. For example, the value of mangroves for coastal protection has been estimated to be as much as US\$300,000 per kilometre of coast, vis-à-vis the cost of installing artificial coastal protection measures. Besides, it considers particularly the most vulnerable groups of people, including women, and the most vulnerable ecosystems. EbA offers multiple solutions too. For example, restoration of mangrove systems can provide shoreline protection from storm surges, but it also provides increased opportunities for fisheries and carbon sequestration. Coral reefs provide a physical barrier—a wall—against tidal surges, extreme weather events, ocean currents, tides and winds (Burke et al., 2002). Mangroves act as physical buffers and can absorb at least 70 to 90 percent of the energy of the waves, depending on their ecological condition (UNEP-WCMC, 2006). Because of these factors, EbA can sometimes secure adaptation benefits for many sectors through a single investment.

## 2. Enhancing livelihoods and ensuring food security

Coastal and marine ecosystems provide a wide range of services—provisioning (e.g., food and fibre), cultural (e.g., recreational and aesthetic) and supporting (e.g., soil formation)—critical to human well-being, including health, livelihoods, food security and social cohesion. For instance, every square kilometre of well-managed coral reef can yield an average of 15 tonnes of fish and other seafood every year (WWF, 2012). The foreign visitor recreational value of a mangrove ecosystem in the western coast of Sri Lanka is estimated at US\$1,196 per hectare per year (Bambaradeniya et al., 2006). Thus, EbA provides important tools for maintaining ecological services and for providing material goods essential for human life, which in turn can help increase the resilience and reduce the vulnerability of communities in the context of climate change. By protecting and restoring healthy ecosystems to be more resilient to the impacts of climate change, EbA strategies can help ensure the continued availability of and access to essential natural resources so that communities can cope better with the current climate variability and future climate change.

EbA can directly meet the needs of community-based adaptation and poverty reduction initiatives. It would be worthwhile to note that according to a recent study in the Indian state of Odisha, ecosystem services contribute to around 60 percent of the rural economy. Similarly, a UNDP-supported project, 'Forest, Fish, and Fruit' (FFF), implemented in the five coastal districts of Bangladesh has improved the livelihoods of 14,350 households that established a green shield of protective and productive vegetation, with an elevated-mound-and-ditch structure interspersed with fish nursery ponds (<http://www.adaptationlearning.net/community-based-adaptation-climate-change-through-coastal-afforestation>). EbA approaches also choose crops with less intensive nutrient and water requirements, control invasive alien species, maintain local landraces and crop varieties, and protect reefs and mangroves for sustainable fisheries.

## 3. Improving the prospects of biodiversity conservation in the wake of climate change

Conserving terrestrial, freshwater and marine ecosystems and restoring degraded ecosystems are essential for addressing climate change because these ecosystems play a key role in the global carbon cycle. While ecosystems are generally more carbon-dense and biologically more diverse in their natural state, the degradation of many ecosystems is significantly reducing their carbon storage and sequestration capacity, leading to increases in emissions of greenhouse gases (GHGs) and loss of biodiversity at the genetic, species and ecosystem levels. Climate change is rapidly increasing stresses on ecosystems and can exacerbate the effects of other stresses, including those from habitat fragmentation; loss and conversion; overexploitation; invasive alien species; and pollution. Human-induced climate change caused by the accumulation of anthropogenic emissions in the atmosphere (primarily from fossil fuels and land use changes) could shift the net natural carbon cycle towards annual net emissions from terrestrial sinks and weaken ocean sinks, thus further accelerating climate change (CBD, 2009).

Protecting, restoring and managing key ecosystems helps biodiversity and people adjust to changing climatic conditions. By conserving carbon stocks, EbA strategies can complement and enhance climate change mitigation—primarily by reducing emissions from ecosystem degradation and enhancing carbon sequestration. Mangroves are important carbon sinks, and they sequester about 18.4 million tonnes of carbon



per year (Laffoley and Grimsditch, 2009). A 20-year-old plantation of mangroves has a carbon burial rate of 580 grams per square metre per year (Fujimoto, 2000). Reduction of carbon emissions through EbA, such as establishment of new protected areas, improved management of existing reserves, protection of wetlands and eco-restoration are important aspects of combating climate change.

#### **4. Sustainable water management**

Managing, restoring and protecting ecosystems can also contribute to sustainable water management by, for example, improving water quality, increasing groundwater recharge and reducing surface water runoff during storms. About one third of the world's largest cities obtain a significant proportion of their drinking water directly from forested protected areas. A study of the overall value of wetlands for flood protection provided an estimated benefit of US\$464 per metre of river bank. Mangrove habitats function as gigantic sponges to trap and slowly release surface water. It is estimated that one acre of wetland can typically store about three acre-feet of water (EPA, 2006). EbA approaches include watershed and forest protection, incorporate wetlands in water treatment and water quality improvement initiatives, and protect wetlands for water storage and flood control. Management schemes that incorporate mangroves and other coastal wetlands into storm protection and coastal defence, protect mangroves, seagrass beds, and coral reefs for sustainable fisheries and promote integrated coastal management to prevent pollution of the marine and coastal environment are critical in this regard.

A detailed account of ecosystem services provided by various coastal and marine ecosystems is given in Table 2.1.

Table 2.1. Ecosystem services of coastal ecosystems

## Ecosystem services of coastal ecosystems

Ecosystem service provided by coral reefs	Description
<b>Provisioning service</b>	
<b>Fish and other species for food</b>	Every square kilometre of well-managed coral reef can yield an average of 15 tonnes of fish and other seafood every year (WWF, 2012). Coral reefs support human life and livelihoods and are economically important. Nearly 500 million people depend directly and indirectly on coral reefs for their livelihoods, food and other resources (Wilkinson, 2004). Further, it is estimated that nearly 30 million of the poorest human populations depend entirely on coral reefs for their food (Wilkinson, 2004).
<b>Aquarium fish, curios, ornamental and medicinal products</b>	The harvest of coral, fish and other organisms for aquaria is for a major form of trade now. Molluscs and marine turtles are collected for making curios or trinkets (Wabnitz et al., 2003). Molluscs, dried sea stars and sea urchins, dried fish (seahorses and puffer fishes) and dried lobsters are sold as souvenirs. Many species are collected for traditional medicine. In addition, there is bio-prospecting for novel remedies in allopathic medicine (Hunt and Vincent, 2006; Vincent, 2006).
<b>Supporting services</b>	
<b>Biodiversity</b>	Coral reefs are extremely productive ecosystems and are called 'the rainforests of the sea'. Despite this, they are extremely delicate, and their balance is disrupted easily and productivity decreases when species are overharvested (Burke et al., 2002).
<b>Primary production</b>	Coral reefs have a primary productivity as high as that of a tropical rain forest (Sorokin, 1995).
<b>Prevention of coastal erosion</b>	Coral reefs dissipate the energy of waves and currents. Without the protective wall of coral reefs, the shoreline becomes more vulnerable to coastal erosion (Burke et al., 2002).
<b>Beach accretion</b>	Coral pieces are broken into smaller and smaller pieces and eventually become part of the beach.
<b>Regulating services</b>	
<b>Protection from climate-related natural hazards</b>	Coral reefs provide a physical barrier—a wall—against tidal surges, extreme weather events, ocean currents, tides and winds (Burke et al., 2002).
<b>Cultural services</b>	
<b>Recreation/tourism</b>	Because it is easy to access coral reefs, visiting them is a significant recreational activity for snorkellers, scuba divers, recreational fishermen and beach lovers.

Source: Miththapala, 2008a

### Ecosystem services of seagrass meadows

<b>Ecosystem services provided by seagrass meadows</b>	<b>Description</b>
<b>Provisioning services</b>	
<b>Food</b>	Seagrass meadows are nursery areas for many commercial fin and shell fish species as well as other species (Heck et al., 2003). Fish, clams and mussels are harvested as a source of protein from seagrass meadows all over the world (Green and Short, 2003).
<b>Supporting services</b>	
<b>Supporting coastal biodiversity</b>	Because of the three-dimensional structure of seagrass meadows in the water, they provide protection for juvenile fish and many marine larvae. They house hundreds of other species as well, such as algae, sponges, round worms, marine worms and even threatened species (e.g., manatees and the Dugong) that feed directly on them (Ruppert et al., 2003; Coles et al., 2007).
<b>Primary production</b>	Seagrasses rank with coral reefs and mangroves in their productivity (Coles et al., 2007).
<b>Enriching nutrients in coastal waters</b>	Seagrasses are important in the detrital food chain. When all the organisms found in the three-dimensional habitat of seagrasses, as well as the seagrasses, die, the released nutrients enter the marine system as carbon and other nutrients (Spalding et al., 2003).
<b>Regulating services</b>	
<b>Carbon sequestration</b>	Seagrass meadows are estimated to store between 27 million tonnes and 40 million tonnes of carbon per year. Given that much of the seagrass biomass is under the sea floor as rhizomatous matter, this is likely to be an underestimation.
<b>Preventing pollution and sedimentation of coastal waters</b>	The leafy 'canopy' of seagrasses slows down water currents, trapping particles, nutrients and pollutants washed from inland waters to coastal seas (Short and Short, 1984).
<b>Stabilizing the floor of coastal seas</b>	The underground stems of seagrasses help stabilize the sea meadows, preventing sand from being washed away and churned up by wave action (Dahm et al., 2005).
<b>Cultural services</b>	
	In many countries, traditional fishing practices are supported by seagrass meadows.
<b>Other services</b>	
<b>'Biological sentinels' and 'coastal canaries'</b>	Like the canaries that were taken into coal mines to test the quality of the air, seagrasses respond to changes in the quality of water, indicating a deterioration of the environment by declining. What is important is that these changes are visible (and very quickly), so that it is possible to take management action (Orth et al., 2006).

Source: Miththapala, 2008c

## Ecosystem services of sand dunes

Ecosystem service provided by sand dunes	Description
<b>Provisioning service</b>	
<b>Sand and other minerals</b>	Sand is mined heavily in many parts of the region. Beach sand mining on the east coast of Sri Lanka is estimated at 500–1,000 cubic metres per kilometre per year (CCD, 2004).
<b>Regulating services</b>	
<b>Stabilizing the shoreline—preventing coastal erosion</b>	The store of sediment in sand dunes protects the land behind them from storm erosion and potential sea level rises. Sand dune vegetation traps and prevents sand from being blown further inland (Dahm et al, 2005).
<b>Flood attenuation</b>	Sand dunes provide a physical barrier against climate-related hazards. Intact sand dunes were the most effective barrier against the tsunami waves that affected the coastal zone of Sri Lanka in 2004 (Bambaradeniya et al., 2006).
<b>Water catchment</b>	Sand dunes are able to store significant amounts of water, which can serve as aquifers for coastal populations (Barbier et al., 2011).
<b>Supporting services</b>	
<b>Biodiversity</b>	Sand dunes are essential components of coastal vistas and coastal biodiversity. They also harbour endangered species such as marine turtles, which lay their eggs on sandy beaches and return to the sites where they were born. Coastal sand dunes with natural vegetation such as Goat's Foot ( <i>Ipomea pes-caprae</i> ) and <i>Spinifex littoreus</i> are ideal nesting sites (Choudury et al., 2003).
<b>Cultural services</b>	
<b>Recreation</b>	Beaches are popular for recreation, and many people enjoy walking on the beach and paddling on beach fronts. Sand dunes can provide source sand for the maintenance of beaches. In many countries, coastal tourism relies on the marketing of intact sand dunes and beach fronts.  Seventy percent of all hotels registered with the Sri Lanka Tourism Authority are located in the coastal zone (CCD, 2004).
<b>Supporting traditional fishing practices</b>	In many countries, traditional fishing practices are supported by sand dunes. Because sand dunes can provide source sand for maintenance of beaches, they indirectly support traditional fisheries. Traditional stilt fisheries and beach seine fisheries are supported indirectly in Sri Lanka by the presence of sand dune ecosystems and sandy sea beds, in combination (Kallesøe et al., 2008).

Source: Miththapala, 2008c

### Ecosystem services of mangroves

Ecosystem service provided by mangroves	Description
<b>Provisioning service</b>	
<b>Food (fin fish, shell fish, vegetables and other plant parts)</b>	Mangroves are permanent or temporary habitats for many aquatic animals and are hatching and nursery grounds for many marine fish. It is estimated that up to 80 percent of global fish catches are directly or indirectly dependent on mangroves (Sullivan, 2005).
<b>Timber and fuel wood</b>	All over the world, the timber of mangrove flora is used to build houses and make furniture, rafters, fences, bridges, poles and boats. Mangrove wood is also used as fuel wood.
<b>Medicines</b>	About 70 species of mangrove flora are listed as having traditional medicinal uses for treatment of various ailments and diseases. In parts of Indonesia, traditional use of mangrove products contributes up to half the income of the poorest households. In southern Thailand, it is thought to generate products worth almost a quarter of the per-capita GDP in coastal villages (Bandaranayake, 1998).
<b>Other non-timber forest products (NTFPs)</b>	<p>The leaves of species such as Water Palm (<i>Nypa</i>) and Screwpine (<i>Pandanus</i>) are used for thatching and weaving, and light woods such as <i>Cerbera manghas</i> are used to carve masks and puppets.</p> <p>The breathing roots of various <i>Sonneratia</i> species are used to make corks and fish floats.</p> <p>Mangrove plants are sources of sodium, and the ash of some species, such as <i>Avicennia</i>, is used as soap.</p> <p>The barks of many species produce gums and tannins, which are still used in the Indian subcontinent for curing leather and tanning fish nets.</p> <p>In Bangladesh and India, gathering honey from mangroves forms an important local industry.</p> <p>Mangrove leaves, fruits, shoots and roots serve as vegetables and edible fruits in many parts of the region, and other non-timber forest products such as sugar and drinks are extracted from different species (Bandaranayake, 1998).</p>
<b>Regulating services</b>	
<b>Protecting the shoreline</b>	Mangroves act as physical buffers between the elements and the shore and can absorb 70–90 percent of the energy of the waves, depending on their ecological condition (UNEP-WCMC, 2006).
<b>Carbon sequestration</b>	Mangroves are important carbon sinks. They sequester about 18.4 million tonnes of carbon per year (Laffoley and Grimsditch, 2009). A 20-year-old plantation of mangroves has a carbon burial rate of 580 grams per square metre per year (Fujimoto, 2000).
<b>Promoting accretion</b>	Mangroves function much like a living groyne to build up sediment, stabilizing the ground and fixing mud banks. It is estimated that there is an annual sedimentation rate ranging between 1 and 8 millimetres in mangrove areas that are expanding in land area (Bird and Barson, 1977). Therefore, they prevent erosion. They also protect coral reefs from sedimentation (Broom et al., 1981).

<b>Flood attenuation</b>	Mangrove habitats function as gigantic sponges to trap and slowly release surface water. A one-acre wetland can typically store about three acre-feet of water (EPA, 2006).
<b>Trapping pollutants</b>	Mangrove roots that help trap sediments also function as filters to sift out pollutants reaching the sea from inland waters (UNEP-WCMC, 2006).
<b>Supporting services</b>	
<b>Primary production</b>	The annual net primary production of mangroves in India is estimated at 6.05604 trillion grams of carbon (Tg C a <sup>-1</sup> ) (Ramachandran et al., 2009). The global mangrove primary production is estimated at about 218 ± 72 Tg C a <sup>-1</sup> (Bouillon et al., 2008).
<b>Biodiversity</b>	Because mangroves grow between the land and the sea, mangrove species are adapted uniquely to living in extreme and variable conditions. Mangroves, therefore, carry a unique assemblage of flora and fauna found in no other ecosystem.
<b>Cultural services</b>	
<b>Tourism</b>	The foreign visitor recreational value of a mangrove ecosystem in the western coast of Sri Lanka is estimated at US\$1,196 per hectare per year (Bambaradeniya et al., 2006).
<b>Supporting traditional fishing</b>	Brush pile fisheries (traditional fishing methods in Bangladesh and Sri Lanka) and other traditional fisheries in South Asia are being sustained because of mangroves.

Source: Miththapala, 2008b

### Ecosystem services of salt marshes

<b>Ecosystem service provided by salt marshes</b>	<b>Description</b>
<b>Provisioning service</b>	
<b>Food (fin fish, shell fish)</b>	Salt marshes provide food and refuge or nursery habitats for more than 75 percent of fisheries species, including shrimps, the Blue Crab and many fin fish (NOAA, 2011a).
<b>Regulating services</b>	
<b>Carbon sequestration</b>	At least 430 million tonnes of carbon is stored in the upper 50 centimetres of salt marsh soils worldwide (Laffoley and Grimsditch, 2009).
<b>Shoreline protection</b>	Like mangroves, salt marshes also protect shorelines from erosion by buffering wave action and trapping sediment.
<b>Flood attenuation</b>	They absorb and slowly release flood water.
<b>Supporting services</b>	
<b>Biodiversity</b>	Salt marshes support large food webs and are often sites for migratory birds to feed in.

### EbA: Linkages in practice

EbA can be applied at different geographical scales (local, regional, national) and within various time-frames (short to long term). It can be implemented as projects and as parts of overall adaptation programmes. It is most effective when implemented as a part of a broad portfolio of adaptation and development interventions, such as early warning systems, education and physical infrastructure. EbA involves a wide range of ecosystem management activities to increase resilience and reduce the vulnerability of people and the environment to climate change.

There are several EbA activities that can be cited as illustrations of effective DRR and CCA. These include not only conservation but also restoration activities. Restoration of ecosystems can be part of a cost-effective adaptation strategy despite the relatively high costs, compared with conservation of existing intact ecosystems. Restoration activities include limiting activities, such as resource extraction to allow ecosystems to recover, and restoring ecological components to provide connectivity of hydrological regimes through activities such as re-flooding wetlands. For example, floodplain restoration can be a useful alternative to constructing additional dams or reservoirs for increasing flood water storage, and reforestation of degraded areas can be an effective strategy to enhance land productivity.

**Case Study 2.1. Restoration of coastal habitats as an effective measure against storm surges, saline intrusion and coastal erosion: Tree walls as an adaptation strategy in the Sundarbans in West Bengal, India**

Climate change is causing increased coastal erosion and saline water intrusion in the Sundarbans, the largest mangrove in the world (straddling India and Bangladesh). Increased salinity has reduced crop productivity and affected fish farming. Repeated occurrences of violent cyclones in the region have reduced livelihood options. After the devastating cyclone, Aila, of 2009, the local community recognized the role of EbA in responding to disasters and has started planting mangroves and tree walls as an adaptation strategy to withstand cyclones and violent storms. This has proved to be very effective. Other measures introduced after Aila are planting saline-resistant cereal and vegetable crops; maintaining non-shrimp brackish water fisheries; raising mangrove nurseries and plantations as an alternative livelihood option; food processing; and other non-farm activities.

*Source: UNDP, 2011b*



### **Case Study 2.2. Restoration of coastal habitats as an effective measure against storm surges, saline intrusion and coastal erosion: Tree walls as an adaptation strategy in Midnapur, West Bengal, India**

Jargram Block in the district of Midnapur, West Bengal, has been facing severe impacts of violent super-cyclones since 2004. After Cyclone Aila, local communities supported by CBOs planted extensive tree walls as an adaptation strategy to withstand cyclones and violent storms. The community takes care of the plants and monitors them. The local community has appreciated the urgency of climate change adaptation and adapted to the change that has proved to be beneficial.

Source: UNDP, 2011b

### **Case Study 2.3. Establishing and effectively managing protected area systems to ensure continued delivery of ecosystem services that increase resilience to climate change and disasters: Conserving marine ecosystems in the Gulf of Mannar, India**

Activities such as mining, overfishing, pollution and unsustainable coastal development activities had degraded the coral reefs in the Gulf of Mannar region in India. Invasion of exotic seaweeds, algal blooms, trap fishing, sewage disposal and seaweed collection were other major threats to biodiversity. A GEF-UNDP intervention in the region coordinated different stakeholders and departments (such as the fisheries, agriculture, rural development, and environment and forests departments; the pollution control board; local communities; and women's groups) to create joint conservation initiatives and enforcement mechanisms for better management of the coastal region. Awareness campaigns conducted by the Gulf of Mannar Biosphere Reserve Trust (GoMBRT) have led to increased awareness of the significance of the coastal and marine ecosystems. The project's initiatives have led to an increase in live coral cover from 37 percent to 43 percent so far, prevented saltwater intrusion and ameliorated the impacts of flooding and cyclones.

Source: UNDP, 2012b

### **Case Study 2.4. Intercropping and floating gardens in Bangladesh**

Establishment of diverse agricultural systems using indigenous knowledge of specific crop and livestock varieties, maintaining genetic diversity of crops and livestock, and conserving diverse agricultural landscapes are crucial for food security in the context of climate change. In drought-prone regions of rural Bangladesh, the resilience of traditional home gardens is strengthened through intercropping of fruit trees with vegetables, and in flood-prone areas, floating gardens have been created for cultivation of a mix of traditional crops, including saline-tolerant vegetables.

Source: [http://satoyama-initiative.org/en/case\\_studies-2/group\\_agriculture-2/the-use-of-agrobiodiversity-by-indigenous-and-traditional-agricultural-communities-in-adapting-to-climate-change/](http://satoyama-initiative.org/en/case_studies-2/group_agriculture-2/the-use-of-agrobiodiversity-by-indigenous-and-traditional-agricultural-communities-in-adapting-to-climate-change/)



### 3. Disaster Risk Reduction

As mentioned in Chapter 1, this toolkit presents the integration of three approaches (EbA, CCA and DRR) to the overarching and dangerous impacts of climate change and an increased intensity and frequency of natural disasters.

Disaster risk reduction—a systematic approach to preventing and reducing the damage from natural hazards (<http://www.unisdr.org/who-we-are/what-is-drr>)—is one of the components of this tripartite approach. It is also critical as the colossal costs of disasters considerably retard the possibility of achieving the Millennium Development Goals (MDGs) (UN, 2010). Direct damage costs, for the last 10 years, are estimated to be nearly a trillion dollars (Munich, 2002; CRED, 2009; UN, 2010). DRR is also essential for climate change adaptation. It is also ‘one of the best links to the human development agenda for promoting biodiversity and sustainable environmental resource management. Disasters like landslides caused by deforestation remind us that our own safety depends dramatically on common sense protection of the environment. Maintaining biodiversity, grasslands, forests, coastal wetlands, reefs and dunes is an important element of protecting human settlements from drought, desertification, landslides, floods, sea-level rise and storms—all of which are predicted to intensify due to climate change’ (UN, 2010).

The devastation caused by the Indian Ocean tsunami of 26 December 2004, one of the most horrific tragedies of recent human history, served to highlight—at global, regional and national levels—the dangers of recurrent natural hazards, such as intense rainstorms, cyclones, floods, and fires and worsened droughts, which are

predicted to increase as a result of climate change (see next chapter). Because natural hazards cannot be stopped or reversed, learning to reduce the vulnerability to these hazards and reducing/eradicating disasters that stem from these recurrent natural hazards become important. Learning to reduce the risks from these disasters—DRR—therefore becomes critically important.

## Disaster-prone Asia

Each year, natural disasters impoverish millions of people in Asia. However, only 0.2 percent of the economic losses are covered by insurance policies because many of those affected are the marginalized and the poor. Asia is also home to over 70 percent of the world's poor. In South Asian countries, the marginalized and poor are already deprived of adequate food, clean drinking water, sanitation and health care. In most cases, it is this section of society that is also forced to live in low-lying and other hazard-prone areas and so is usually the first to be hit by floods, landslides and cyclones. This section has the fewest resources to deal with these recurrent shocks and stresses (IUCN, 2006a). See Box 3.1 for more details.

Amongst the poor, it is the women and children who are most vulnerable in any disaster. Out of the 1.4 billion people in the developing world who live below the poverty line, 70 percent are women. After the tsunami of 2004, a shocking statistic revealed that the numbers of deaths of women and children were disproportionately larger than that for men (Oxfam, undated). In the worst affected village in Aceh, Indonesia, 80 percent of the dead were women, and in Cuddalore (India), three times more women were killed compared with men. Vulnerability to disasters depends on the control of financial, physical, natural, human and social assets and compared with men, women in developing countries traditionally have limited access to and control over these assets (IUCN, 2006a). An increase in the frequency of natural disasters will have overarching impacts on ecosystem services, but it will cripple Asia, which is already stressed with the pressures of population, poverty, resource overuse and the spread of disease (Reid and Simms, 2007).

### Box 3.1. Focus on South Asia

The South Asian region is highly vulnerable to many natural hazards—earthquakes, floods, landslides, droughts and cyclones. Between 1967 and 2006, there were 784 reported disasters, which caused 0.8 million deaths and cost US\$80 billion.

Of these, 25 percent were cyclones, which caused half a million deaths. Floods represented 50 percent of the disasters, and in combination with droughts, they affected as many as 2 billion people. Earthquakes are also significant, having caused 196,400 deaths and cost US\$11.6 billion.

About 50 percent of the population of the area is exposed to a high risk of hazards, and 10 percent is exposed to a high risk of earthquake hazards (UNISDR, 2010).

### Box 3.2. Disasters in Odisha

**Odisha** is a coastal state in eastern India that has been dubbed the disaster capital of India. It is reported that a “deadly cocktail of floods, cyclones and droughts” beset Odisha in the last century. Since 1965, disasters are more frequent and are affecting areas not previously affected before (Roy et al., 2002).

## Coastal vulnerability in South Asia

More than 400 million people live along the coastline of South Asia. Coastal communities in South Asia are exposed to a range of natural hazards such as cyclones, floods, droughts and earthquakes.

Just as there are several marginalized groups—such as women and the poor—who are more vulnerable to the impacts of natural disasters, there are some ecosystems more vulnerable than others to natural disasters.

Coastal communities are vulnerable to catastrophic events such as tropical cyclones, tidal surges, tsunamis and floods that result from heavy monsoonal winds. Other slow-onset disasters such as droughts are also common when monsoons fail. Much of the coastline of South Asia lies in the cyclone-prone area of the Bay of Bengal. Table 3.1 provides a list of hazards prevalent in coastal South Asia, followed by maps showing the risks from different hazards.

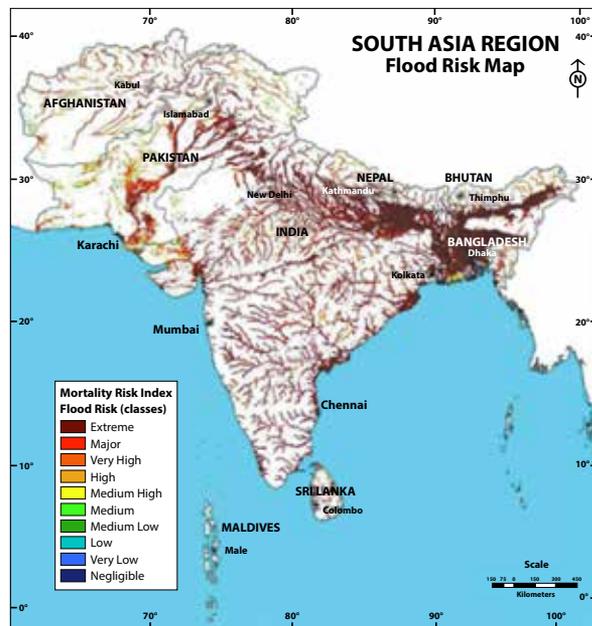
Coastal ecosystems such as coral reefs, seagrasses, mangroves and salt marshes are at the forefront of such recurrent natural disasters and often bear the brunt of it. Although they play a vital role in mitigating the impacts of such disasters, they, in turn, are often damaged beyond their natural resilience when disasters are intense or frequent. Investing in enhanced conservation and restorations (where needed) of such ecosystems—integrating disaster reduction strategies into coastal conservation—therefore becomes important.



Table 3.1. Types of hazards prevalent in South Asia

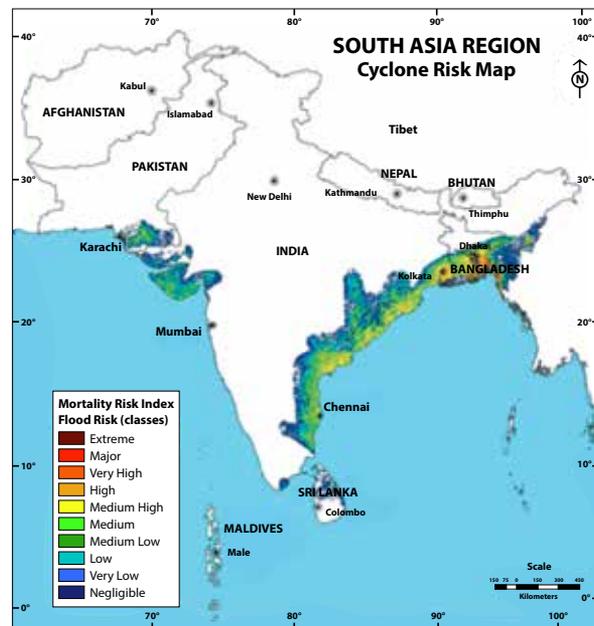
Type of hazard	Cause	Where prevalent in South Asia
<b>Earthquakes</b>	Caused by faulting, a sudden lateral or vertical movement of tectonic plates. Earthquakes do not happen randomly in the world but are usually concentrated near tectonic plate boundaries.	Pakistan, India and Bangladesh are located within the seismically active Himalayan–Hindukush belt. Sri Lanka, Maldives and large parts of the coastal areas of Bangladesh, India and Pakistan are vulnerable to earthquakes in the Indian Ocean that generate tsunamis (SAARC, 2009).
<b>Floods</b>	Occur when usually dry areas on banks of rivers, streams, lakes, or coastal areas become submerged with water. Floods can be set off by severe thunderstorms, tornadoes, tropical cyclones, monsoons or melting snow.  In coastal areas, storm surges —caused by tropical cyclones, tsunamis, or rivers swollen by extremely high tides —can cause flooding.	Monsoons bring heavy rains that cause recurrent floods in all the target countries. Nearly 80 percent of Bangladesh is in the floodplains of the large Gangetic Delta. Floods count among the significant disasters that occur there.
<b>Droughts</b>	Just as floods are caused by an excess of water, droughts are caused by the opposite: a lack of water. A drought is an extended period during which there is no soil water. When a drought occurs, there is not enough water for human needs, agriculture and ecosystems.	Many areas of India, Pakistan and Sri Lanka are drought-prone.
<b>Tropical cyclones</b>	These are huge, rotating masses of wind and thunderstorms up to hundreds of kilometres across, which form around areas of very low atmospheric pressure over warm tropical waters. Winds can reach speeds of 200 kilometres per hour or more. Tropical cyclones, therefore, produce not only heavy, lashing rain but also gale-force winds. The combination of wind-driven waves and the low pressure of a tropical cyclone can produce a coastal storm surge (a raising of the sea level), which, when it approaches the shore, can flood coastal areas and wash away everything in its path. As the cyclone moves over land, it loses energy, and so coastal areas are most affected by tropical cyclones.	The Bay of Bengal is prone to recurrent tropical cyclones. Bangladesh, India, Pakistan and Sri Lanka are particularly prone to cyclones. The Maldives are less prone, but when cyclones do hit, they are extremely destructive.
<b>Tsunamis</b>	These are a series of waves generated when a large body of water is displaced. The most common natural cause of a tsunami is an earthquake, followed by volcanic eruptions. When the sea floor changes as a result of an earthquake (mostly commonly through subduction at plate boundaries), water is displaced vertically. This water then radiates outwards (like ripples in a pond).	The Andaman and Nicobar Islands of India, Sri Lanka and the Maldives suffered damage from the Indian Ocean tsunami of 2004.

Figure 3.1. South Asia: Flood risk map



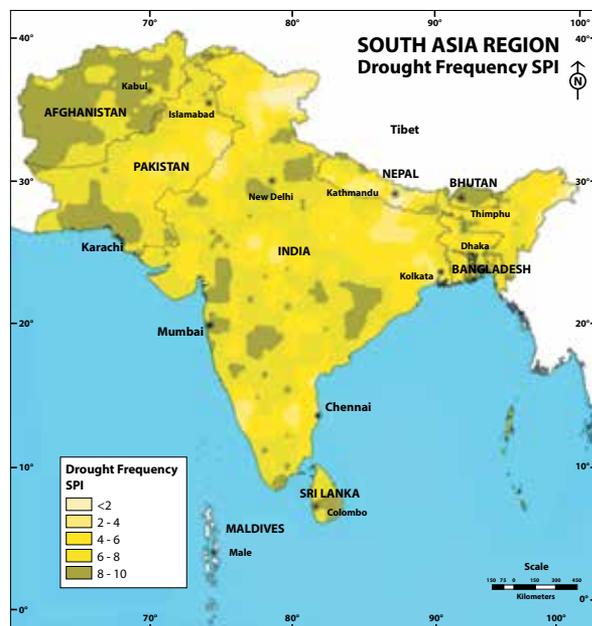
Source: UNISDR, 2010

Figure 3.2. South Asia: Cyclone risk map



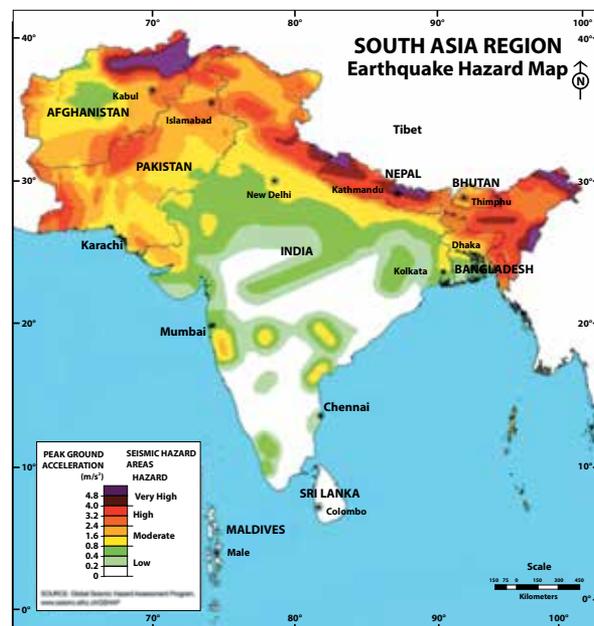
Source: UNISDR, 2010

Figure 3.3. South Asia: Drought frequency map



Source: UNISDR, 2010

Figure 3.4. South Asia: Earthquake hazard map



Source: UNISDR, 2010

A key study of UNISDR in 2010 on disasters in South Asia reports the following:

- Bangladesh is highly vulnerable to floods and cyclones. Fifty-five percent of disasters examined (during 1967–2006) were cyclone-related, while 38 percent were flood-related. Both floods and cyclones incurred enormous costs, amounting to US\$12 billion for floods and US\$2.9 billion for cyclones, respectively.
- India is affected and is highly vulnerable to floods, earthquakes and cyclones. Because India is a very large

country, both the number of people affected and the number of disasters are high. Of the disasters assessed from 1967 to 2006, 53 percent were floods (affecting 730 million people), and 23 percent were cyclones. Droughts also affected 961 million people during this period. The greatest number of deaths was caused by earthquakes, and the next was caused by floods. Floods were the most costly disaster, costing US\$33.3 billion.

- The Maldives are highly impacted by tsunamis, cyclones, storm surges and a rising sea level. Most of the country is low in elevation.
- Pakistan is highly flood-, earthquake- and cyclone-prone. Between 1967 and 2006, there were 94 reported disasters, of which 51 percent were floods and 29 percent were earthquakes. Earthquakes caused the greatest number of deaths—78,000—but floods affected the greatest number of people—41.8 million. The mostly costly hazards are earthquakes—costing US\$53 billion during this period of analysis.
- Sri Lanka is affected badly by floods, droughts and cyclones. Seventy-two percent of disasters reported during 1967–2000 were floods, which also incurred the highest costs of US\$370 million. Floods, droughts and cyclones affected 9.7 million, 8.2 million and 1.38 million people, respectively.

Table 3.2 provides details of major hazards that caused damage in the South Asian countries as well as of their impacts on coastal and marine ecosystems.

**Table 3.2. Natural hazards and their impacts on focus countries and coastal ecosystems**

Hazard	Country	Impact on lives	Impacts on coastal ecosystems that create issues for coastal managers
<b>Floods</b>	<p>Nearly 75 percent of the <b>Bangladesh</b> landmass is approximately only 10 m above sea level, and as 80 percent is in the floodplains of the large Gangetic delta, floods count among the significant disasters that occur there.</p> <p>During the last 50 years, at least 7 mega floods have occurred, affecting about 35–75 percent of the land area.</p> <p>Major flooding recorded in recent years occurred in 1987, 1988, and 1998, 2004 and 2007.</p>	<ul style="list-style-type: none"> <li>• In Bangladesh, about 18 percent of the country is flooded each year, killing more than 5,000 people and destroying 7 million homes.</li> <li>• 1987: 300,000 houses were destroyed, 1,000 people were killed, and 30 million more were made homeless. Two thirds of the country was under water.</li> <li>• 1988: There were 2,379 deaths, and 45 million people were directly affected. The total flood damage was estimated at US\$2.137 billion (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=14">http://www.preventionweb.net/english/countries/statistics/?cid=14</a>).</li> <li>• 1998: There were 1,050 deaths, and 15 million people were affected (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=14">http://www.preventionweb.net/english/countries/statistics/?cid=14</a>). Two</li> </ul>	<p><b>Coastal flooding</b></p> <ul style="list-style-type: none"> <li>• affects coral growth;</li> <li>• alters salinity regimes in mangroves—resulting in a change in the species composition;</li> <li>• loss of land occupied by mangroves;</li> <li>• increases salinity in lagoons and estuaries, affecting the species composition;</li> <li>• inundates the banks of lagoons and estuaries; and</li> <li>• intensifies severe coastal erosion.</li> </ul> <p><b>Saltwater intrusion from coastal flooding</b></p> <ul style="list-style-type: none"> <li>• alters salinity regimes in mangroves, sand dunes, lagoons and estuaries in favour of salt-tolerant species and changes the species composition of each community; and</li> <li>• affects freshwater aquifers.</li> </ul>

Hazard	Country	Impact on lives	Impacts on coastal ecosystems that create issues for coastal managers
		<p>thirds of the country was under water (<a href="http://www.climateavenue.com/cl.imp.sealevel.Bangladesh.htm">http://www.climateavenue.com/cl.imp.sealevel.Bangladesh.htm</a>). The damage was estimated to be US\$4 billion (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=14">http://www.preventionweb.net/english/countries/statistics/?cid=14</a>).</p> <ul style="list-style-type: none"> <li>2004: There were 747 deaths. More than 30 million people were affected directly. More than 4 million houses were damaged, and 4 million people were displaced. Thirty-nine of the 64 districts of the country were affected. Dhaka was also affected. Flood water remained standing for up to 3 months in some areas. The damage is estimated to be about US\$2.2 billion (<a href="http://www.climateavenue.com/cl.imp.sealevel.Bangladesh.htm">http://www.climateavenue.com/cl.imp.sealevel.Bangladesh.htm</a>).</li> <li>2007: There were 4,234 deaths, and 13 million people were affected (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=14">http://www.preventionweb.net/english/countries/statistics/?cid=14</a>); 53,000 people were affected by water-borne diseases (<a href="http://www.climateavenue.com/cl.imp.sealevel.Bangladesh.htm">http://www.climateavenue.com/cl.imp.sealevel.Bangladesh.htm</a>). The damage is estimated to be about US\$2 billion (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=14">http://www.preventionweb.net/english/countries/statistics/?cid=14</a>).</li> </ul>	
	<p>Floods in <b>India</b> are generally caused by monsoonal rains and are exacerbated by</p>	<ul style="list-style-type: none"> <li>In 2009: Flooding occurred across South India. It was one of the worst floods in the area in the last 100</li> </ul>	

Hazard	Country	Impact on lives	Impacts on coastal ecosystems that create issues for coastal managers
	<p>deforested catchments and obstructions to the natural flow of water. River deltas are also prone to floods.</p> <p>Between 1980 and 2010, there were 184 floods (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=79">http://www.preventionweb.net/english/countries/statistics/?cid=79</a>).</p>	<p>years, killing 250 people and making 500,000 homeless (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=79">http://www.preventionweb.net/english/countries/statistics/?cid=79</a>).</p> <ul style="list-style-type: none"> <li>2011: In Odisha, 2,600 villages spread over 19 districts were flooded. There were eight deaths, and 1,100,000 people were affected (<a href="http://articles.timesofindia.indiatimes.com/2011-09-11/bhubaneswar/30141440_1_daleighai-orissa-floods-lakh-cusec">http://articles.timesofindia.indiatimes.com/2011-09-11/bhubaneswar/30141440_1_daleighai-orissa-floods-lakh-cusec</a>).</li> </ul>	
	<p>The <b>Maldives</b> are generally not prone to floods but are affected seriously when swells hit as all the atolls are low-lying.</p> <p>Between 1980 and 2010, there were only 2 floods in the Maldives (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=106">http://www.preventionweb.net/english/countries/statistics/?cid=106</a>).</p>	<ul style="list-style-type: none"> <li>2007: A series of swells hit an estimated 68 islands in the Maldives, causing flooding up to 600 metres from the coastline. A total of 1,649 people were evacuated from their homes (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=106">http://www.preventionweb.net/english/countries/statistics/?cid=106</a>).</li> </ul>	
	<p>Floods in <b>Pakistan</b> are generally caused by monsoonal rains and exacerbated by deforested catchments and obstructions to the natural flow of water. River deltas are also prone to floods.</p> <p>Between 1980 and 2010, there were 58 floods in Pakistan (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=129">http://www.preventionweb.net/english/countries/statistics/?cid=129</a>).</p>	<ul style="list-style-type: none"> <li>2003: There were 3,084 deaths in the Sindh province.</li> <li>2010: There were 1,781 deaths, 2,966 people were injured, and more than 1.89 million homes were destroyed in the provinces of Sindh and Balochistan. This floods is considered to be the worst in Pakistani history (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=129">http://www.preventionweb.net/english/countries/statistics/?cid=129</a>).</li> <li>2010: A flash flood in July and August resulted in 1,985 deaths. There were</li> </ul>	

Hazard	Country	Impact on lives	Impacts on coastal ecosystems that create issues for coastal managers
	<p>Floods in <b>Sri Lanka</b> are generally caused by monsoonal rains and exacerbated by human activities such as deforested catchments and obstructions to the natural flow of water.</p> <p>Between 1980 and 2010, there were 45 floods in Sri Lanka (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=162">http://www.preventionweb.net/english/countries/statistics/?cid=162</a>).</p>	<p>20.4 million victims, and the cost was US\$9.5 billion, representing 5.9 percent of the country's GDP (Guha-Sapir et al., 2011).</p> <ul style="list-style-type: none"> <li>• 1989: There were 325 deaths, 501,000 were affected, and the damage is estimated at US\$35 million (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=162">http://www.preventionweb.net/english/countries/statistics/?cid=162</a>).</li> <li>• 2003: There were 235 deaths, and 695,000 were affected. The damage worthies estimated at US\$29 million (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=162">http://www.preventionweb.net/english/countries/statistics/?cid=162</a>).</li> </ul>	
<p><b>Tropical cyclones</b></p>	<p><b>Bangladesh</b>, due to its unique geographic location, suffers from frequent, devastating tropical cyclones. The funnel-shaped northern portion of the Bay of Bengal causes tidal bores when cyclones make landfall, and thousands of people living in coastal areas are affected.</p> <p>Some of the most devastating natural disasters in recorded history, with high casualties, were tropical cyclones that hit the region now forming Bangladesh.</p> <p>Between 1980 and 2010, Bangladesh experienced 108 storms.</p>	<ul style="list-style-type: none"> <li>• 1970: Cyclone Bhola alone claimed more than 500,000 lives in what was then East Pakistan.</li> <li>• During the period 1991–2007, 10 cyclones hit Bangladesh, with human and livestock casualties numbering in the hundreds of thousands and with severe impacts on the country's economy, estimated at hundreds of billions of taka (<a href="http://en.wikipedia.org/wiki/List_of_Bangladesh_tropical_cyclones">http://en.wikipedia.org/wiki/List_of_Bangladesh_tropical_cyclones</a>).</li> <li>• 1991: There were 138,000 deaths and extensive damage was caused when whole villages were swept away.</li> <li>• 2007: The number of deaths reported to be caused by Cyclone Sidr is between 5,000 and 10,000;</li> </ul>	<p><b>Increased erosion</b> Cyclones shift and reshape sand dunes and in the process increase erosion.</p> <p><b>Damage to or death of flora and fauna</b> Cyclones can break crowns or branches of mangroves. The raging waves damage and break coral reefs.</p> <p>Dead birds and other wildlife maybe observed on beaches after a cyclone.</p> <p><b>Disruption of turtle nesting sites</b> Debris from a cyclone litters beaches and prevents nesting of marine turtles. Nests already on a beach can get smothered by shifting sand or flooded by water.</p>

Hazard	Country	Impact on lives	Impacts on coastal ecosystems that create issues for coastal managers
	<p>The east coast of <b>India</b> is more prone to tropical cyclones than is the west coast.</p> <p>Both coasts have been hit, by 92 storms, between 1980 and 2010 (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=79">http://www.preventionweb.net/english/countries/statistics/?cid=79</a>).</p>	<p>the damage caused is estimated at US\$1.7 billion (<a href="http://en.wikipedia.org/wiki/Cyclone_Sidr">http://en.wikipedia.org/wiki/Cyclone_Sidr</a>).</p> <ul style="list-style-type: none"> <li>• 1971: Odisha was hit by a cyclone that caused 10,000 deaths (Gol, 2011).</li> <li>• 1977: Andhra Pradesh was hit by a cyclone that resulted in 10,000 deaths; hundreds of thousands were made homeless. The cyclone destroyed 40 percent of India's foodgrains (Gol, 2011).</li> <li>• 1998: Gujarat was hit by a cyclone that claimed the lives of 1,173 persons. A total of 1,774 persons were reported missing (Gol, 2011).</li> <li>• 1999: Odisha was affected by a severe cyclonic storm and a super cyclone in quick succession: 9,885 people lost their lives (Gol, 2011).</li> </ul>	<p><b>Decreasing phytoplankton</b> One major effect on marine food webs is that cyclones dramatically reduce the biomass of phytoplankton, with concurrent, significant increases in the concentrations of nitrate, nitrite, phosphate and silicate (Changlu et al., 1996). These changes have major impacts on marine food webs.</p> <p><b>Changing salinity</b> Cyclones can generate both short- and long-term effects in estuarine systems. Increased rainfall can cause freshwater intrusion into saline areas and cause the death of flora and fauna adapted to brackish water. Long-term effects include changes in the species composition.</p> <p><b>Nutrient loading</b> Organic debris decomposes and results in an increased nutrient loading in the water, causing algal blooms and, eventually, the death of other aquatic organisms, many of which may be commercially important.</p> <p>The aftermath of cyclones is usually heavy rainfall, which can result in floods and their impacts on coastal ecosystems.</p>
	<p>While the <b>Maldives</b> are less prone to tropical cyclones than are the other focus countries, when cyclones do strike, they are extremely destructive.</p> <p>Only 11 tropical cyclones have crossed the country in the last 128 years (<a href="http://www.saarc-sadkn.org/countries/maldives/hazard_profile.aspx">http://www.saarc-sadkn.org/countries/maldives/hazard_profile.aspx</a>).</p>	<ul style="list-style-type: none"> <li>• 1991: A total of 23,849 people were affected and damage to the effect of US\$30 million was caused.</li> </ul>	
	<p><b>Pakistan</b> is also prone to tropical cyclones. Between 1980 and 2010, Pakistan was affected by 18 storms (<a href="http://www.preventionweb">http://www.preventionweb</a>).</p>	<ul style="list-style-type: none"> <li>• 1965: A total of 10,000 people were affected in Karachi (<a href="http://pakistanweatherportal.com/2011/03/31/history-of-cyclones-in-pakistan/">http://pakistanweatherportal.com/2011/03/31/history-of-cyclones-in-pakistan/</a>).</li> </ul>	

Hazard	Country	Impact on lives	Impacts on coastal ecosystems that create issues for coastal managers
	<p>net/english/countries/statistics/?cid=129).</p>	<ul style="list-style-type: none"> <li>• 1999: Cyclone 2A was the strongest and most intense cyclone in recorded history, killing 6,200 people (<a href="http://pakistanweatherportal.com/2011/03/31/history-of-cyclones-in-pakistan/">http://pakistanweatherportal.com/2011/03/31/history-of-cyclones-in-pakistan/</a>).</li> <li>• 2007: Cyclone Yemyn claimed the lives of 730 people, and it affected the lives of 2 million people. The cyclone was the third deadliest cyclone in recorded history in Pakistan (<a href="http://pakistanweatherportal.com/2011/03/31/history-of-cyclones-in-pakistan/">http://pakistanweatherportal.com/2011/03/31/history-of-cyclones-in-pakistan/</a>).</li> </ul>	
	<p>Between 1992 and 2009, six cyclones affected <b>Sri Lanka</b>.</p>	<p>The cyclone of 2000 in Sri Lanka resulted in at least 500,000 people becoming homeless (<a href="http://en.wikipedia.org/wiki/2000_Sri_Lanka_cyclone">http://en.wikipedia.org/wiki/2000_Sri_Lanka_cyclone</a>).</p>	
<p><b>Droughts</b></p>	<p>Droughts in <b>Bangladesh</b> usually occur inland in the northwestern districts (<a href="http://www.banglapedia.org/httpdocs/HT/D_0284.HTM">http://www.banglapedia.org/httpdocs/HT/D_0284.HTM</a>). They occur when the monsoons fail or are delayed.</p>	<ul style="list-style-type: none"> <li>• 1983: A total of 20,000,000 people were affected (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=14">http://www.preventionweb.net/english/countries/statistics/?cid=14</a>).</li> </ul>	<p><b>Death of flora and fauna</b> The lack of resources makes plants and animals vulnerable to predation and disease-causing deaths. Protected areas become vulnerable to rampant grazing by livestock from sites that may not even be close to the areas. Forest fires usually are extensive.</p> <p><b>Scarcity of drinking water</b> This is the most common consequence of droughts and can cause mortalities among humans, livestock and wildlife.</p> <p><b>Failure of crops</b> Depending on the severity of a drought, the loss in agricultural output can</p>
	<p>Droughts in <b>India</b> are caused by the failure of the monsoons (specifically, the summer monsoon) and exacerbated by overexploitation of groundwater and surface water.</p>	<ul style="list-style-type: none"> <li>• 1982: A total of 100,000,000 people were affected.</li> <li>• 1987: The number of people affected was 300,000,000.</li> <li>• 2000: Fifty thousand people were affected.</li> <li>• 2002: A total of 300,000,000 people were affected (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=79">http://www.preventionweb.net/english/countries/statistics/?cid=79</a>).</li> </ul>	

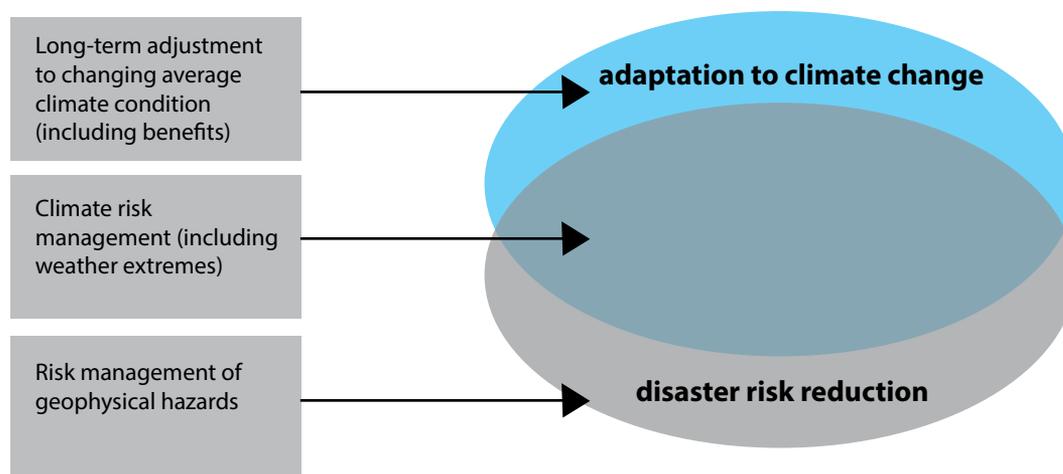
Hazard	Country	Impact on lives	Impacts on coastal ecosystems that create issues for coastal managers
	Droughts are not a major hazard in the <b>Maldives</b> .		affect sections of society in different ways. Both rain-fed agriculture and irrigated tracts are affected. This in turn may increase extractive use of coastal ecosystems.
	As much as 60 percent of <b>Pakistan</b> is classified as semi-arid or arid ( <a href="http://gfdrr.org/ctrydrmnotes/Pakistan.pdf">http://gfdrr.org/ctrydrmnotes/Pakistan.pdf</a> ). As in India and Bangladesh, <b>Pakistan</b> too suffers droughts as a result of the failure of the monsoons.	<ul style="list-style-type: none"> <li>• 1998–2002: The provinces of Balochistan and Sindh were affected by the worst drought in 50 years. This drought caused 127 deaths, and 1.2 million people were affected (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=129">http://www.preventionweb.net/english/countries/statistics/?cid=129</a>), and the economic cost of this drought was US\$2.5 billion (<a href="http://gfdrr.org/ctrydrmnotes/Pakistan.pdf">http://gfdrr.org/ctrydrmnotes/Pakistan.pdf</a>).</li> </ul>	<p><b>Changes in salinity</b> The dearth of water can make brackish water more saline and affect plant and animal communities in mangroves, salt marsh and tidal flats. This ultimately leads to changes in the community structure.</p>
	<b>Sri Lanka</b> , being close to the equator, has a warm climate. A large part of the island is termed the 'dry zone', in which rain is sharply seasonal, falling only during the northeast monsoon. When this is delayed or fails, drought conditions prevail.	<ul style="list-style-type: none"> <li>• 1982: 2,000,000 people were affected.</li> <li>• 1987: A total of 2,200,000 people were affected.</li> <li>• 1988: The number of people affected was 806,000.</li> <li>• 2001: A total of 1,000,000 people were affected.</li> <li>• 2004: The number of people affected was 3,000,000 (<a href="http://www.preventionweb.net/english/countries/statistics/?cid=162">http://www.preventionweb.net/english/countries/statistics/?cid=162</a>). Fourteen out of 25 districts were hit by drought, and 158,000 families lost their livelihoods (<a href="http://www.desinventar.lk/des_html/disaster_profile/drought.pdf">http://www.desinventar.lk/des_html/disaster_profile/drought.pdf</a>).</li> </ul>	
<b>Earthquakes</b>	<b>Bangladesh</b> is surrounded by areas of high seismic activity, and the rivers basins are, therefore, prone to seismic movements. Although Bangladesh is extremely vulnerable to seismic activity, the nature and the level of	<ul style="list-style-type: none"> <li>• 1997: An earthquake of magnitude 6.0 occurred near Chittagong, causing minor damage in the town.</li> <li>• 1999: An earthquake of magnitude 5.2 occurred on Maheshkhali Island. Houses were cracked, and in some cases they collapsed.</li> <li>• 2003: On 27 July an</li> </ul>	<p><b>Collection of debris</b> One of the immediate consequences of earthquakes is the collection of debris, which smothers and damages natural vegetation and fauna.</p> <p><b>Uplifts and submersion</b> Earthquakes move the</p>

Hazard	Country	Impact on lives	Impacts on coastal ecosystems that create issues for coastal managers
	<p>this activity are yet to be defined. Complete earthquake monitoring facilities are not available (<a href="http://www.banglapedia.org/httpdocs/HT/E_0002.HTM">www.banglapedia.org/httpdocs/HT/E_0002.HTM</a>).</p>	<p>earthquake of magnitude 5.1 occurred at Kolabunia union of Barkal Upazila, Rangamati District (<a href="http://www.banglapedia.org/httpdocs/HT/E_0002.HTM">www.banglapedia.org/httpdocs/HT/E_0002.HTM</a>).</p>	<p>earth—in some areas the earth is lifted, and in others, it sinks. What is known as liquefaction of earth takes place, so that it flows like a liquid and does not remain solid (<a href="http://ecan.govt.nz/publications/Reports/eq-effects-summary-river-lowres.pdf">http://ecan.govt.nz/publications/Reports/eq-effects-summary-river-lowres.pdf</a>).</p> <p>Uplifts can cause landslides, which smother fauna and flora, while submersion causes drowning.</p> <p><b>Tsunamis</b> When the epicentre of a powerful earthquake is located offshore, the sea bed may be displaced sufficiently to cause a tsunami.</p>
	<p>The whole of the northern and northeastern parts of India (Assam and nearby states), especially along the Himalayan trend, are highly prone to earthquakes. Gujarat is another earthquake-prone state. The coastal parts of Maharashtra are also moderately prone to earthquakes.</p>	<ul style="list-style-type: none"> <li>• 1991: Uttarkashi- in Uttarakhand, magnitude 7.0 &gt;2000 deaths. A large number of houses collapsed;</li> <li>• 1993: Latur, Maharashtra, magnitude 6.2, human death toll 7,928 and another 30,000 injured (Gol, 2011); and</li> <li>• 2001: Gujarat—25,000 deaths and 6.3 million people affected (Gol, 2011).</li> </ul>	<p><b>Volcanic activity</b> Occasionally earthquakes may trigger volcanic activity (<a href="http://en.wikipedia.org/wiki/Earthquakes">http://en.wikipedia.org/wiki/Earthquakes</a>).</p> <p><b>Eutrophication</b> There is an influx of raw waste water. The influx of sewage results in nutrient loading, eutrophication and a consequent loss of aquatic life.</p>
	<p>In <b>Pakistan</b>, the coastal provinces of Sindh and Balochistan are vulnerable to earthquake-triggered disasters.</p>	<ul style="list-style-type: none"> <li>• 2005: Parts of Khyber and Azad Kashmir were affected by an earthquake of magnitude 7.8, and the human death toll was 80,000.</li> <li>• 2008: An earthquake of magnitude 6.4 struck Quetta (Balochistan). It caused 215 deaths and left 120,000 homeless.</li> <li>• 2011: An earthquake of magnitude 7.2 struck Balochistan. Details of the damage caused are not known (<a href="http://pakistanweatherportal.com/2011/07/30-history-of-earthquakes-in-pakistan-in-detail/">http://pakistanweatherportal.com/2011/07/30-history-of-earthquakes-in-pakistan-in-detail/</a>).</li> </ul>	<p><b>Volcanic activity</b> Occasionally earthquakes may trigger volcanic activity (<a href="http://en.wikipedia.org/wiki/Earthquakes">http://en.wikipedia.org/wiki/Earthquakes</a>).</p> <p><b>Eutrophication</b> There is an influx of raw waste water. The influx of sewage results in nutrient loading, eutrophication and a consequent loss of aquatic life.</p>
	<p>The <b>Maldives</b> are not considered a seismic hazard area.</p>		
	<p><b>Sri Lanka</b> is not considered a seismic hazard area.</p>		

## Inter-linkages among DRR, CCA and ecosystem-based management

The overlap between DRR and CCA is already recognized and widely known (Mitchell and van Aalst, 2008; Thomalla et al., 2006) (Figure 3.5).

**Figure 3.5. The overlap between CCA and DRR**



Source: Mitchell and van Aalst, 2008

Less known are the interlinkages among CCA, DRR and ecosystem-based management in coastal and marine areas (Figure 1.2 in Chapter 1). For example, climate change is now known to increase the intensity and frequency of natural hazards (IPCC, 2007). More frequent coastal disasters, such as cyclones, that cause physical damage to both marine and coastal ecosystems will reduce the resilience of coastal ecosystems. This, in turn, reduces their ability to buffer coastal communities from hazards and provide other vital goods and services to communities. Climate change can exacerbate this scenario. Tables 3.3 and 3.4 depict the linkages between climate change, hazards and ecosystems.

**Table 3.3. The impacts of climate change on hazards and ecosystems**

Impact of climate change	On hazards	On ecosystems
Temperature increase	Increased droughts	Damage to coastal ecosystems; Coral bleaching; Water shortages for flora and fauna - resulting in drought-tolerant species thriving; changes in species composition; Decreased provisioning.
Sea level rise	Increased coastal flooding	Affects coral growth; Alters salinity regimes in mangroves – resulting in a change in species composition; Loss of land occupied by mangroves; Increased salinity in lagoons and estuaries, affecting species composition; Decreased provisioning.
Changes in weather patterns	Increased cyclones, storm surges, floods	Increases damages to coastal ecosystems; Reduces natural resilience; Reduces protective and provisioning services of ecosystems.

**Table 3.4. The impacts of ecosystem degradation on hazards and climate change**

Ecosystem degradation	Impact on hazards	Impact on climate change
Mangrove destruction	 Loss of protective barrier: worsens the impact of cyclones, storm surges and floods. Aggravates erosion.	 Reduces carbon sequestration.
Salt marsh destruction	 Worsens the impacts of storm surges and floods. Aggravates erosion.	 Reduces carbon sequestration.

These linkages serve to highlight the importance of integrating DRR and CCA into coastal and marine management. CCA and DRR experts have many aims in common, and in the last few years, they have been working closely together and are benefitting from the expertise of each other ([http://www.preventionweb.net/files/7846\\_climatechange1.pdf](http://www.preventionweb.net/files/7846_climatechange1.pdf)).



## 4. Climate Change

As already mentioned in the previous chapters, there is clear scientific evidence to confirm that the earth's climate system is rapidly changing, mainly due to the accumulation of greenhouse gases (GHGs). Between 1970 and 2004, the annual emission of carbon dioxide (CO<sub>2</sub>) grew by about 80 percent, and during the last century the concentration of CO<sub>2</sub> in the atmosphere has risen 12-fold (IPCC, 2007). The Intergovernmental Panel on Climate Change (IPCC) Special Report on Emission Scenarios projects an increase of global GHG emissions by 25–90 percent between 2000 and 2030 (IPCC, 2007). Correspondingly, during the last century, the global temperature increased by about 0.8°C—the largest increase in 1,000 years. The records are startling: The last decade was the warmest decade on record, with 2005 and 2010 tying for the hottest year on record worldwide (IPCC, 2007; NOAA, 2011b).

While carbon sources increased, carbon sinks—forests and other natural ecosystems—are being depleted. It is reported that during the last decade there was a net forest loss of 5.2 million hectares per annum (UN, 2012). Forests and natural habitats, when destroyed, release large quantities of CO<sub>2</sub> and other GHGs into the atmosphere ([http://wwf.panda.org/about\\_our\\_earth/aboutcc/cause/](http://wwf.panda.org/about_our_earth/aboutcc/cause/)). Deforestation alone is responsible for up to 20 percent of all carbon emissions globally ([http://wwf.panda.org/what\\_we\\_do/footprint/climate\\_carbon\\_energy/forest\\_climate/](http://wwf.panda.org/what_we_do/footprint/climate_carbon_energy/forest_climate/)). In addition, as ecosystems are destroyed or degraded, and the richness of species diminishes, the resilience of ecosystems also decreases. All these limit the options for coping with the impacts of climate change (UNEP, 2006).

In addition to the provision of essential services such as pollination, nutrient cycling and water purification, biodiversity and ecosystems have a direct role in climate regulation. Ecosystems are critical for carbon sequestration, regulation of evapotranspiration and micro-climate regulation (UNEP, 2006). As discussed in Chapter 1, coastal and marine ecosystems, such as mangroves, seagrass meadows and salt marshes, are storehouses for carbon burial. Many coastal ecosystems also serve to mitigate the impacts of natural disasters, which have become more frequent and intense as a consequence of climate change, through their protective functions as natural barriers. This again reiterates the need to integrate CCA measures into coastal and marine management. This chapter provides an overview of the basic aspects of climate change (Box 4.1), its impacts on coastal and marine ecosystems and the broad approaches to combating climate change.

### **Box 4.1 Climate change-related terminology**

(All definitions are from <http://www.ipcc.ch/ipccreports/tar/wg1/518.htm> except if noted in the text.)

#### **Weather**

“Weather is described as atmospheric conditions at a particular place, in terms of air temperature, pressure, humidity, wind speed, and precipitation—for example, it can be hot or cold, wet or dry” ([www.thefreedictionary.com/weather](http://www.thefreedictionary.com/weather)).

#### **Climate**

“Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO)”.

#### **Climate variability**

“Climate variability refers to 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. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability)”. Examples of climate variability include extended droughts, floods and conditions that result from periodic El Niño and La Niña events.

#### **El Niño/La Niña**

“El Niño, in its original sense, is a warm water current which periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. This oceanic event is associated with a fluctuation of the inter-tropical surface pressure pattern and circulation in the Indian and Pacific oceans, called the Southern Oscillation. This coupled atmosphere-ocean phenomenon is collectively known as El Niño–Southern Oscillation, or ENSO. During an El Niño event, the prevailing trade winds weaken and the equatorial countercurrent strengthens, causing warm surface waters in the Indonesian area to flow eastward to overlie the cold waters of the Peru Current. This event has great impact[s] on the wind, sea surface temperature and precipitation patterns in the tropical Pacific. It has climatic effects throughout the Pacific region and in many other parts of the world. The opposite of an El Niño event is called La Niña”.

#### **Global warming**

“The recent and ongoing global average increase in temperature near the earth’s surface” (<http://epa.gov/climatechange/glossary.html#G>).

#### **Greenhouse gas**

“Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation

emitted by the Earth's surface, the atmosphere and clouds. This property causes the greenhouse effect. Water vapour (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>), nitrous oxide (N<sub>2</sub>O), methane (CH<sub>4</sub>) and ozone (O<sub>3</sub>) are the primary greenhouse gases in the Earth's atmosphere. Moreover there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine and bromine containing substances, dealt with under the Montreal Protocol. Besides CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub>, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF<sub>6</sub>), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs)<sup>6</sup>.

#### **Greenhouse effect**

"Greenhouse gases effectively absorb infrared radiation, emitted by the earth's surface, by the atmosphere itself due to the same gases, and by clouds. Atmospheric radiation is emitted to all sides, including downward to the earth's surface. Thus greenhouse gases trap heat within the surface-troposphere system. This is called the *natural greenhouse effect*. Atmospheric radiation is strongly coupled to the temperature of the level at which it is emitted. In the troposphere the temperature generally decreases with height. Effectively, infrared radiation emitted to space originates from an altitude with a temperature of, on average, -19°C, in balance with the net incoming solar radiation, whereas the earth's surface is kept at a much higher temperature of, on average, +14°C. An increase in the concentration of greenhouse gases leads to an increased infrared opacity of the atmosphere, and therefore to an effective radiation into space from a higher altitude at a lower temperature. This causes a radiative forcing, an imbalance that can only be compensated for by an increase of the temperature of the surface-troposphere system. This is the enhanced greenhouse effect".

#### **Carbon sequestration**

"Terrestrial, or biologic, carbon sequestration is the process by which trees and plants absorb CO<sub>2</sub>, release the oxygen, and store the carbon. Geologic sequestration is one step in the process of carbon capture and sequestration, and involves injecting carbon dioxide deep underground where it stays permanently (<http://epa.gov/climatechange/glossary.html#G>).

#### **Carbon source**

Anything that releases more carbon than it absorbs. (Industries, vehicles, etc. are carbon sources.)

#### **Carbon sink**

Anything that absorbs more carbon than it releases. Forests, mangroves, seagrass meadows and salt marshes are carbon sinks.

## Impacts of climate change on the coastal and marine environment of South Asia

Climate change has serious impacts on coastal and marine ecosystems, especially for mangroves, estuaries and coral reefs, which are already under stress because of coastal zone development and population growth. Climate change-induced temperature fluctuations could affect salinity levels, aquatic oxygen concentrations and the physiology, abundance and distributions of plants and animals and lead to flooding of wetlands, shoreline erosion and enhanced storm surges. Coral reefs, which are already threatened by multiple stressors such as destructive fishing practices, pollution, increased disease outbreaks and invasive species, will also be severely hit<sup>6</sup>.

Climate modelling has shown that the annual temperature increase for South Asia may be between 2.4°C and 4.5°C by the end of the century. The IPCC Report (2007) predicts a sea level rise of at least 40 cm by 2100 that shall inundate vast areas on the coast, and up to 88 per cent of the coral reefs, termed the 'rainforests of

<sup>6</sup> UNDP, 2011, India Coastal and Marine Programme document.

the ocean', may be lost. For instance, the sea level along Maharashtra in India (west coast) has gone up by 5–6 centimetres in the past 20 years (Down to Earth, 2010). Increased warming will also lead to coral bleaching. Apart from the loss of critical biodiversity, damage to coral reefs will mean irreparable loss to fisheries and the recreational opportunities provided by reefs.

To date, non-climate-related anthropogenic stressors have likely accounted for most of the global average annual rate of mangrove loss<sup>7</sup>. However, climate change-induced perturbations, including a relative sea level rise and change in salinity, may constitute a substantial proportion of predicted future losses (Gilman et al., 2008). A rising sea level brings in salts and sulphates; diminution of rainfall reduces mudflow and nutrient influxes. An increased frequency of tropical cyclones with inundation of low-lying areas and salt water incursion is also not ruled out. These changes might ultimately result in changed biodiversity and species migration<sup>8</sup>.

The region is also expected to face an increase in tropical cyclones (IISD, 2007). As already mentioned, Asia is the world's most disaster-prone region, having suffered about half of the world's major disasters over the past 50 years, 67 percent of the casualties and 28 percent of the economic losses (Reid and Simms, 2007). It is estimated that 1 in every 19 people is affected by natural disasters in Asia, compared with 1 in every 1,500 people in Organization for Economic Co-operation and Development (OECD) countries—which is a risk differential of about 79 (HDR 2007/8). The sea level rise is a particular concern to the island countries of the Maldives and Sri Lanka, as well as the low-lying coastal belts of India and Bangladesh (IISD, 2011). In short, it is clear that coastal and marine ecosystems in South Asia, which are already under considerable stress, will become worse due to climate change. Some of the visible and predicted impacts of climate change on coastal and marine environment are given in Box 4.2.



<sup>7</sup> India's Initial National Communication (INC, 2004) to the UNFCCC notes that with the exception of the mangroves of the Andaman and Nicobar Islands, the mangroves of the country are already considerably degraded. The development of agriculture in the deltas of the major rivers, the reclamation of coastal wetlands for settlement and the use of mangroves to supply products such as fuel wood have resulted in a considerable shrinkage of the mangrove areas. According to one estimate, the mangrove cover of the country decreased by 35 per cent during the period 1987–1995 alone (estimate made by Sustainable Wetlands, Environmental Governance-2 in 1999).

<sup>8</sup> UNDP, 2011, India Coastal and Marine Programme documents.

## **Box 4.2. Visible and predicted impacts of climate change on coastal and marine environment**

### **Melting glaciers**

Melting snow and retreating glaciers cause sea level rises. The current rate of sea level rise is three times the historical rate, and the sea level has already risen by 10–20 centimetres in the last century (IPCC, 2007). The IPCC predicts that the global sea level could rise between 0.09 and 0.88 metres by 2100. This could mean that many low-lying areas in the South Asian countries such as Bangladesh, Mumbai and large parts of the Maldives could face the threat of inundation and flooding.

### **Sea-water intrusion**

Coastal flooding will result in the intrusion of saline water into freshwater bodies. This will diminish freshwater supplies for coastal communities and affect livelihoods and human well-being.

### **Ocean warming and acidification**

Oceans absorb far more heat than does the atmosphere. The uppermost three metres of the ocean alone contain as much heat as the entire atmosphere above it. However, heating of the oceans happens over time, and there is a time lag between the heating of the atmosphere and the heating of the oceans. Further, as more CO<sub>2</sub> becomes dissolved in the oceans, forming weak carbonic acid, oceans become more acidic.

### **Changing ocean currents**

Ocean currents are becoming seriously affected by global warming. Usually, heat moves from the equator to the poles and vice versa not only through the atmosphere but also through ocean currents. Such currents are extremely important in maintaining the continental climate, especially in coastal areas. When both the temperature and salinity of oceans change as a result of global warming, these currents change, with serious effects on weather patterns.

### **Changes in the distribution of species**

Changing weather patterns are also resulting in changes in the distribution and ranges of species and are disrupting the resilience and functionality of ecosystems. For instance, increasing salinity and precipitation patterns affect the distribution of salt-tolerant mangroves such as *Avicennia* and *Rhizophora* species. The seedlings of these species require specific salinity gradients for their growth, and any change in salinity could affect their survival, growth and productivity. Changes in species distribution are also expanding the range of disease vectors such as mosquitoes, and so diseases are spreading, affecting human health.

### **Changing weather patterns**

There are visible changes in the world's climate. Rainfall patterns are changing, and the effects of El Niño and La Niña episodes have worsened, resulting in an increased frequency of cyclones, flooding and landslides. Dry areas are becoming dryer, leading to more droughts and heat waves. These, in turn, lead to famine, increased numbers of wildfires and pest attacks and the spread of invasive alien species (IPCC, 2007). The world's hydrological systems will be rearranged, causing changes in seasonal flows. In water-scarce regions, the availability of water will be reduced, while it will be improved in some other areas. Generally, the quality of freshwater habitats will be degraded by higher water temperatures. Changes upstream will have impacts on downstream supplies, affecting water security.

### **Increase in the frequency and intensity of natural disasters**

The link between climate change and the increase in frequency of natural disasters cannot be overemphasized. The progression is clear: Climate change is worsening El Niño and La Niña events, and this is causing more intense, more frequent natural hazards such as floods, cyclones, hurricanes and wildfires. Because the intensity and extent of these natural hazards have worsened, they are causing natural disasters.

Table 4.1 summarizes the impacts of climate change on coastal ecosystems and human well-being in the coastal areas of South Asia.

**Table 4.1. Impacts of climate change on coastal ecosystems and human well-being in coastal areas**

<b>Effect of climate change</b>	<b>Impacts on ecosystem well-being</b>	<b>Impacts on human well-being</b>
<b>Higher temperatures</b>	<ul style="list-style-type: none"> <li>• Affects the metabolism and spawning patterns of species, as well as their distribution</li> <li>• Coral bleaching leads to a reduced species diversity and increased susceptibility to pathogens and diseases.</li> <li>• Leads to eutrophication in lagoons and estuaries, damaging the quality of the water</li> </ul>	<ul style="list-style-type: none"> <li>• Affects provisioning services of coastal ecosystems, worsening food security and livelihoods</li> <li>• Affects coastal tourism, i.e., cultural services</li> </ul>
<b>Melting glaciers</b>	<ul style="list-style-type: none"> <li>• In the short term, rapidly melting glaciers mean intense flooding downstream.</li> <li>• In the long term, the reduced quantity of ice produces less freshwater downstream. The snow melts of the Himalaya feed the Ganges, Indus and Brahmaputra rivers.</li> </ul>	<ul style="list-style-type: none"> <li>• Short term: increased flooding</li> <li>• Long term: increased water stress</li> <li>• The Ganges, which alone provides water to 400 million of people, is predicted to lose two thirds of its water as a result of climate change (Reid and Simms, 2007).</li> </ul>
<b>Sea level rise</b>	<ul style="list-style-type: none"> <li>• Coastal flooding</li> <li>• Affects coral growth</li> <li>• Alters salinity regimes in mangroves, resulting in a change in the species composition</li> <li>• Loss of land occupied by mangroves</li> <li>• Increases salinity in lagoons and estuaries, affecting the species composition</li> <li>• Inundates the banks of lagoons and estuaries</li> <li>• More severe coastal erosion</li> </ul>	<ul style="list-style-type: none"> <li>• Loss of protective and regulatory services leaves coastal communities more vulnerable to natural disasters. This could mean that many coastal countries and cities such as Bangladesh, the Maldives, Mumbai and Bangkok could become flooded by sea water. It is estimated that in India alone, millions of people are at high risk from rising sea levels.</li> <li>• All these impacts result in impaired provisioning services of coastal ecosystems, affecting the security of resource access and maintenance of livelihoods.</li> </ul>
<b>Sea water intrusion</b>	<ul style="list-style-type: none"> <li>• Alters salinity regimes in mangroves, sand dunes, lagoons and estuaries, favouring salt-tolerant species and changing the species composition of each community</li> <li>• Affects freshwater aquifers</li> </ul>	<ul style="list-style-type: none"> <li>• Changes in the species composition in these habitats will affect coastal fisheries, as well as agriculture, in turn affecting both food security and livelihoods.</li> <li>• Changes in sand dunes affect tourism and cultural services.</li> <li>• Salinated freshwater supplies will have impacts on human health, basic amenities and livelihoods.</li> </ul>

Effect of climate change	Impacts on ecosystem well-being	Impacts on human well-being
<b>Increased acidification of the oceans</b>	<ul style="list-style-type: none"> <li>• Reef building is retarded.</li> <li>• Marine food webs are disrupted.</li> </ul>	<ul style="list-style-type: none"> <li>• Reduces protective and regulatory functions of coral reefs, leaving coastal communities more vulnerable to natural disasters</li> <li>• Reduces provisioning services, affecting food security and livelihoods</li> </ul>
<b>Changing wave climates</b>	<ul style="list-style-type: none"> <li>• Increases coastal erosion</li> <li>• Damages mangrove habitats</li> <li>• Aggravated erosion of dunes and beaches</li> <li>• Increased flooding</li> <li>• The pattern of flows into and out of lagoons and estuaries can change, and lagoon mouth stability may be affected.</li> </ul>	<ul style="list-style-type: none"> <li>• Damage to mangroves and changes in lagoon structure will impair provisioning services. This, in turn, affects the security of resource access and livelihoods.</li> <li>• Increased erosion of sand dunes and increased flooding impact coastal tourism, affecting cultural services.</li> </ul>
<b>Changing weather patterns—increased precipitation</b>	<ul style="list-style-type: none"> <li>• Retards growth of mangrove seedlings</li> <li>• Results in changes in the species composition in mangroves</li> <li>• Flooding in wetlands, lagoons and estuaries</li> </ul>	<ul style="list-style-type: none"> <li>• Impairs provisioning services of mangroves and affects food security and livelihoods</li> <li>• Affects regulatory services of lagoons and estuaries</li> </ul>
<b>Changing weather patterns—decreased precipitation</b>	<ul style="list-style-type: none"> <li>• Drought-tolerant species will thrive in mangroves, lagoons and estuaries.</li> <li>• Results in changes in the species composition in mangroves, lagoons and estuaries</li> <li>• Wetlands could become dryer.</li> </ul>	<ul style="list-style-type: none"> <li>• Impairs provisioning services of mangroves and affects food security and livelihoods</li> </ul>
<b>Changing weather patterns—increased storms/monsoonal variability</b>	<ul style="list-style-type: none"> <li>• Physical damage could outpace natural regrowth.</li> <li>• Aggravated erosion of sand dunes and beaches</li> <li>• Increases flooding and exacerbates flooding in lagoons and estuaries</li> </ul>	<ul style="list-style-type: none"> <li>• All these impacts result in impaired protective and regulatory functions of coastal ecosystems, leaving coastal communities more vulnerable to natural disasters.</li> </ul>
<b>Increased frequency and intensity of storms and extreme weather events</b>	<ul style="list-style-type: none"> <li>• Increases damage to coastal habitats</li> </ul>	<ul style="list-style-type: none"> <li>• Increased vulnerability of coastal communities</li> </ul>

Source: Adapted from IUCN, 2006

## Approaches to dealing with climate change

### Mitigation

The term 'mitigation' in relation to climate change has a different, distinct meaning. **Mitigation in climate change relates specifically to reduction in carbon emissions.** Mitigation promotes carbon clean energy (wind, water and solar power), carbon offsets (balancing emissions from carbon sources with absorption in carbon sinks) and carbon trading (buying and selling carbon credits among countries). However, climate

change mitigation alone will not be enough. Even if GHG emissions are reduced drastically, the current effects of climate change will be felt for several more decades due to the already accumulated GHGs in the atmosphere.

## Adaptation

CCA is the single most effective response to climate change at the local level. CCA is defined as “the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (<http://www.preventionweb.net/english/professional/terminology/v.php?id=7804>). The UNFCCC describes the options related to adaptation as follows:

- “Behavioural change at the individual level, such as the sparing use of water in times of drought;
- Technological and engineering options such as increased sea defences or flood-proof houses;
- Risk management and reduction strategies such as early warning systems for extreme events;
- Promotion of adaptive management strategies;
- Development of financial instruments such as insurance schemes;
- Promotion of ecosystem management practices, such as biodiversity conservation to reduce the impacts of climate change on people, e.g. by conserving and restoring mangroves to protect people from storms” ([http://unfccc.int/press/fact\\_sheets/items/4985.php](http://unfccc.int/press/fact_sheets/items/4985.php)).

An effective response strategy for combating climate change would involve both adaptation and mitigation measures. Of particular mention in the context of coastal and marine ecosystem in South Asia is EbAs, which are the major focus of this publication.



## 5. A Snapshot of the Physical Features and Socio-economics of the Focal Region

### South Asia

The southern region of the Asian continent is known as South Asia and is bordered by West Asia, Central Asia, East Asia and South-East Asia. It is also surrounded by three major water bodies—the Bay of Bengal, the Indian Ocean and the Arabian Sea. South Asia comprises Afghanistan, Bangladesh, Bhutan, India, Iran, the Maldives, Nepal, Pakistan and Sri Lanka. However, given that the focus of this paper is the coastal region, the countries considered here are Bangladesh, India, the Maldives, Pakistan and Sri Lanka.

### Physical and ecological features

The region is physiographically diverse and ecologically rich in natural and crop-related biodiversity. Although the present population of the region is principally rural, it includes 7 of the 25 largest cities in the world. Agriculture is the main industry in several countries in this region. The exploitation of natural resources associated with rapid urbanization, industrialization and economic development has led to increasing air and water pollution, land degradation and other environmental problems in the focus countries. Climate change represents a further stress. Over the long period of human occupation in this area, human use systems have developed some resilience to a range of environmental stresses (IPCC, 1998).

South Asia's climate varies considerably from one area to another, ranging from a tropical monsoonal climate in the south to a temperate climate in the north. This variation is influenced by altitude as well as by factors such as proximity to the coast and the monsoons (<http://en.wikipedia.org/wiki/Asia>).

Much of the climate of South Asia is driven by monsoons and is characterized by wet summers and dry winters. The southwest monsoon (late May to October) brings the maximum rainfall, followed by the northeast monsoon. The precipitation and climate vary significantly from place to place in different countries within the region due to the variations in land forms. The climate varies from a semi-arid type in Pakistan to a tropical monsoon and hot-dry, humid-dry type in the rest of the region (SACEP, 2012). The region's temperatures vary, ranging from as low as -20°C in the cold deserts to a scorching 48°C in desert areas in some plains.

The climatic conditions contribute not only to the increased incidence of hazards but also to socio-economic development in the area (UNISDR, 2010).

### **Box 5.1. Geography and natural disasters**

South Asia's geography makes it particularly susceptible to natural disasters. Its enormous deltas and lengthy coastline, along which its population is concentrated, combined with the monsoons and the Bay of Bengal, make it vulnerable to floods, cyclones and droughts.

Much of South Asia is a subcontinent that rests on the Indian Plate. It was formerly a small continent, which collided with the Eurasian Plate 50–55 million years ago, giving rise to the Himalayan Range and the Tibetan Plateau.

Some of the world's largest river systems are in South Asia. The Indus River (3,200 kilometres long and with 20 tributaries) originates in Tibet and flows through India and Pakistan, out to the Arabian Sea. (A 1,114 kilometre length lies within the state of Jammu and Kashmir in India.) The Ganga–Brahmaputra river systems begin in Bhutan, India, China and Nepal and flow to Bangladesh and India. The Ganges (Ganga—2,525 kilometres in length) originates in the western Himalaya, in the Indian state of Uttarakhand, and flows into Bangladesh through north India. Here, it meets the Bay of Bengal.

The Brahmaputra River (2,900 kilometres long) begins in southwestern Tibet (where it is known as the Yarlung Tsangpo River). It flows through Arunachal Pradesh and the Assam Valley (known in these as the Dihang and Brahmaputra, respectively) in India and then through Bangladesh (known there as the Jamuna—not to be confused with the Yamuna of India), where it merges with the Padma, the main distributary of the Ganges, and the Meghna before meeting the Bay of Bengal (SACEP, 2012).

There are many other rivers in India that flow into the Arabian Sea, on the western coast, or the Bay of Bengal, on the eastern coast. The Tapti and Narmada rivers are significant rivers flowing to the western coast, and the Godavari, Krishna and Kaveri rivers are significant rivers flowing to the eastern coast. In Bangladesh, the main rivers are the Ganges, Brahmaputra and Meghna.

There are 103 rivers draining in a radial pattern from the central highland of Sri Lanka, along the

**Table 5.1. Flora and fauna of South Asia**

<b>Taxon</b>	<b>Number of species</b>
<i>Flora</i>	
Flowering plants	39,875
Conifers and cycads	66
Ferns	764
<i>Fauna</i>	
Mammals	933
Birds	4,494
Reptiles	923
Amphibians	332
Freshwater fish	342

Source: [http://www.sacep.org/html/regional\\_abtsa.htm](http://www.sacep.org/html/regional_abtsa.htm)

island's coastline. The longest of these is the Mahaveli River (335 kilometres long), which drains into the Bay of Bengal (SACEP, 2012).

Given that there is significant variation in factors such as latitude, altitude, climate and topography across the region, South Asia also exhibits considerable diversity in vegetation, ranging from temperate to tropical and desert types. The forests of the region make up 2.73 percent of the total forest area that remains in the world, with approximately 18.6 percent of the land area of South Asia having forest cover. However, only approximately 5 percent of the region's land area is protected at present (SACEP, 2012).

The region is also home to 15.5 percent of the world's flora and 12 percent of its fauna.

## Coastline

Given under Table 5.2 is the length of the coastline in each of the focus countries.

## Economy

Asia has the second largest nominal gross domestic product (GDP) of all continents after Europe but the largest when measured in purchasing power parity (PPP)<sup>9</sup>. As of 2010, the largest economies in Asia are China, Japan, India, South Korea and Indonesia. Based on Global Office Locations 2011, Asia dominated the office locations, with four of the top five locations being in Asia: Hong Kong, Singapore, Tokyo and Shanghai. Around 68 percent of all international firms have offices in Hong Kong (<http://en.wikipedia.org/wiki/Asia>).

From the late 1990s and early 2000s, the economy of India has been growing rapidly. Sri Lanka has experienced a rapid growth after the cessation of the civil war in 2008. Both countries now have average annual growth rates between 6 and 8 percent.

According to Citigroup, 9 of the 11 Global Growth Generator countries are from Asia, driven by population and income growth. Three of these nine countries—Bangladesh, India and Sri Lanka—are in the South Asian region.

The focus countries have relatively small economies, with the exception of India, which ranks 12th in the world in terms of GDP, but have shown rapid growth over the past two decades, particularly in the industry and service sectors. This has led to increasing levels of industrial development in the coastal zones. All the South Asian economies are reducing their reliance on the agriculture sector, with the exception of India.

Of the focus countries under discussion, the Maldives have the highest GDP per capita in the region, while Bangladesh has the lowest.

India is the largest economy in the region (US\$1.54 trillion) and makes up almost 82 percent of the South Asian economy. It is the world's 10th largest economy in nominal terms and the 4th largest by purchasing power adjusted against exchange rates. Pakistan has the next largest economy and the fifth highest GDP per capita in the region, followed by Bangladesh ([http://en.wikipedia.org/wiki/South\\_Asia#Economy](http://en.wikipedia.org/wiki/South_Asia#Economy)).

**Table 5.2. Length of the coastline in each focal country**

Country	Length of coastline (kilometres)
Bangladesh	3,306
India	9,611*
The Maldives	644
Pakistan	1,046
Sri Lanka	1,585

*\*The length of the mainland coastline of India is 7,517 kilometres, and the islands (the Andaman, Nicobar and Lakshadweep islands) contribute an additional 2,094 kilometres (Sawarkar, personal communication).*

Source: [http://earthtrends.wri.org/country\\_profiles/](http://earthtrends.wri.org/country_profiles/)

<sup>9</sup>An economic theory that estimates the amount of adjustment needed on the exchange rate between countries for the exchange to be equivalent to each currency's purchasing power (<http://www.investopedia.com/terms/p/ppp.asp#axzz1l6L6rBZF>).

Presented overleaf are trends in GDP at current prices (US\$) for each of the focal countries.

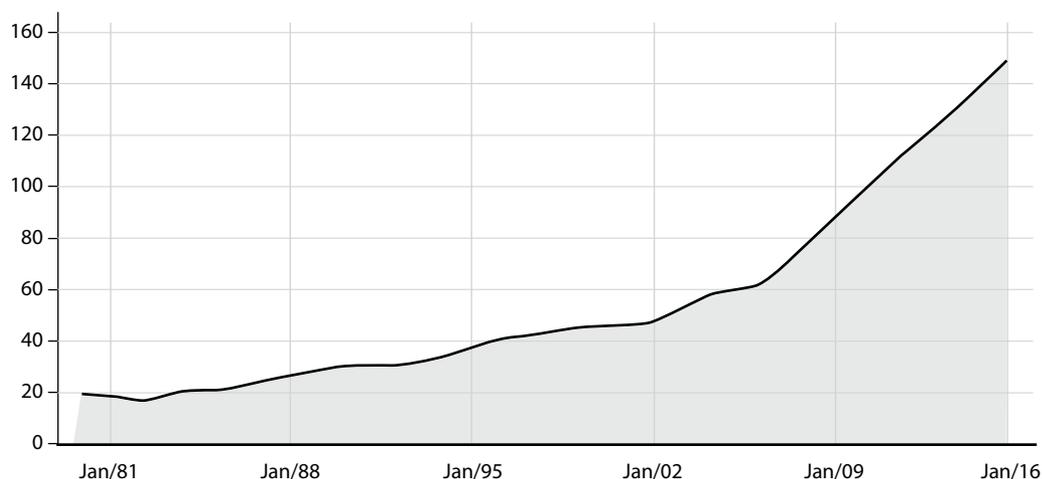
**Table 5.3. Economic indicators in the focal countries**

Country	Annual GDP growth rate percent (2010)	GDP, PPP ( in billions ) (current international )	GDP per capita (current US\$) (2010)	GDP per capita, PPP(current international dollars)
Bangladesh	6.07	246.7	674.9	1659.1
India	8.81	4194	1410.3	3425.4
The Maldives	9.86	2.69	6039.4	8519.3
Pakistan	4.14	466	1018.8	2687.6
Sri Lanka	8.01	105.9	2375.4	5077.9

Source: World Bank, 2012

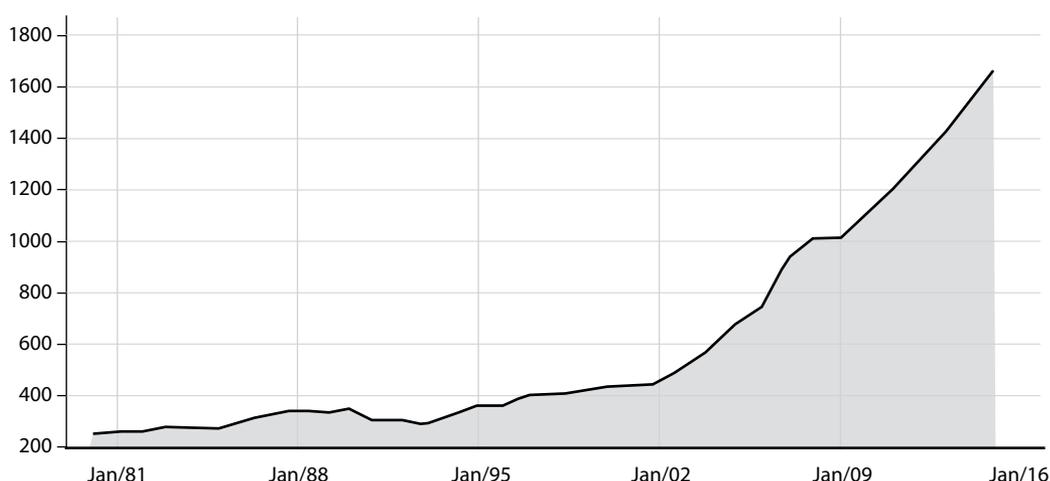
Presented below are trends in GDP at current prices (US\$) for each of the focal countries.

**Figure 5.1. The trend in the GDP of Bangladesh at current prices (US\$)**



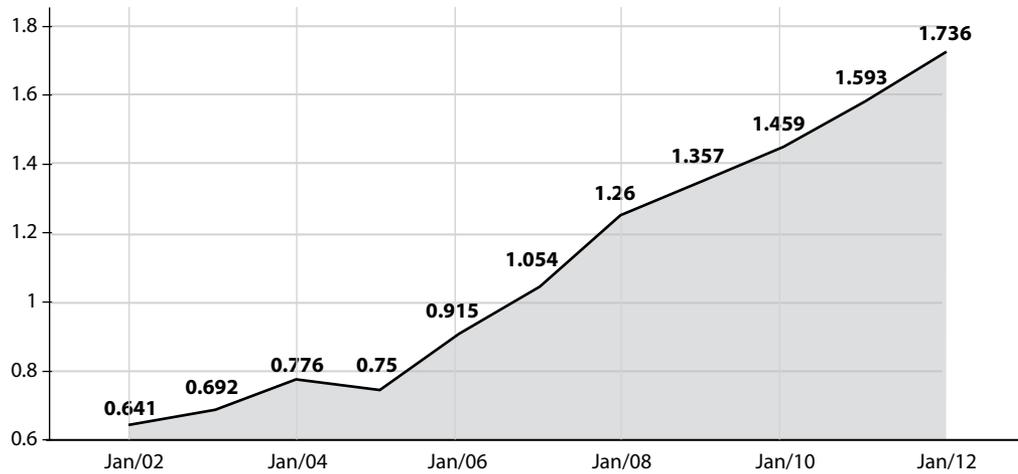
Source: <http://www.tradingeconomics.com/bangladesh/gdp-at-current-prices-in-us-dollars-imf-data.html>

**Figure 5.2. The trend in the GDP of India at current prices (US\$)**



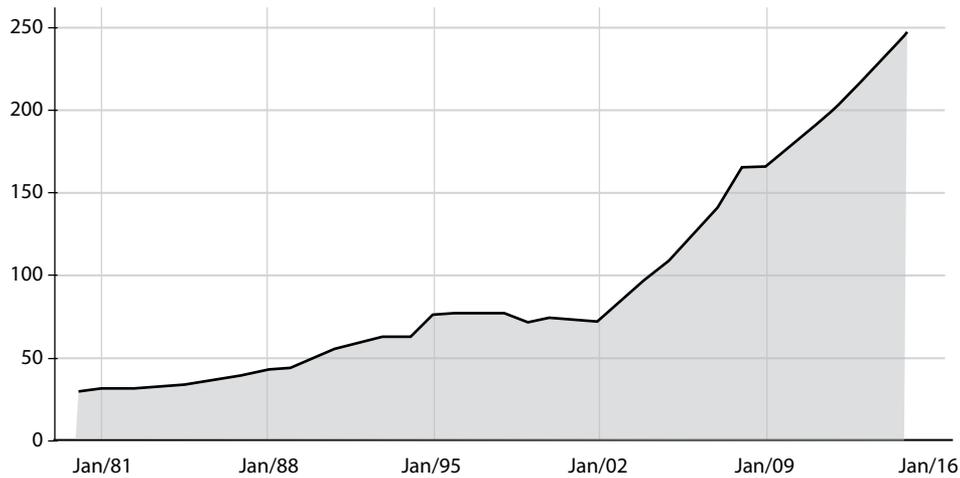
Source: <http://www.tradingeconomics.com/india/gdp-per-capita-at-current-prices-in-us-dollars-imf-data.html>

**Figure 5.3. The trend in the GDP of Maldives at current prices (US\$)**



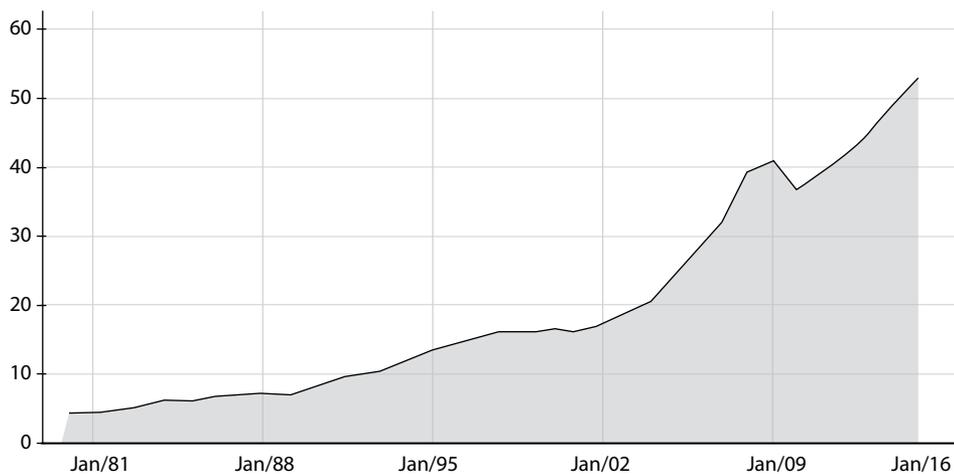
Source: <http://www.tradingeconomics.com/maldives/gdp-at-current-prices-in-us-dollars-imf-data.html>

**Figure 5.4. The trend in the GDP of Pakistan at current prices (US\$)**



Source: <http://www.tradingeconomics.com/sri-lanka/gdp-at-current-prices-in-us-dollars-imf-data.html>

**Figure 5.5. The trend in the GDP of Sri Lanka at current prices (US\$)**



Source: <http://www.tradingeconomics.com/sri-lanka/gdp-at-current-prices-in-us-dollars-imf-data.html>

## Poverty

Although economic indicators suggest that South Asia has experienced a long period of robust economic growth (averaging 6 percent a year over the past 20 years), this growth masks the truth of the stark poverty that is widespread in the region. South Asia has the largest concentration of poor people on earth—over half the world’s poor live in South Asia (<http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/0,,contentMDK:21265405~menuPK:2298227~pagePK:146736~piPK:146830~theSitePK:223547,00.html>). More than 600 million people (of whom 450 million are in India) live on less than US\$1.25 a day (World Bank, 2009). While South Asia is at a far more advanced stage of development than is sub-Saharan Africa, it has many more poor people. Population growth is also adding to the absolute number of poor people (<http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/0,,contentMDK:21265405~menuPK:2298227~pagePK:146736~piPK:146830~theSitePK:223547,00.html>).

### Box 5.2. Poverty and natural disasters

Poverty is a serious issue in dealing with changes that come in the wake of natural disasters because the poor have a significantly limited ability to deal with such crises. For example, the poor live in temporary housing on marginal land and fragile lands such as steep hillsides or floodplains. Economic standing is critical in dealing with changes in circumstances and with threats, which come in several forms including ecological degradation and the reduction of natural resources, successfully (Diamond, 2005). In short, “poverty is a central component of vulnerability” (Martine and Guzman 1999).

The poor will also be more susceptible to the long-term impacts of climate change.

While economies in the region have grown, they show a fractured pattern of progress, with prosperity in sectoral fragments within the large matrix of abject poverty, especially along the coasts. Growing slums represent the interface of such discordance (DESA, 2010). This is supported by the fact that 81 percent, 76 percent and 40 percent of the populations along the coasts of Bangladesh, India and in Sri Lanka, respectively, have an income that amounts to less than US\$2 per day (UNDP, 2009; BOBLME, 2010). The incidence of poverty in Pakistan is reportedly 17.2 percent (of the total population).

**Table 5.4. Poverty statistics for the focal countries**

Country	Percent of population living on less than US\$1.25 per day*	Percent of the population living below the national poverty line
Bangladesh	49.6	40.0
India	41.6	27.5
The Maldives	<2.0	21
Pakistan	22.6	22.3
Sri Lanka	7.0	7.6

Source: <http://www.adb.org/publications/search/90?keyword=fact+sheets>

In **Bangladesh**, poverty has been strongly linked to education and employment. Research papers published by the Bangladesh Institute of Studies have shown that poverty acts as both a cause and effect of a lack of education, which in turn adversely affects employment opportunities ([http://en.wikipedia.org/wiki/Poverty\\_in\\_Bangladesh](http://en.wikipedia.org/wiki/Poverty_in_Bangladesh)). Having an unskilled workforce also decreases the productivity significantly, which decreases the appeal to foreign direct investments and thus impedes sustainable economic growth. In essence, education is an important contribution to the social and economic development of a country.

**India** has the world’s largest number of poor people in a single country. Of its more than 1 billion inhabitants, an estimated 260.3 million are below the poverty line —of which 193.2 million live in rural areas (approximately 75 percent in villages) and 67.1 million live in urban areas. The poverty level is not uniform across India: It is

below 10 percent in states such as Delhi, Goa and Punjab, in contrast with levels of below 50 percent in Bihar (43 percent) and Odisha (47 percent) and levels of between 30 and 40 percent in the northeastern states of Assam, Tripura and Meghalaya and the southern states of Tamil Nadu and Uttar Pradesh ([www.azadindia.org](http://www.azadindia.org)).

In **the Maldives**, there has been progress in poverty reduction, but there is a high degree of transient income poverty (associated with individuals moving in and out of poverty status). The causes of poverty include remoteness (distances between inhabited islands); a lack of land-based natural resources (there are no rivers or streams); a mismatch of skills (the immigrant workforce is employed at both the top and bottom ends of the labour market, doing work that local people are either unable or unwilling to do); low female labour force participation; youth unemployment; access to basic services (such as health and education); and overcrowding in Malé (ADB, 2007).

Poverty in **Pakistan** is a continuing source of concern. Although its middle class has grown to 40 million, nearly a quarter of the population is classified as poor (as of October 2006). In 2007/08, 17.2 percent of the total population lived below the poverty line—the lowest figure in the history of Pakistan.

The wealth distribution in Pakistan is highly uneven, with 10 percent of the population earning 27.6 percent of the income. According to the United Nations Human Development Report, Pakistan's human development indicators—especially those for women—fall significantly below those of countries with comparable levels of per capita income (<http://southasia.oneworld.net/article/view/135153/1/1893>).

The gender discriminatory practices of Pakistani society also shape the distribution of poverty in the country. Traditional gender roles in Pakistan define the woman's place as being in the home and not in the workplace and define the man as the breadwinner. Consequently, the society invests far less in women than in men. Women in Pakistan suffer from a lack of opportunities throughout their lives.

**Sri Lanka** is an early achiever in the Millennium Development Goals (MDGs) of universal primary school enrolment, gender parity in school enrolment, under-five mortality, universal provision of reproductive health services, tuberculosis prevalence and death rates, and sanitation. Sri Lanka is on track to halve extreme poverty between 1990 and 2015. Nevertheless, 15.2 percent of all Sri Lankans remained poor in 2010, and differences by region and sector are large (ADB, 2012).

Poverty was significantly reduced in the urban and rural sectors between 1990 and 2006. However, poverty in the estates increased by more than 50 percent. In the plantation estates, there is widespread child malnutrition, and maternal mortality rates are exceptionally high. The Western Province has performed much better than other regions. It accounts for half of the national gross domestic product (GDP), while other provinces contribute 10 percent or less each.

The pace of poverty reduction (according to recent government studies) has resulted in a decline in poverty, from 15.2 percent in 2006/07 to 8.9 percent in 2009/10 ([http://www.statistics.gov.lk/poverty/PovertyIndicators2009\\_10.pdf](http://www.statistics.gov.lk/poverty/PovertyIndicators2009_10.pdf)).

## Demography

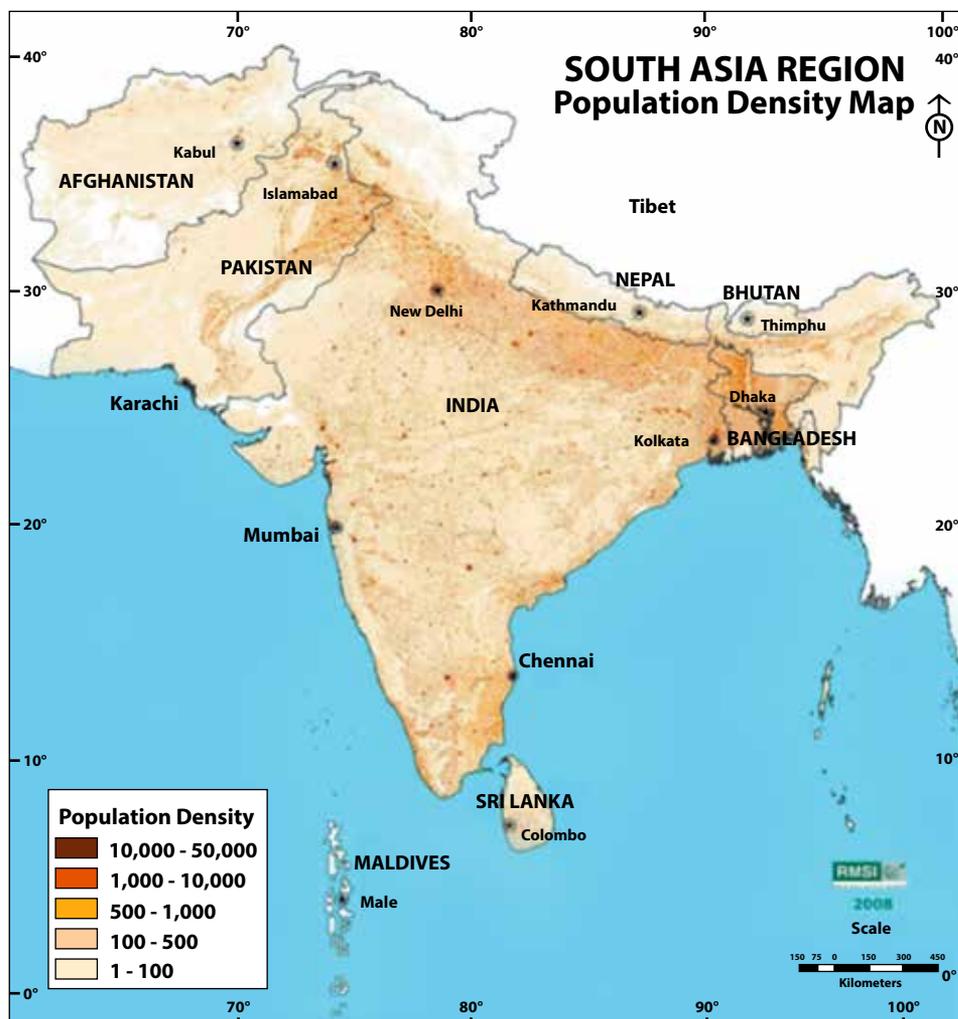
South Asia is the most populous and most densely populated geographical region in the world, with over one fifth of the world's population living in the region. The countries in the subregion are among the most populous in the world, with Bangladesh, India and Pakistan leading the group. India, after the People's Republic of China, is the second most populous country in the world. Although the present population of the region is principally rural, 7 of the 25 largest cities in the world are found in South Asia.

### Box 5.3. Population and natural disasters

The sheer numbers of people in the focal countries—totalling some 450 million within 200 kilometres of the coastline (SEDAC, 2010, in BOBLME, 2010)—results in more deaths and more affected people than in other parts of the world.

Population pressure is known to be an indirect driver of ecosystem change and a root cause of many problems (MA, 2005; BOBLME, 2010).

Figure 5.6. Population density in South Asia



Source: [www.unisdr.org/files/18873\\_southasiadisasterriskassessmentstud.pdf](http://www.unisdr.org/files/18873_southasiadisasterriskassessmentstud.pdf)

Table 5.5. Population statistics for the focal countries

Country	Area (km <sup>2</sup> )*	Population rank in the world+	Population in 2011 in millions**	Population density (per km <sup>2</sup> )*	Average annual population growth rate % (2010)*	Coastal population (taken to be population living in areas where the elevation is less than 5 m) (as % of total in 2000)*
Bangladesh	130,170	9	150.5	1142	1.124	13.59
India	3,287,263***	2	1,241.5	411	1.387	3.76
The Maldives	300	179	0.3	1053	1.321	100
Pakistan	770,880	6	176.7	255	1.801	1.27
Sri Lanka	62,710	56	21	332.6	0.918	5.44

\*World Bank, 2012.

+[http://en.wikipedia.org/wiki/List\\_of\\_countries\\_by\\_population](http://en.wikipedia.org/wiki/List_of_countries_by_population).

\*\* (UNDP, 2011a).

\*\*\* [www.fsi.org.in/cover\\_2011/summary.pdf](http://www.fsi.org.in/cover_2011/summary.pdf).

**Bangladesh's** population growth was among the highest in the world in the 1960s and 1970s, when the country's population swelled from 65 million to 110 million. With the promotion of birth control in the 1980s, the growth rate has slowed. The population is relatively young, with 60 percent being 25 years old or younger and 3 percent being 63 years old or older. The life expectancy is 63 years for both males and females (<http://en.wikipedia.org/wiki/Bangladesh>).

**India** accounts for only approximately 2.4 percent of the world's landmass but is home to about 16 percent of the global population. The magnitude of the annual increase in population is illustrated by the fact that India adds to the global population every year a number of people equivalent to the individual populations of Australia and Sri Lanka ([http://www.mongabay.com/reference/country\\_studies/india/SOCIETY.html](http://www.mongabay.com/reference/country_studies/india/SOCIETY.html)). A 1992 study of its population notes that India has more people than all of Africa, as well as more people than in North and South America combined. Between 1947 and 1991, India's population more than doubled ([www.indianchild.com](http://www.indianchild.com)). As its total fertility rate remains high at 2.8, India's population will continue to grow at a rapid rate. The US Census Bureau predicts that a near-replacement total fertility rate of 2.2 will be reached in India in 2050. Population projections for India anticipate that the country's population will reach 1.5 billion to 1.8 billion by 2050. ([www.geography.about.com](http://www.geography.about.com)). India's high population growth results in increasingly impoverished and sub-standard conditions for growing segments of the Indian population.

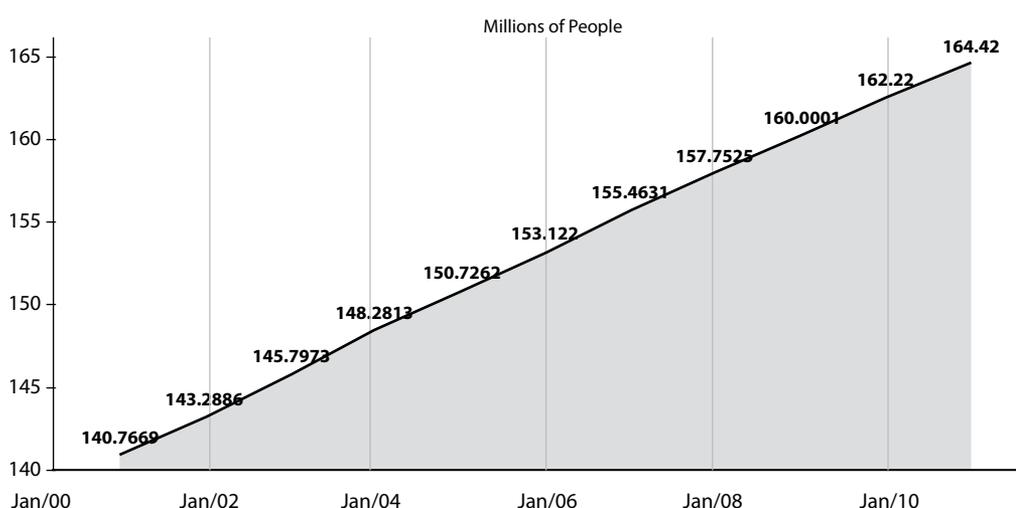
The number of Indians living in urban areas has grown by 31.2 percent between 1991 and 2001. As such, in 2001, more than 70 percent of the population lived in rural areas. According to the 2001 census, there are 27 million-plus cities<sup>10</sup> in India, with Mumbai, Delhi, Kolkata and Chennai being the largest.

In **the Maldives**, as of April 2008, more than 70,000 foreign employees lived in the country, while another 33,000 illegal immigrants accounted for more than one third of the Maldivian population. They consisted mainly of people from the neighbouring South Asian countries such as India, Sri Lanka, Bangladesh and Nepal (<http://en.wikipedia.org/w/index.php?title=Maldives&oldid=471053368>).

At 2.03 percent, **Pakistan** has the highest population growth rate among the South Asian Association for Regional Cooperation (SAARC) countries, resulting in an annual addition of 3.6 million people to its population. The population is projected to reach 210.13 million by 2020 and is expected to double in the next 34 years. By 2030, Pakistan is expected to overtake Indonesia as the largest Muslim country in the world.

Presented below are population trends for the focus countries.

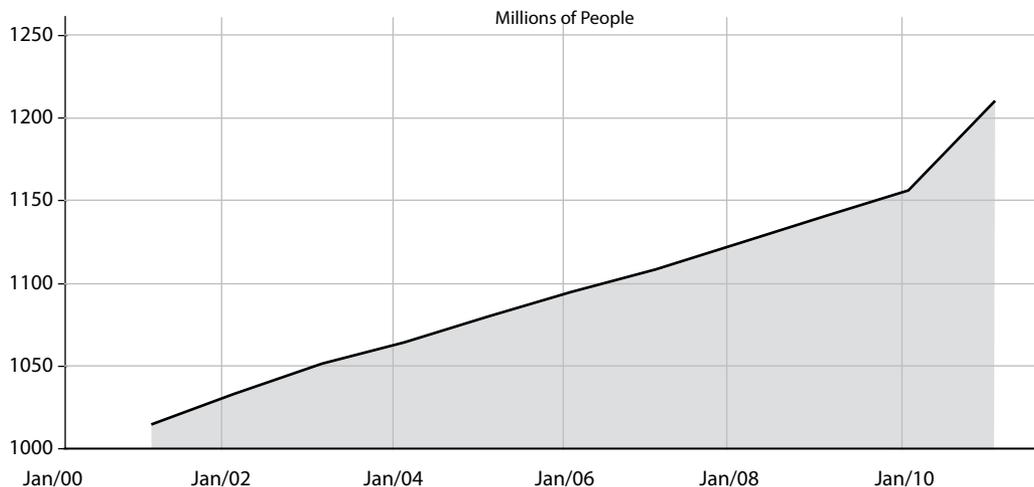
**Figure 5.7. Trends in Bangladesh's population growth**



Source: <http://www.tradingeconomics.com/bangladesh/population>

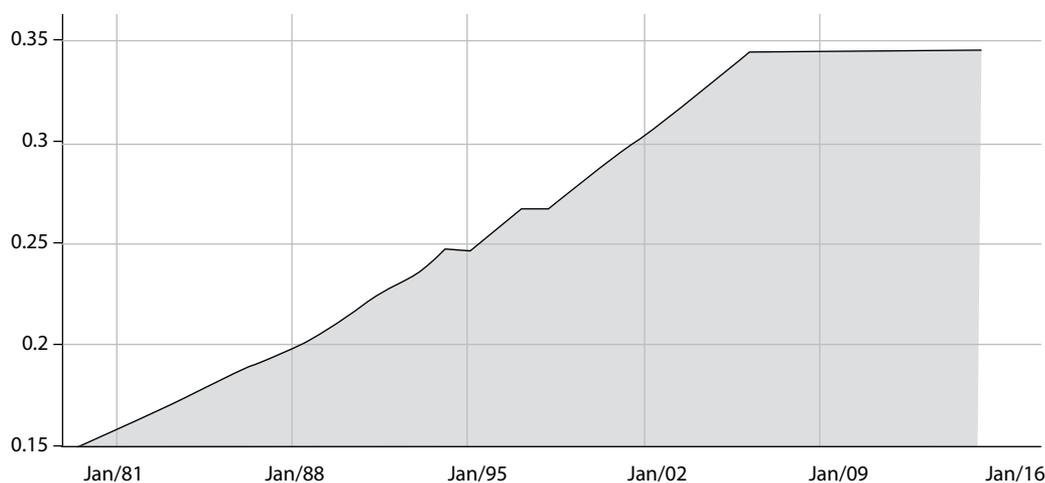
<sup>10</sup> Cities with a population of 1 million or more people ([http://en.wikipedia.org/wiki/List\\_of\\_million-plus\\_agglomerations\\_in\\_India](http://en.wikipedia.org/wiki/List_of_million-plus_agglomerations_in_India)).

**Figure 5.8. Trends in Indian population growth**



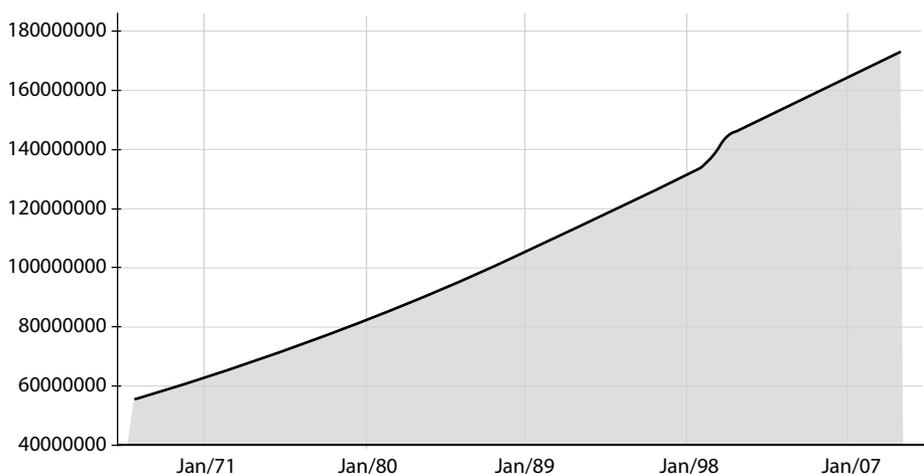
Source: <http://www.tradingeconomics.com/india/population>

**Figure 5.9. Trends in Maldivian population growth**

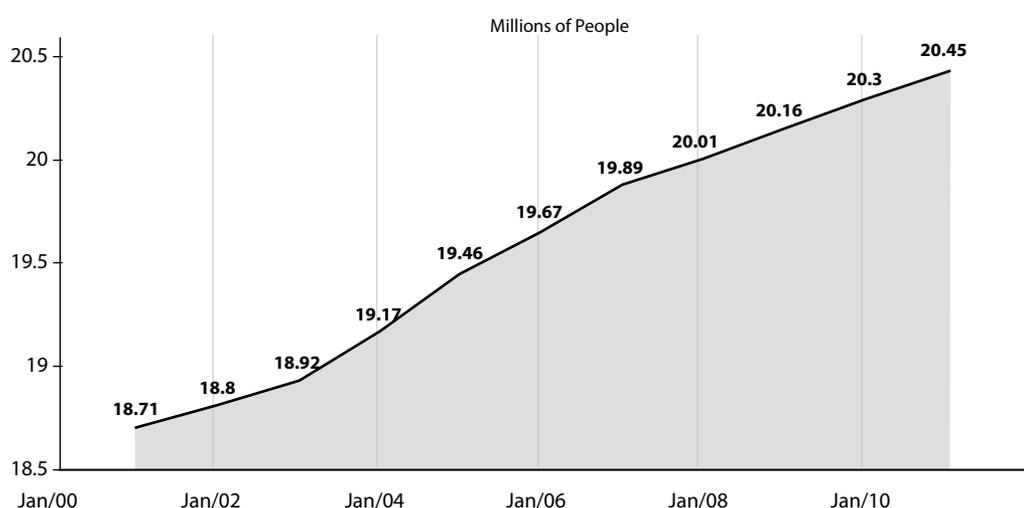


Source: <http://www.tradingeconomics.com/maldives/population-imf-data.html>

**Figure 5.10. Trends in Pakistan's population growth**



Source: <http://www.tradingeconomics.com/pakistan/population>

**Figure 5.11. Trends in Sri Lanka's population growth**

Source: <http://www.tradingeconomics.com/sri-lanka/population>

Pakistan is a 'young' nation, with a median age of approximately 20 years and 104 million people under 30 years of age (as of 2010) (<http://en.wikipedia.org/w/index.php?title=Pakistan&oldid=471241075>).

In **Sri Lanka**, the population density is 322 per square kilometre for the island as a whole, but it is as high as 3,330 and 1,539 per square kilometre in the western districts of Colombo and Gampaha, respectively (<http://www.statistics.gov.lk/abstract2010/Pages/indicators.htm>).

## Health

Human development in the focal countries has not kept up with the pace of income growth. More than 250 million children are undernourished. More than one third of adult women are anaemic. South Asia has the second worst life expectancy, infant mortality and malnutrition, and incidence of tuberculosis and HIV in the world, next to Africa (Hate and Gannon, 2010). Layered on to these health issues are inadequate sanitation, poor access to health services, poor maternal health and spreading disease epidemics (for example, dengue) (Hate and Gannon, 2010).

### Box 5.4. Health and natural disasters

Human health, especially along the coasts, is subject to several risk factors, including those relating to sanitation and water supply (the quality of which is affected by saltwater intrusion in aquifers in some tracts). Coasts are also subjected to cyclones and flooding (BOBLME, 2010). The incidence of communicable diseases can increase during a natural disaster.

When the communities are already malnourished and are suffering chronic diseases, the risk is exacerbated.

Most **Bangladeshis** continue to live on subsistence farming in rural villages. For those in rural areas, 62 percent of the health care providers practicing modern medicine are village doctors with little or no formal training, while just four percent of the total health workforce is formally trained. The health-seeking pattern of the villagers shows that nearly 70 percent of the patients who consulted a health care provider for curative services contacted a village doctor, showing clearly that village doctors are a major player in the health care system.

Health problems springing from poor water quality and prevalence of infectious diseases are common. The water crisis is acute, with widespread bacterial contamination of surface water and arsenic contamination of groundwater. Common diseases include malaria, leptospirosis and dengue (<http://en.wikipedia.org/wiki/Bangladesh> and [www.adpc.net/v2007/ikm/Country\\_Profiles/Bangladesh](http://www.adpc.net/v2007/ikm/Country_Profiles/Bangladesh)).

For the chronic poor, issues such as food security and health hamper social mobility. According to a study carried out by the World Bank on Dhaka, the poor suffer from a lack of proper health care in their areas due to expensive and poor quality health care services. The poverty-stricken areas either do not have the available facilities or can only afford low-quality health care. This is a problem that is common to both the rural and urban poor. For the urban poor, the problem has worsened as they can only afford to stay in slums, where there are problems of overcrowding and unhygienic living conditions. These two factors result in the spread of diseases among the poor, who cannot afford better health care. (World Bank 2002; <http://www.acdi-cida.gc.ca/acdi-cida/ACDI-CIDA.nsf/eng/JUD-31105911-LRJ>).

According to the World Health Organization (WHO), 900,000 **Indians** die each year from drinking contaminated water or breathing polluted air. There are approximately 50 physicians per 100,000 Indians.

Acute respiratory infection (ARI) is one of the major health problems among children and adults in **the Maldives**. Tuberculosis (TB)—regarded as one of the most fatal diseases in the history of the Maldives—is still not completely under control. The TB prevalence rate of 35 (cases per 1000 people in population) in 1974 declined to 0.26 in 2004. Childhood TB is almost absent in recent years due to the high vaccination coverage of infants. Leprosy is well under control since the introduction of multidrug therapy in 1983, with the prevalence of leprosy being 0.06 per 1000 people in the population in 2005. With the successful implementation of the Expanded Programme on Immunization (EPI), the vaccine-preventable diseases of childhood are well under control. No indigenous polio cases have been reported since 1981. The spread of HIV/AIDS is still at an early stage. Worm infestation is high in the country, and 50 percent to 75 percent of the children below the age of five are estimated to be affected by intestinal parasites.

The Maldives has one of the highest incidences of thalassaemia in the world, and significant efforts are focused on resolving this problem. One out of every 6 persons is a thalassaemia carrier, and about 60 to 70 children are born with the disease every year. Cardiovascular diseases and cancer are also perceived as important problems, and an increasing trend is expected in the future. It is estimated that 37.4 percent of the males and 15.6 percent of the females use tobacco ([http://www.searo.who.int/en/Section313/Section1521\\_10903.htm](http://www.searo.who.int/en/Section313/Section1521_10903.htm)).

Child health care in **Pakistan** is among the most important of national issues and has been given much attention. Child mortality in Pakistan is a major cause of concern, with 1 among every 10 children dying before reaching the age of five and 1 among every 30 dying just after birth. Pakistan is among the developing nations of the world that has yet to do much for the welfare of the general public. Pneumonia and air pollution are among the key factors affecting the health of the children of Pakistan. Air pollution is caused mostly by harmful emissions of biogas, which is used in most houses in Pakistan. Other issues include high fertility rates, a lack of skilled attendants at birth, insufficient availability of proper maternal and child care services, communicable diseases, a low female literacy, poverty and insufficient emergency obstetric and newborn care systems.

Women's health in Pakistan is more than just an issue of underdevelopment in the country but is also an issue that involves the social norms and constructs that have for long kept women in the shadows. The maternity issues in the country are a major cause for the death of both mothers and children during the time of pregnancy. It is the rural areas of Pakistan that still have the longest way to go in terms of securing a healthy

Table 5.6. Health indicators in the focal countries

Country	Life expectancy at birth (years)*	Infant mortality (per 1,000 live births)**	Malnutrition prevalence (chronic), weight for age (% of children under 5)*	Prevalence of wasting (acute) (% of children under 5)*	Mortality rate, female child (per 1,000 female children aged 1)*	Mortality rate, male child (per 1,000 male children aged 1)*	Number of maternal deaths (2010)*	Improved water source (% of population with access) (2010)*	Improved sanitation facilities (% of population with access) (2010)*	Diarrhoea treatment (% of children under 5 receiving oral rehydration and continued feeding)*
Bangladesh	68.6	52	41.3 (2007)	17.5 (2007)	20 (2007)	16 (2007)	7,200	81	56	68.0 (2007)
India	65.1	66	43.5 (2006)	20 (2006)	12.4 (2006)	9 (2006)	56,000	92	34	32.7 (2006)
The Maldives	76.5	13	17.8 (2009)	10.2 (2009)	4.6 (2009)	4.6 (2009)	3	98	97	62.6 (2009)
Pakistan	65.2	87	31.3 (2001)	14.2 (2001)	22 (2007)	14 (2007)	1,200	92	48	36.6 (2007)
Sri Lanka	74.7	15	21.6 (2009)	11.8 (2009)	Not available	Not available	130	91	92	66.8 (2007)

\*(World Bank, 2012).

\*\* (UNDP, 2011a).

Data for different years are presented when there are no data for a specific year.

life for women. The primary factors of women's death in the rural areas are negligence, ignorance regarding health and diseases and the lack of proper medical infrastructure.

**Sri Lanka** has made health care a priority since independence, and consequently, the health indicators have been far better than those of the other countries (ADB, 2012). Immunization programmes have been extremely successful, and it is claimed that Sri Lanka has eradicated diseases such as polio and malaria.

## Education

Education is recognized as a basic human right. It is included in the Universal Declaration of Human Rights and is acknowledged in the Millennium Development Goals (UN, 2012). Education, in the modern world, is a critical basic need for human well-being (World Bank, 2012). It is also vital in reducing poverty and inequality (World Bank, 2012).

Yet, more than 9 million children do not go to school in the focal countries (see Table 5.7). Even many of those who are enrolled in primary school drop out before completion, and adult literacy rates are very low in some countries, restricting options for livelihoods. The adult literacy rates in Bangladesh and Pakistan are 55.9 percent and 55.3 percent, respectively (UNDP, 2011a). In Pakistan, adult literacy can vary from over 80 percent in large cities to less than 20 percent in rural areas (<http://ilm.com.pk/Pakistan/>).

### Box 5.5. Education and natural disasters

Educational deficiencies reduce livelihood and economic opportunities and therefore, the capabilities of people to respond to changes in circumstances successfully.

In other words, these are factors that contribute to resilience.

**Table 5.7. Education indicators in the focal countries**

Country	Literacy rate, adult total (% of people aged 15 and above)*	Mean years of schooling (years) *	School enrolment, primary (% net)**	Persistence to last grade of primary, total (% of cohort)**	Children out of school, primary**	Secondary education, pupils (% female)**	Public spending on education, total (% of GDP)**
<b>Bangladesh</b>	55.9	4.8	92.19 (2009)	66.6 (2008)	719,499 (2009)	51.6 (2010)	2.23 (2009)
<b>India</b>	62.8	4.4	92.07 (2008)	65.7 (2005)	2,958,100 (2008)	44.6 (2008)	3.09 (2006)
<b>The Maldives</b>	98.4	5.8	97.19 (2008)	Not available	1252 (2011)	51.92 (2004)	8.71 (2009)
<b>Pakistan</b>	55.5	4.9	74.05 (2010)	61.5 (2009)	5,125,373 (2011)	50.6 (2010)	2.37 (2010)
<b>Sri Lanka</b>	90.6	8.2	94.02 (2010)	98.6 (2006)	106,527 (2009)	49.44 (2004)	2.06 (2009)

\* (UNDP, 2011a).

\*\* (World Bank, 2012).

**Table 5.8. The impacts of climate change and natural disasters on women**

Women are disproportionately affected by the impacts of climate change and natural disasters (Anguilar, 2009). The following table is taken directly from Anguilar (2009).

Potential risks	Potential effects on women
<b>Direct risks</b>	
Increased drought and water shortage	Women and girls in developing countries are often the primary collectors, users and managers of water. A decreased water availability will jeopardize their families' livelihoods and increase their workloads, putting their capacity to attend school at risk.
Increased natural disasters	An analysis of 141 countries between 1981 and 2002 found that natural disasters (and their subsequent impacts) on average killed more women than men in societies where women economic and social rights are not protected.
<b>Indirect risks</b>	
Increased epidemics	Women have less access to medical services than do men, and their workloads increase when they have to spend more time caring for the sick. Adopting new strategies for crop production or rearing livestock is harder for female-headed households and those affected by epidemics.
Loss of species	Women often rely on crop diversity to accommodate climate variability, but a permanent temperature change will reduce the agro-biodiversity and traditional medicine options.
Decreased crop production	Rural women in particular are responsible for half of the world's food production.

The following is compiled from Reid and Simms (2007).	
<b>Other risks</b>	
Saltwater intrusion	Women and children are disproportionately affected by increased salinity as it is they who have to find freshwater, sometimes walking as much as 10 kilometres for it. Things become more difficult in the rainy season, when it is slippery and wet.
Collecting firewood	On average, women spend 2–3 hours a day for collecting wood and cooking. When there is increased flooding or tropical storms, for example, this becomes more difficult.
Scarcity of food	Women are more likely to be affected by food shortages after a natural disaster as they tend to feed their families first. In the long term, this has an effect on their nutritional levels.

Source: Miththapala, 2008a



## 6. Issues Relating to DRR, CCA and Ecosystem Management in South Asia

### Introduction

The focus countries—Bangladesh, India, the Maldives, Pakistan and Sri Lanka—are diverse in terms of culture, religion, ideologies and politics, each with its own priorities and concerns in relation to DRR, CCA and ecosystem management. It is also diverse geo-morphologically (Pallewatte, 2010). Yet, in the South Asian region, there are shared environmental issues, such as a rapid loss of biodiversity and degradation. Loss and degradation of coastal and marine ecosystems result in greater vulnerabilities of coastal communities to natural disasters and the long-term impacts of climate change. Underlying these proximate drivers of ecosystem change are deeper causes of continuing poverty and burgeoning populations, resulting in increased and intense pressures on an already stressed coastal resource base (BOBLME, 2010). In continuation of what is dealt in the previous sections, this chapter attempts to discuss some of the specific issues relating to integrating DRR, CCA and ecosystem management in South Asia.

### Loss of coastal habitats in the region

As already mentioned, the coastal and marine ecosystems in the region are facing considerable pressures from a multitude of sources. The extent of such threats in certain key ecosystems in the region is described in the following.

### Coral reefs

Asia's coral reefs are undergoing rapid degradation (Cesar et al., 1997; Nie et al., 1997; Pennisi, 1998), with a significant coral decline and heavy damage to entire reefs. In 1998, large-scale bleaching in the South Asian region after an El Niño event destroyed much of the coral cover. Up to 90 percent mortality was observed in the Maldives, but the mortality was less in the Gulf of Mannar and the Andaman and Nicobar Islands (Wilkinson, 2008).

### Mangroves

It is estimated that between 1980 and 2005, globally, 35,000 square kilometres of mangroves was lost, representing one fifth of the world's mangrove cover. The rate of loss is three to four times higher than that of deforestation on land (World Bank, undated). In countries affected by the Indian Ocean tsunami, there has been a net loss of 12 percent of mangrove habitats between 1975 and 2005 (Giri et al., 2008). Experts say that the services provided by mangroves may likely be lost altogether within 100 years (Duke et al., 2007).

### Seagrasses

Information regarding the extent of seagrass meadows in the region is sparse. Globally, seagrass meadows are found over 177,000 square kilometres (World Bank, undated). Since the 19th century, this extent has reduced by 29 percent, with the rate of loss increasing by an order of magnitude in the past 40 years (Waycott et al., 2009).

### Salt marshes

Globally, about 25 percent of the historical extent of salt marshes has been lost, with an estimated further loss at a rate of 1–2 percent per annum (World Bank, undated). For example, in northwestern Sri Lanka nearly 50 percent of the total recorded extent of salt marshes in the Mi Oya Basin was lost in a decade (Dayaratne et al., 1997).

More detailed accounts of the threats to important coastal and marine ecosystems in the South Asian region are presented in Table 6.1, Table 6.2, Table 6.3, Table 6.4 and Table 6.5.

**Table 6.1. Threats to coral reefs**

Threat	Result
<p><b>Overexploitation for food</b></p>	<ul style="list-style-type: none"> <li>• The human global population is expected to double in the next 50 years. With this doubling, a demand for life essentials such as food will also increase. Fish is the primary source of protein for one fifth of the world's population. The demand for fish has doubled in the last 50 years, and fish production will have to double again in the next 25 years to keep up with the demand and population growth.</li> <li>• Because coral reefs are within the reach of small boats, they are especially vulnerable to overfishing. Particular groups of coral reef fish such as groupers, snappers and large wrasses have been overexploited.</li> <li>• Hong Kong and other Asian markets are the primary buyers of live reef fish for food (Donaldson et al., 2003). The Giant Grouper (<i>Epinephelus lanceolatus</i>) and Humphead Wrasse (<i>Cheilinus undulates</i>) are listed in the 2007 IUCN Red List as Vulnerable and Endangered, respectively, as a direct consequence of overfishing (Baillie and Groombridge, 2007).</li> </ul>

<p><b>Overexploitation for the aquarium trade</b></p>	<ul style="list-style-type: none"> <li>• The practice of maintaining marine aquaria as a hobby has increased in the last decade. It is reported that, globally, between 1.5 million and 2 million people keep saltwater aquaria (Wabnitz et al., 2003). As a result, more than 800 species of reef fish, hundreds of coral species and other invertebrates are now exported for aquarium markets.</li> <li>• One hundred and forty species of stony coral and 61 species of soft coral are traded globally.</li> </ul>
<p><b>Overexploitation for trinkets</b></p>	<ul style="list-style-type: none"> <li>• Other species are at risk from overexploitation for use as curios or trinkets. As many as 5,000 species of mollusc are processed or used raw to make curios and trinkets. Some 40 species of coral are also traded for this purpose; and many sea stars, sea urchins, sand dollars and their relatives are also traded (Vincent, 2006). At least 32 species of fish—such as seahorses and porcupine fish—are used in the trinket trade. The trinkets include sharks’ teeth and the ‘noses’ of sawfish.</li> <li>• Six out of seven species of marine turtle are Red Listed as Endangered or Critically Endangered, partly as a result of overexploitation for the use of their shells in the trinket trade. The Hawksbill Turtle (<i>Eretmochelys imbricata</i>), with its ornate shell, is Critically Endangered (Baillie and Groombridge, 2007).</li> <li>• <i>Corallium</i> species are a group of about 31 species of coral that have a global distribution. Their dominant colour ranges from white to pink, orange and red. They are used extensively to make jewellery and curios and are now threatened with extinction.</li> </ul>
<p><b>Overexploitation for medicinal products</b></p>	<ul style="list-style-type: none"> <li>• Species are also overexploited for medicinal purposes, mainly for use in traditional medicine. Many species such as seahorses and pipefish are overharvested for traditional Chinese medicine (TCM) (Hunt and Vincent, 2006).</li> <li>• Another emerging threat is marine bio-prospecting. Coral reefs are relatively easy to access and have many species of nonmoving, soft-bodied organisms, which are armed with a wide of chemicals as defence weapons. These chemicals have a range of potential medical and industrial uses, and because of this, reefs are targeted for bio-prospecting. In order to extract enough chemicals for the development of medicines and clinical trials, the quantities required are of the order of tonnes or thousands of tonnes (Meliane, undated). Therefore, the potential for overexploitation is very high.</li> <li>• Thirteen species of seahorse (<i>Hippocampus spp.</i>) used in traditional medicine are Red Listed (Hunt and Vincent, 2006).</li> <li>• The Smooth Tail Devil ray (<i>Mobula thurstoni</i>) and Giant Manta (<i>Manta birostris</i>) are Near Threatened because of the demand for their gill filaments, which are used for medicinal purposes (Baillie and Groombridge, 2007);</li> <li>• In 2001, India banned the collection of all <i>Bêche de mer</i> (sea cucumbers), which were being exported for TCM and as a culinary delicacy (Nithyanandan, 2003).</li> </ul>
<p><b>Destructive fishing practices</b></p>	<ul style="list-style-type: none"> <li>• Destructive fishing practices often accompany overfishing—these include purse seining, fine-mesh fishing, the use of ‘moxy’ nets, cyanide fishing, and blast fishing—that result in unsustainable damage (Wilkinson, 2004). It should be noted, though, that all these practices mentioned above have been made illegal in South Asia.</li> <li>• It is estimated that more than 6,000 divers annually use about 150,000 kilograms of cyanide on 33 million coral polyps worldwide (Briggs, 2003).</li> <li>• A large proportion of the fish caught using cyanide die—50 percent of food fish species and more than 80 percent of ornamental fish species—and even those that do survive usually die 4 to 6 weeks after capture (Briggs, 2003).</li> </ul>

<p><b>Coral mining</b></p>	<ul style="list-style-type: none"> <li>• In South Asia and Southeast Asia, corals are mined for limestone and construction materials. In this process, the reef is blasted and coral removed, causing immediate destruction but also resulting in indirect detrimental effects such as sand erosion and sedimentation. It was estimated that in 1995, 20,000 square metres of coral per year were collected in the Maldives for construction materials (Brown et al., 1995). Coral mining is prevalent in most South Asian and Southeast Asian countries (Rajasuriya et al., 2004).</li> </ul>
<p><b>Sediment, nutrient and chemical pollution</b></p>	<ul style="list-style-type: none"> <li>• One of the greatest threats to coral reefs is human development, which alters either the marine or land-based physical environment. Certain development activities lead to increases in freshwater runoff, resulting in large amounts of sediment being washed into the sea.</li> <li>• To a limited extent, soil washes naturally into rivers, but poor agricultural and land use practices intensify this process, resulting in excessive sedimentation. Upland activities such as logging, land conversion, river modifications (dams and diversions) and road construction increase erosion greatly. The sediment from such erosion carries with it not only particulate matter but also high levels of nutrients from agricultural areas or sewage systems.</li> <li>• In addition to nutrient and sediment pollution, industrial effluents washed into waterways and agricultural runoff carry with them chemical pollutants such as petroleum products, including oils and insecticides (Source: Adapted from Miththapala, 2008a).</li> <li>• Increased sedimentation smothers reefs.</li> </ul>
<p><b>Marine-based pollution</b></p>	<ul style="list-style-type: none"> <li>• Marine pollution in the form of oil (which often leaks into the seas), discharged ballast water and solid waste dumped from ships is also causing damage to coral reefs in the region.</li> <li>• Anti-fouling bottom paints used on boats form toxic compounds harmful to corals and other species.</li> <li>• Of the above forms of pollution, oil pollution is the most common. Oil damages the life cycle of corals. Although major oil spills make the news, minor spills occur all the time in the seas of the region, for example, through the discharge of ballast water, marine traffic and the effects of ship engines being cleaned.</li> </ul>
<p><b>Irresponsible tourism</b></p>	<ul style="list-style-type: none"> <li>• Tourism is essential for the economic development of many countries in the region. For example, marine and coastal tourism is the largest industry in the Maldives and accounts directly for 20 percent of the country's GDP, while its wider effects help generate 74 percent of the national income, and almost 40 percent of the workforce is employed in the industry (Emerton, 2006).</li> <li>• When carried out in a controlled and sustainable manner, tourism can be a positive economic earner and should be an incentive for countries to invest in managing coral reef ecosystems to continue attracting tourist revenue.</li> <li>• However, when managed poorly, tourism has both direct and indirect negative effects on coral reefs.</li> <li>• Snorkelling, diving and boating can cause direct physical damage to reefs, while overexploitation of reef species as food, for aquaria and as curios for tourist markets can threaten the survival of species.</li> <li>• In some cases, bad tourism practices are not prevented. For example, tourists are allowed to walk on reefs, causing physical damage to the reef structure and stirring up sediment.</li> <li>• Sometimes they even directly collect species off reefs.</li> <li>• Boats carrying tourists can damage reefs by dropping anchors directly onto reefs, disturbing species and causing marine pollution through excessive traffic.</li> <li>• Indirectly, careless and irresponsible building of infrastructure directly on reefs or too close to beaches, river mouths and lagoons results in increased sedimentation and leaves the infrastructure vulnerable to damage from extreme weather events.</li> <li>• Often, another indirect effect of tourism is the irresponsible disposal of sewage and solid waste. Two decades ago, sewage and solid waste were mostly disposed directly into the sea, but the current situation has greatly improved.</li> </ul>
<p><b>Climate change</b></p>	<ul style="list-style-type: none"> <li>• These impacts have been detailed in Chapter 4.</li> </ul>

Source: Adapted from Miththapala, 2008c

**Table 6.2. Threats to seagrass meadows**

<b>Threat</b>	<b>Result</b>
<b>Pollution: sedimentation affecting water clarity</b>	<ul style="list-style-type: none"> <li>• One of the most common and significant threats to seagrass meadows is the deterioration of water clarity through sediment loading. Because seagrass meadows are dependent on sunlight for photosynthesis, water clarity and quality are important for the health of this ecosystem. When there is excessive sedimentation and the turbidity of the water increases, seagrass meadows are affected. When there is too much sediment, seagrasses can become smothered (<a href="http://www.sms.si.edu/IRLspec/Seagrass_Habitat.htm">http://www.sms.si.edu/IRLspec/Seagrass_Habitat.htm</a>). Dredging and coastal development can also cause water turbidity, affecting seagrasses.</li> <li>• Sedimentation has the greatest impact on tropical seagrasses (Duarte and Gattuso, 2008).</li> </ul>
<b>Pollution: resulting in eutrophication</b>	<ul style="list-style-type: none"> <li>• When runoff from inland waters—carrying with it excessive nitrogen and phosphorus from fertilizers, animal and domestic waste—increases minerals in coastal waters, there is an extreme burst in the growth of algae (i.e., causes massive algal blooms). Algae block light and oxygen from reaching the waters below the surface. The water then turns cloudy and green, further blocking light penetration. The balance in the ecosystem is destroyed by this process, which is called eutrophication. Seagrass meadows are extremely susceptible to eutrophication (<a href="http://www.sms.si.edu/IRLspec/Seagrass_Habitat.htm">http://www.sms.si.edu/IRLspec/Seagrass_Habitat.htm</a>).</li> </ul>
<b>Pollution: from other sources</b>	<ul style="list-style-type: none"> <li>• Marine pollution can also cause damage to seagrasses through engine oil discharge.</li> <li>• Thermal effluents from industries also affect the condition of seagrasses.</li> </ul>
<b>Habitat destruction/ degradation for artificial erosion defence structures</b>	<ul style="list-style-type: none"> <li>• The building of artificial coastal stabilization measures such as bulkheads, sea walls, revetments, sandbags and groynes can damage seagrass meadows.</li> <li>• Dredging for such structures also adversely affects seagrass meadows (Spalding et al., 2003).</li> </ul>
<b>Other human influences</b>	<ul style="list-style-type: none"> <li>• Port, harbour and jetty development facilities on the coastline are required for the shipping industry. Such development decreases the sunlight incident on seagrass meadows or fragments the meadows (Spalding et al., 2003).</li> </ul>
<b>Irresponsible fishing and tourism</b>	<ul style="list-style-type: none"> <li>• Mooring, propellers and jet skis are emerging as a major threat to seagrass meadows (Fonseca et al., 1998). When boats used for fishing or recreation enter areas with seagrass meadows, their propellers can slash seagrass leaves as well as rhizomes, leading to fragmentation of the habitat, which, in turn, leads to erosion (<a href="http://www.sms.si.edu/IRLspec/Seagrass_Habitat.htm">http://www.sms.si.edu/IRLspec/Seagrass_Habitat.htm</a>).</li> <li>• Similarly, irresponsible mooring and recreation can endanger these habitats. Trampling or using fishing gear that rakes up seagrasses is also damaging. For example, push nets and drag nets cause immense damage to seagrass meadows in coastal wetlands in Sri Lanka (C. Bambaradeniya, personal communication).</li> </ul>
<b>Invasive alien species</b>	<ul style="list-style-type: none"> <li>• Worldwide, at least 28 non-native species have become established in seagrass meadows. Sixty-four percent of these have been shown to have negative effects on the ecosystem (Orth et al., 2006).</li> </ul>
<b>Climate change</b>	<ul style="list-style-type: none"> <li>• These impacts have been detailed in Chapter 4.</li> </ul>

Source: Adapted from Miththapala, 2008c

**Table 6.3. Threats to sand dunes**

Threat	Result
<b>Habitat destruction for infrastructure</b>	<ul style="list-style-type: none"> <li>• Sand dunes are cleared for many reasons. Structures such as beach huts and beach restaurants are often built illegally, destroying sand dunes.</li> <li>• Even where infrastructure is built under legal restrictions, property holders may clean beaches, uprooting existing vegetation and levelling the beach. When this happens, erosion is increased, and objects such as small rocks, which can serve as centres for accretion, are removed (UK Biodiversity Group, 1999).</li> </ul>
<b>Habitat destruction for planting shelter belts and replanting mangroves</b>	<ul style="list-style-type: none"> <li>• After the Indian Ocean tsunami of December 2004, some Asian governments proposed the establishment of shelter belts, while others set about replanting mangroves. There is a great danger that sand dunes can be levelled or damaged when artificial green belts are established or mangrove replanting is undertaken. When exotic species such as the Whistling Pine (<i>Casuarina equisetifolia</i>) are planted, additional problems, such as the prevention of marine turtles from nesting, also ensue (Choudury et al., 2003).</li> </ul>
<b>Sand mining and resultant erosion of sand dunes</b>	<ul style="list-style-type: none"> <li>• Mining for river sand is a major threat in Asian countries. In the normal dynamics of beach morphology, sand is always lost offshore but is replaced continually by sediment that is brought from rivers. When rivers are mined, then the amount of sand being washed to coastal stretches reduces, resulting in coastal erosion (CCD, 2004). The mining of dunes occurs on the landward sides (R. Galappatti, personal communication).</li> <li>• Large-scale sand mining in the east and west coasts of Sri Lanka removes 500–1,000 and 150,000 cubic metres per kilometre per year, respectively. Land lost through coastal erosion in Sri Lanka is estimated at 200,000–300,000 cubic metres a year in 685 kilometres along the western, southwestern and southern coastal stretches (CCD, 2004).</li> <li>• Any removal of sand—inland or from a beach—affects sand dunes (Salm et al., 2000). When there is coastal erosion, the nesting habits of endangered marine turtles are disrupted. In India, there is severe damage to the nesting beaches of the Olive Ridley Turtle (<i>Lepidochelys olivacea</i>) along the coasts of Odisha, Andhra Pradesh and Kerala as a result of sand and mineral mining on beaches (Choudury et al., 2003).</li> </ul>
<b>Irresponsible use</b>	<ul style="list-style-type: none"> <li>• Recreation is a major use of sand dunes and beaches, which are used extensively by tourists. Excessive trampling of sand dune vegetation causes death of the flora and can result in erosion of dune sites.</li> </ul>
<b>Invasive alien species</b>	<ul style="list-style-type: none"> <li>• Species such as the Prickly Pear (<i>Opuntia stricta</i>) and Mesquite (<i>Prosopis juliflora</i>) are spreading on sand dunes and beaches and destroying natural vegetation (Bambaradeniya et al., 2006). In southern Sri Lanka, the Prickly Pear has spread on sand dunes and beaches after the tsunami, preventing the regeneration of natural vegetation such as <i>Spinifex</i> (Bambaradeniya et al., 2006).</li> </ul>
<b>Climate change</b>	<ul style="list-style-type: none"> <li>• These impacts have been detailed in Chapter 4.</li> </ul>

Source: Adapted from Miththapala, 2008c

**Table 6.4. Threats to salt marshes**

<b>Threat</b>	<b>Result</b>
<b>Changes to the natural hydrology of the ecosystem</b>	<ul style="list-style-type: none"> <li>• Any road, building, etc. causes tidal restrictions, leading to the disruption of natural flooding regimes, alterations to the soil and water chemistry and changes to natural plant and animal communities.</li> </ul>
<b>Pollution from inland</b>	<ul style="list-style-type: none"> <li>• Salt marshes are areas where water is retained for some time. They therefore act as areas where inland pollutants are stored.</li> <li>• Excess nutrients—from the agriculture sector—are a particular problem in salt marshes because they lead to eutrophication.</li> <li>• Industrial pollution may contain toxic chemical such as mercury, lead and aluminium, which cause lethal and chronic risks to flora, fauna and humans.</li> </ul>
<b>Coastal development and reclamation of the ecosystem</b>	<ul style="list-style-type: none"> <li>• Land use changes in coastal areas have increased greatly in the focus regions. Salt marshes are filled with dredged material to create roads, residential communities and businesses.</li> <li>• Habitat destruction resulting from this use alters the flooding regime, elevation, soil type and plant and animal communities.</li> </ul>
<b>Coastal ‘squeeze’</b>	<ul style="list-style-type: none"> <li>• Ideally, salt marshes shift with changing environmental conditions. Many salt marshes are being ‘squeezed’ between the rising sea and fixed flood defence walls.</li> </ul>
<b>Invasive alien species</b>	<ul style="list-style-type: none"> <li>• Because salt marshes are a unique mixture of both terrestrial and aquatic habitats, invasive species from the land and sea pose threats to their well-being.</li> </ul>
<b>Climate change</b>	<ul style="list-style-type: none"> <li>• These impacts have been detailed in Chapter 4.</li> </ul>

Source: <http://des.nh.gov/organization/commissioner/pip/factsheets/cp/documents/cp-08.pdf>

**Table 6.5. Threats to mangroves**

Threat	Result
<b>Overexploitation of resources</b>	<ul style="list-style-type: none"> <li>It is estimated that 26 percent of mangrove habitats are degraded because of overexploitation for fuel wood and timber production (Valiela et al., 2001).</li> </ul>
<b>Habitat destruction, shrimp farming and aquaculture</b>	<ul style="list-style-type: none"> <li>Shrimp culture is reported to be the greatest threat to mangroves, contributing to 38 percent of mangrove habitat loss, with other aquaculture accounting for another 14 percent (EJF, 2005). Once mangroves are cleared, the coast is made vulnerable to erosion, and coral reefs and seagrass beds become vulnerable to sedimentation. To grow as much shrimp as possible, shrimp farmers add artificial feeds with chemical additives (including chlorine) and insecticides (such as malathion and parathion, which persist in the environment) as well as antibiotics to prevent disease. This chemical soup is often dumped into surrounding land or waterways, harming aquatic life as well as people who depend on these waterways.</li> <li>Land that is adapted to the ebb and flow of the tide is now flooded permanently, and this damages the soil.</li> <li>Often (every five years or so), shrimp farms are abandoned as they are no longer viable (<a href="http://oceans.greenpeace.org">http://oceans.greenpeace.org</a>).</li> </ul>
<b>Coastal development and land reclamation</b>	<ul style="list-style-type: none"> <li>Coastal development, conversion to agriculture and land reclamation remain major causes of mangrove destruction. Historically, mangroves and wetlands have been considered wastelands that needed draining, filling and development (Conde and Alarcón, 1993). In India, in the last three decades, 40 percent of the mangrove habitats on the western coast have been converted for agriculture and urban development (Upadhyay et al., 2002).</li> </ul>
<b>Habitat degradation: diversion of inland freshwater</b>	<ul style="list-style-type: none"> <li>Mangroves are seriously affected by inland freshwater diversion schemes: It is estimated that 11 percent of the mangrove habitats are degraded globally by inland water extraction (EJF, 2005).</li> <li>The Indus River, which flows through Pakistan, supports some 129,000 hectares of mangrove forests. Over the last 60 years, a series of dams, barrages and irrigation schemes have been built in upstream parts of the Indus River. As a result, only 15 percent of the Indus River mangroves are considered healthy, and the rate of degradation of mangrove forests in the Indus Delta has been estimated at 6 percent between 1980 and 1995 (Stedman-Edwards, 2000).</li> </ul>
<b>Pollution</b>	<ul style="list-style-type: none"> <li>Inland farming, housing and development result in chemical and sewage pollution, which can over-fertilize coastal waters, causing the growth of 'tides' of algae that rapidly reduce productivity by blocking sunlight from reaching below-water surfaces. These algal tides can also turn toxic.</li> </ul>
<b>Invasive alien species</b>	<ul style="list-style-type: none"> <li>Invasive alien species can replace native species in mangrove areas.</li> </ul>
<b>Climate change</b>	<ul style="list-style-type: none"> <li>These impacts have been detailed in Chapter 4.</li> </ul>

Source: Adapted from Miththapala, 2008b

## Coastal erosion and its impacts on coastal ecosystems

Coastal erosion is a part of a natural phenomenon called coastal drift wherein land and beach sand and dunes are worn away by the beating of waves and deposited elsewhere. However, various anthropogenic actions are disrupting the delicate balance between erosion and accretion. For example, when forests are cleared inland, there is increased sedimentation in rivers and this ends up on the coastline. In contrast, when rivers are mined for sand or are dammed upstream, then the sediment load reaching the coastline is insufficient, resulting in increased erosion (UNEP, 2002).

Increased natural disasters and other impacts of climate change will exacerbate coastal erosion. (See Chapters 3 and 4 for details.) Increased sedimentation smothers corals reefs and seagrasses, retarding growth and, in the extreme, killing the habitat. More importantly, increased turbidity as a result of increased mud coming down through rivers (from forest-denuded catchments, etc.) also prevents coral reefs and seagrasses from growing normally and causes, in the long term, the death of these ecosystems. Conversely, the reduction in the sediment load results in the net loss of beaches—loss of sand dunes and ‘squeezing’ of mangroves and salt marshes.

## Coastal infrastructure and its impacts on coastal ecosystems

Coastal infrastructure development is another human activity that has long-lasting and severe impacts on coastal and marine ecosystems. Such development includes tourist resorts, roads and airports, which severely modify and sometimes totally destroy coastal ecosystems. The unseen impacts are the changes caused in natural beach processes—such as coastal drift and winds — by development along the coastline, disrupting transport of sand and water (<http://coastalcare.org/sections/inform/poor-coastal-development>). Often, piers and marinas are built on coral reefs and seagrass meadows, destroying them; sand dunes are levelled so that the view for tourists is unimpeded; nesting sites for marine turtles are destroyed both during construction and also by an influx of tourists; and salt marshes and mangroves are cleared to make way for construction ([http://wwf.panda.org/about\\_our\\_earth/blue\\_planet/problems/tourism/tourism\\_pressure/](http://wwf.panda.org/about_our_earth/blue_planet/problems/tourism/tourism_pressure/)).

Layered on this damage are the additional impacts of large numbers of tourists concentrated in small areas: increased solid waste and sewage, that, if not disposed of properly, ends up polluting coastal waters and increased use of resources on a daily basis (such as energy for lighting, cooling rooms and cooking; and water for laundries and swimming pools).

Much coastal infrastructure in the region is built with little regard to proper zoning clearances. As a consequence, such infrastructure is at serious risk from extreme weather events and other impacts of climate change such as a sea level rise.

Issues related to DRR, CCA and ecosystem management in the region were presented for each country by country experts at a regional workshop held in Delhi on 6 and 7 March 2012. An overarching issue for all focus countries is that development still takes precedence over prudent coastal management. For example, coastal industries are multiplying along the coasts of India, while tourism infrastructure is mushrooming along the coastline of Sri Lanka. Quite often, the developmental process is carried out at the cost of conservation, rather than sustainably and along with conservation.

Other issues relating to the region are outlined in the following.

## Knowledge management concerns

Although there exists some knowledge base in each country related to the subject relevant to this publication, there still are serious gaps—for example at local or site-specific levels—knowledge dissemination (horizontally across sectors and vertically from national to local levels) and knowledge sharing across the region.

Knowledge generation gaps identified at the above workshop included the lack of:

- Spatial and temporal data (sociological, biological and physical) at local levels;
- An understanding of traditional knowledge and its integration into modern tools and approaches;
- Site-specific understanding of processes and events associated with climate variability and change;
- Linkages between inland and coastal habitats;
- Knowledge of bio-indicators and their threshold limits;
- Knowledge of changes in the species composition and species range shifts related to climate change;
- Knowledge about the effect of the above range shifts and species composition changes on ecosystem services;
- Vulnerability mapping of coastal areas; and
- Regular monitoring of ecosystem functioning.

Knowledge dissemination gaps identified at the above workshop included the lack of:

- A two-way process of knowledge dissemination—i.e., national to local as well as local to national (for example, traditional knowledge into national plans); and
- Proper communication—knowing exactly how much and how to disseminate and pitching the message correctly.

Knowledge-sharing gaps identified at the above workshop included the lack of:

- A sharing of information available among various relevant departments; and
- An information hub (or knowledge information system) that houses relevant data at national and regional levels.

## Capacity concerns

The technical capacity for DRR and CCA has increased dramatically in the region since the Indian Ocean tsunami of 2004. However, this capacity is not necessarily retained and readily available among coastal managers, and there is also a felt need to improve the capacities of local communities, as well as national planners. Capacity gaps identified at the above workshop included the lack of:

- An understanding of DRR and CCA by the different stakeholders;
- Awareness of the importance of ecosystems in mitigating the impacts of natural hazards and the long-term effects of climate change; and
- Awareness among policy makers, planners and administrators (including politicians) about the linkages among DRR, CCA and ecosystem management.

## Coordination

Often it is seen that there is a multiplicity of agencies, with overlapping mandates and responsibilities, carrying out activities along the coasts and in marine areas. This results in poor coordination and cooperation, inter-agency conflicts, duplications of effort and a distinctly sectoral approach to coastal and marine resource management. Coordination gaps identified at the above workshop included the lack of:

- A common action plan and strategy used by DRR, CCA and ecosystem managers that has shared and individual responsibilities that may be implemented in a phased manner;
- Environmental management plans (that include DRR and CCA) in development sectors (for example, tourism); and
- A mechanism for ensuring coordination among all coastal stakeholders.

## Institutions

An institution is defined as “any structure or mechanism of social order and cooperation governing the behaviour of a set of individuals within a given human community” (<http://en.wikipedia.org/wiki/Institution>). Among the focal countries, there is considerable variation in the legal, administrative and management situations (BOBLME, 2010). However, across the region there are similar gaps and constraints relating to institutions.

## Laws

Gaps related to laws identified at the above workshop included the following:

- Although the focus countries have enacted a number of laws that relate to coastal and marine environment, enforcement of these laws remains weak across the region.
- Many of the laws are sectoral in their approach.
- “Major gaps relate to ensuring the objectives of long term sustainable use, the precautionary approach and ecosystem approach to underpin governmental actions in the [coastal] and marine sector” (BOBLME, 2010).

## Organizations

Organizations are the agencies that implement laws and are essential components of institutions.

Gaps related to organizations identified at the above workshop included the following:

- It was noted that among all the focus countries, there is a multiplicity of agencies, with overlapping mandates and responsibilities, carrying out activities along the coasts and in marine areas.
- It was noted that within the main organizations related to coastal management, specific capacity for integrating DRR and CCA into coastal management needs considerable strengthening.
- The other main issue identified is the lack of convergence and the wholly sectoral approach to management.



## 7. Knowledge Needs of Coastal Managers

Chapters 1–6 of this document dealt with the key linkages among ecosystems, DRR and CCA (see also Figure 1.2 and Figure 3.5). It is quite evident that these interconnections can be meaningfully addressed only through an integrated, holistic, comprehensive and cross-sectoral approach. Gaps and issues related to such an integrated approach, as discussed in Chapter 6, centred on knowledge management, capacity, coordination and institutions. This chapter focuses on knowledge issues and gaps that represent a vital prerequisite for effective coastal and marine ecosystem management.

Coastal and marine managers have a wealth of knowledge related to their own locations, but they need also to learn to view these issues through a lens that includes both DRR and CCA. The knowledge needs of coastal and marine managers for such an integrated approach can be clustered as knowledge generation, knowledge sharing and dissemination, and knowledge resources. These are dealt with in detail in the following.

### Knowledge generation

Braatz et al. (2006) note that knowledge generation for an integrated inter-sectoral approach consists of three primary phases, namely,

- Phase I: Hazard vulnerability and risk assessments
- Phase II: Mitigation strategy planning
- Phase III: Institutional building (which fosters ecosystem-based strategies and integrated coastal zone management).

The following is extracted from Preuss (2006).

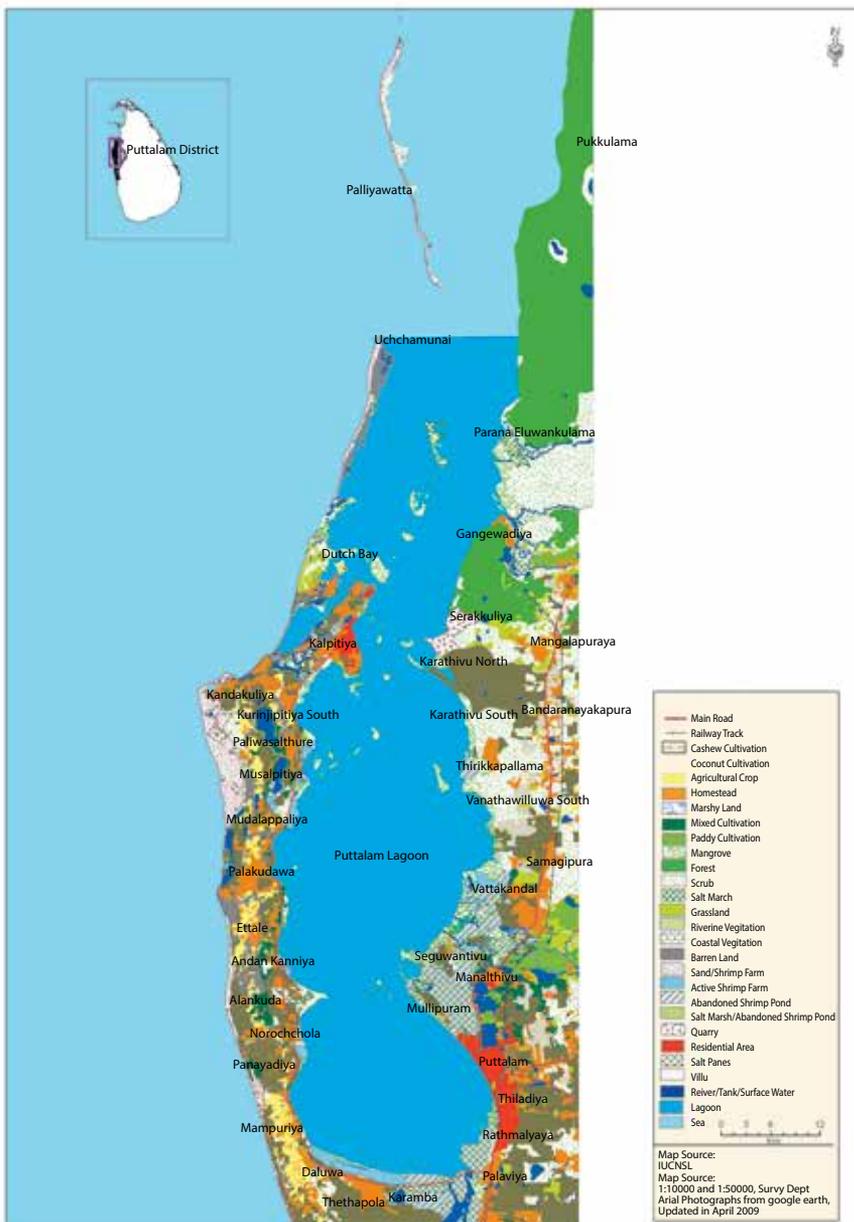
### Hazard vulnerability and risk assessments

During this phase of hazard vulnerability and risk assessment, a baseline for decision making is commenced, and it requires four steps.

#### 1. Define the boundaries of the target area

Using maps, define the target area, choosing an appropriate scale and delineating existing land use as shown in the example of Puttalam Lagoon and its environs in northwestern Sri Lanka.

**Figure 7.1. Land use of the Puttalam Lagoon area in 2009**



Source: Weragodatenna (2010) from Goggle Earth maps, April 2009, in IUCN 2012

### Box 7.1. The value of integrated assessments

When an ecosystem based approach is used, the scope of regularly used rapid biodiversity assessments needs to be widened to include several sub-assessments, including assessment of biodiversity, ecosystem services and economic values; as well as livelihoods and human well-being (Kallesøe et al, 2008).

As Kallesøe et al. (2008) note, “the biodiversity assessment establishes the composition and structure of the ecosystem, its status and health. The ecosystem service assessment focuses on identifying the services being provided by the ecosystem, as well as the expected impacts on the provision of these services from changes in biodiversity composition and structure. The livelihood assessment describes the elements and factors that determine human well-being in relation to the services provided by the economy and other factors. Finally, the economic assessment values the significance of ecosystem services as shown through their contribution to the various elements of human well-being”. A combined integrated assessment of all four components allows managers to establish a baseline on the status of ecosystem well-being and human well-being so that informed and planned decisions are made in relation to management interventions.

All the above knowledge can then be distilled to identify high-risk areas, the most likely hazard, the vulnerabilities of communities and the risk to critical habitats.

## 2. Identify and map the hazard

Just as some countries are more hazard-prone for a specific hazard than others (for example, Bangladesh is one of the most flood-prone countries in the world), at a micro level, some areas of a particular coastline are more prone to hazards than others. For example, low-lying areas are more vulnerable to floods than are higher areas; river mining upstream increases coastal erosion. For this reason, it is important to “obtain maps for as many types of hazards as possible and to delineate clearly the specific characteristics and small-scale, location-based variables that will become important considerations when developing a mitigation strategy” (Preuss, 2006). In short, it is necessary to identify key hazards.

Hazard maps show where a natural hazard is likely to occur. They also map the intensity (Coburn et al., 1994) and the frequency of occurrence, which allows for assessment not only of recurrence but also of cumulative impacts. Variables for hazard maps could include, for example, the extent and boundaries of flood levels, the extent and boundaries of erosion, etc. In addition, it is important to obtain maps related to different IPCC climate change scenarios, related to variables such as sea level rises, agricultural productivity losses, etc.

The following questions need to be asked:

- What: what kind of hazard occurs? For example, a heavy rain causes a flood, a landslide or a debris flow.
- Where: where does the hazard occur? For example, tidal surges affect coastal areas; landslides are more common on hill slopes. Which ecosystems are affected?
- How large is the scale of the hazard?
- How intense is it? For example, there is a heavy rain of 500 mm in one day, or a wind speed of 117 kilometres per hour.
- How does the phenomenon develop or spread? Is it rapid, slow-onset or cyclic?
- When does it occur or when is it likely to occur?
- What is the frequency or probability of occurrence? For example, there is a heavy rain that occurs once for 30 years, or cyclones hit the Bay of Bengal every year.
- Who and how many suffer from the ensuing disaster?
- How high is the grade of disaster?

- How many deaths, building damage or collapse?
- How much is the total loss?

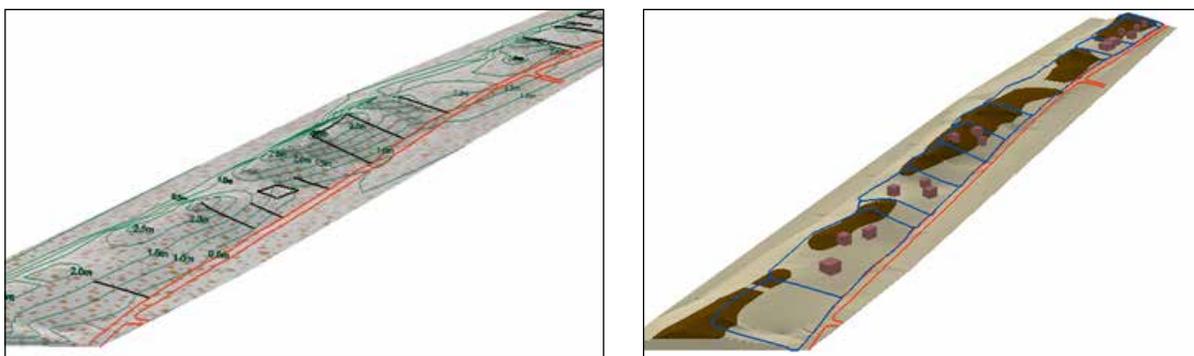
The end result is the generation of a hazard profile.

### 3. Assess the vulnerability

“Vulnerability defines the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard” (<http://www.preventionweb.com>). The variables assessed include natural ones such as ecosystems, built infrastructure, and demographic and social variables such as population density, percentage of poor, and percentages of other marginalized groups. Impacts from prior events (obtained from the hazard profile), as well as impacts from future recurring events and predicted changes related to climate change are identified. These impacts must be compared with the coastal morphology. Waves nearing the shore are influenced strongly by the coastal morphology. Waves are attenuated in narrow bays and inlets.

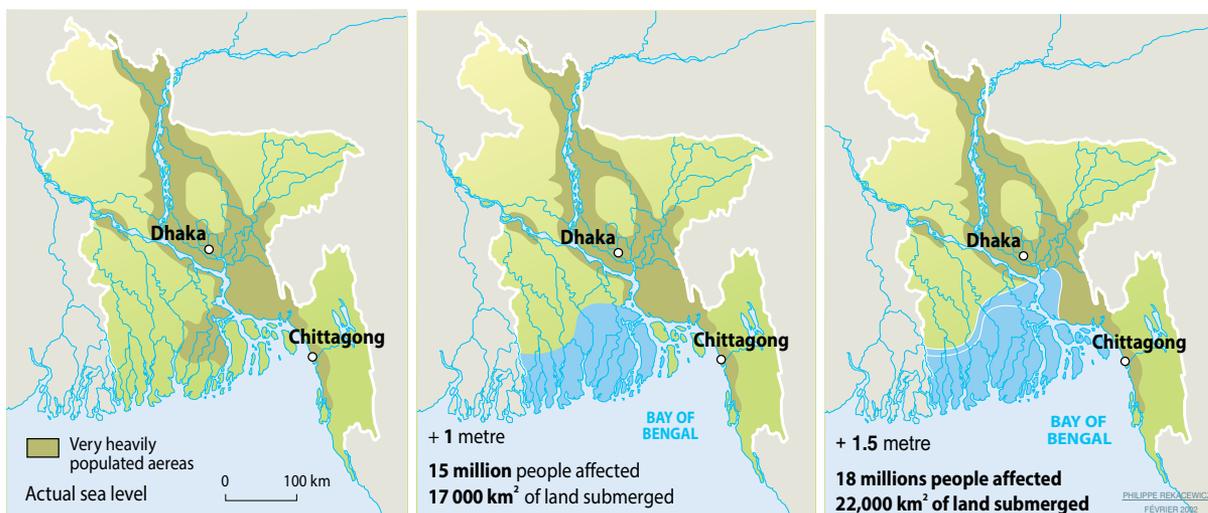
**Figure 7.2. Sand dunes and households at risk in Negombo Lagoon**

Shown below is a simple graphic of a contour map of sand dunes in the Negombo Lagoon area in northwestern Sri Lanka, superimposed with human habitation. It clearly shows risk for certain households from floods.



Source: Anil Premaratne, personal communication.

**Figure 7.3. The impact of sea level rise on Bangladesh**



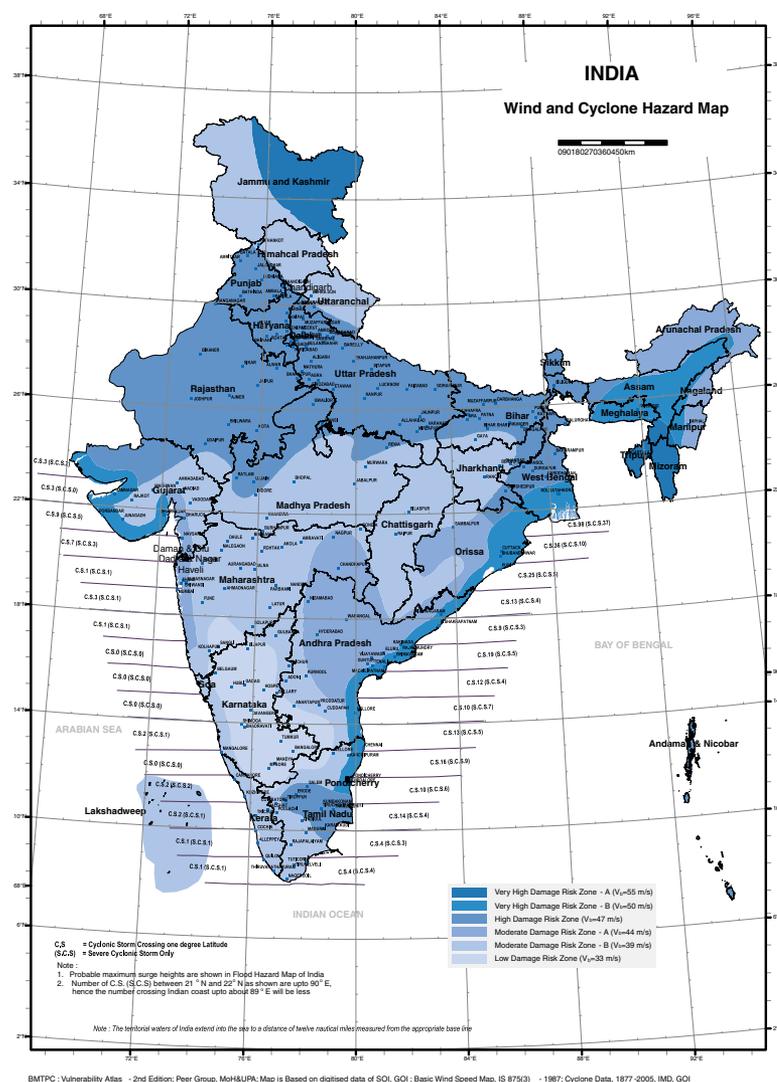
Source: [http://www.grida.no/graphicslib/detail/impact-of-sea-level-rise-in-bangladesh\\_e7fc](http://www.grida.no/graphicslib/detail/impact-of-sea-level-rise-in-bangladesh_e7fc)

The extent of coastal ecosystems also contributes to the increase or decrease in vulnerability. As was described in Chapter 2, healthy ecosystems often act as physical barriers of defence against natural hazards. But they are also damaged when a hazard occurs. The presence/absence and extent of coral reefs, seagrasses, sand dunes, salt marshes, mud flats, mangroves and other coastal vegetation should be noted. It is also important to know whether there are key species within the target areas: endemics or threatened species. Land use (agricultural land, housing and settlements), built infrastructure (hotels, other buildings, harbours and ports, roads and railways), and hard engineering protective structures (such as revetments) should also be noted (Preuss, 2006).

#### 4. Assess risk

From these data, it is possible to assess the risk. A risk profile is usually defined “as an analysis of the mortality and economic loss risk for a particular coastal hazard” (<http://www.preventionweb.com>), but for a coastal manager it also includes the risk to coastal ecosystems and species. Initially, it is necessary to identify, through synthesizing data, ‘coastal hotspots’ where multiple variables coincide. How often an event will occur is also important for the recognition of future impacts. It is therefore important to assess the probability of occurrence for a given duration. The probability of occurrence may be high, medium or low (Preuss, 2006). Shown below is a risk map of cyclones and winds for India.

Figure 7.4. Cyclone and wind risk map for India



Source: <http://hpsdma.nic.in/ResourceList/Maps/WindIndia.pdf>

The consequences of climate change under various IPCC scenarios can be examined in relation to the variables used in the vulnerability assessment.

## Mitigation strategy planning

This phase involves planning for the mitigation of impacts and losses. Tools and strategies are used to reduce risks identified in the risk assessment (Preuss, 2006). There are two parts to this phase.

### **Box 7.2. The importance of GIS mapping in the integrated approach**

GIS mapping is an invaluable tool for obtaining maps of the coastal habitats. Using GIS mapping and overlaying areas of natural habitats with population and other socio-economic data, it is possible to identify critical areas that need conservation. Overlaying with maps of different climate change impact scenarios will yield a map of habitats at risk from climate change.

Spatial data can be used in GIS to produce visual displays of hazard risk and vulnerability to facilitate planning to reduce the impacts of disasters on humans and infrastructure. Hazard maps can also show where roads, hospitals, schools and other major infrastructure are situated to reduce the degree of risk. In newly developing areas, hazard maps can be crucial in ensuring that key infrastructure, human settlements and tourism facilities are located out of high-risk zones. In already developed areas, while complete avoidance of hazardous areas may not be possible, hazard maps can be very useful in planning for evacuation and for employing different or additional design standards for structures to ensure that they can withstand shocks or to ensure that only noncritical components are lost to such hazards. GIS can be used also to identify ecologically sensitive areas.

Hazard maps can be also very important in identifying the sources and causes of hazards at a location that increase the degree of potential damage from various types of disasters. For instance, using a simple GIS model, land cover maps, overlaid with risk and topography maps, can be used to identify and further test linkages between vegetation cover and flood or storm surge risk in disaster-prone areas. More complex GIS applications can provide an important analysis, for instance, of the increased landslide or flood threat as a result of the construction of a highway in a fragile hilly environment.

Models can be used to evaluate future aspects of disaster risk, for example for a set of land-use planning scenarios towards developing a prior understanding of the potential risks and for arriving at the best possible alternatives, within the given constraints. These can be prepared based on the historic data of any past similar events and modelling for the dispersion of disaster impacts. Such an analysis can be coupled with information on the changes in demographics and socio-economic profiles of a region—such as population concentration, degree of poverty, land use and wildlife attributes—to identify clearly and demonstrate the linkages between ecological damage and worsening of the impacts of natural disasters.

In the aftermath of a disaster, spatial information is very useful in damage assessment to provide information for rehabilitation and construction. Economic evaluation can be carried out to assess the percentage damage or cleaning/reconstruction cost and pollution/contamination concentration ranges, especially in the case of damaged sewage works or industrial complexes. Following a disaster, the results of such models could also provide information for analysis of the long-term impacts of disasters, such as impacts on wildlife or fish stocks, which will, in turn, impact the tourism and fisheries sectors and, thereby, the capacity and amount of time required by local communities to recover from a disaster (R. Roberts, personal communication, in Miththapala, 2008d).

## Identify mitigation tools

### Hard engineering

In the past, hard engineering practices—groynes, revetments, sea walls and breakwaters—were used to prevent coastal erosion. Hard engineering solutions address immediate coastal erosion, but they do not build back a beach front, nor do they address the root cause of erosion. They are also costly (R. Galappatti, personal communication). These have not always been successful as they result in erosion elsewhere, as seen in Figure 7.5.

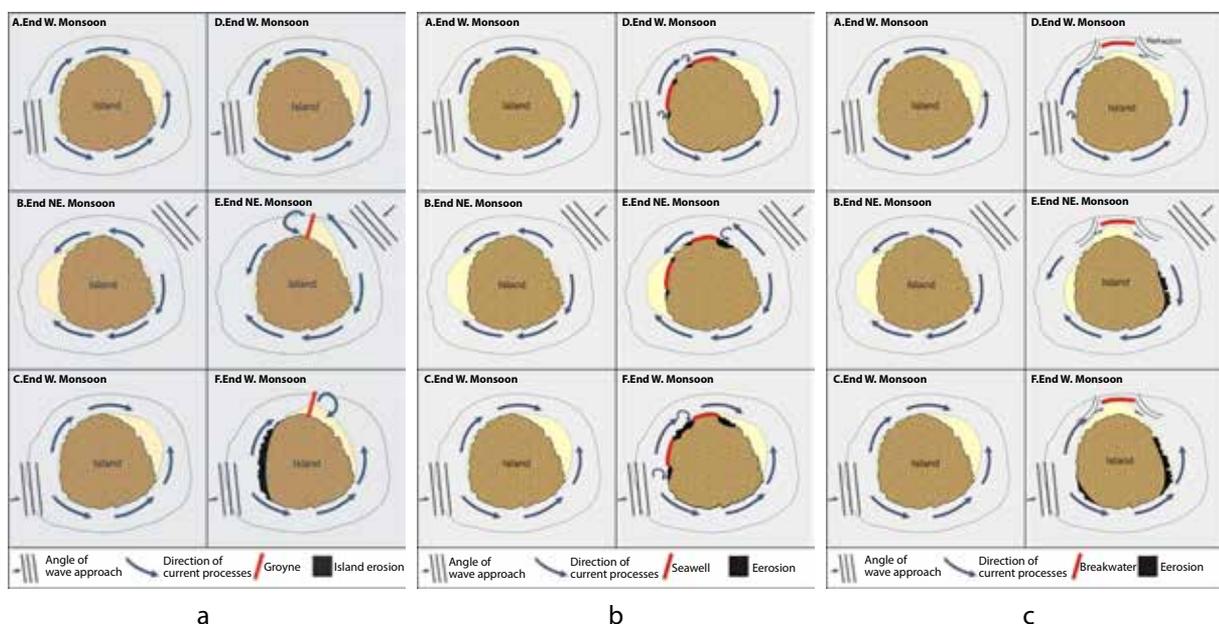
The visual unattractiveness and high cost of these structures has led to the establishment of soft engineering solutions or a mixture of both hard and soft engineering as a practical approach.

### Ecosystem restoration

This is called ‘soft engineering’. Soft engineering solutions include:

- Planting vegetation to trap and bind the sand together, preventing sand from being blown away and stabilizing sand dunes;
- Planting mangroves along the coastline, where their roots bind the soil;
- Nourishing beaches by adding a large amount of sand to eroded beaches;
- Nourishing island ridges: placing sediment on an island margin and introducing vegetation to add sediment volume to the island surface;
- Encouraging the growth of coral reefs to serve as ramparts against wave action;
- Relocating assets: an analysis of the rate of shoreline change and lifetime of the asset at risk allows a decision about whether the asset should be relocated landwards, away from the active shoreline.

**Figure 7.5. The effects of (a) groynes; (b) sea walls; and (c) breakwaters on erosion in a Maldivian island**



Source: Mohamed, personal communication

In some cases, it necessary to restore ecosystems. Ecosystem restoration is the “process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed” (SER, 2004). Ecosystem restoration is usually used to restore natural capital, but in the context of climate change, it becomes a vital tool for conserving endangered species and assisting migratory species.

The restoration, creation or expansion of native habitats and the development of migration corridors minimizes the impacts of localized but severe weather events on endangered species. Restoration is an important part of coastal management. Foundation documents for ecosystem restoration can be located at [http://www.iucn.org/about/union/commissions/cem/cem\\_work/cem\\_restoration/](http://www.iucn.org/about/union/commissions/cem/cem_work/cem_restoration/).

Restoration of coastal habitats would include:

### **Mangrove restoration**

([http://mangroveactionproject.org/files/restoration/MAP\\_%206\\_Step\\_EMR\\_Method.pdf](http://mangroveactionproject.org/files/restoration/MAP_%206_Step_EMR_Method.pdf))

- “Understand both the individual and community species ecology of the naturally occurring mangrove species at the site, paying particular attention to patterns of reproduction, distribution, and successful seedling establishment;
- Understand the normal hydrology that controls the distribution and successful establishment and growth of targeted mangrove species;
- Assess the modifications of the mangrove environment that occurred and that currently prevent natural secondary succession;
- Select appropriate restoration areas through application of Steps 1–3, above, that are both likely to succeed in rehabilitating a forest ecosystem and are cost-effective. Consider the available labour to carry out the projects, including adequate monitoring of their progress towards meeting quantitative goals established prior to restoration. This step includes resolving land ownership/use issues necessary for ensuring long-term access to and conservation of the site;
- Design the restoration program at appropriate sites selected in Step 4, above, to restore the appropriate hydrology and use natural volunteer mangrove recruitment for natural plant establishment.
- Utilize actual planting of propagules or seedlings only after determining through Steps 1-5, above, that natural recruitment will not provide the quantity of successfully established seedlings, rate of stabilization or rate of growth as required for project success” ([http://mangroveactionproject.org/files/restoration/MAP\\_%206\\_Step\\_EMR\\_Method.pdf](http://mangroveactionproject.org/files/restoration/MAP_%206_Step_EMR_Method.pdf)).

### **Coral reef restoration**

Coral reef restoration uses the same principle as gardening: Seeds are grown in nurseries and then replanted on the reef, on a substrate, which can range from discarded tyres, wire or concrete structures and abandoned ships.

### **Preserving and enhancing sand dunes and sand bars**

Sand dunes are managed by stabilizing the soil. Much of the management is through prevention of activities that impede the natural processes that make sand dunes: sediment supply and depletion through wind.

#### **Case Study 7.1. Mangrove restoration in the Indus Delta**

The Indus Delta, bordering Pakistan and India, stretches over 200 kilometres and extends over an area of some 600,000 hectares as a fan-shaped delta with creeks and mudflats. In the early 1980s, about 42 percent of the area was covered with mangroves. A project implemented by IUCN Pakistan raised 50 hectares of mangrove plantations in the coastal villages of Ibrahim Hyderi and Rehri. In the Indus Delta area, it completed the rehabilitation of over 20,000 hectares of degraded mangroves (<http://www.iucn.pk/emg.htm>).

### Case Study 7.2. Coral reef restoration in southern Sri Lanka

Rumassala Reef, in Galle, Sri Lanka, is being enriched by the Nature Conservation Group, a local NGO begun in 1992. The group collects coral broken by fishermen, tourists and wave action and replants them to recolonize degraded reef areas. Coral nurseries have been set up, and it is planned that within 3–4 years the restored coral sites will reach nearly 100% of the surface cover ([http://www.climateadaptation.lk/attachments/1312197920653Project\\_Protecting%20%20%20coast%20%20and%20%20marine%20%20eco%20%20system%20in%20%20%20Lanka%20through%20%20coral%20%20reef%20restoration,%20conservation%20%20%20and%20%20community%20%20management%20%20in%20%20Rumassala%20,%20Galle,%20Sri%20Lanka.pdf](http://www.climateadaptation.lk/attachments/1312197920653Project_Protecting%20%20%20coast%20%20and%20%20marine%20%20eco%20%20system%20in%20%20%20Lanka%20through%20%20coral%20%20reef%20restoration,%20conservation%20%20%20and%20%20community%20%20management%20%20in%20%20Rumassala%20,%20Galle,%20Sri%20Lanka.pdf)).

### Box 7.3. A caveat to ecosystem restoration

As with any action, whether or not ecosystem restoration is needed must be examined thoroughly against the specific context, and caution must be exercised before restoration is commenced. A precautionary approach is always recommended as ecosystems are usually resilient. Resilience is the capacity of an ecosystem to resist disturbance or recover quickly. A resilient ecosystem has the capacity to withstand stressors and, if damaged, rebuild itself. Ecosystems with a greater diversity of species have greater resilience than those with few species. When there is greater diversity, many species can perform the same function—such as decomposition—and can compensate or replace one another in a time of stress.

#### Guiding principles of ecosystem restoration

- Management of marine ecosystems should focus on stress relief rather than active restoration (IUCN, 2006a).
- Emphasize the urgent need to remove negative pressures on marine and coastal ecosystems, such as increased sedimentation and pollution through inappropriate discharge of waste, unsustainable exploitation of marine resources (damaging fishing practices, sand and coral mining, etc.). This is done to facilitate natural recovery and is imperative (IUCN, 2006a).
- Allow coastal habitats to recover naturally. (The composition and structure may change and the recovery rate will depend on external influences.) (IUCN, 2006a)
- When ecosystem restoration is found to be essential, ensure that ecosystems are restored to where they were originally and not in new habitats. For example, in some instances after the Indian Ocean tsunami of 2004, sand dunes were levelled to plant mangroves, an example of an erroneous action (Feagin et al., 2010).
- Monocultures must, at all costs, be avoided. Many mangrove restoration projects use a single species—such as *Avicennia marina*—and these, when successful, turn into plantations, rather than functional ecosystems.

Dune stabilization includes planting of sand dune vegetation (creepers that allow sand accretion), fencing off sensitive areas and establishing walkways.

#### Planting shelter belts and tree walls

Planted shelter belts and tree walls have been discussed in Chapter 2, Case Study 2.2 and Case Study 2.3.

## Evaluate and select mitigation tools

Coastal managers always have to balance development with the needs of ecosystems and species. There is no single 'best' tool for mitigation of impacts; rather, the choice of tool will be dictated by competing needs for the coast and the 'winner' of such a competition. Often, decisions are based on politics rather than science (Preuss, 2006). In this context, integrated coastal zone management —“an interdisciplinary and inter-sectoral approach to problem definition and solutions in the coastal zone” (World Bank, 2012)—becomes exceedingly important.

Ensuring that decisions related to coastal ecosystems and coastal species are included in developmental planning requires that data obtained in the preceding phases are channelled into instituted processes, such as environmental impact assessments.

Above and beyond the phases listed below and the knowledge that is required for them, coastal managers also need species-specific information related to their locations.

## Other knowledge needs

### Carrying out climate-specific research on species

Climate change is already significantly impacting biodiversity and ecosystems in many ways, including the following:

- **Changes in species distribution:** For example, it has been estimated that on average, the spatial distributions of a sizeable portion of species studied have shifted 6.1 kilometres per decade towards the poles or 1 metre in elevation per decade (UNEP, 2006).
- **Changes in population sizes:** For example, scientists are concerned that the remaining tigers (*Panthera tigris*) left in the wild (as few as 3,200), already compromised seriously by habitat loss, inadequacy of prey species and poaching, may be dealt a death knell by rising sea levels ([http://wwf.panda.org/about\\_our\\_earth/aboutcc/problems/impacts/species/](http://wwf.panda.org/about_our_earth/aboutcc/problems/impacts/species/)).
- **Changes in the timing of reproduction:** For example, flowering and production of new leaves during spring are occurring on average 2.3 days earlier per decade. This, in turn, has affected the seasonal movement of species (UNEP, 2006).
- **Changes in migratory patterns:** For example, for a wide range of taxa (cetaceans, birds, turtles and insects), it has been documented that there have been changes in the length, timing and location of migratory routes in response to changing climates.
- **Increases in the frequency of pest and disease outbreaks:** For example, it is hypothesized that increased warming of the oceans may also increase the incidence of fibropapilloma tumours in Green Turtles (*Chelonia mydas*). Empirical data show that this disease has increased since the 1980s (UNEP, 2006).
- **Extinction:** One endemic species—the Golden Toad (*Bufo perigrines*) of cloud forest habitats of Costa Rica—is known to have become extinct because of climate change. It is predicted that climate change (using mid-range warming scenarios) will cause the extinction by 2050 of 15–37 percent of a sample of approximately 1,000 endemic species from various parts of the world (Thomas et al., 2004).
- **Climate change** is predicted to affect most species with limited or patchy distributions —such as endemic species —and ecosystems restricted to certain climatic ranges—such as coral reefs and mangroves.

Much of the existing research related to species and climate change is for temperate species, and little is known about changes occurring in species and species interactions in the focal region. This is a major knowledge gap that must be filled.

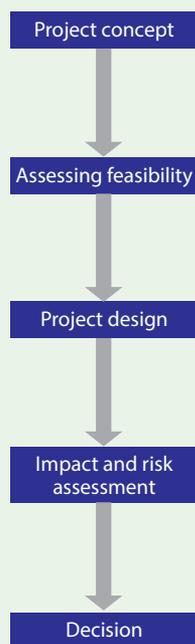
### Box 7.4. Integrating DRR and CCA into environmental impact assessments

“An Environmental Impact Assessment (EIA) is an assessment of the possible impact—positive or negative—that a proposed project may have on the natural environment. The purpose of the assessment is to ensure that decision makers consider the ensuing environmental impacts to decide whether to proceed with the project” ([http://en.wikipedia.org/wiki/Environmental\\_impact\\_assessment](http://en.wikipedia.org/wiki/Environmental_impact_assessment)).

EIAs are now standard practice in the region and are required by law in certain countries.

The following diagram shows how an EIA aids in the decision-making process.

**Diagram of the EIA process**



Source: D. Weerakoon, personal comm.

### Box 7.5. Entry points for DRR and CCA into the EIA process\*

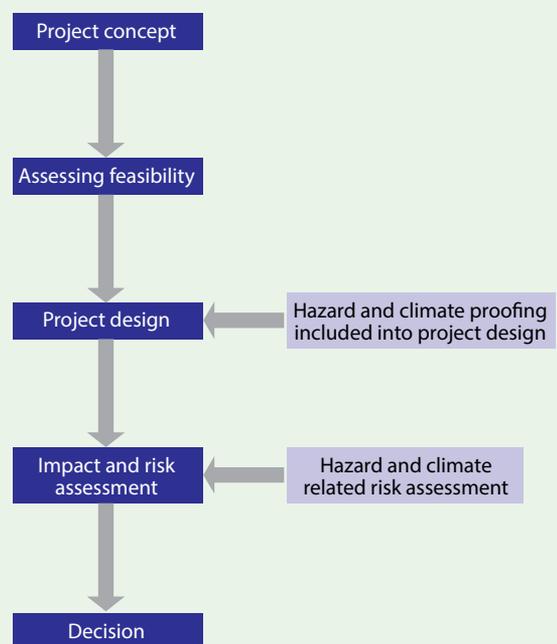
In the current context of more frequent, recurrent and intense natural disasters and the knowledge of the long-term insidious impacts of climate change, it has become essential that EIAs also cover the risks associated with natural hazards and climate change (Benson and Twigg, 2007).

Benson and Twigg (2007) list three actions that need to be integrated into EIAs to ensure that risk from natural hazards is addressed:

- The EIA process should include collection and collation of data on natural hazards and hazard-related risk as a basic, essential step.
- The EIA process should include a systematic analysis of the potential disaster-related risk of the proposed project.
- Post-disaster relief and rehabilitation actions should be inherent in the EIA.

In addition,

- the EIA process should include the impacts of climate change scenarios; and
- the EIA should recommend actions for climate-proofing the proposed project in terms of predicted risks.



Source: Adapted from D. Weerakoon, personal comm.

### Case Study 7.3. Loss of turtle nesting areas in the Odisha coast

Gahirmatha, Odisha, India is a site famous for massive synchronized nesting of Olive Ridley Turtles (*Lepidochelys olivacea*). More than 600,000 turtles are reported to have nested along this coast in one week in 1991. However, now this mass nesting is not as regular as it was in previous decades. Scientists believe changes in the beach profile are one of the primary causes for this.

In 2004, the mass nesting area was 3,000 metres × 60 metres.



In 2009, the mass nesting area was 900 metres × 87 metres.



In 2010, the mass nesting area was 1,000 metres × 53 metres.



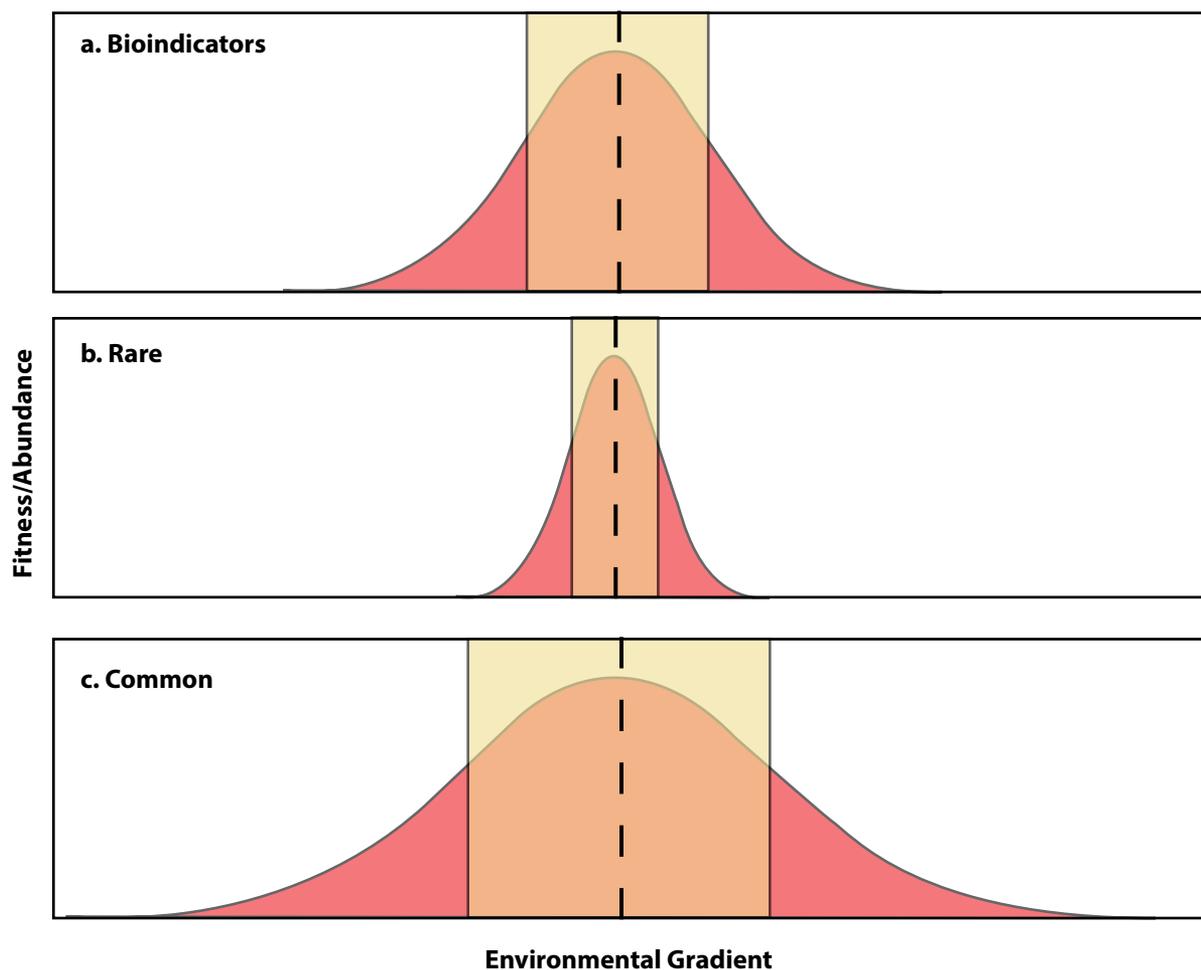
### Using bio-indicators as natural early warnings of changes in ecosystem health

Biological indicators (bio-indicators) are species/habitats used to monitor the health of or changes to an ecosystem. Seagrasses have been termed ‘biological sentinels’ because they respond to changes in the quality of water, indicating deterioration of the environment by declining. What is important is that these changes are visible (and very quickly) so that it is possible to take management action (Orth et al., 2006).

Changes in the environment are usually attributed to short-range impacts such as overexploitation, pollution and habitat destruction. However, bio-indicators can be used to monitor long-term change. Bio-indicators have specific characteristics that allow their use for this purpose. They are moderately tolerant of environmental variability (Figure 7.6). Rare species, however, have narrow tolerances, and common species have broad tolerances. Therefore, neither rare nor common species alone may be used to represent a generalized response to environmental changes.

Red areas represent an environmental variable (e.g. sea level rise, precipitation) where an individual, species, or community has a fitness or abundance greater than zero. The dashed line represents the peak performance along this particular environmental gradient, while yellow boxes include the optimum range or tolerance. Bio-indicators are moderately tolerant to changes in the specific variable, compared with rare and common species. This tolerance affords them sensitivity to indicate environmental change and simultaneously the endurance to withstand some variability and reflect the general biotic response (extracted and adapted slightly from <http://www.nature.com/scitable/knowledge/library/bio-indicators-using-organisms-to-measure-environmental-impacts-16821310>). Bio-indicators for assessing changes related to natural disasters and climate change need to be identified and studied for future monitoring.

**Figure 7.6. Comparison of environmental tolerances of (a) bio-indicators, (b) rare species and (c) common species**



#### **Case Study 7.4. Bio-indicators from traditional knowledge**

- *Cassia fistula* blooms abundantly about 45 days before the onset of the monsoon (Acharya, 2010).
- In Tripura (in northeastern India), which is a predominantly agrarian state, dependent on rain-fed agriculture, villagers use the phenology of *Nyctanthes abor-tristis* to predict the onset of the monsoon. Studies have shown these predictions to be accurate (Acharya, 2010).
- *Agave americana*, *Alocasia indica*, *Bambusa sp.*, *Brasica campestris*, *Ficus rumphii*, *Hibiscus cannabinus*, *Mangifera indica*, *Platynerium wallichii*, *Quercus serrata* and *Terminalia tomentosa* are all used by indigenous communities in Manipur, India, to predict weather changes (Singh, 2010).

### **Integrating traditional knowledge into the knowledge base**

The Indian Ocean tsunami of December 2004 highlighted two stories about traditional disaster warning systems, the first about Simeuleans living off the coast of Sumatra, Indonesia, and the second about Moken, living in the Surin Islands, off the coast of Thailand and Myanmar. Not many Simeuleans died during this devastating event because they used a traditional practice called 'smong' and fled to higher ground after the earthquake. This practice had been used since the 19th century, and using it, Simeuleans flee to the mountains whenever there is an earthquake (ISDR, 2008).

The Moken are 'sea gypsies', one of three groups who have roamed the waters between southern Thailand and Myanmar for centuries. They are semi-nomadic and live out in boats during the dry season and come ashore during the wet months. When the water receded on 26 December, the Moken recognized signs of danger and fled to higher ground for safety. This practice had been passed down through generations (ISDR, 2008).

Priority 3 of the Hyogo Framework for Action focuses on education and knowledge. One of the activities identified under this priority action "focuses on the importance of information management and exchange, and highlights the use of relevant traditional and indigenous knowledge and cultural heritage to be shared with and adapted to different target audiences" (ISDR, 2008).

There is an urgent need to integrate local and traditional knowledge about weather-related issues into coastal and marine management.

A whole suite of manuals exists for developing community-based DRR and CCA practices. The reader is referred to [http://www.preventionweb.net/english/search/?cx=014932112152556794315%3Aqvpujdbtzi&cof=FORID%3A11&q=community+based+disaster+risk+reduction&so=1&search\\_go.x=0&search\\_go.y=0](http://www.preventionweb.net/english/search/?cx=014932112152556794315%3Aqvpujdbtzi&cof=FORID%3A11&q=community+based+disaster+risk+reduction&so=1&search_go.x=0&search_go.y=0).

### **Knowledge sharing and dissemination**

Although knowledge is available (see the next section), it is scattered in various departments and with different organizations, and there is a critical need for collecting and collating information from various departments and setting up an easily accessible and retrievable one-stop knowledge management system such as the Environmental Information System for India (ENVIS) (<http://www.envis.nic.in/>).

There is also a need to improve telecommunications facilities to achieve faster dissemination of climate change-related information to communities. Shown in the box below (Case Study 7.6) are working examples that should be multiplied in the region.

### Case Study 7.5. Case studies of traditional knowledge already incorporated into DRR

- Floating gardening is a traditional practice in Bangladesh (Irfanullah et al., 2011). Usually, the Water Hyacinth (*Eichhornia crassipes*) is used to construct a floating raft on which vegetables and other crops are cultivated during the monsoons, when the land is inundated. This method is practiced commonly in the hoar (wetland) regions of Bangladesh, where communities are poor and marginalized. Many of them do not own land, and, even if they do, it is flooded for most of the year. This practice of floating gardening is now being implemented in other regions of Bangladesh (Irfanullah et al., 2011).
- Unusual chirping of various species of birds, the behaviour of livestock and the phenology of plants are all used to predict the onset of rains in Tripura, India (Acharya, 2011).
- The districts of Mansehra and Battagram in the North West Frontier Province (NWFP) of Pakistan are extremely vulnerable to hazards—such as recurring landslides, flash floods and earthquakes—as well as extreme weather events such as heavy rains, storms, severe snow and hailstorms. Houses in these communities are built with structural reinforcements and on carefully selected ground (ISDR, 2008).
- In Sri Lanka, the ancient cascading village tank system allowed storage and recycling of water during droughts (ISDR, 2008).
- In the Maldives, traditionally constellations have been used to predict the weather, including the onset of the monsoons. This practice is called *nakaiky* in Dhivehi (Mohamed, personal communication).

### Case Study 7.6. Effective dissemination of information in India

- The Karnataka State Natural Disaster Monitoring Centre has state-of-the-art disaster portal where real-time information is collected, collated and disseminated to villages via phone alerts ([http://geospatialtoday.com/gst/index.php?option=com\\_content&view=article&id=151%3Akarnataka-chooses-esri-technology-for-disaster-management-portal&catid=43%3Apress-releases&Itemid=100](http://geospatialtoday.com/gst/index.php?option=com_content&view=article&id=151%3Akarnataka-chooses-esri-technology-for-disaster-management-portal&catid=43%3Apress-releases&Itemid=100)).
- The Indian National Centre for Oceanic Information Systems (INCOIS) provides information related to potential fishing areas in 500 fish landing centres/fishing villages extending over the entire coastline of India. These advisories are flashed on electronic display boards in several languages [http://www.incois.gov.in/Incois/advisory\\_pzf\\_main.jsp](http://www.incois.gov.in/Incois/advisory_pzf_main.jsp).

## Knowledge resources

There is a wealth of knowledge resources available on the Internet. However, because the three elements of DRR, CCA and ecosystem management are not integrated, this information lies scattered all over. The following is a selected list of websites relevant to all three elements:

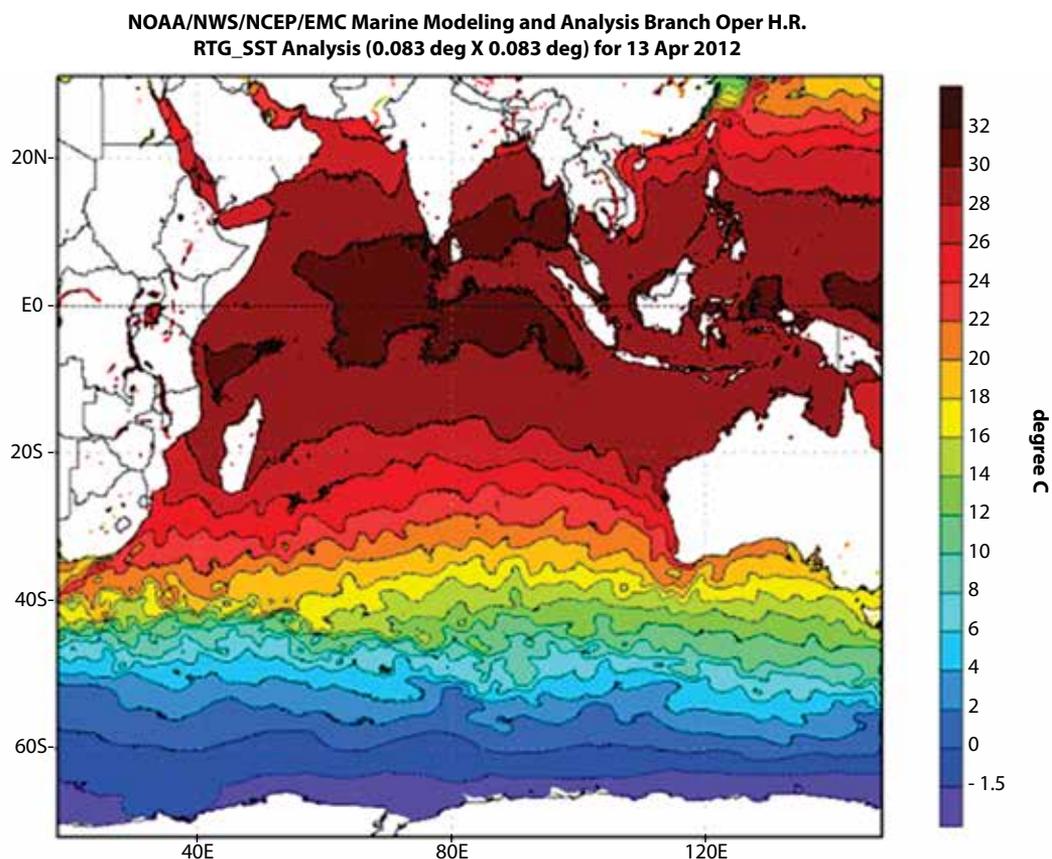
### DRR

1. <http://www.preventionweb.net/english/> PreventionWeb is a one-stop shop for information on DRR. It provides detailed terminology, statistics and information related to hazards and disasters.
2. [http://reliefweb.int/updates?search=&sl=environment-report\\_listing%252Ctaxonomy\\_index\\_tid\\_source-1503%252Ctaxonomy\\_index\\_tid\\_content\\_format-12](http://reliefweb.int/updates?search=&sl=environment-report_listing%252Ctaxonomy_index_tid_source-1503%252Ctaxonomy_index_tid_content_format-12) ReliefWeb contains maps related to hazards and risk developed by the UN Office for the Coordination of Humanitarian Affairs (OCHA).
3. <http://reliefweb.int/> ReliefWeb is a United Nations website that provides information to humanitarian relief organizations, with a directory of non-governmental organizations in operation.

## Climate change

- <http://www.unep.org/climatechange/> UNEP's website on climate change contains information about climate change mitigation, adaptation and Reducing Emissions from Deforestation and forest Degradation (REDD) and has a resource kit on climate change.
- <http://www.climate.noaa.gov/> NOAA's climate programme website has a climate glossary and a listing of services that relate to various topics such as El Nino and climate variability.
- <http://data.nodc.noaa.gov/geoportal/> NOAA's databases contain information about selected chemical variables such as chlorophyll in the oceans (which measures primary productivity), dissolved oxygen (which measures the extent of eutrophication) and turbidity levels.
- <http://www.cbd.int/> The Convention on Biological Diversity (CBD) website has a database of adaptation planning that provides Web-based guidance on the integration of biodiversity into climate change adaptation planning.
- <http://sdwebx.worldbank.org/climateportal/index.cfm> is the World Bank's Web portal on climate change and is a hub of information, data and reports about climate change around the world.
- <http://www.loicz.org/> Land and Ocean Interaction in the Coastal Zone (LOICZ) aims to provide information to educate and contribute to the sustainability of the world's coastal zone.
- <http://www.ioc-goos.org/> The Global Ocean Observing System (GOOS) has real-time data sets that include information on sea level rises, coral reefs, ENSO and arctic ice.

**Figure 7.7. Real-time sea surface temperatures for the Indian Ocean extracted from [http://polar.ncep.noaa.gov/sst/ophi/color\\_sst\\_IND\\_ophi0.png](http://polar.ncep.noaa.gov/sst/ophi/color_sst_IND_ophi0.png)**



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## Biodiversity and ecosystems

- <http://www.cbd.int/> The website of the CBD contains a source book for the ecosystem approach.
- [http://www.conservation.org/where/priority\\_areas/hotspots/Pages/hotspots\\_main.aspx](http://www.conservation.org/where/priority_areas/hotspots/Pages/hotspots_main.aspx) Conservation International has a dedicated website giving details about the world's biodiversity hotspots—the most biodiverse and most threatened areas of the world.
- <http://www.iucnredlist.org/> IUCN's Red List™ is a database of Endangered, Threatened and Vulnerable species.
- <http://www.gbif.org/> The Global Biodiversity Information Facility (GBIF) encourages free and open access to biodiversity data.
- <http://seaturtlestatus.org/> The State of the World's Sea Turtles (SWoT) is a website to protect sea turtles and their habitats worldwide.
- <http://www.fishbase.org/search.php> FishBase contains information about more than 30,000 species of fish.
- <http://ramsar.wetlands.org/Database/AbouttheRamsarSitesDatabase/tabid/812/Default.aspx> is the Ramsar database of Wetlands of International Importance. The Ramsar website also contains brochures on good practices for wetlands.
- <http://www.glomis.com/> The Global Mangrove Database and Information System contains a world atlas of mangroves and satellite images of selected mangroves;
- <http://www.reefbase.org/main.aspx> ReefBase contains a global database about corals around the world with a database on maps of reefs and marine protected areas (MPA);
- <http://www.gcrmn.org/> Global Coral Reef Monitoring Network (GCRMN) is a global network to improve management and conservation of coral reefs. It contains manuals and databases related to reefs.
- <http://www.seagrasswatch.org/publications.html> Seagrass Watch is a website that has a collection of publications, field guides and training manuals on seagrasses.

**Figure 7.8. The distribution of Olive Ridley Turtle nesting sites in the Indian Ocean obtained from SWoT**



Source: <http://seamap.env.duke.edu/swot>

**Checklist 1. Checklist for knowledge generation for coastal managers**

Check		Generating knowledge	Specifics	Brief description
<b>Phase I: Hazard vulnerability and risk assessments</b>				
<input type="checkbox"/>	Step 1	Define the boundaries of the target area and detail land use	GIS is invaluable for this	Different departments will have these maps, but land use departments are usually the best source.
<input type="checkbox"/>	Step 2	Identify and map the hazard.	GIS is invaluable for this.	See below.
<input type="checkbox"/>		Hazard assessment	Hazard profile	A hazard profile is a description and analysis of a specific type of local hazard. It is performed for each natural hazard and is based on criteria such as frequency, duration and speed of onset. It also includes human exposure and economic exposure. The URL that follows is the tsunami hazard profile for the world: <a href="http://www.preventionweb.net/english/hazards/statistics/risk.php?hid=71">http://www.preventionweb.net/english/hazards/statistics/risk.php?hid=71</a> .
<input type="checkbox"/>			Hazard mapping	Hazard maps show where a natural hazard is likely to occur. They also map the intensity of occurrence. Most often hazard mapping is defined as “the process of establishing geographically where and to what extent particular phenomena are likely to pose a threat to people, property, infrastructure, and economic activities”. However, this omits the integral need to assess the impacts of climate change and threats to ecosystems as well. Therefore, with the integration of disaster risk reduction and climate change adaptation into ecosystem management, this definition should read to mean that hazard mapping is the process that establishes where and to what extent a natural hazard, in the short term, and climate change, in the long term, are likely to pose a threat to humans, biodiversity, property and infrastructure (natural ecosystems and man-made constructions), livelihoods and economic activities (Coburn et al., 1994).
<input type="checkbox"/>	Step 3	Assess the vulnerability	Impacts from prior events, future impacts, coastal morphology, and species and habitat vulnerability are also important for coastal managers in	

Check		Generating knowledge	Specifics	Brief description
			addition to what is listed below.	
<input type="checkbox"/>		Vulnerability assessment	Obtaining a vulnerability profile of the area	Vulnerability defines the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard.  Vulnerability profiles are available with the disaster management department/authority/ministry of each country. They are also found at <a href="http://www.preventionweb.com">http://www.preventionweb.com</a> .
	Step 4	Assess risk	In addition to what is listed below, it is necessary for coastal managers to assess coastal hotspots.	
			Obtaining a risk profile of the area	A risk profile is an analysis of the mortality and economic loss risk for a particular coastal hazard ( <a href="http://www.preventionweb.com">http://www.preventionweb.com</a> ).  Risk profiles are available with the disaster management department/authority/ ministry of each country. They are also found at <a href="http://www.preventionweb.com">http://www.preventionweb.com</a> .
<b>Phase II: Mitigation strategy planning</b>				
<input type="checkbox"/>	Step 1	Identify mitigation tools.	Tools and strategies are used to reduce risk identified in the risk assessment.	
<input type="checkbox"/>		Hard engineering solutions	Revetments, dykes, groynes	
<input type="checkbox"/>		Soft engineering solutions including ecosystem restoration	Mangrove restoration	As with any action, whether or not ecosystem restoration is needed must be examined thoroughly against the specific context and caution applied before restoration is commenced. A precautionary approach is always recommended as ecosystems are usually resilient.
<input type="checkbox"/>			Coral reef restoration	

Check		Generating knowledge	Specifics	Brief description
<input type="checkbox"/>			Sand dune stabilization	
<input type="checkbox"/>			Shelter belts and tree walls	
<input type="checkbox"/>	Step 2	Evaluate and select mitigation tools.	There is no single, 'best' tool for mitigation of impacts; rather the choice of tool will be dictated by competing needs for the coast and the 'winner' of such a competition.	
<input type="checkbox"/>		Ensure that decisions related to coastal ecosystems and coastal species are included in developmental planning.	Integrate DRR and CCA into the existing EIA process.	
Other knowledge needs				
<input type="checkbox"/>	Step 1	Carry out climate-specific research on species	This should include research on changes in species distribution; changes in population sizes; changes in the timing of reproduction; changes in migratory patterns; increases in the frequency of pest and disease outbreaks; extinction; and species, such as endemics, with patchy distributions and ecosystems restricted to certain climatic conditions.	
<input type="checkbox"/>	Step 2	Use bio-indicators as natural early warning of changes in ecosystem health	Biological indicators (bio-indicators) are species/habitats used to monitor the health of or changes to an ecosystem.	Bio-indicators for assessing changes related to natural disasters and climate change need to be identified and studied for future monitoring.

Check		Generating knowledge	Specifics	Brief description
<input type="checkbox"/>	Step 3	Integrating traditional knowledge into the knowledge base	Priority 3 of the Hyogo Framework for Action focuses on education and knowledge. One of the activities identified under this priority action “focuses on the importance of information management and exchange, and highlights the use of relevant traditional and indigenous knowledge and cultural heritage to be shared with and adapted to different target audiences” (ISDR, 2008).	There is an urgent need to integrate local and traditional knowledge about weather-related issues into coastal management.



## 8. Institutional Strengthening for Better Governance

In Asia the disciplines of DRR and CCA are new compared with coastal and marine ecosystem management, and by and large, each of them has been developed independent of each other (Mitchell and Van Aalst, 2008; Mitchell et al., 2010; Thomalla et al., 2006). Much effort is going on to examine the overlap and potential synergies among DRR and CCA (Mitchell and Van Aalst, 2008; Mitchell et al., 2010; Thomalla et al., 2006), but less attention is being paid to the integration of the three themes.

One of the consequences of isolation of DRR, CCA and ecosystem management is that the organizational and legal base for coordinated management becomes unwieldy. A central, holistic approach that integrates coastal and marine management, DRR and CCA must recognize that spatial, temporal, sectoral, political and institutional integration are all essential for success. The first step towards this objective would be for the coastal and marine area manager to understand the institutional context in which he or she works.

### 1. Carry out institutional mapping

In order to carry out institutional mapping, it is necessary to carry out both organizational mapping and a review of the laws.

### Box 8.1. Definition of institutions and governance

An institution is defined as “any structure or mechanism of social order and cooperation governing the behaviour of a set of individuals within a given human community” (<http://en.wikipedia.org/wiki/Institution>). Institutions, therefore, encompass both laws and organizations that implement these laws (McFadden et al., 2010). These have been mandated with particular service or regulatory roles in the coastal environments (McFadden et al., 2010).

Governance encompasses institutions and the process of governing. “Governance is a:

- process that brings together actors ;
  - from the public and the private sphere;
  - to steer (parts of) societies;
  - by a variety of mechanisms; and
  - that include institutions, but also, e.g., partnerships, networks, belief systems, etc.”
- (McFadden et al., 2010).

Governance is the interaction of a government and its citizens (Moore et al., 2011).

### Box 8.2. Organizations involved in coastal management in Sri Lanka

For example, in Sri Lanka, four agencies have overlapping jurisdiction over coastal and marine ecosystems. The Coast Conservation and Coastal Resources Management Department, under the Ministry of Defence, has primary authority over all coastal areas in Sri Lanka. It is responsible for developing national management plans, as well as overseeing current management and research. The Department of Wildlife Conservation manages marine and coastal protected areas, while the Forest Department has jurisdiction over mangroves, which are found in coastal areas (Joseph, 2003; IUCN, 2012). The Department of Fisheries and Aquatic Resources has management jurisdiction over fisheries resources in lagoons. Added to these layers are players from provincial and local governments.

## Step 1: Carry out organizational mapping

It is normal for the region to have a multiplicity of organizations—sometimes with overlapping mandates, at other times with conflicting responsibilities —that have important roles to play in coastal management. Coordination and holistic management is, therefore, a considerable challenge.

### Box 8.3. Organizations involved in DRR, CCA and coastal management in India

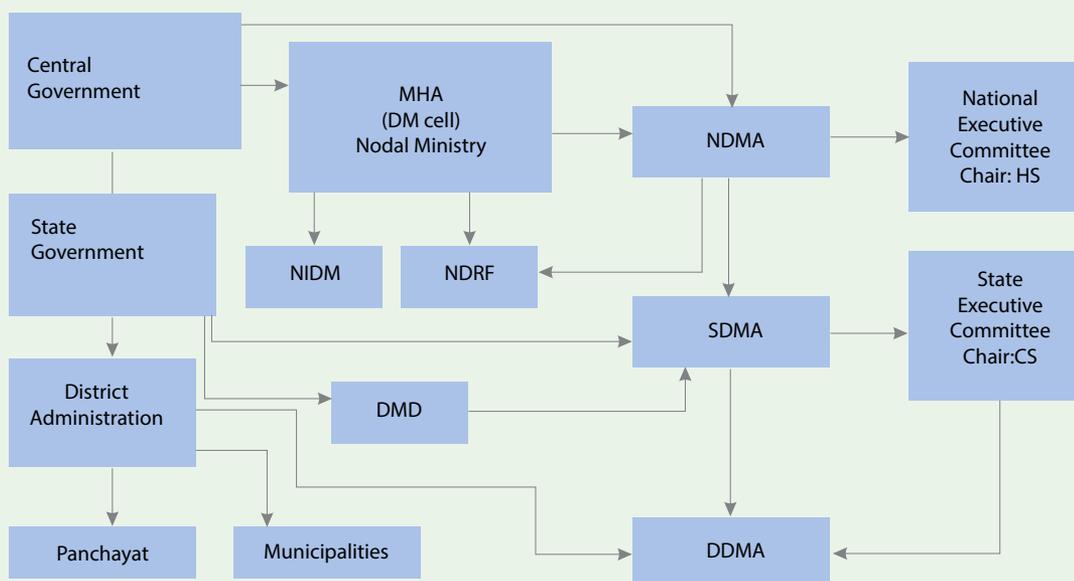
#### Organizations related to disaster management

- The National Disaster Management Authority (NDMA) is the apex body for disaster management, headed by the Prime Minister. The NDMA has the responsibility for laying down policies, plans and guidelines for DM and coordinating their enforcement and implementation for ensuring timely and effective responses to disasters. The NDMA is mandated to deal with all types of disasters; natural or manmade.
- The National Executive Committee (NEC) is the executive committee of the NDMA. The NEC comprises the Union Home Secretary as Chairperson, and the secretaries to the GoI in the ministries/

departments of Agriculture, Atomic Energy, Defence, Drinking Water Supply, Environment and Forests, Finance (Expenditure), Health, Power, Rural Development, Science and Technology, Space, Telecommunications, Urban Development, and Water Resources and the Chief of the Integrated Defence Staff of the Chiefs of Staff Committee as members. Secretaries in the Ministry of External Affairs, Earth Sciences, Human Resource Development, Mines, Shipping, and Road Transport and Highways, and the Secretary, NDMA are special invitees to the meetings of the NEC.

- The State Disaster Management Authorities (SDMAs) are headed by the Chief Ministers. SDMAs lay down policies and plan for disaster management in the State. It, *inter alia*, approves the State Plan in accordance with the guidelines laid down by the NDMA.
- The State Executive Committee (SEC) assists the SDMA in the performance of its functions. The SEC is headed by the Chief Secretary to the State Government and coordinates and monitors the implementation of the National Policy, the National Plan and the State Plan. The SEC also provides information to the NDMA relating to different aspects of disaster management.
- The District Disaster Management Authority (DDMA) is headed by the District Collector, Deputy Commissioner or District Magistrate as the case may be, with the elected representative of the local authority as the Co-Chairperson. The DDMA acts as the planning, coordinating and implementing body for disaster management at the district level. It *inter alia* prepares the District Disaster Management plan for the district and monitors the implementation of the National Policy, State Policy, National Plan, State Plan and District Plan. The DDMA ensure that the guidelines laid down by the NDMA and the SDMA are followed by all the departments of the state government at the district level and the local authorities in the district.
- Local authorities include *Panchayati Raj* Institutions (PRIs), municipalities, district and cantonment boards, and town planning authorities that control and manage civic services. These bodies will ensure capacity building of their officers and employees for all phases of disaster management.
- The National Institute of Disaster Management (NIDM) has capacity development as one of its major responsibilities, along with training, research, documentation and development of a national-level information base.
- The National Disaster Response Force (NDRF) is mandated to provide a specialized response to a threatening disaster situation or disasters/ emergencies, both natural and manmade.
- The Ministry of Home Affairs is engaged in disaster management.

**Legal-Institutional Framework  
Disaster Management Act 2005**



### **Organizations related to Climate change**

- The Prime Minister's Council on Climate Change is the apex body for dealing with climate change issues and is chaired by the Prime Minister. Key stakeholders include the government, industry and civil society. The council lays down broad directions for national actions with respect to climate change.
- Core Negotiating Team (multi-ministry)
  - o Technical Support Group (multiministry);
- Coordination Unit for Implementation of National Plan of Action for Climate Change (MoEF)
  - o Ministry Specific Agenda (ministries);
- Research Agenda Principal Scientific Adviser to GoI Ministry of Science and Technology (specific units of MST/other ministries).
- Eight National Missions, which form the core of the National Action Plan, and institutions to support these missions. These are
  - o National Solar Mission
  - o National Mission for Enhanced Energy Efficiency
  - o National Mission on Sustainable Habitat
  - o National Water Mission
  - o National Mission for Sustaining the Himalayan Ecosystem
  - o National Mission for a Green India
  - o National Mission for Sustainable Agriculture
  - o National Mission on Strategic Knowledge for Climate Change
- State, district and local authorities.

### **Organizations related to coastal management**

- Ministry of Environment and Forests, at the national-level, directs policies;
- State forest departments draw up coastal zone management plans and enforce them;
- State Environmental Impact Assessment Authority (SEIAA) approves/rejects proposed activities in the coastal zone;
- National Centre for Sustainable Coastal Management (NCSCM) assists state in formulating plans;
- The SEIAA constitutes district-level committees under the chairmanship of the District Magistrate, with at least three representatives of local traditional coastal communities, including fishermen;
- The Ministry of Agriculture, which oversees fisheries management and coastal aquaculture;
- The Coast Guard, under the Ministry of Defence, which controls, *inter alia*, oil pollution and poaching;
- The Pollution Control Board, which controls coastal pollution;
- The Ministry of Commerce, which oversees marine product development and special economic zones;
- The Ministry of Surface Transport, which manages transport, ports and harbours;
- The Ministry of Tourism, which oversees tourism development;
- The Ministry of Urban Development, which controls town and country planning;
- The Ministry of Industries, which manages coastal industries;
- The Ministry of Mines, which controls coastal and offshore mining;
- The Ministry of Petroleum and Natural Gas, which controls exploration and exploitation of oil and natural gas;
- The Ministry of Chemicals and Fertilizers, which controls storage and handling of chemicals and fertilizers in port areas; and
- State/union territory environment departments, which manage the coastal and marine environment under various acts such the Water Act and Air Act.

Sources: [http://nidm.gov.in/PDF/policies/ndm\\_policy2009](http://nidm.gov.in/PDF/policies/ndm_policy2009); <http://pmindia.nic.in/Climate%20Change.doc>; <http://www.environment.tn.nic.in/CRZNotification-2011.pdf>; [http://moef.nic.in/divisions/iass/cmz\\_report.pdf](http://moef.nic.in/divisions/iass/cmz_report.pdf)

First it is important for a coastal manager to know the entire gamut of stakeholders. For this, he/she needs to carry out organizational mapping.

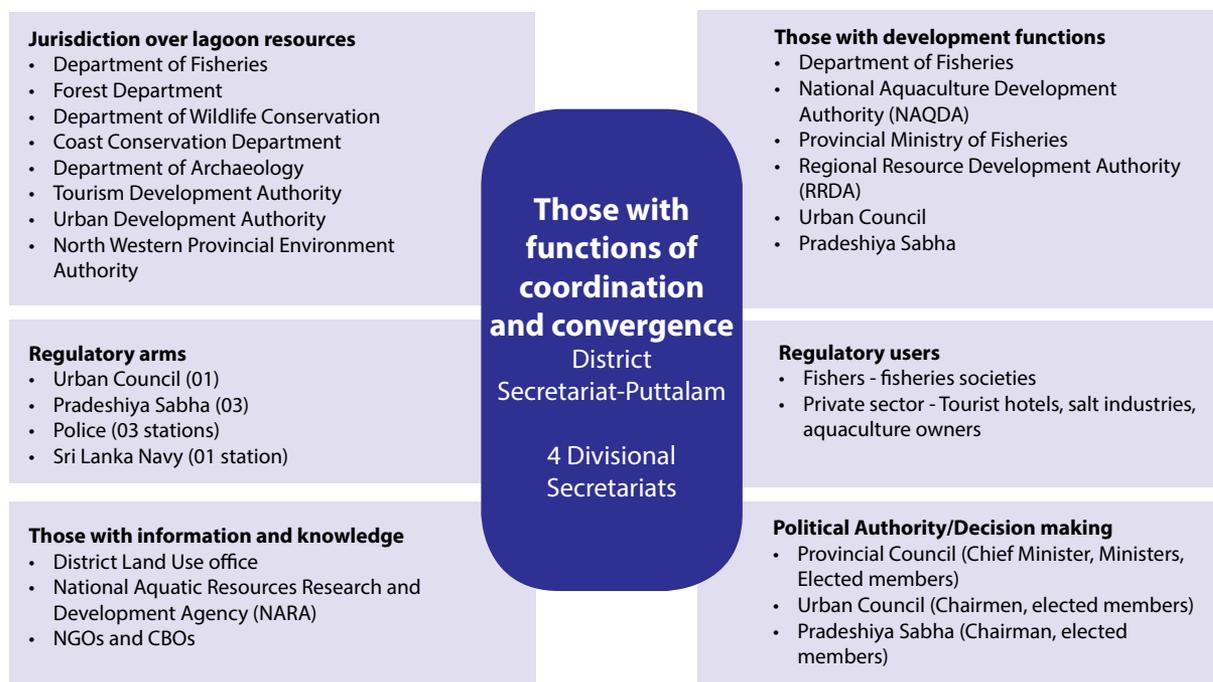
- Which organizations (governmental, non-governmental and community-based) are involved in addressing key issues and problems related to climate change?
- What do they do? What is their mandate?
- What are their functional and geographical boundaries?
- How do they interact with communities?
- How do they interact with each other?
- Where are the overlaps with other organizations?
- Where are the gaps in capacity?
- How might some organizations impede the work of others?
- What are the strengths and weaknesses of the institutions?
- What is the institution’s level of influence over planning and implementation of adaptation?

This will allow the coastal manager to understand processes and people important in management.

**Figure 8.1. Institutional mapping of the Puttalam Lagoon in Sri Lanka**

Shown in Figure 8.1 is an example of institutional mapping carried out by IUCN Sri Lanka, for Puttalam Lagoon in northwestern Sri Lanka.

(A district is the layer of administration below the provincial level. Divisional secretariat divisions are subdivisions of a district. *Pradeshiya Sabhas* are rural councils. Source: IUCN, 2012)



## Step 2: Carry out a review of existing laws and treaties

All the focal countries have enacted some laws or adopted policies related to protecting coastal and marine resources, DRR and CCA. It is essential that a coastal manager know all the laws, their synergies and contradictions, and their ambit in his or her target area. Although it is beyond the purview of a coastal manager

working in the field to change legislation or carry out a review of existing laws, it is in the manager's best interests to know the following:

- The complete suite of laws that is relevant to the specific locale, including laws related to development activities such as tourism;
- The basic objectives of these laws and their scope (i.e., what does the law do and where does it apply);
- Who implements each law? Which is the primary organization that implements the law?
- Which actions are allowed and which actions are prohibited under each law?
- Are there synergies between/among clauses/articles in laws? Where are they?
- Are there conflicts between/among clauses/articles in laws? In this case, which is the law that takes precedence? Which is the organization that therefore has control?

#### **Box 8.4. The Hyogo Framework for Action (HFA): The international framework for DRR**

The Hyogo Framework for Action (HFA) is referred to as the international blueprint for DRR (<http://www.unisdr.org/>). "The HFA is a 10-year plan to make the world safer from natural hazards." It was adopted by 168 member states of the United Nations in 2005 at the World Disaster Reduction Conference, in Kobe, Hyogo (Japan).

"The Hyogo Framework for Action (HFA) is the key instrument for implementing disaster risk reduction, adopted by the Member States of the United Nations. Its overarching goal is to build resilience of nations and communities to disasters, by achieving substantive reduction of disaster losses by 2015—in lives, and in the social, economic, and environmental assets of communities and countries. The HFA offers five areas of priorities for action, guiding principles and practical means for achieving disaster resilience for vulnerable communities in the context of sustainable development" (<http://www.unisdr.org/>).

These five priorities are:

- Priority Action 1: Ensure that DRR is a national and a local priority with a strong institutional basis for implementation.
- Priority Action 2: Identify, assess and monitor disaster risks and enhance early warnings.
- Priority Action 3: Use knowledge, innovation and education to build a culture of safety and resilience at all levels.
- Priority Action 4: Reduce the underlying risk factors.
- Priority Action 5: Strengthen disaster preparedness for effective response at all levels.

Countries that have committed to this framework are obligated to take action on these priorities and submit their progress each year. National progress reports are available at <http://www.preventionweb.net/english/hyogo/progress/reports/?pid:222>. (See Annexure 1 for complete framework.)

#### **Box 8.5. The United Nations Framework Convention on Climate Change: The international framework for CCA**

For climate change, the international framework followed is the United Nations Framework Convention on Climate Change (UNFCCC), developed at the Earth Summit in Rio, in 1992 (see Annexure 2). The objective of the treaty was to stabilize GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. This treaty was legally

nonbinding as it did not set mandatory limits to GHG emissions and lacks enforcement mechanisms. Instead, it provided for updates—called protocols—that would set these limits.

By 1995, the Kyoto Protocol was adopted. The Kyoto Protocol legally binds developed countries to emission reduction targets. The Protocol’s first commitment period started in 2008 and ends in 2012. It also introduced Kyoto mechanisms such as emissions’ trading, clean development mechanisms and joint implementation. Successive conferences of parties (COP) were held without much agreement until COP 13 was held in Bali, Indonesia. This COP succeeded in developing an agreement on a timeline and negotiation on the post-Kyoto period through the adoption of the Bali Action Plan ([http://unfccc.int/essential\\_background/items/6031.php](http://unfccc.int/essential_background/items/6031.php)).

Also developed under the UNFCCC were national adaptation programmes of action (NAPAs). These NAPAs provide a “process for Least Developed Countries (LDCs) to identify priority activities that respond to their urgent and immediate needs to adapt to climate change — those for which further delay would increase vulnerability and/or costs at a later stage” ([http://unfccc.int/national\\_reports/napa/items/2719.php](http://unfccc.int/national_reports/napa/items/2719.php)).

A summary of laws, policies and status of international treaties in the focus countries is provided in the following.

**Table 8.1. Laws, policies and international treaties related to protecting coastal and marine resources, DRR and CCA in the focal countries**

Country	Ecosystem management-related laws	Policies and strategies related to environmental conservation	HFA	UNFCCC/NAPA
Bangladesh	4	<ul style="list-style-type: none"> <li>Several, including the Coastal Zone Policy (2005) and National Conservation Strategy (1991)</li> </ul>	<ul style="list-style-type: none"> <li>Hyogo adopted;</li> <li>A national disaster management act is being formulated.</li> </ul>	<ul style="list-style-type: none"> <li>Ratified in 1994;</li> <li>NAP in place by 2005;</li> <li>Proactively implementing CCA programmes.</li> </ul>
India	6	<ul style="list-style-type: none"> <li>Several, including the National Environmental Policy (2006)</li> </ul>	<ul style="list-style-type: none"> <li>Hyogo adopted;</li> <li>Disaster Management Act, enacted in 2005.</li> </ul>	<ul style="list-style-type: none"> <li>Ratified in 1993;</li> <li>National Action Plan on Climate Change released in 2008.</li> </ul>
The Maldives	2	<ul style="list-style-type: none"> <li>Several, including the National Framework for Development (2009–2013)</li> </ul>	<ul style="list-style-type: none"> <li>Hyogo adopted;</li> <li>Disaster Management Act, enacted in 2006.</li> </ul>	<ul style="list-style-type: none"> <li>Ratified in 1992;</li> <li>NAPA in place by 2006.</li> </ul>
Pakistan	9 (some provincial)	<ul style="list-style-type: none"> <li>Several, including the National Environmental Policy (2005)</li> </ul>	<ul style="list-style-type: none"> <li>Hyogo adopted;</li> <li>Disaster Management Act, enacted in 2010.</li> </ul>	<ul style="list-style-type: none"> <li>Ratified in 1994;</li> <li>No specific policy or programme for CCA.</li> </ul>

Country	Ecosystem management-related laws	Policies and strategies related to environmental conservation	HFA	UNFCCC/NAPA
Sri Lanka	7	<ul style="list-style-type: none"> <li>Several, including a third-generation Coastal Management Plan (CCD, 2004)</li> </ul>	<ul style="list-style-type: none"> <li>Hyogo adopted;</li> <li>Disaster Management Act, enacted in 2005.</li> </ul>	<ul style="list-style-type: none"> <li>Ratified in 1993;</li> <li>The National Climate Change Adaptation Strategy (NCCAS) released in 2010.</li> </ul>

Source: UNISDR, 2012

The implementation of these instruments is a mixed bag. While there is good progress in certain areas, by and large, there is a lot more to do for the better enforcement implementation of laws and policies. Further, some of the legal instruments are highly sectoral in their approach and sometimes contradictory to the objectives of other sectors. There is a critical need to review these laws with the objective of long-term sustainable use of natural resources, driven by a precautionary approach and maintenance of ecosystems (BOBLME, 2010).

Institutional mapping is an exercise that allows the coastal manager to identify all key players, the laws that govern interactions among these players and their functional relationships (McFadden et al., 2010).

## 2. Forge partnerships

Even after coastal and marine managers have appraised risks, hazards, and vulnerabilities of biodiversity and ecosystems, they may not always have the financial or technical resources to undertake the DRR and CCA components of their programmes. To achieve complete integration, coastal managers need to establish and forge partnerships with relevant organizations to strengthen their DRR and CCA programming. Conversely, DRR- and CCA-focused organizations need to build partnerships with environmental organizations.

### Checklist 2. Checklist for institutional strengthening

Check		Strengthening coordination	Specifics	Brief description
	<b>1. Carry out institutional mapping</b>		Institutional mapping is an exercise that allows the coastal manager to identify all key players, the laws that govern interactions among these players and their functional relationships.	
<input type="checkbox"/>	Step 1	Carry out organizational mapping.	It is normal for the region to have a multiplicity of organizations—sometimes with overlapping mandates, at other times with conflicting responsibilities—that have important roles to play in coastal management.	It is important for a coastal manager to know the entire gamut of stakeholders: (a) Which organizations (governmental, non-governmental and community-based) are involved in addressing key issues and problems related to climate change? (b) What do they do? What is their mandate? (c) What are their functional and geographical boundaries? (d) How do they interact with communities? (e) How do they interact with other each other? (f) Where are the overlaps with other organizations? (g) Where are the gaps in capacity? (h) How might some organizations impede the work of others? (i) What are the strengths and weaknesses of the institutions? (j) What is the institution's level of influence over planning and implementation of adaptation?

Check		Strengthening coordination	Specifics	Brief description
☐	Step 2	Carry out a review of existing laws and treaties.	It is essential that a coastal manager know all the laws, their synergies and contradictions, and their ambit in his or her target area.	<p>Although it is beyond the purview of a coastal manager in the field to change legislation or carry out a review of existing laws, it is in the manager's best interests to know the following:</p> <ul style="list-style-type: none"> <li>• The complete suite of laws that is relevant to the specific locale; including laws related to development activities such as tourism;</li> <li>• The basic objectives of these laws and their scope (i.e., what does the law do and where does it apply);</li> <li>• Who implements each law? Which is the primary organization that implements the law?</li> <li>• Which actions are allowed and which actions are prohibited under each law?</li> <li>• Are there synergies between/among clauses/articles in laws? Where are they?</li> <li>• Are there conflicts between/among clauses/articles in laws? In this case, which is the law that takes precedence? Which is the organization that therefore has control?</li> </ul>
☐	2. Forge partnerships		To achieve complete integration, coastal managers need to establish and forge partnerships with relevant mainstream organizations to strengthen their DRR and CCA programming. Conversely, DRR- and CCA-focused organizations must build partnerships with environmental organizations.	



## 9. Improving Coordination

There are competing needs from different organizations for the coastal zone of South Asia. For example, often the tourism sector and the conservation sector vie for different uses of the same space in coastal areas.

Because of these conflicting aspirations, as well as existing contradictions in mandates (see Chapter 8), there is usually a plethora of organizations and a range of different stakeholders involved in coastal management, each with its own vision and objectives.

Further, there are decentralized governments—national, state/provincial and local—with complex, sometimes overlapping and mostly uncoordinated functions (BOBLME, 2010).

Community participation in decision making and planning is, in general, weak across the focus region.

Therefore, there are weak linkages top-down and bottom-up, as well as laterally. This invariably leads to conflict and confusion among organizations (BOBLME, 2010) and near nonexistent coordination.

**The need for coordination between agencies was identified repeatedly at the regional workshop held in Delhi, on 6 and 7 March 2012.**

Coordination gaps identified at the above workshop included the lack of:

1. A mechanism for ensuring coordination among all coastal stakeholders;
2. A common action plan and strategy used by DRR, CCA and ecosystem managers that has shared and individual responsibilities and may be implemented in a phased manner; and
3. Environmental management plans (that include DRR and CCA) in development sectors (for example, tourism).

### **Step 1: Develop a mechanism for ensuring coordination among all coastal stakeholders**

A coastal manager should be aware of the array of stakeholders involved in coastal management/resource use in coastal areas in the sphere of his or her influence. He or she should also be cognizant of the relevant laws and their strengths and weaknesses. In addition, a coastal manager also needs to be conscious of the following:

- There is little or no understanding of the linkages between the inland actions and coastal impacts;
- Linkages between the management of landscapes and seascapes need to be established;
- There are conflicts between coastal agriculture/aquaculture and coastal fisheries, and these need to be resolved; and
- There are transboundary issues that transcend the ambit of national governments, which need to be addressed at a regional level.

The next step, therefore, is to ensure that there is coordinated action among this range of players and the issues that exist at the ground level.

The primary need in relation to the current lack of coordination is to develop a mechanism that will allow such coordination. There are a few examples (given below) where a mechanism has been forged, fostered and has become routine. However, such a mechanism will always be site- and situation-specific, and this listing must not be read as prescriptive.

However, the following principles should be followed as appropriate:

- The best rule-of-thumb is to use an existing structure within each context. Government officials spend a lot of time at meetings and are leery of further committees and meetings;
- An alternate approach is to forge a new structure, such as a trust, as seen in Case Study 9.2. This must remain the exception rather than the norm as the establishment of new government structures is not easy to achieve in the focus region;
- Ensure that the approach is holistic, not sectoral;
- Ensure that a multi-stakeholder platform (MSP) is established that includes government officials from relevant organizations as well as representatives of local communities.
- Ensure that this multi-stakeholder platform is chaired by the highest government official in the area—such as a district secretary (in Sri Lanka) or the District Collector (in India)—to ensure participation from government officials.

#### **Case Study 9.1. Multi-stakeholder platforms in Sri Lanka**

The coastal belt of Amparai District, on the east coast of Sri Lanka, has a diverse range of ecosystems including dry mixed evergreen forests, riverine forests, grasslands, streams and rivers, reservoirs and ponds, mangrove habitats, sand dunes, beaches and lagoons. Among the lagoons is Periyakalapu Lagoon, meaning 'big lagoon' in Tamil, where most of the area's fishing is done. About 2,000 fishers—more than the carrying capacity of the lagoon—fish in this lagoon, resulting in overexploitation of fishery resources.

Under an IUCN project funded by the Canadian International Development Agency (CIDA) to carry out post-tsunami restoration in Amparai District, a multi-stakeholder platform was established in Periyakalapu. This MSP is chaired by the district secretary and has, since its establishment, been responsible for averting some damaging development projects in the region.

In 2009, Peryakalapu Lagoon was declared a fisheries management area, and this promulgation provides the basis for sustainable use of the lagoon as well as stakeholder participation in resource management.

Source: IUCN, 2011

### Case Study 9.2. The Gulf of Mannar Biosphere Trust

The Gulf of Mannar lies between the southeastern tip of India (in the state of Tamil Nadu) and the northwestern coast of Sri Lanka. Between India and Sri Lanka lies a chain of limestone islands (Adam's Bridge), which are covered with sand, as well as sand islands, stretching from India's Rameshwaram Island to Sri Lanka's Mannar Island. The Gulf of Mannar is known as an area of considerable biological significance—in fact, one of the richest coastal areas of India—harbouring some 3,600 plant and animal species, as well as sizeable mangrove forests, coral reefs and seagrass meadows.

Because of this, the Indian Government declared the area a protected area. The protected area is a national park with a core area of a biosphere reserve called the Gulf of Mannar Biosphere Reserve (GOMBR), extending over 10,500 square kilometres.

Under the aegis of the Global Environment Facility (GEF) and UNDP, a project on "Conservation and Sustainable Use of Gulf of Mannar Biosphere Reserve's Coastal Biodiversity" was commenced in 2002 to conserve and sustainably use the resources of the GOMBR through effective participatory management and to develop socially acceptable sustainable livelihoods.

A trust—the Gulf of Mannar Biosphere Reserve Trust (GOMBRT)—was established as an independent governmental statutory body to ensure holistic implementation of proposed activities and to function as a flexible, transparent system to deliver integrated coastal development in the reserve.

Source: <http://www.gombrt.org/gombrt/why-trust.html>

### Case Study 9.3. Co-management as a mechanism to improve coordination

"Co-management of fisheries is defined as a partnership arrangement in which government, the community of local fishery resource users, external agents (NGOs, researchers, academics) and other coastal resource stakeholders (boat owners, fish traders, tourism interests, etc.) share the responsibility and authority for decision-making (governance) in the management of a fishery" (IDRC, 2001; Samarakoon et al., 2011).

The estuarine stake-net fishery in Negombo Lagoon, in northwestern Sri Lanka, is a good example of co-management. This is mainly a shrimp fishery conducted by some 285 fishers, all members of fisheries societies.

All decisions regarding fisheries are "based on democratic principles in keeping with a code of conduct guided by a set of rules" (Samarakoon, et al., 2011). This area has been designated as a fisheries management area, and the management embodies all the characteristics required for co-management: rules and enforced penalties; equitable benefit sharing; limitation of access; and free-rider elimination (Samarakoon, et al., 2011).

Source: Samarakoon et al., 2011

## **Step 2: Develop a common action plan and strategy to be used by DRR, CCA and ecosystem managers with shared and individual responsibilities**

Usually coastal managers operate through a management plan that has been formulated. Often, these plans are narrow in their focus and sectoral in their approach. For example, wildlife managers may have management plans for national parks, forest officers may have plans for forest reserves and a tourism department may have its own implementation programmes set up.

If a coordination mechanism—as described above—is established and maintained properly, then an integrated planning model and process can be adopted. Figure 9.1 shows a model for a non-integrated approach, and the next figure, Figure 9.2 presents a model for an integrated approach:

## **Step 3: Integrate environmental management plans that include DRR and CCA into development sectors (for example, tourism)**

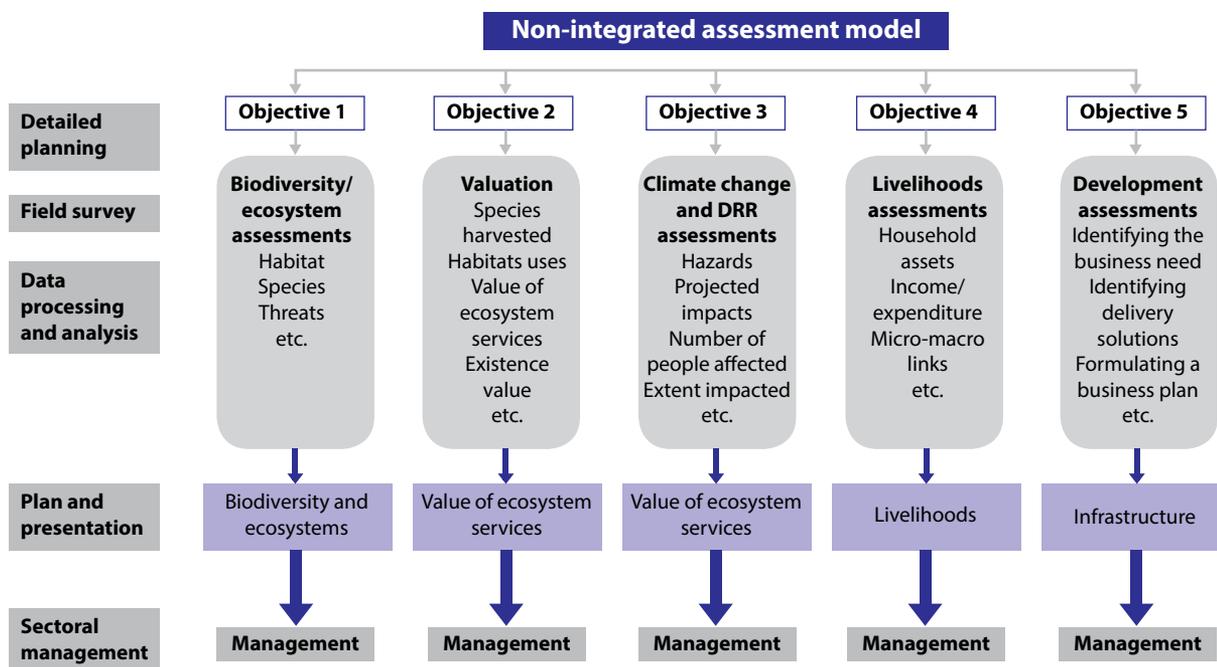
When a coordination mechanism is established, then integrated management becomes easier. It is then possible to influence and assist sectors that would normally be viewed as largely incompatible with ecosystem management.

For example, green building practices can be introduced when tourism infrastructure is needed. These practices could include the following:

- Ensuring that the building blends into the habitat;
- Ensuring that the siting of the building takes into account
  - cooling measures (not artificial cooling but natural ventilation);
  - flood prevention measures;
  - measures to deal with drought and water shortages;
  - measures to avoid high winds;
- Ensuring that buildings are energy-efficient and minimize the use of fossil-based energy;
  - wherever possible, introducing alternate energy such as solar, hydro or wind power to generate electricity;
- Minimizing water consumption (recycling waste and grey water; using water-saving cisterns, low-flow shower heads);
- Minimizing solid waste generation (using recycled materials as much as possible, providing waste separation facilities, providing composting facilities);
- Ensuring proper indoor air quality:
  - During construction, choosing paints and furnishes with zero or low volatile organic chemical (VOC) emissions;
  - Preventing the accumulation of dampness, which leads to fungal and microbial growth;
- Preventing chemical pollution by using water-based, non-toxic paints;
- Using environmentally friendly materials. For example, using only wood that has been recycled (i.e., old door and window frames) or wood from sustainably managed plantation forests;
- Mitigating the effects of climate change by purchasing materials locally (Miththapala, 2011).

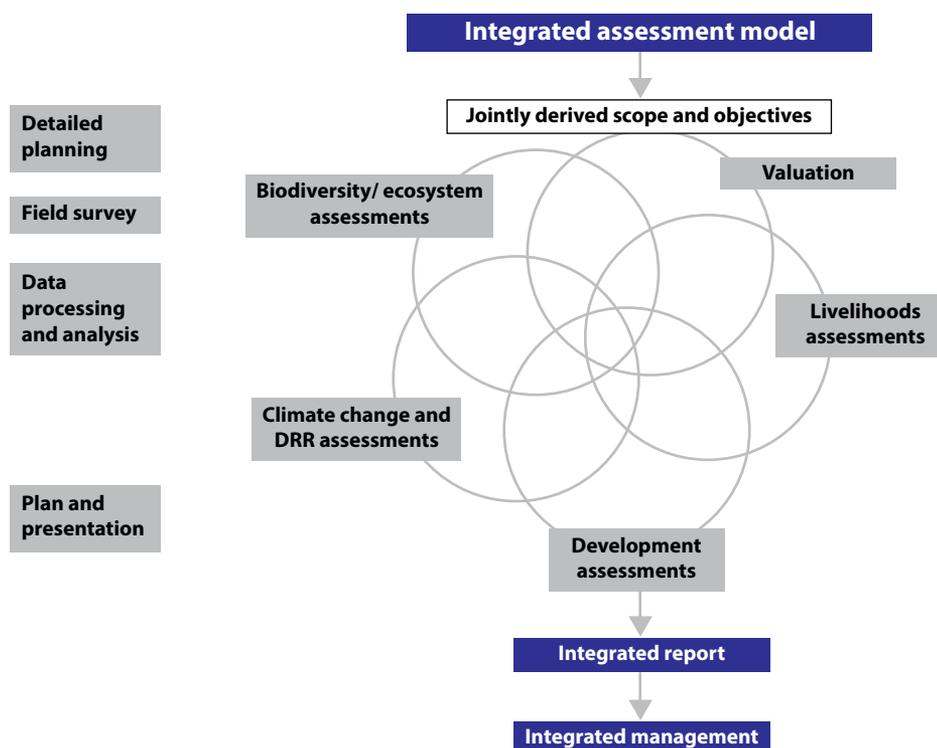
Disaster management centres or departments can provide tourism developers with hazard maps so that the developer is forced to take possible changes into account when building.

Figure 9.1. A diagram of a non-integrated model



Source: Adapted from Springate-Baginski et al., 2009

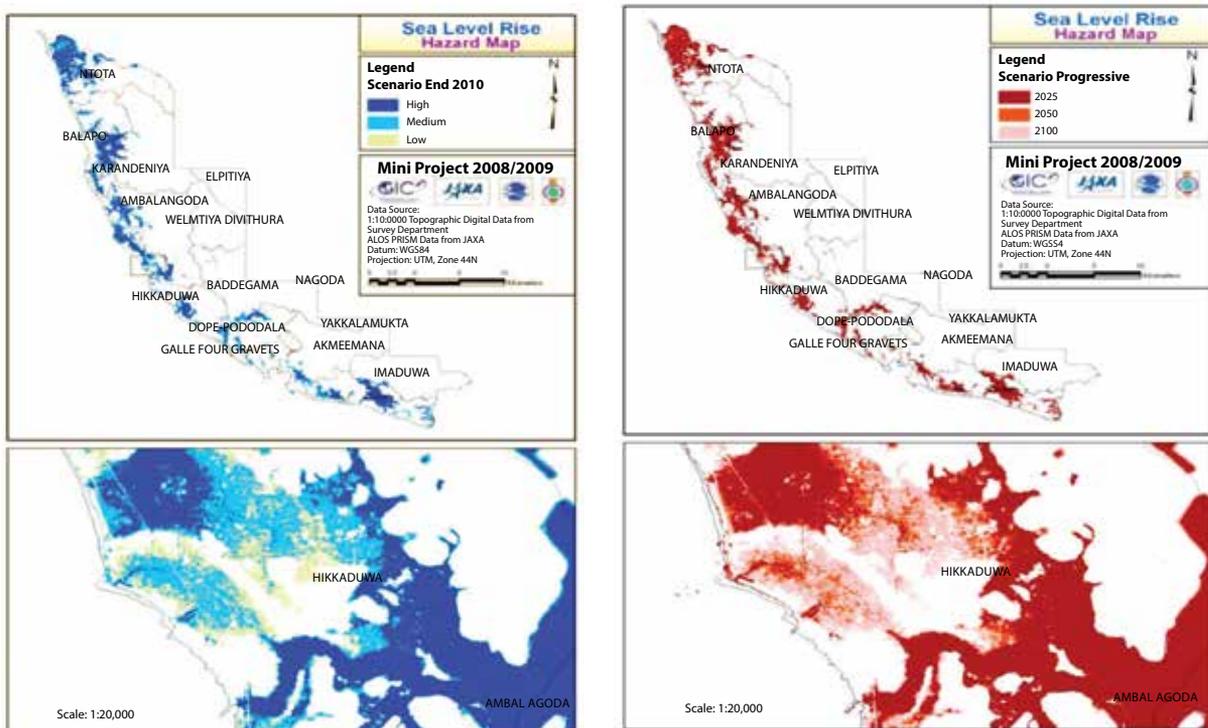
Figure 9.2. Integrated assessment model



Source: Adapted from Springate-Baginski et al., 2009



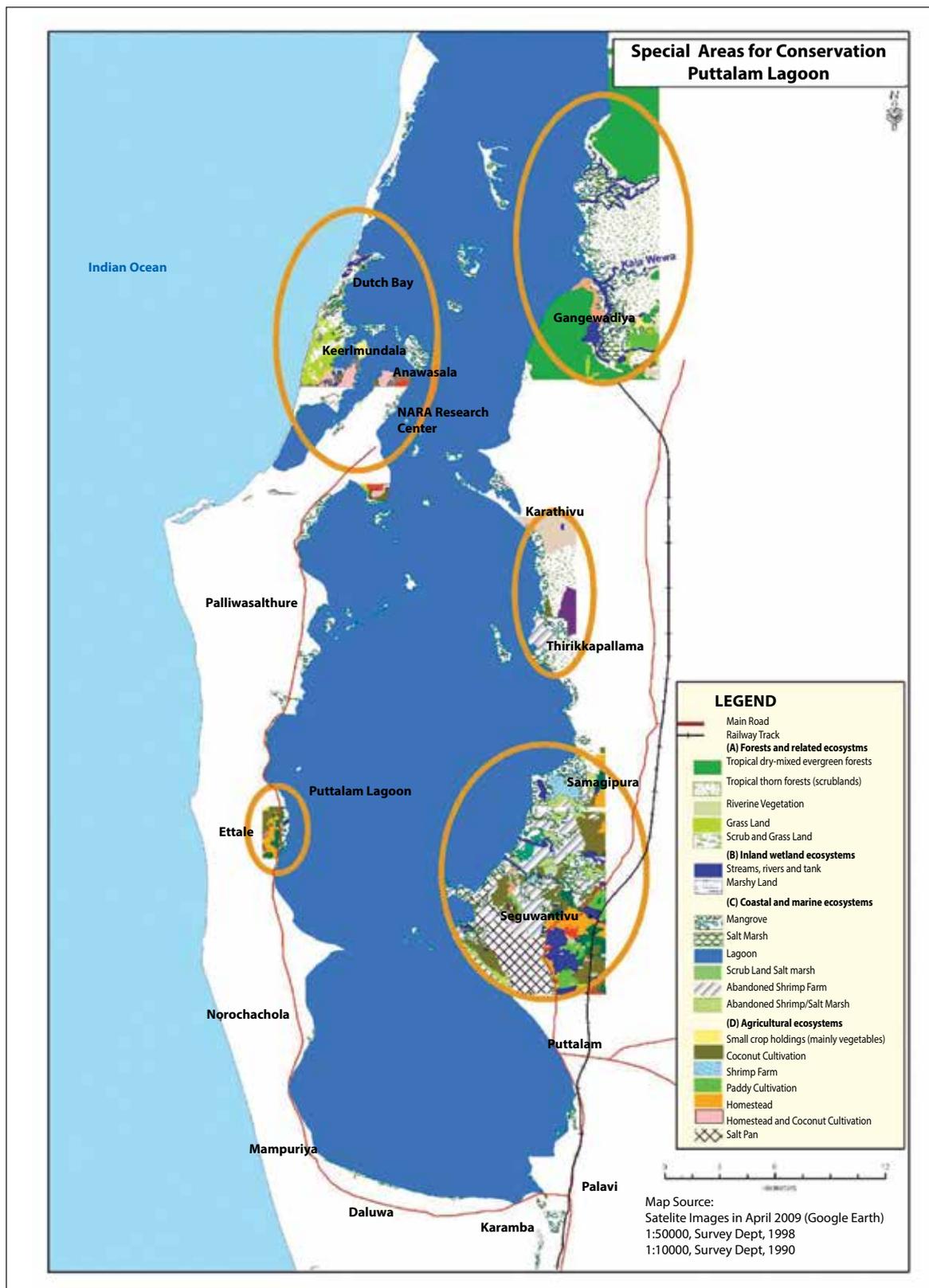
**Figure 9.3. Hazard maps for southern Sri Lanka, provided to developers by the Coast Conservation and Coastal Management Department**



Source: Amil Premeratne, personal communication

Similarly, coastal managers can highlight ecologically sensitive areas so that use conflicts are highlighted.

**Figure 9.4. Ecologically sensitive areas in Puttalam Lagoon, northwestern Sri Lanka**



Source: IUCN, 2011

**Checklist 3. Checklist for strengthening coordination**

	<b>Strengthening coordination</b>	<b>Specifics</b>	<b>Brief description</b>
Step 1	Develop a mechanism for ensuring coordination among all coastal stakeholders	A mechanism must be forged, fostered and made routine. However, such a mechanism will always be site- and situation-specific.	<ul style="list-style-type: none"> <li>• The best rule-of-thumb is to use an existing structure within each context. Government officials spend a lot of time at meetings and are leery of further committees and meetings;</li> <li>• An alternate approach is to forge a new structure, such as a trust, as seen in Case Study 9.2. This must remain the exception rather than the norm as the establishment of new government structures is not easy to achieve in the focus region;</li> <li>• Ensure that the approach is holistic, not sectoral;</li> <li>• Ensure that a multi-stakeholder platform (MSP) is established that includes government officials from relevant organizations as well as representatives of local communities.</li> <li>• Ensure that this multi-stakeholder platform is chaired by the highest government official in the area—such as a district secretary (in Sri Lanka) or the district controller (in India)—to ensure participation from government officials.</li> </ul>
Step 2	Develop a common action plan and strategy to be used by DRR, CCA and ecosystem managers with shared and individual responsibilities	An integrated approach to planning is needed.	An integrated model for planning and strategy will have a jointly derived scope and objectives, joint planning and a joint plan of action.
Step 3	Integrate environmental management plans that include DRR and CCA into development sectors (for example, tourism)	When a coordination mechanism is established, integrated management becomes easier. It is then possible to influence and assist sectors that would normally be viewed as largely incompatible with ecosystem management.	<p>For example, green building practices can be introduced when tourism infrastructure is needed.</p> <p>Disaster management centres or departments can provide tourism developers with hazard maps so that the developer is forced to build taking possible changes into account.</p> <p>Ecosystem managers can highlight ecologically sensitive areas, so that use conflicts are highlighted.</p>



## 10. Strengthening Capacity

Since the Indian Ocean tsunami of 2004, there has been a dramatic increase of technical capacity in the region, for disaster risk reduction and climate change adaptation. However, this capacity is not necessarily available to coastal managers. In addition, the capacities of local communities, as well as national planners, need to be strengthened.

Capacity gaps identified at the workshop of experts included the lack of:

- An understanding of DRR and CCA by the different stakeholders;
- Awareness of the importance of ecosystems in mitigating the impacts of natural hazards and the long-term effects of climate change; and
- Awareness among policy makers, planners and administrators (including politicians) about the linkages among DRR, CCA and ecosystem management.

### Gap 1. Lack of understanding of DRR and CCA by the different stakeholders

#### Step 1. Improve the capacity of coastal managers for DRR and CCA

A wealth of information is available on the Internet for coastal managers to improve their knowledge and skills relating to DRR and CCA. Given below is a selection of these websites. A list of resource websites has also been presented in Chapter 7.

- PreventionWeb has a series of educational materials as well as publications to improve capacity (<http://www.preventionweb.net/english/professional/trainings-events/edu-materials/>).
- The Asian Disaster Preparedness Centre (ADPC) has a regional training manual on DRR for coastal managers ([http://www.mangrovesforthefuture.org/Assets/documents/DRR\\_coastal%20zone%20managers\\_reg\\_manual.pdf](http://www.mangrovesforthefuture.org/Assets/documents/DRR_coastal%20zone%20managers_reg_manual.pdf)).
- Country training manuals are also available for certain countries ([http://www.unep.org/dnc/portals/155/dnc/docs/drr\\_training/Sri\\_Lanka\\_Training\\_Manual.pdf](http://www.unep.org/dnc/portals/155/dnc/docs/drr_training/Sri_Lanka_Training_Manual.pdf)).
- IUCN has a three-volume manual for integrating environmental safeguards into disaster management ([http://www.iucn.org/about/union/secretariat/offices/asia/regional\\_activities/elg/mcp/oapn/knowledge\\_products/](http://www.iucn.org/about/union/secretariat/offices/asia/regional_activities/elg/mcp/oapn/knowledge_products/)).
- The CCA resource has an online training course on CCA (<http://www.climatechangeadaptation.info/training-resource/>).
- The adaptation learning mechanism is a knowledge-sharing platform (<http://www.adaptationlearning.net/>).
- The United Nations Institute for Training and Research (UNITAR) has training material for climate change vulnerability and adaptation <http://www.c3d-unitar.org/c3d/>).
- Eldis has an adaptation focus with some DRR, including linking climate adaptation and community-based adaptation exchange, as well as up-to-date resources and publications for researchers, with about 1,100 summarized documents [www.eldis.org/go/topics/resource-guides/climate-change](http://www.eldis.org/go/topics/resource-guides/climate-change).
- The World Bank Climate Change Portal has data for policymakers and development practitioners and includes a mapping visualization tool for climate variables and climate-related data [www.sdwebx.worldbank.org/climateportal](http://www.sdwebx.worldbank.org/climateportal).

## **Step 2. Improve the capacity of communities for DRR and CCA**

Communities are storehouses of traditional knowledge, but they need strengthening in terms of knowledge and action related to integrated coastal management, which includes DRR and CCA.

Before building the capacity of communities, it is necessary to map all stakeholders to identify not only the range but also the primary, secondary and key stakeholders.

### **1. Identify your stakeholders and categorize them**

- Stakeholders with regulatory functions:
  - Department of wildlife conservation/forest conservation;
  - Department of coast conservation;
  - The ministry/department of environment;
  - Department of fisheries;
  - Disaster management unit of the district/locality;
  - Climate change unit of the district/locality;
  - Police;
  - Navy; and
  - Coast Guard.
- Stakeholders with developmental functions:
  - Department of land use planning;
  - Urban planners; and
  - Department of tourism.
- Stakeholders with decision-making functions:
  - District governors (district secretary/district collector); and
  - Urban/rural councils.
- Stakeholders who are natural resource users:
  - Communities.

Also analyse by use and impact (extracted and modified from <http://www.cbd.int/cepa/toolkit/2008/doc/CBD-Toolkit-Section3.pdf>).

Primary stakeholders:

- Whose permission, approval or financial support is needed for coast conservation?
  - Local/district/state or province coastal conservation authority;
  - Ministry of environment;
  - Departments of wildlife/forests; and
  - Land use department.
- Who is directly affected by coast conservation?
  - Land owners and/or residents of the coast;
  - Tourism developers;
  - Other developer operators; and
  - Recreational and other users (divers, snorkellers, collectors).

Secondary stakeholders:

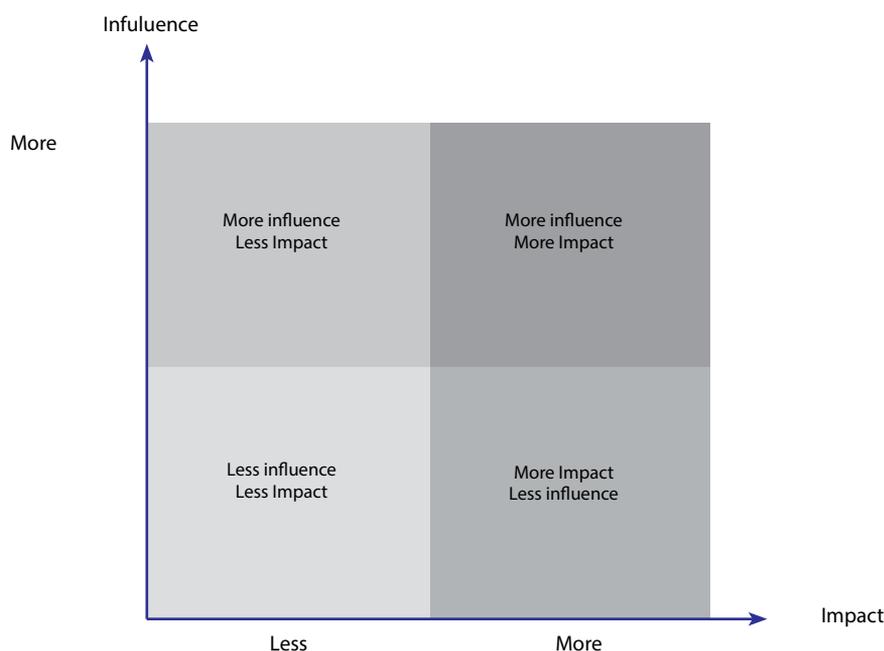
- Who is indirectly affected by coast conservation?
  - Local business;
  - Land owners and/or residents outside the protected area; and
  - Environmental NGOs.

Tertiary stakeholders:

- Who is not involved or affected by proposed actions but can influence opinions either for or against it?
  - Local opinion leaders (religious leaders, business or trade union leaders, teachers, local celebrities);
  - Local media;
  - Relevant departments of universities, research institutes; and
  - National media, through environmental inserts in newspapers or special programmes.

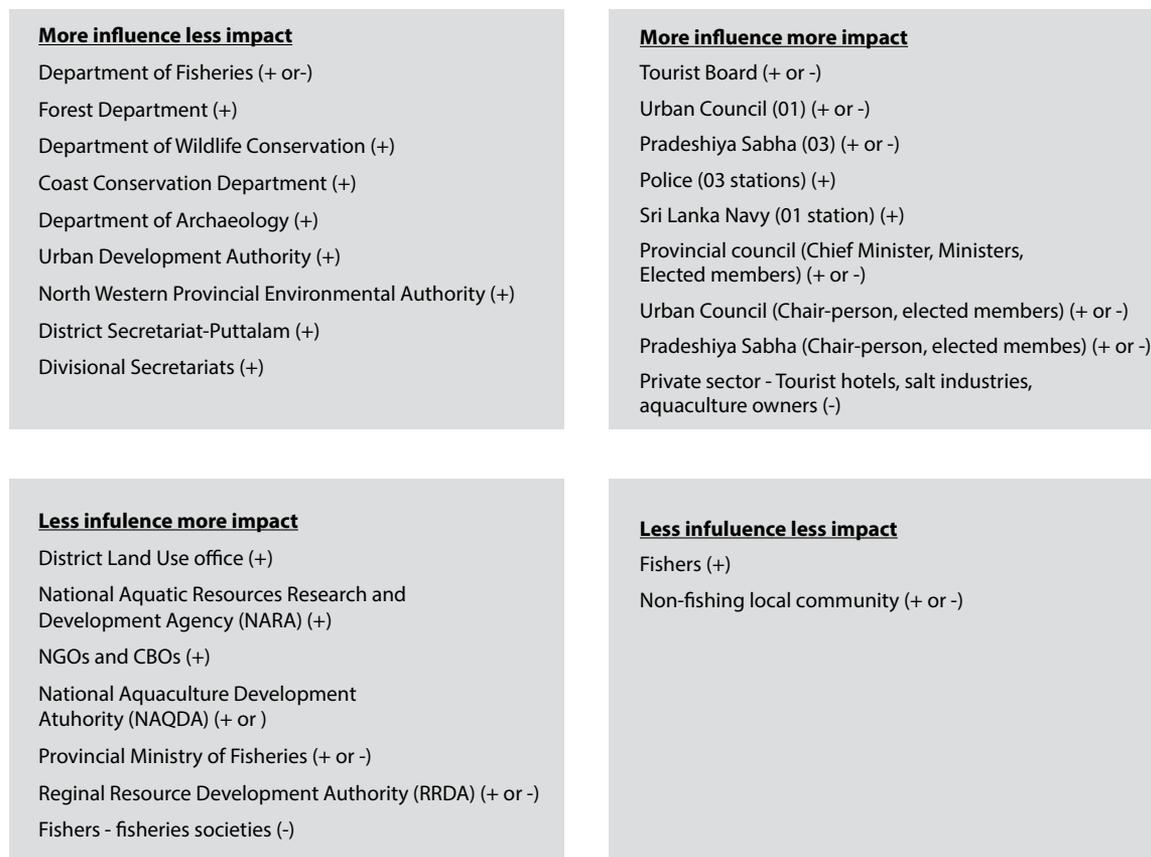
## 2. Analyse stakeholders by impact and influence

**Figure 10.1. Analyzing stakeholder impact and influence**



Source: adapted from [http://www.mindtools.com/pages/article/newPPM\\_07.htm](http://www.mindtools.com/pages/article/newPPM_07.htm)

**Figure 10.2. Influence and impact derived from stakeholder mapping in Puttalam Lagoon, Sri Lanka**



Source: IUCN, 2012

### 3. Understand stakeholders

Understanding stakeholders is an essential prerequisite for knowing how to improve their capacity:

- What is the best way of motivating them?
  - What information do they need? What depth is necessary to improve capacity?
- For example, to a politician eager for votes, the protection of a Critically Endangered mangrove plant may mean nothing, yet showing a link between the degradation of a mangrove forest and reduction in fish production would be very meaningful (IUCN, 2012).

For communities, warning alerts that give details of wind speeds and intensities of cyclones mean nothing, but indications of whether a cyclone will hit their village and when are more appropriate.

- What is the best way to communicate with them?

### Box 10.1. The importance of listening in communication

“Listening is key to [good] communication. Communication requires the person communicating the message to ‘listen’ to stakeholders.

This helps to explore and use opportunities to establish common ground and ‘find’ motives and reasons for stakeholders to change their policies and practices in a more nature friendly way. Often these motives and reasons may have little to do with biodiversity [and ecosystem] conservation per se.”

Source : <http://www.cbd.int/cepa/toolkit/2008/doc/CBD-Toolkit-Section3.pdf>

Currently, there is a plethora of communication tools available, and any of these tools may be used. Mobile phone text messages, television programmes and PowerPoint presentations are just a few examples of communication methods that can be used effectively with communities.

Giving a 30-page technical report to a decision maker is a futile exercise. The best approach would be advocacy-based: to collect, collate and paraphrase knowledge and information in effective packages directed at each sector in terms of how it would be affected and how it might integrate these issues into its planning and actions.

### Case Study 10.1. Using mobile phones to convey flood alerts to Bangladeshi villagers

Of the 150 million people who live in Bangladesh, more than 40 million are mobile phone subscribers. The government signed a deal with mobile phone operators to send instant alerts on cyclones or flood warnings to all subscribers.

## 4. Engage the stakeholders

Engaging stakeholders is a critical step in an ecosystem-based approach:

- Find the leaders in a community and involve them from the onset.
- Use formal and informal means of communication.
  - Formal methods include letters, speeches and minutes of meetings.
  - Informal methods include one-to-one discussions and focal group interviews (<http://www.cbd.int/cepa/toolkit/2008/doc/CBD-Toolkit-Section3.pdf>).
- Engage stakeholders directly in activities such as hazard mapping.

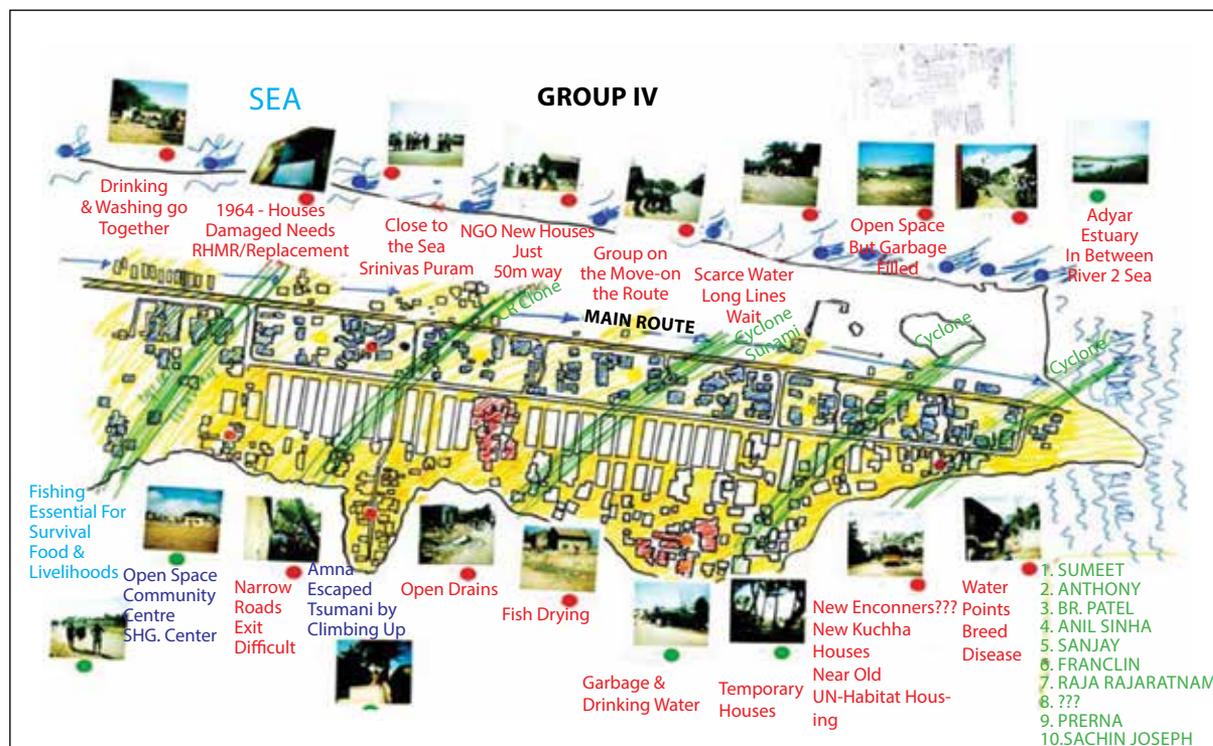
### Step 4. Improving the capacity of decision makers for DRR and CCA

This is likely to fall beyond the purview of a coastal manager, but it is good for a coastal manager to understand the need and extent to which decision makers must be ‘educated’.

Biologists often convene workshops for government officials. But before doing so, they need to ask:

- “Do decision makers have time for this?
- Do they feel the need and desire to be educated?
- Do they see the relevance of such workshops?
- Will such workshops even be counter-productive?” (<http://www.cbd.int/cepa/toolkit/2008/doc/CBD-Toolkit-Section3.pdf>).

**Figure 10.3. A hazard map drawn at a training-of-trainers programme in Chennai (India)**



Source: <http://www.adrc.asia/events/Chennai/Presentation/Final%20Report%20Tentative.pdf>

It is much more effective to understand their level of interest and formulate the message in terms that can best be understood by them (<http://www.cbd.int/cepa/toolkit/2008/doc/CBD-Toolkit-Section3.pdf>).

## Gap 2. Awareness of the importance of ecosystems in mitigating the impacts of natural hazards and the long-term effects of climate change

### Step 1. Improve the capacity of coastal managers in EbA

Again, much information is available on the Internet for coastal managers to improve their knowledge and skills on ecosystem-based management. Although coastal managers routinely engage in ecosystem management, a new approach with a broader focus is needed for better, holistic management. The ecosystem approach integrates ecological, socio-economic and institutional perspectives in a collaboratively developed vision of desired future conditions with the ultimate goal of long-term sustainability (Meffe et al., 1997).

Given below is a selection of papers.

- Shepherd, Gill (2004). *The Ecosystem Approach: Five Steps to Implementation*. Gland, Switzerland and Cambridge, UK: IUCN. vi + 30 pp.
- Gupta, A., and S. Nair (2012). *Ecosystem Approach to Disaster Risk Reduction*. New Delhi: National Institute of Disaster Management. 202 pp. [http://www.gdnonline.org/resources/nidm\\_ecosystem\\_approach.pdf](http://www.gdnonline.org/resources/nidm_ecosystem_approach.pdf)
- The Partnership for Environment and Disaster Risk Reduction (PEDRR) is a global alliance of UN agencies, NGOs and specialist institutes, and their website has some resources. <http://www.pedrr.net/Resources.aspx>, [http://www.preventionweb.net/english/hyogo/gar/2011/en/bgdocs/PEDRR\\_2010.pdf](http://www.preventionweb.net/english/hyogo/gar/2011/en/bgdocs/PEDRR_2010.pdf)
- The Convention on Biological Diversity website has information about EbA. <http://www.cbd.int/ecosystem/>

## Step 2. Improve the capacity of communities for EbA

Communities have long practiced many principles of ecosystem-based management such as soil and water conservation practices, crop rotation and fallowing. In addition, as discussed in Chapter 7, they also practice weather-related traditional adaptation measures.

This knowledge can be harnessed and additional knowledge imparted to them by engaging the stakeholders as was done in the previous subsection.

An excellent resource for this is the chapter in the CBD toolkit titled How to Engage stakeholders and Mainstream Biodiversity <http://www.cbd.int/cepa/toolkit/2008/doc/CBD-Toolkit-Section3.pdf>.

## Gap 3. Awareness among policy makers, planners and administrators (including politicians) about the linkages among DRR, CCA and ecosystem management

The same questions as for Step 4 in the earlier subsection need to be asked.

Trying to make all politicians and decision makers understand the above linkages may be ineffective, and it is best to focus on how best to integrate these linkages into agendas. Formal and informal communication can be used for this, but the best means of getting a message across is to ensure that there is a benefit to the politicians. The actual monetary value of such integration should be conveyed.

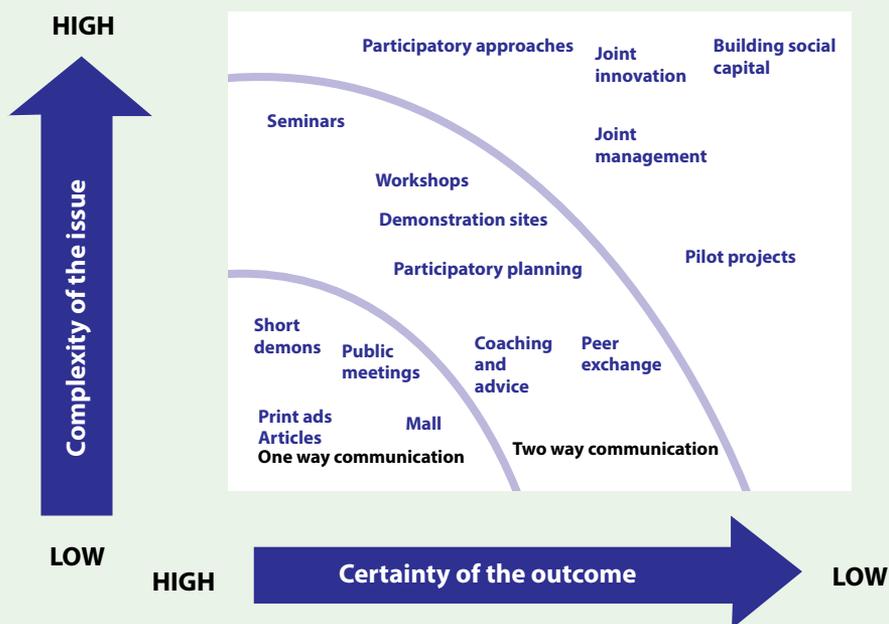
**Table 10.1. The monetary value of coastal ecosystem services**

Ecosystem service	Location	Value
Provisioning—food (fish)	Indus River Delta, Pakistan	The annual value of catch from mangrove-dependent fish species in the Indus Delta is estimated at around US\$20 million. Shrimps are also particularly important, with a domestic value of US\$70 million and an export value of about 1.5 times this figure, and the export of mud crabs contributes an additional US\$3 million to the regional economy (Ifthikar, 2002).
Provisioning—traditional use of mangrove products (for fodder)	Gujarat, India	The value of mangroves as fodder for the mangroves in Gujarat was estimated at US\$14.7 million per annum (Hirway and Goswamy, 2004).
Protection against storms	Hambantota, Sri Lanka	US\$2,196,000–9,884,000 per hectare coastal protection in three villages (Ranasinghe and Kallesoe, 2006).
Flood protection	Muthurajawela Marsh, Sri Lanka	US\$5,394,556 per year (US\$2,500 per hectare, Emerton and Kekulandala, 2002)
Water purification	Muthurajawela Marsh, Sri Lanka	US\$1,803,444 per year (Emerton and Kekulandala, 2002)
Recreation (coastal tourism)	The Maldives	Tourism produces 74 percent of the national income (Emerton, 2006).

Ecosystem service	Location	Value
Cost of damage to mangroves and their services (siltation and salinization)	Indus River Delta, Pakistan	Thirty thousand households incurred average annual losses of US\$70,000 in crop damage and US\$45,000 from reduction in fish catches as a result of saltwater intrusion (Iftikhar, 2002).
Total economic value of a lagoon	Rekawa Lagoon, Sri Lanka	A total economic value (TEV) assessment of the lagoon ecosystem found that it was US\$1,088 per hectare per year, or US\$217,600 per year, based on 200 hectares of mangrove. Forestry net benefits accounted for US\$4,800 per year, lagoon fisheries for US\$53,600 per year; coastal fisheries for US\$98,600 per year; erosion control and buffer against damage from storms for US\$60,000 per year; and existence, bequest and option values to local communities for US\$520 per year (Gunawardena and Rowan, 2005).
Carbon sequestration	Muthurajawela Marsh, Sri Lanka	Carbon sequestration accounted for US\$8,700 per year (Emerton and Kekulandala, 2002).

### Box 10.2. Selecting an approach for engaging stakeholders

Selecting an approach for engaging stakeholders is dependent on whether the issue to be discussed is complex or easy and whether the outcome is certain or uncertain.



Source: <http://www.cbd.int/cepa/toolkit/2008/doc/CBD-Toolkit-Section3.pdf>

## Checklist 4. Checklist for strengthening capacity

Check		Strengthening coordination	Specifics	Brief description
<b>Gap 1. Lack of understanding of DRR and CCA by the different stakeholders</b>				
<input type="checkbox"/>	Step 1	Improve the capacity of coastal managers	Coastal managers need to learn more about DRR and CCA	A wealth of information is available on the Internet for coastal managers to improve their knowledge and skills in relation to DRR and CCA.
<input type="checkbox"/>	Step 2	Improve the capacity of communities for DRR and CCA	Communities are storehouses of traditional knowledge, but they need strengthening in terms of knowledge and action related to integrated coastal management, which includes DRR and CCA.	
<input type="checkbox"/>		Identify your stakeholders and categorize them	Categorize by function or whether primary, secondary or peripheral	Identify stakeholders with regulatory functions; stakeholders with developmental functions; stakeholders with decision-making functions; stakeholders who are natural resource users Or Primary stakeholders (whose permission, approval or financial support is needed for coast conservation or are directly affected by coast conservation); Secondary stakeholders (indirectly affected by coast conservation); and Tertiary stakeholders (not involved or affected by proposed actions but capable of influencing opinions for or against it)
		Analyse stakeholders by impact and influence	Identify who has the most impact Who has the most influence	The end categories will be those with more impact, more influence those with more impact, less influence those with more influence, less impact those with less influence, less impact
<input type="checkbox"/>		Understand stakeholders	Understanding stakeholders is an essential prerequisite for knowing how to improve their capacity	Identify The best way of motivating them What information do they need? What depth is necessary to improve capacity? What is the best way of communicating with them?
<input type="checkbox"/>		Engage the stakeholders	Engaging stakeholders is a critical step in an ecosystem-based approach	Find the leaders in a community and involve them from the onset. Use formal and informal means of communication. Engage stakeholders directly in activities such as hazard mapping.

Check		Strengthening coordination	Specifics	Brief description
<input type="checkbox"/>	Step 3	Improving the capacity of decision makers for DRR and CCA	It is good for a coastal manager to understand the need and extent to which decision-makers must be 'educated'	The most effective way is to understand their level of interest and formulate the message in terms that can best be understood by them.
<b>Gap 2. Awareness of the importance of ecosystems in mitigating the impacts of natural hazards and the long-term effects of climate change</b>				
<input type="checkbox"/>	Step 1	Improve the capacity of coastal managers in EbA	The ecosystem approach integrates ecological, socio-economic and institutional perspectives in a collaboratively developed vision of desired future conditions with the ultimate goal of long-term sustainability	There is a wealth of information on the Internet on EbA.
<input type="checkbox"/>	Step 2	Improve the capacity of communities for EbA	Communities have practiced for long many principles of ecosystem-based management	This knowledge can be harnessed and additional knowledge imparted to them, by engaging the stakeholders as was done in the previous subsection.
<b>Gap 3. Awareness among policy makers, planners and administrators (including politicians) about the linkages among DRR, CCA and ecosystem management.</b>				
<input type="checkbox"/>			The best means of getting a message across to ensure that there is a benefit to the politician.	Using the monetary value of ecosystem services is a good way of doing so.



## 11. Improving the Management of Coastal Areas

The previous chapters showed the need for better knowledge management, obtaining a clear understanding of the existing framework of governance, increasing technical capacity in a range of stakeholders and improving coordination.

Improving management involves combining all the above.

### **Step 1: Ensure that management plans have DRR and CCA incorporated into them**

The Hyogo Framework for Action urges “encourage[ment of] the sustainable use and management of ecosystems, including through better land-use planning and development activities to reduce risk and vulnerabilities.” The HFA promotes “integrated environmental and natural resource management approaches that incorporate disaster risk reduction, including structural and non-structural measures, such as integrated flood management and appropriate management of fragile ecosystems” (<http://www.preventionweb.net/english/hyogo/gar/background-papers/documents/Chap5/thematic-progress-reviews/UNEP-Environmental-Management-for-DRR.pdf>).

The Stern Review on the Economics of Climate Change recommended that policies were developed for “climate sensitive public goods including natural resource protection, coastal protection and emergency preparedness” (Dudley et al., 2010).

Yet, current management plans for coastal managers lack references to DRR or CCA. Once knowledge, capacity and coordination are improved, then it will be possible to incorporate these elements into management plans.

## **Step 2: Involve communities in management**

Usually, the relationship between a government field officer (such as a wildlife or forest range officer) and a community is largely adversarial. When there is a shift from this attitude to include communities as essential participants in conservation —critical to an ecosystem-based approach —then management becomes easier. Engaging and involving communities, as discussed in the last chapter, yields its own dividends, when communities move from being users only to become protectors, enforcers and sustainable users.

### **Case Study 11.1. Maintaining a shelter belt as an adaptation strategy, Midnapur, West Bengal**

Since 2004, Midnapur District, in West Bengal, has been facing the impacts of severe cyclones. After Cyclone Aila of 2009, local communities supported planting a tree wall as an adaptation measure to withstand cyclones and violent storms. The community takes care of the plants and monitoring activities.

*Source: Krishnan and Soni, 2011*

### **Case Study 11.2. Awareness campaigns in the Gulf of Mannar Biosphere Reserve, Indian Ocean**

Activities such as mining, over-fishing, pollution and unsustainable coastal development activities have disturbed coral reefs in the Gulf of Mannar. Invasion of exotic seaweed, algal bloom, trap fishing, sewage disposal and seaweed collection have emerged as other major threats to biodiversity. A GEF-UNDP intervention in the region coordinates among different stakeholders and departments (such as the fisheries, agriculture, rural development, pollution control board, environment and forests, local communities, SHGs) to create joint conservation initiatives and enforcement mechanisms for the better management of the coastal region. Awareness campaigns conducted by the Gulf of Mannar Biosphere Reserve Trust (GoMBRT) have led to increased awareness of the significance of the coastal ecosystem. The projects initiatives have seen an increase in live coral cover from 37% to 43%, so far which have the potential of preventing salt water intrusion and impacts of flooding and cyclones.

*Source: Krishnan and Soni, 2011*

### **Case Study 11.3. Community-based socio-economic monitoring in the Lakshadweep Islands of India**

During the past decade, there has been a rapid change in the economy of these islands from a subsistence economy to a commercial one. Communities were engaged in 2001 and 2002 to monitor the coral reef resources of the islands, given the shift in economy. This has automatically raised awareness about the pressures on coral reef resources.

*Source: Hoon et al., 2008*

### Step 3: Promote climate-resilient livelihoods

It is important to incorporate CCA measures (that will also serve in DRR) at community levels, particularly for vulnerable households and individuals. These vulnerable households and people will have been identified through the vulnerability profile described in Chapter 7.

Such measures will include:

- Flood protection measures in flood-prone areas:
  - o houses built on raised platforms;
  - o floating houses;
  - o raised platforms for storage of valuables;
  - o floating platforms for livestock;
- Earthquake protection measures in earthquake-prone areas:
  - o reinforced buildings;
  - o flexible joints in buildings;
- Water conservation practices in drought-prone areas:
  - o Rainwater harvesting practices;
  - o drip/pot irrigation systems that do not waste water;
- Traditional agricultural methods:
  - o crop rotation;
  - o innovative practices such as floating plots in Bangladesh;
- Sustainable fisheries.

#### Case Study 11.4. Planting short-duration paddy in flood prone-areas of Uttar Pradesh, India

Oxfam, through its partner organizations, has introduced a short-duration paddy variety in the flood-prone areas of eastern Uttar Pradesh and Bihar. This paddy can be harvested before the monsoon sets in to avoid the risk of floods and to maximize returns to farmers on their investments. By harvesting paddy early, sowing a short-duration mustard and then sowing a variety of wheat, farmers are able to harvest three crops in two seasons.

*Source: Krishnan and Soni, 2011*

### Step 4: Know disaster response procedures for the locality

A coastal manager also needs to be aware of local emergency procedures.

These will include knowing:

- Where the official safe areas and temporary shelters are;
- Which is/are the designated route(s) to shelters;
- Who the important contacts are for an emergency; and
- Who the focal point is for disaster response in a community.

### Step 5: Ensuring better management of protected areas

A pervading problem in the focus region is weak enforcement of laws and inadequate implementation of management plans.

## **Know all the protected areas in the locality**

In many countries there are a range of protected areas under the jurisdiction of different departments or ministries, each with different objectives and restrictions. It is essential to know thoroughly these locations, objectives and restrictions.

For example, Bangladesh has national parks and wildlife sanctuaries defined by the Bangladesh Wildlife Preservation Act of 1974. Another type of protected area in Bangladesh is the 'ecologically critical area' (ECA), which is defined under the Environmental Conservation Act of 1995. There are also designated fishing zones and species-specific protection for certain fish species.

Sri Lanka has protected areas (ranging from national parks to strict nature reserves) declared under the Flora and Fauna Protection Ordinance of 1930, and its amendments, that fall under the jurisdiction of the Department of Wildlife Conservation. The Forest Department declares forest reserves, proposed forest reserves and conservation forests through the Forest Ordinance of 1907 and its amendments. The Central Environmental Authority can declare environmental protected areas through the National Environmental Act 47 of 1980 and its amendments. The Department of Fisheries, through the Fisheries and Aquatic Resources Act of 1996 and its amendments, declares fisheries management areas, which allow for joint management. The Coast Conservation Department, through the Coast Conservation Act of 1981 and its amendments, has the power to declare special area management (SAM) sites, which also promote sustainable use and joint management.

### **Box 11.1. Coastal and marine protected areas**

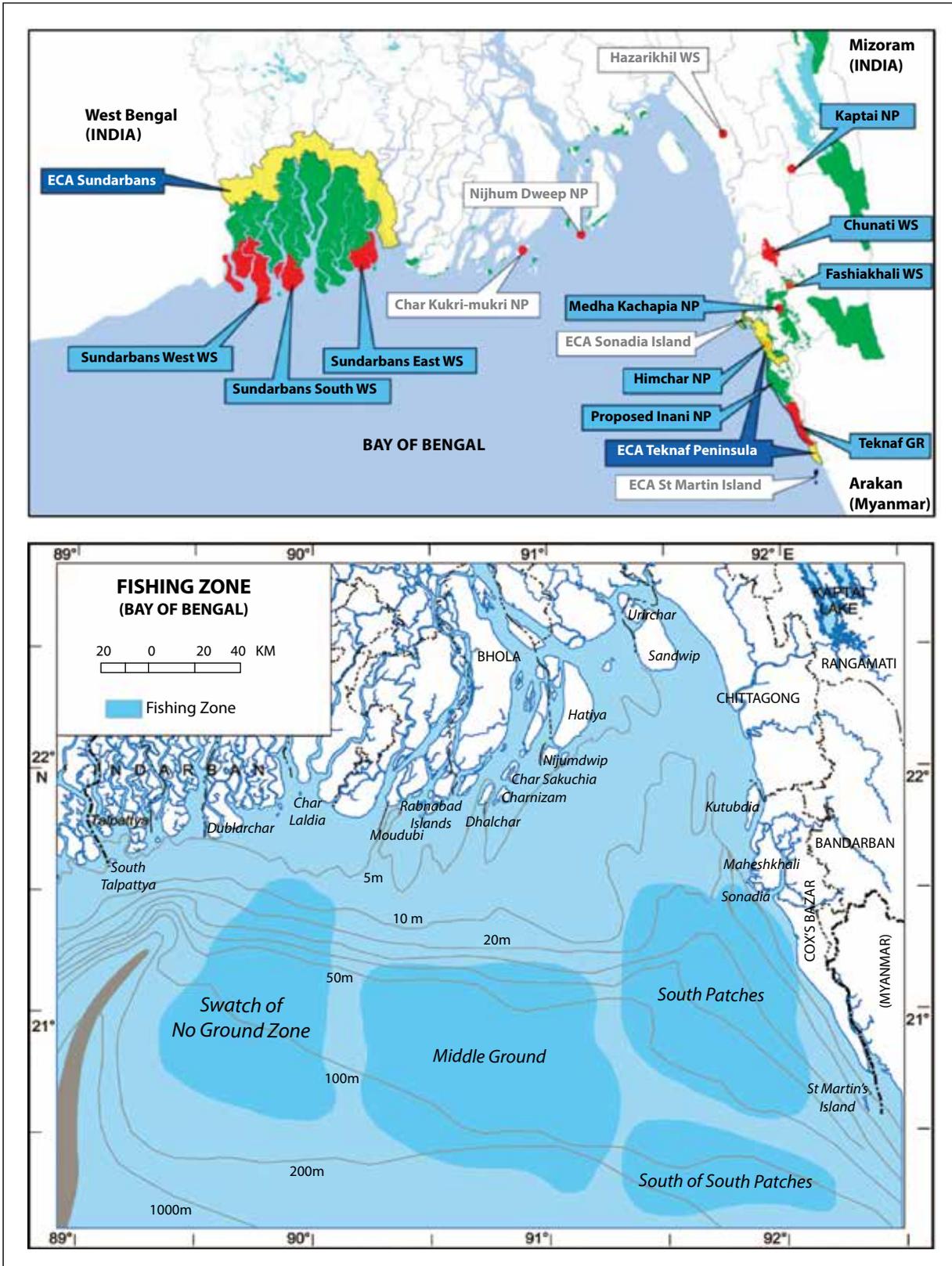
Marine and coastal protected areas (MCPAs) are an essential tool in the ecosystem approach.

The importance of protected areas as carbon sinks that combat the impacts of climate change has been highlighted recently (Dudley et al., 2010).

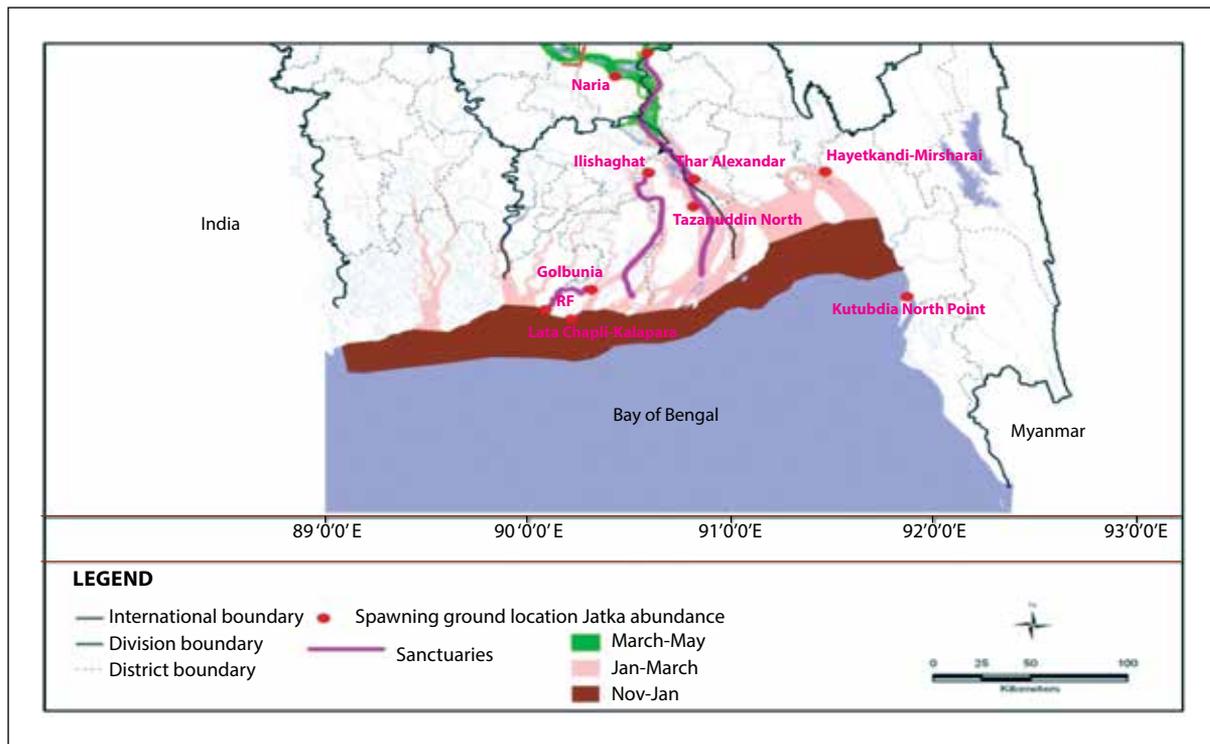
It is also known that protected areas have advantages over other approaches to CCA because of the following:

- They are legally defined entities whose boundaries are clearly marked and are supported by clearly defined legal frameworks.
- Because their boundaries are clearly known, it is possible to measure carbon storage capacities and determine the value of other ecosystem services.
- They are based on a commitment to long-term protection—usually backed by government commitments to international treaties such as the CBD and Ramsar.
- They are usually managed through formulation of management plans.
- They are supported by trained staff and equipment.
- They usually have long-term data sets which can be used to monitor changes.
- Many protected areas house Threatened species, which in turn could become affected by climate change.
- They provide a suite of ecosystem services such as flood attenuation, catchment protection and protection of commercially important natural resources (Dudley et al., 2010).

**Figure 11.1. Coastal protected areas of Bangladesh**  
 Top, coastal and marine PAs; middle, fishing zones; bottom, species-specific PA

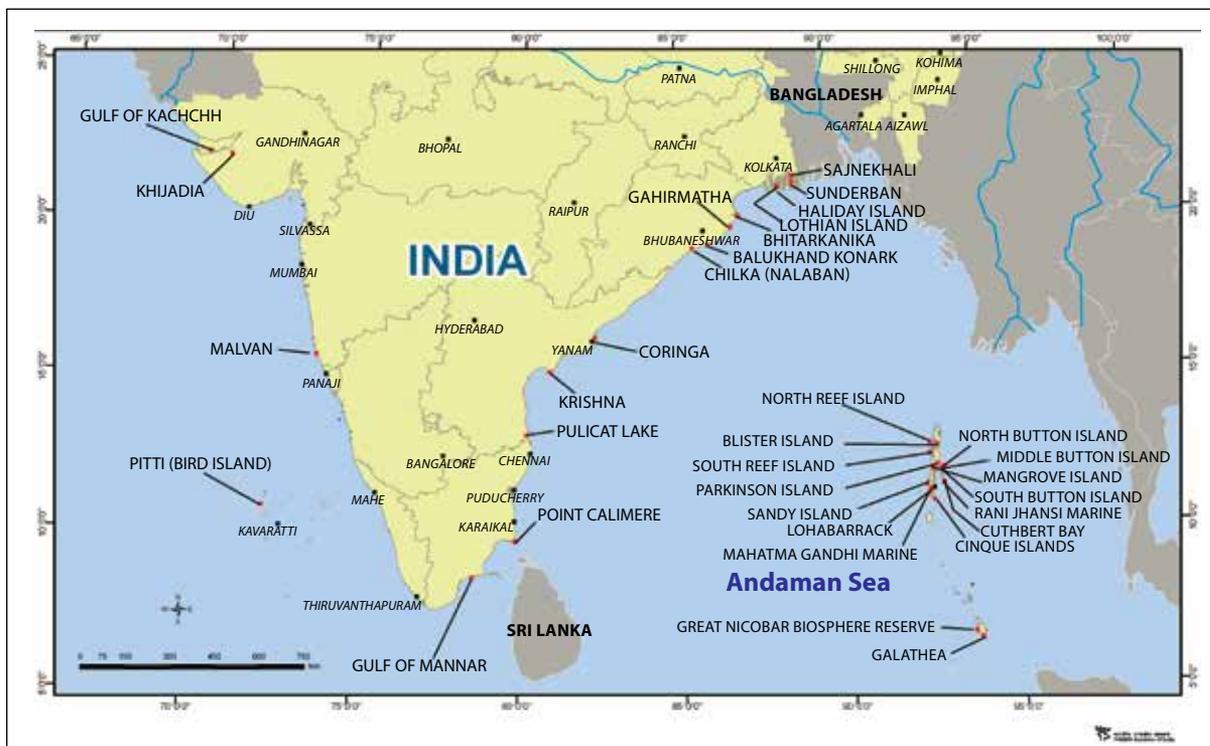


Source: Soban, personal communication

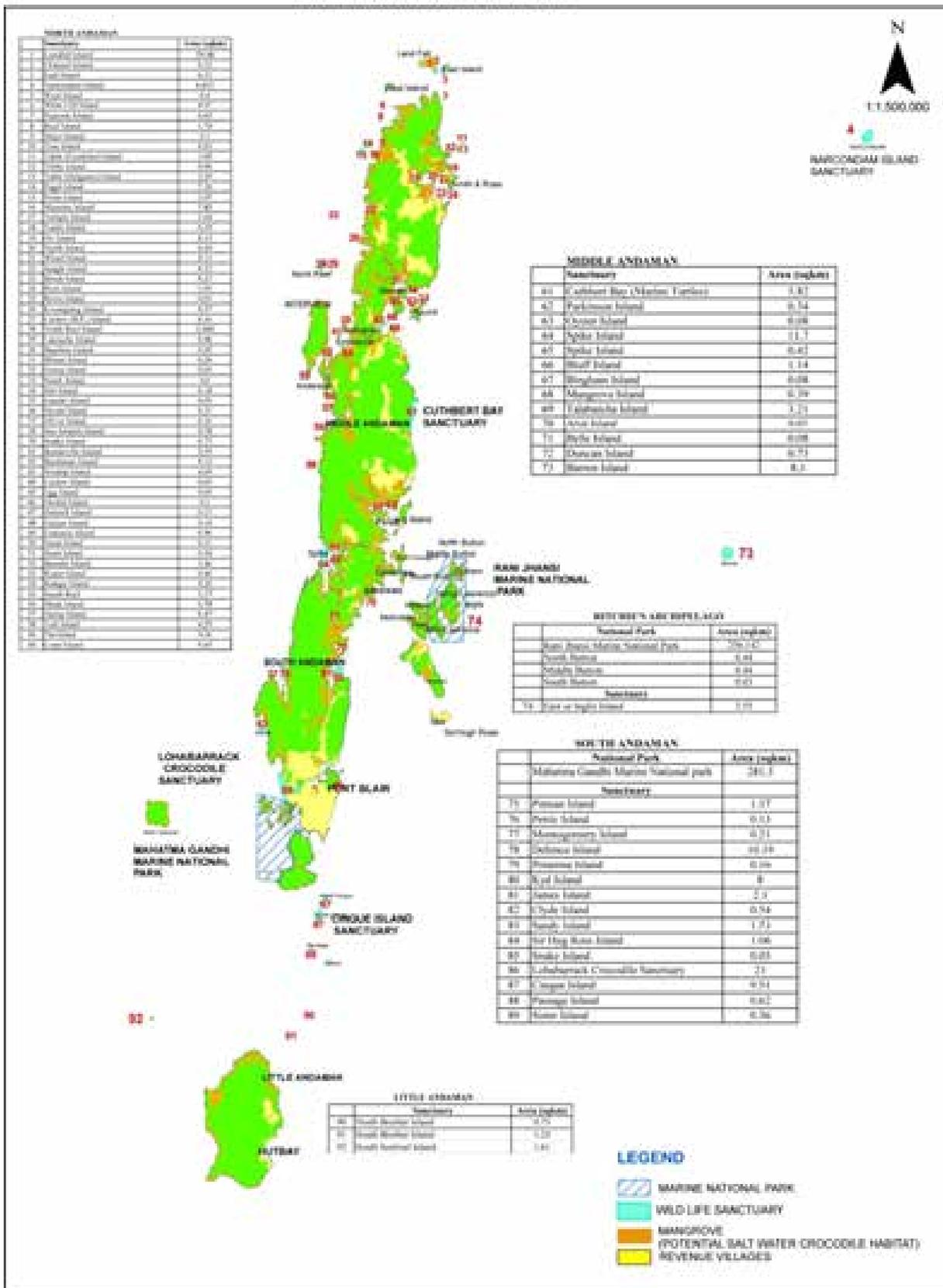


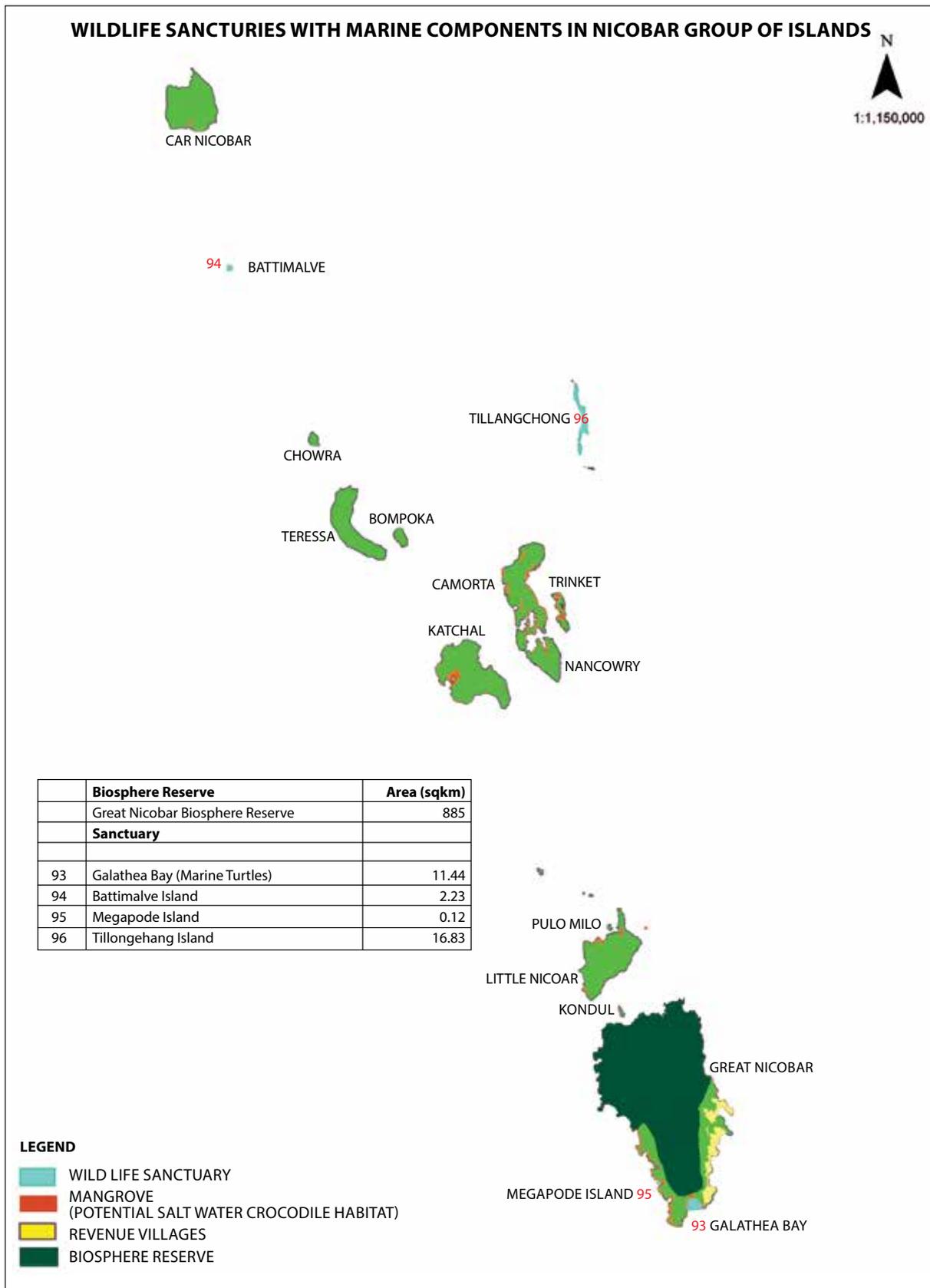
Source: Soban, personal communication

Figure 11.2. Coastal protected areas of India



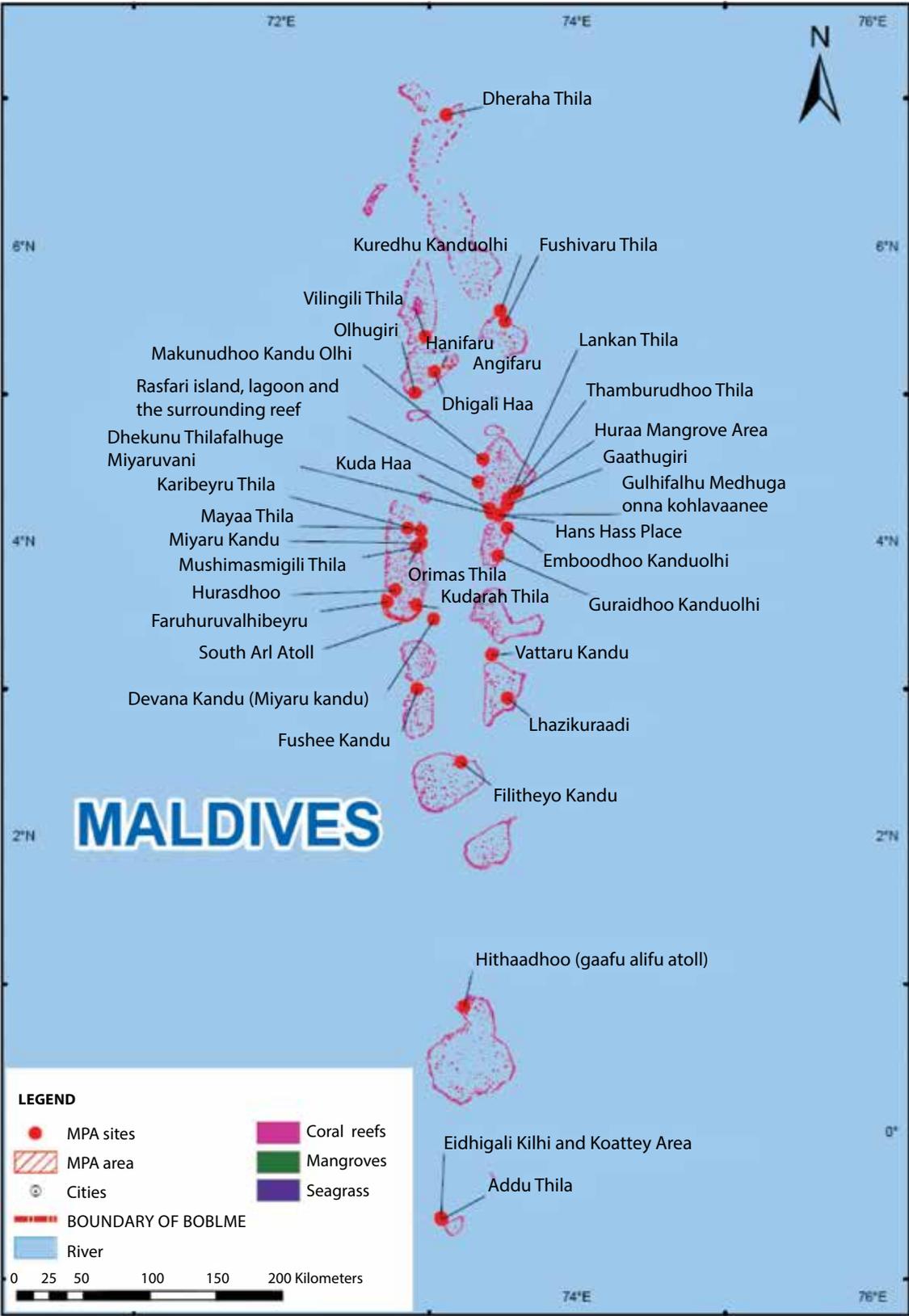
**MARINE NATIONAL PARKS AND WILDLIFE SANCTUARIES WITH MARINE COMPONENTS IN ANDAMAN GROUP OF ISLANDS**





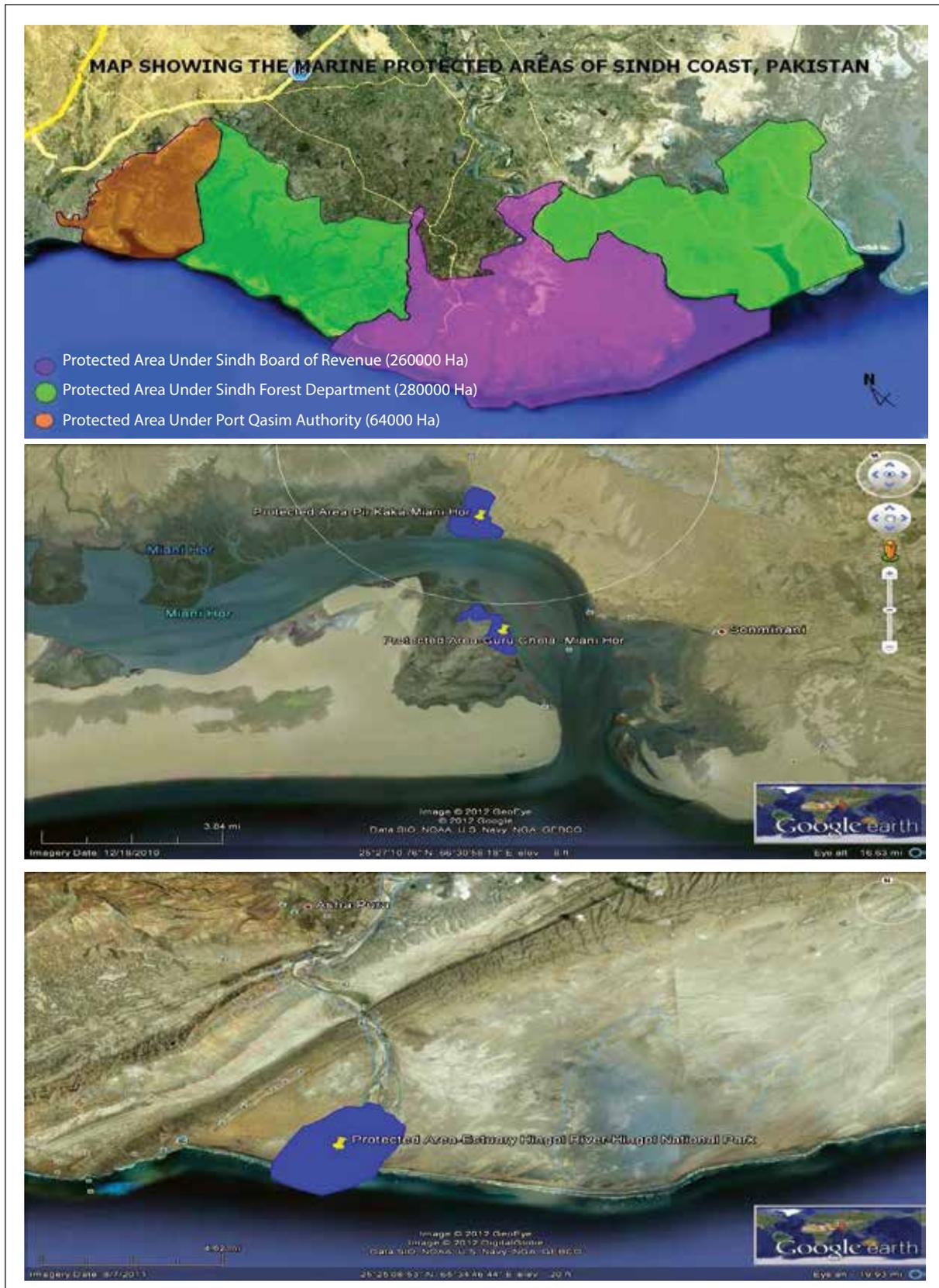
Sources: top, mainland India, Wildlife Institute of India; islands: Saxena, personal communication

Figure 11.3. Protected areas of the Maldives



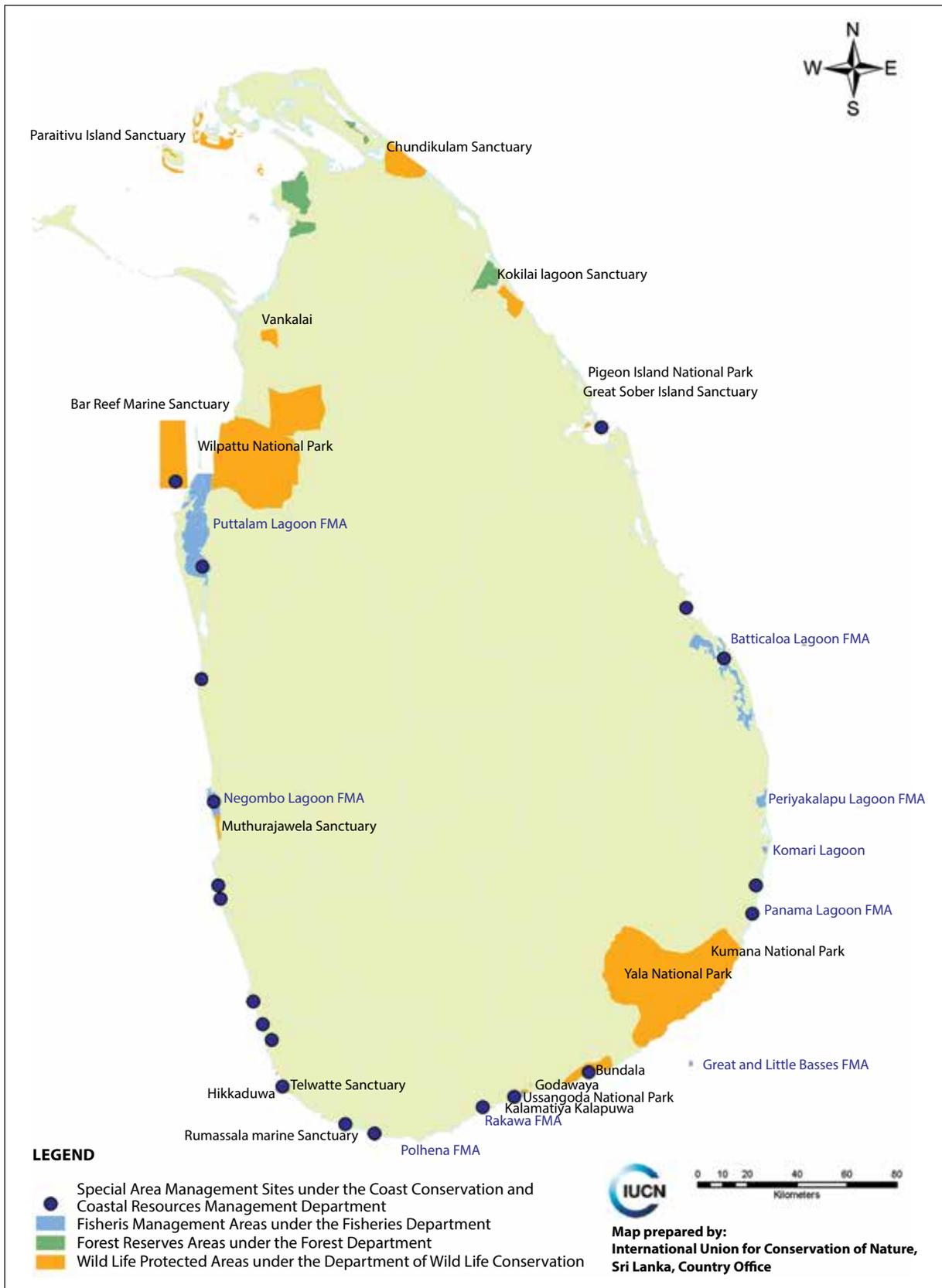
Sources: BOBLME, 2010

Figure 11.4. Coastal protected areas of Pakistan



Sources: IUCN, Pakistan, personal communication/google earth

Figure 11.5. Coastal and marine protected areas of Sri Lanka



Sources: IUCN, Sri Lanka, personal communication

## Step 6: Make management adaptive

Change is inevitable in ecosystems as they are dynamically functional units (<http://www.cbd.int/ecosystem/principles.shtml>). Anthropogenic pressures will continue; natural hazards will occur; and climate change will have impacts that are not readily measurable. The only certainty for a coastal manager is that he or she works within a context of uncertainty.

Under these conditions, management must always be adaptive. A coastal manager needs to be able to adapt to a changing situation. Adaptive management combines science, social learning and community participation ([http://www.sustainability-now.org/adaptive\\_management.htm](http://www.sustainability-now.org/adaptive_management.htm)).

### Checklist 5. Checklist for strengthening management

Check		Strengthening coordination	Specifics	Brief description
<input type="checkbox"/>	Step 1	Ensure that management plans have DRR and CCA incorporated into them	The Stern Review on the Economics of Climate Change recommended that policies be developed for climate-sensitive public goods including natural resource protection, coastal protection and emergency preparedness.	Once knowledge, capacity and coordination are improved, it will be possible to incorporate these elements into management plans.
<input type="checkbox"/>	Step 2	Involve communities in management	Communities are essential participants in conservation - critical to an ecosystem-based approach. When communities become involved in management, then management becomes easier	Engaging and involving communities as described in the last chapter
<input type="checkbox"/>	Step 3	Promote climate-resilient livelihoods	It is important to incorporate CCA measures that will also serve in DRR at community levels.	Such measures will include: flood protection measures in flood-prone areas; earthquake protection measures in earthquake-prone areas; water conservation practices in drought-prone areas; traditional agricultural methods' and sustainable fisheries.

Check		Strengthening coordination	Specifics	Brief description
<input type="checkbox"/>	Step 4	Know the disaster response procedures of the locality	Coastal managers also need to be aware of local emergency procedures.	These will include knowing (a) where the official safe areas and temporary shelters are; (b) which is/are the designated route(s) to shelters; (c) who the important contacts are for an emergency; and (d) who the focal point is for disaster response in a community.
<input type="checkbox"/>	Step 5	Ensuring better management of protected areas	Know all the protected areas.	In many countries there are a range of protected areas under the jurisdiction of different departments or ministries, each with different objectives and restrictions. It is essential to know thoroughly these locations, objectives and restrictions.
<input type="checkbox"/>	Step 6	Make management adaptive	Change in ecosystems is inevitable.	The only certainty for a coastal manager is that he/she works within a context of uncertainty.



## 12. Conclusion

At the 2000 Millennium Summit of the United Nations, 189 heads of states signed the Millennium Declaration to “free our fellow men, women and children from the abject and dehumanizing conditions of extreme poverty, to which more than a billion of them are currently subjected” (<http://www.endpoverty2015.org/en/goals>).

The vision for the future envisaged at the summit was one with better survival, health, education, equality and environment, with less poverty, hunger and disease (<http://www.ips.org/institutional/global-themes/the-millennium-development-goals-and-the-eradication-of-global-poverty/>).

The Millennium Development Goals (MDGs) “are eight targeted development aims designed to free humanity from extreme poverty, hunger, illiteracy and disease by 2015. Together, they form a blueprint for development agreed upon by all the world’s countries and all the world’s leading development institutions” (UN, 2011). The MDGs are accompanied by targets against which progress can be measured. These MDGs are the following:

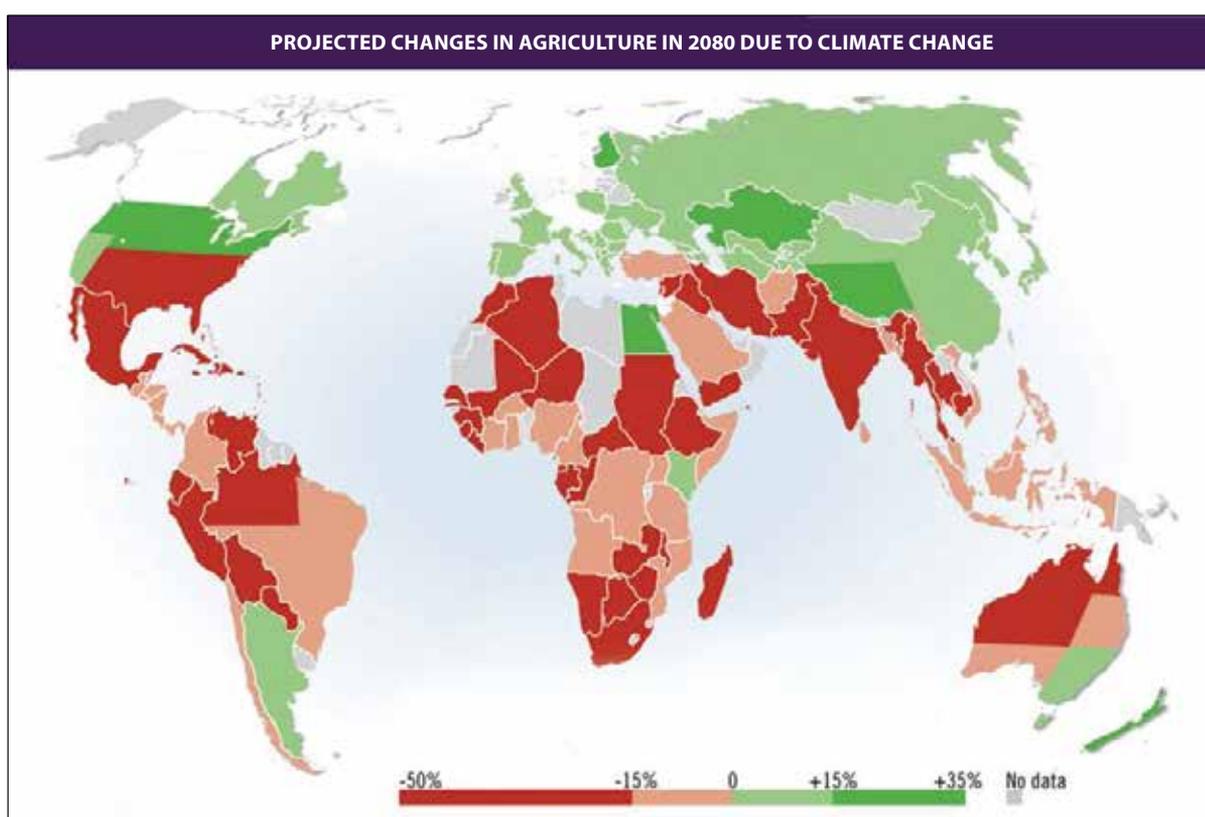
- MDG 1: Eradicate extreme poverty and hunger;
- MDG 2: Achieve universal primary education;
- MDG 3: Promote gender equality and empower women;
- MDG 4: Reduce child mortality;
- MDG 5: Improve maternal health;
- MDG 6: Combat HIV/AIDS, malaria and other diseases;
- MDG 7: Ensure environmental sustainability;
- MDG 8: Develop a global partnership for development.

Achievement of these MDGs is confounded by all the three themes discussed in this document.

## The impacts of natural disasters on MDGs

- The colossal costs incurred that result in the aftermath of natural disasters impede the achievement of **MDG 1**—eradicating poverty.
- The impacts of floods, cyclones, droughts and other natural hazards ‘push people back into poverty’ and impede the achievement of MDG 1 (RCC, 2010). In addition, repeated disasters negatively affect food security (UN, 2010).
- As noted in Chapter 4, the impacts of natural disasters are felt more by the poor and marginalized. The RCC (2010) notes that 11 percent of people exposed to natural hazards live in countries with low human development indices, but they constitute more than 53 percent of the total recorded deaths that ensue from natural disasters.
- Natural disasters also retard the achievement of **MDG 2**. It is reported that some 5,927 educational institutions were fully or partially damaged by Cyclone Sidr in Bangladesh, costing US\$57.6 million (RCC, 2010).
- As noted in Chapter 4, natural disasters disproportionately affect women and children, endangering the achievement of **MDGs 3, 4, and 5** (RCC, 2010).
- The spread of disease increases in the aftermath of disasters and affects the achievement of **MDG 6**. It is reported that in Muzaffarabad (Pakistan), following the 2005 earthquake, diarrhoea spread in a camp and infected over 750 people (RCC, 2010).
- As noted in Chapter 3, natural disasters also negatively impact ecosystems, retarding the achievement of MDG 7. It is reported that Cyclone Sidr damaged the normal functioning of the Sundarbans in Bangladesh.

**Figure 12.1. Change in agricultural output potential, 2000–2080**



Source: Cline (2007) in <http://www.wri.org/map/change-agricultural-output-potential-2000-2080>

- The effects of natural disasters may last only minutes or hours, but their impacts can “wipe out decades of progress and development in just a few seconds” (RCC, 2010), thus impeding the achievement of **MDG 8**.

## The impacts of climate change on MDGs

- Of the world’s population that lives on US\$2 per day, almost 2 billion people live in rural areas, in countries which are dependent on natural resources. The impacts of climate change on food security —already evident in part of the world — are, again, impeding the achievement of MDG 1 (eradication of hunger) (<http://www.wri.org/map/change-agricultural-output-potential-2000-2080>).
- Climate change will also reduce opportunities for well-being —such as access to health, water, shelter and sanitation and livelihoods. It is projected to reduce the assets and livelihoods of many poor people, for example health, access to water, homes, and infrastructure (GTZ, 2010). Because of the impacts that climate change will have on natural systems, it is predicted that they will alter the pace of economic growth, affecting MDG 1.
- Women, in poorer countries, are involved in more natural resource-dependent livelihoods— such as agriculture —and will be disproportionately affected by climate change, thereby impeding the achievement of MDG 3 (GTZ, 2010).
- Increased heat and cold waves —will result in increased mortality and associated illnesses; certain vector-borne diseases (such as malaria) are predicted to spread more with climate change; increased natural disasters increase the vulnerability to water-borne diseases such as cholera and dysentery (GTZ, 2010). Climate-induced water stress will result in decreased water quality and a higher incidence of water-borne diseases (GTZ, 2010). All the above will retard the achievement of MDGs 4, 5 and 6.
- Children and pregnant women are particularly vulnerable to any of the above, endangering MDGs 3, 4, 5 and 6.
- Decreased food security, induced by climate change, will impact MDGs 3 and 4.
- Climate change will have an overarching and synergistic impact on all other anthropogenic pressures on the environment, worsening an already bad situation and impeding the achievement of MDG 7.

## The impacts of biodiversity loss on MDGs

Loss of biodiversity and ecosystems continues unabated. A trans-boundary diagnostic analysis in the eight countries surrounding the Bay of Bengal were beset with issues of overexploitation, habitat loss and pollution (BOBLME, 2010). It is predicted that if humans continue with ‘business as usual’

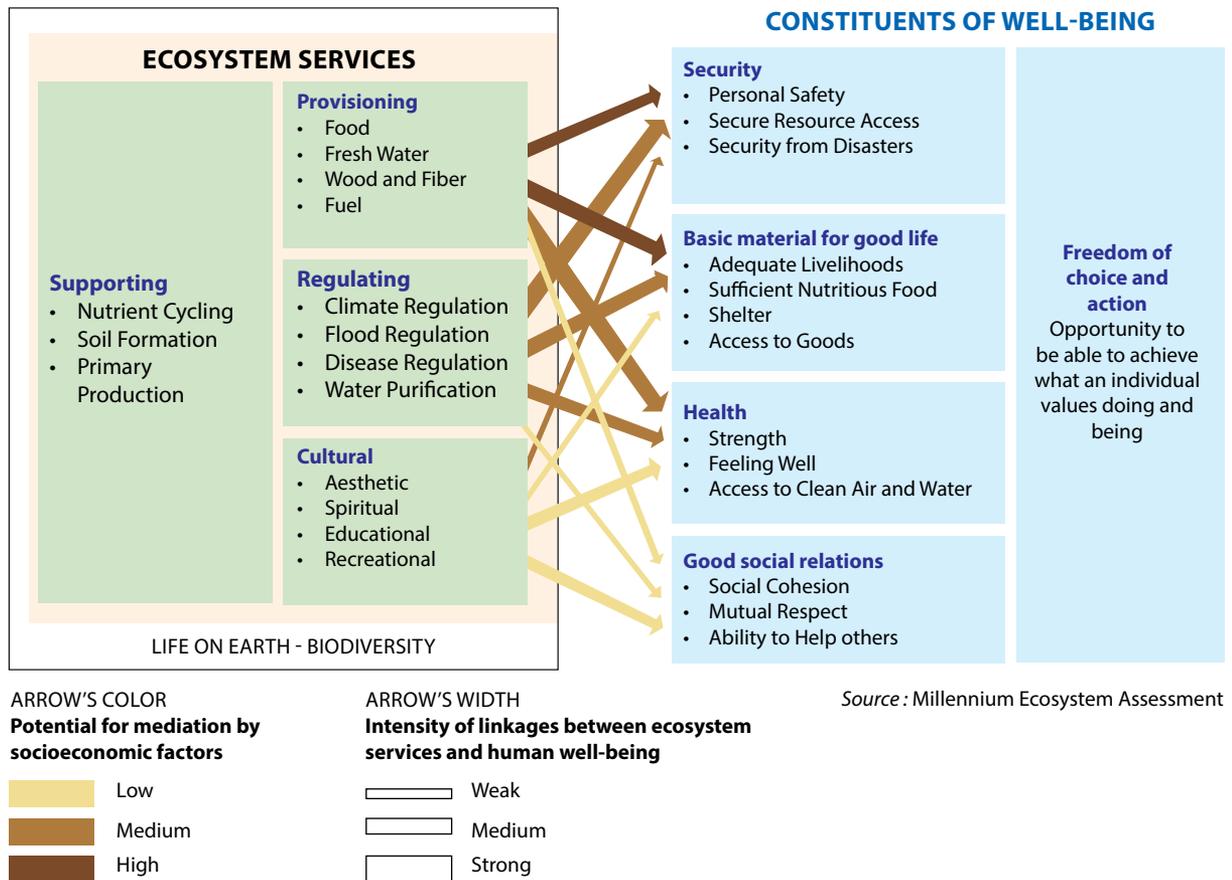
- Conversion to agriculture, development and climate change could result in the loss of 11 percent of the natural areas remaining in 2000;
- Conversion of 40 percent of low-impact agricultural land to high-impact, intensive agriculture will increase biodiversity loss; and
- Overexploitation, pollution, the spread of disease and invasive alien species, and coral bleaching from climate change could result in the loss of 60 percent of coral reefs ([http://www.eurekalert.org/pub\\_releases/2008-05/haog-teo052908.php](http://www.eurekalert.org/pub_releases/2008-05/haog-teo052908.php)).
- In terms of forest loss, this loss translates economically to between US\$1.35 trillion and US\$3.1 trillion per annum ([http://www.eurekalert.org/pub\\_releases/2008-05/haog-teo052908.php](http://www.eurekalert.org/pub_releases/2008-05/haog-teo052908.php)). This, in turn, translates to more loss for the global economy than resulted from the banking crisis a few years ago ([http://www.eurekalert.org/pub\\_releases/2008-05/haog-teo052908.php](http://www.eurekalert.org/pub_releases/2008-05/haog-teo052908.php)).

These losses ultimately affect human well-being.

“Ecosystems and their biodiversity underpin the global economy and human well-being and need to be valued and protected” (TEEB, 2009).

Given that all the MDGs are affected in some way or another, by the three themes discussed in this toolkit — EbA, DRR and CCA—it naturally follows that ensuring that CCA and DRR are addressed through EbA, will help achieve the eight MDGs.

**Figure 12.2. The Millennium Ecosystem Framework, which links ecosystem well-being and human well-being**



Source: MA, 2005

The ecosystem approach—by its nature, holistic—provides the unifying base for promoting CCA and DRR. Ensuring that DRR and CCA are integrated into this holistic approach covers all the bases, as it were. This approach will ensure that the vision for the future developed at the Millennium Summit is achieved.

Governments and policy makers at national levels may make changes according to politically driven agendas. But a coastal manager at the field level using this toolkit as a source of information has an opportunity to make effective, on-the-ground changes to ensure a sustainable future.

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## 14. Annex 1

# Hyogo Framework for Action (HFA)

(Extracted directly from <http://www.unisdr.org/we/coordinate/hfa>. The full text of the framework can be obtained from [http://www.unisdr.org/files/1037\\_hyogoframeworkforactionenglish.pdf](http://www.unisdr.org/files/1037_hyogoframeworkforactionenglish.pdf).)

The Hyogo Framework for Action (HFA) is the first plan to explain, describe and detail the work that is required from all different sectors and actors to reduce disaster losses. It was developed and agreed on with the many partners needed to reduce disaster risk - governments, international agencies, disaster experts and many others - bringing them into a common system of coordination. The HFA outlines five priorities for action, and offers guiding principles and practical means for achieving disaster resilience. Its goal is to substantially reduce disaster losses by 2015 by building the resilience of nations and communities to disasters. This means reducing loss of lives and social, economic, and environmental assets when hazards strike.

**Priority Action 1:** Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation.

Countries that develop policy, legislative and institutional frameworks for disaster risk reduction and that are able to develop and track progress through specific and measurable indicators have greater capacity to manage risks and to achieve widespread consensus for, engagement in and compliance with disaster risk reduction measures across all sectors of society.

**Priority Action 2:** Identify, assess and monitor disaster risks and enhance early warning.

The starting point for reducing disaster risk and for promoting a culture of disaster resilience lies in the knowledge of the hazards and the physical, social, economic and environmental vulnerabilities to disasters that most societies face, and of the ways in which hazards and vulnerabilities are changing in the short and long term, followed by action taken on the basis of that knowledge.

**Priority Action 3:** Use knowledge, innovation and education to build a culture of safety and resilience at all levels.

Disasters can be substantially reduced if people are well informed and motivated towards a culture of disaster prevention and resilience, which in turn requires the collection, compilation and dissemination of relevant knowledge and information on hazards, vulnerabilities and capacities.

**Priority Action 4:** Reduce the underlying risk factors.

Disaster risks related to changing social, economic and environmental conditions and land use, and the impact of hazards associated with geological events, weather, water, climate variability and climate change, are addressed in sector development planning programmes as well as in post-disaster situations.

**Priority Action 5:** Strengthen disaster preparedness for effective response at all levels.

At times of disaster[s], impacts and losses can be substantially reduced if authorities, individuals and communities in hazard-prone areas are well prepared and ready to act and are equipped with the knowledge and capacities for effective disaster management.

## 15. Annex 2

# The United Nations Framework Convention on Climate Change (UNFCCC)

(Extracted directly from <http://www.climatechangeinsights.com/2008/04/articles/international/summary-of-the-unfccc-and-plans-for-moving-forward/>.)

For the text of the full convention, go to <http://unfccc.int/resource/docs/convkp/conveng.pdf>.

For the full text of the Kyoto Protocol, go to <http://unfccc.int/resource/docs/convkp/kpeng.pdf>.

For the full text of the Bali Road Map, go to [http://unfccc.int/key\\_documents/bali\\_road\\_map/items/6447.php](http://unfccc.int/key_documents/bali_road_map/items/6447.php).

For the full text of the Cancun agreements, go to [http://unfccc.int/meetings/cancun\\_nov\\_2010/items/6005.php](http://unfccc.int/meetings/cancun_nov_2010/items/6005.php).

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) sought to launch a global climate change regime. In 2005 the well-known Kyoto Protocol, to which a large group of developed and emerging countries became signatories, laid the groundwork for a detailed system of incentives and targets for carbon emissions reductions, but the Protocol will remain in effect only through 2012. The December 2007 meeting in Bali of the Kyoto Conference of the Parties (COP) began to address a new international climate change treaty to take effect in 2013 upon the expiration of the Kyoto Protocol. Their “Bali Road Map” identified the core issues a new treaty must address: adaptation, mitigation, technology, finance, and cooperative action.

In 1992 the United Nations Framework Convention on Climate Change (UNFCCC) was adopted as the first step toward establishing a systematic, uniform global solution to the problem of climate change. This was followed by the Kyoto Protocol in 2005, to which a large group of developed and emerging countries became signatories. The Kyoto Protocol provided signatory countries a system of incentives and targets for carbon emissions reductions. However, the Kyoto Protocol will remain in force only through 2012. A meeting of the Conference of the Parties (COP) in December 2007 set the groundwork for a new international climate change treaty to take effect in 2013 upon the expiration of the Kyoto Protocol. The outcome of this meeting was the “Bali Road Map,” in which the COP identified the five elemental concepts around which a new treaty will be organized: adaptation, mitigation, technology, finance, and cooperative action.

Representatives of 180 countries met in Bali, Indonesia from December 3 through 14 of 2007 at the Conference of the Parties (COP), the annual United Nations Conference on climate change. Their goal was to set the groundwork for a new international climate change treaty to go into force and effect in 2013, upon the expiration of the Kyoto Protocol. At this meeting, the COP established a two-year process, the so-called Bali Road Map, which is designed to culminate in the enactment of a new treaty by the end of 2009, at or around the annual meeting of the UN conference on climate change in Copenhagen.

The first meetings toward a new accord were held in Bangkok between March 31 and April 4, 2008. Delegates from 162 countries met for the purpose of developing a substantive framework for the Bali Road Map. The participants contemplate work over the next two years toward an international pact that would halt the increase in global emissions within the next ten to fifteen years. The Kyoto Protocol Working Group also met to define the next phase of its work in redefining emissions reduction targets and obtaining commitments from signatory countries.

In the meetings the COP identified five elements or concepts around which the work for a new treaty would be centered; adaptation, mitigation, technology, finance and cooperative action. These will be addressed and molded into treaty provisions in three more working sessions that will take place this year. The Kyoto Protocol Working Group then reaffirmed the use of emissions trading, the Clean Development Mechanism, and joint implementation by developed countries to meet their emissions reductions targets, and, in so doing, sent a clear signal to private businesses in those countries about the criteria to use for their investments and operations going forward.

## 16. Annex 3

# The Convention on Biological Diversity (CBD)

(Extracted directly from [http://europa.eu/legislation\\_summaries/development/sectoral\\_development\\_policies/l28102\\_en.htm](http://europa.eu/legislation_summaries/development/sectoral_development_policies/l28102_en.htm). The full text of the convention may be obtained at <http://www.cbd.int/doc/legal/cbd-en.pdf>.)

The Convention on Biological Diversity (CBD) was signed by the Community and all the Member States at the United Nations Conference on Environment and Development in Rio de Janeiro from 3 to 14 June 1992. This Decision approves the Convention on behalf of the European Community. For many decades there has been a substantial loss of biological diversity worldwide and in Europe due to human activities (pollution, deforestation, etc.). The United Nations Environment Programme (UNEP) estimates that up to 24% of species belonging to groups such as butterflies, birds and mammals have completely disappeared from the territory of certain European countries. This situation is a cause for concern. Adequate biological diversity limits the effects of particular environmental risks such as climate change and parasite invasions. Diversity is essential for the long-term viability of farming and fishing activities and forms the basis for various industrial processes and the production of new medicines. The conservation and sustainable use of biological diversity are essential to ensure sustainable development and the millennium development goals relating to poverty, health and the environment. At the Johannesburg World Summit on Sustainable Development in 2002, the Heads of State agreed on the need to significantly reduce the loss of biological diversity by 2010. The CBD has been recognised as the main means of achieving this aim. In 2001 the Göteborg European Council adopted the objective of halting the loss of biodiversity in the Union by 2010.

States are responsible for the conservation of their biological diversity and the sustainable use of their biological resources.

There is a general lack of information and knowledge regarding biological diversity. Consequently, it is necessary to develop scientific, technical and institutional capacities to provide the basic understanding upon which to plan and implement appropriate measures with a view to maintaining biological diversity.

The CBD is designed to conserve biological diversity, ensure the sustainable use of this diversity and share the benefits generated by the use of genetic resources, in particular through appropriate access to genetic resources and appropriate transfer of relevant technologies, taking into account all rights over those resources and technologies, and through adequate funding.

States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

Subject to the rights of other States, and except as otherwise expressly provided for in the Convention, the provisions of the Convention apply, in relation to each Contracting Party:

- in the case of components of biological diversity, in areas within the limits of its national jurisdiction;
- in the case of processes and activities, regardless of where their effects occur, carried out under its jurisdiction or control, within the area of its national jurisdiction or beyond the limits of national jurisdiction.

Each Contracting Party must, as far as possible, cooperate with other Contracting Parties directly or, where appropriate, through competent international organisations both in respect of areas beyond national jurisdiction and on other matters of mutual interest, for the conservation and sustainable use of biological diversity.

Each Contracting Party should, in accordance with its particular conditions and capabilities:

- develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programmes;
- integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral and cross-sectoral plans, programmes and policies.

Each Contracting Party should as far as possible:

- identify components of biological diversity important for its conservation and sustainable use, having regard to the indicative list of categories set down in Annex I;
- monitor, through sampling and other techniques, the components of biological diversity identified, paying particular attention to those requiring urgent conservation measures and those which offer the greatest potential for sustainable use;
- identify processes and categories of activities which have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity and monitor their effects through sampling and other techniques;
- maintain and organise, by any mechanism, data derived from identification and monitoring activities pursuant to the points set out above.

Each Contracting Party should, as far as possible, adopt economically and socially sound measures that act as incentives for the conservation and sustainable use of components of biological diversity.

The Convention makes provision for the following:

- establishment and maintenance of programmes for scientific and technical education and training for the identification, conservation and sustainable use of biological diversity and its components and providing support for such education and training for the specific needs of developing countries;
- encouragement of research which contributes to the conservation and sustainable use of biological diversity, particularly in developing countries;
- promoting the use of scientific advances in biological diversity research in developing methods for conservation and sustainable use of biological resources.

Public education should be promoted and awareness enhanced to highlight the importance of biological diversity through the media and the inclusion of these topics in educational programmes.

The Contracting Parties should facilitate the exchange of information, from all publicly available sources, relevant to the conservation and sustainable use of biological diversity, taking into account the special needs of developing countries (exchange of information on the results of technical, scientific and socio-economic research as well as information on training and surveying programmes, etc.).

The Convention emphasises the role of indigenous and local communities in conserving biodiversity. These populations heavily and traditionally depend on the biological resources on which their traditions are based.

## 17. Annex 4

# Principles of the Ecosystem Approach

(Extracted directly from <http://www.cbd.int/ecosystem/principles.shtmlb>.)

The following 12 principles are complementary and interlinked.

**Principle 1: The objectives of management of land, water and living resources are a matter of societal choices.**

Different sectors of society view ecosystems in terms of their own economic, cultural and society needs. Indigenous peoples and other local communities living on the land are important stakeholders and their rights and interests should be recognized. Both cultural and biological diversity are central components of the ecosystem approach, and management should take this into account. Societal choices should be expressed as clearly as possible. Ecosystems should be managed for their intrinsic values and for the tangible or intangible benefits for humans, in a fair and equitable way.

**Principle 2: Management should be decentralized to the lowest appropriate level.**

Decentralized systems may lead to greater efficiency, effectiveness and equity. Management should involve all stakeholders and balance local interests with the wider public interest. The closer management is to the ecosystem, the greater the responsibility, ownership, accountability, participation, and use of local knowledge.

**Principle 3: Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.**

Management interventions in ecosystems often have unknown or unpredictable effects on other ecosystems; therefore, possible impacts need careful consideration and analysis. This may require new arrangements or ways of organization for institutions involved in decision-making to make, if necessary, appropriate compromises.

**Principle 4: Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:**

- a. Reduce those market distortions that adversely affect biological diversity;
- b. Align incentives to promote biodiversity conservation and sustainable use;
- c. Internalize costs and benefits in the given ecosystem to the extent feasible.

The greatest threat to biological diversity lies in its replacement by alternative systems of land use. This often arises through market distortions, which undervalue natural systems and populations and provide perverse incentives and subsidies to favor the conversion of land to less diverse systems.

Often those who benefit from conservation do not pay the costs associated with conservation and, similarly, those who generate environmental costs (e.g. pollution) escape responsibility. Alignment of incentives allows those who control the resource to benefit and ensures that those who generate environmental costs will pay.

**Principle 5: Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.**

Ecosystem functioning and resilience depends on a dynamic relationship within species, among species and between species and their abiotic environment, as well as the physical and chemical interactions within the environment. The conservation and, where appropriate, restoration of these interactions and processes is of greater significance for the long-term maintenance of biological diversity than simply protection of species.

**Principle 6: Ecosystem must be managed within the limits of their functioning.**

In considering the likelihood or ease of attaining the management objectives, attention should be given to the environmental conditions that limit natural productivity, ecosystem structure, functioning and diversity. The limits to ecosystem functioning may be affected to different degrees by temporary, unpredictable or artificially maintained conditions and, accordingly, management should be appropriately cautious.

**Principle 7: The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.**

The approach should be bounded by spatial and temporal scales that are appropriate to the objectives. Boundaries for management will be defined operationally by users, managers, scientists and indigenous and local peoples. Connectivity between areas should be promoted where necessary. The ecosystem approach is based upon the hierarchical nature of biological diversity characterized by the interaction and integration of genes, species and ecosystems.

**Principle 8: Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.**

Ecosystem processes are characterized by varying temporal scales and lag-effects. This inherently conflicts with the tendency of humans to favour short-term gains and immediate benefits over future ones.

**Principle 9: Management must recognize the change is inevitable.**

Ecosystems change, including species composition and population abundance. Hence, management should adapt to the changes. Apart from their inherent dynamics of change, ecosystems are beset by a complex of uncertainties and potential “surprises” in the human, biological and environmental realms. Traditional disturbance regimes may be important for ecosystem structure and functioning, and may need to be maintained or restored. The ecosystem approach must utilize adaptive management in order to anticipate and cater for such changes and events and should be cautious in making any decision that may foreclose options, but, at the same time, consider mitigating actions to cope with long-term changes such as climate change.

**Principle 10: The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.**

Biological diversity is critical both for its intrinsic value and because of the key role it plays in providing the ecosystem and other services upon which we all ultimately depend. There has been a tendency in the past to manage components of biological diversity either as protected or non-protected. There is a need for a shift to more flexible situations, where conservation and use are seen in context and the full range of measures is applied in a continuum from strictly protected to human-made ecosystems.

**Principle 11: The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.**

Information from all sources is critical to arriving at effective ecosystem management strategies. A much better knowledge of ecosystem functions and the impact of human use is desirable. All relevant information from any concerned area should be shared with all stakeholders and actors, taking into account, *inter alia*, any decision to be taken under Article 8(j) of the Convention on Biological Diversity. Assumptions behind proposed management decisions should be made explicit and checked against available knowledge and views of stakeholders.

**Principle 12: The ecosystem approach should involve all relevant sectors of society and scientific disciplines.**

Most problems of biological-diversity management are complex, with many interactions, side-effects and implications, and therefore should involve the necessary expertise and stakeholders at the local, national, regional and international level, as appropriate.





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