Managing Coastal Marine Biodiversity and Protected Areas

For MPA managers

Module 8

Coasts, Climate Change, Natural Disasters and Coastal Livelihoods

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On behalf of:
Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
of the Federal Republic of Germany

Disclaimer:

This Training Module is a part of the training resource material on "Managing coastal marine biodiversity and protected areas" for MPA managers. This training resource material has been developed under the Human Capacity Development component of the GIZ Project –'Conservation and Sustainable Management of Existing and Potential Coastal and Marine Protected Areas (CMPA)', under the Indo-German Biodiversity Programme, in partnership with the Ministry of Environment, Forests and Climate Change (MoEFCC) Government of India. The CMPA Project is commissioned by the German Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety (BMUB) with the funds provided under the International Climate Initiative (IKI). The CMPA project is implemented in selected coastal states in India and focuses on capacity developed of the key stakeholders in forest, fisheries and media sectors.

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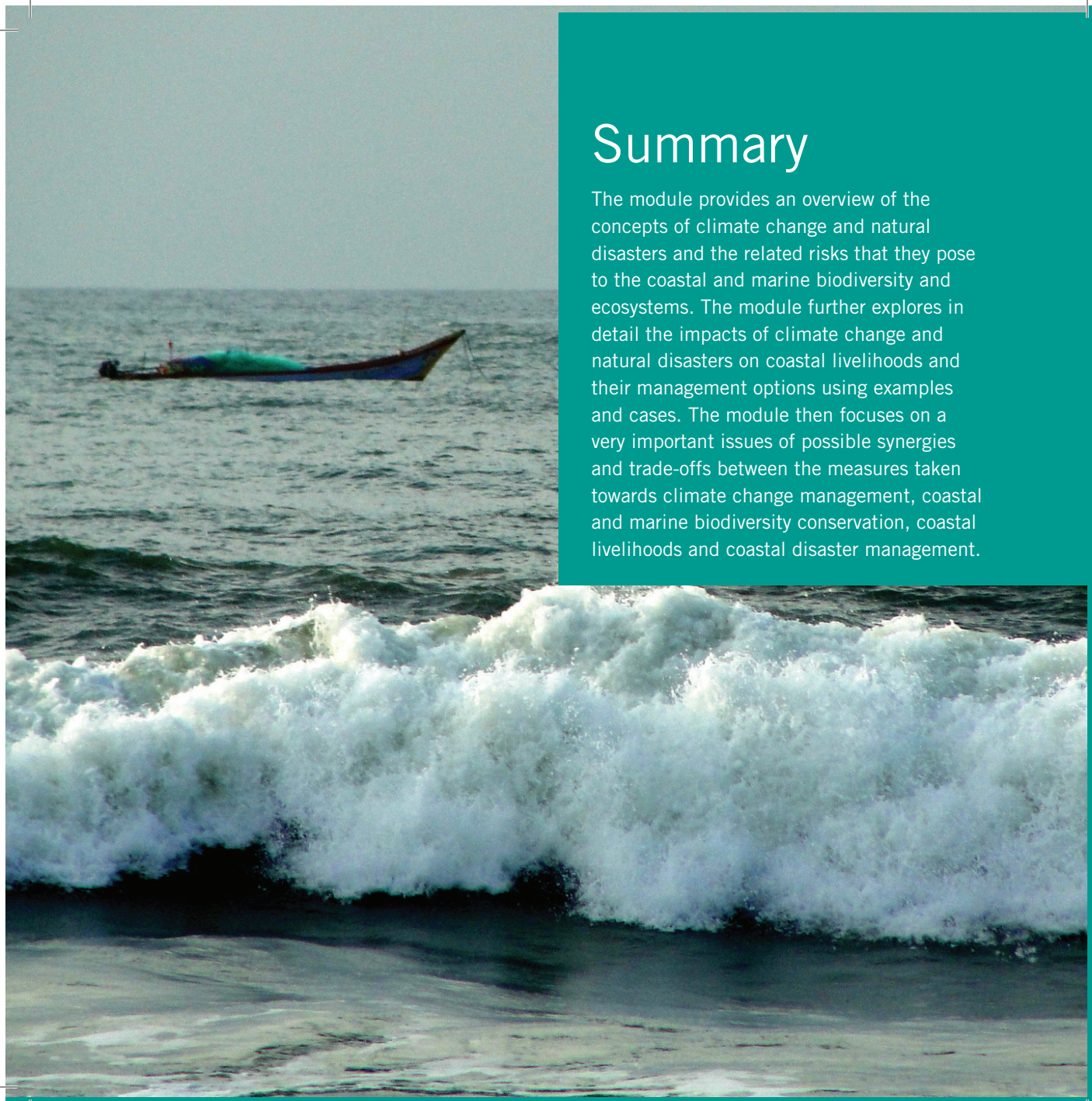


Summary

The module provides an overview of the concepts of climate change and natural disasters and the related risks that they pose to the coastal and marine biodiversity and ecosystems. The module further explores in detail the impacts of climate change and natural disasters on coastal livelihoods and their management options using examples and cases. The module then focuses on a very important issues of possible synergies and trade-offs between the measures taken towards climate change management, coastal and marine biodiversity conservation, coastal livelihoods and coastal disaster management.

Key Messages

- ‘Climate change’ refers to a change in the state of the climate that can be identifi ed (e.g., by using statistical tests) by changes in the mean global temperatures and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing factors such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use.
- The livelihoods of the rural poor are affected, in one way or the other, by three major factors, viz, climate change, disruption/loss of ecosystem services and disasters.
- The goal of climate change adaptation (CCA) planning is to fi nd local or locally adapted sustainable solutions for robust and diversified livelihood options, especially in climate-sensitive sectors such as agriculture, forestry and tourism.
- Though the objective of both CCA and disaster risk reduction is reducing the vulnerability of the local communities, some CCA and disaster risk interventions may unintentionally leave people even more vulnerable than before to the impacts of natural disasters and vice versa.
- Many marine and coastal ecosystems no longer deliver the full suite of ecosystem services that humans have come to rely upon due to the existence of trade-offs between the activities of different sectors.
- Trade-offs can be minimized if the primary goal of all the activities in the marine and coastal ecosystems is maintaining a sustainable fl ow of ecosystem services

8.1 What is climate change? How climate change impacts coastal and marine ecosystems

8.1.1 Basic science of climate change

In the atmosphere, CO_2 is the dominant carbon bearing trace gas. Additional trace gases include methane and carbon monoxide and still smaller amounts of hydrocarbons, black carbon aerosols and organic compounds.

The terrestrial biosphere reservoir contains carbon in organic compounds in vegetation living biomass, in dead organic matter in litter and soils, old soil carbon in wetland soils, and in permafrost soils.

Since the beginning of the Industrial Era, humans have been producing energy by burning of fossil fuels (coal, oil and gas), a process that is releasing large amounts of CO2 into the atmosphere. The second major source of anthropogenic CO2 emissions to the atmosphere is caused by changes in land use (mainly deforestation), which causes globally a net reduction in land carbon storage, although recovery from past land use change can cause a net gain in in land carbon storage in some regions.

According to the United Nations Framework Convention on Climate Change (UNFCCC), climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

In this description of climate change, the term, climate variability, refers to variations in the mean state and other statistics (such as standard deviations and statistics of extremes) of the climate on all temporal and spatial scales beyond those of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability) or variations in natural or man-made external forcing factors (external variability) (UNFCCC 2001).

According to the IPCC, climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity.

Note that the UNFCCC makes a distinction between climate change attributable to human activities that alter the atmospheric composition and climate variability attributable to natural causes.

SOME KEY TERMS

- *Hazard.* It is the potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. In this report, the term 'hazard' usually refers to climate-related physical events or trends or their physical impacts.
- *Exposure.* The presence of people, livelihoods, species (or ecosystems), environmental functions, services and resources, infrastructure or economic, social or cultural assets in places and settings that could be adversely affected.
- *Vulnerability.* The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.
- *Impacts.* Effects on natural and human systems. In this report, the term 'impacts' is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure of the interaction of climate changes or hazardous climate events occurring within a specific time period on an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts and sea-level rises, are a subset of impacts called 'physical impacts.'

WHAT'S THE DIFFERENCE BETWEEN CLIMATE CHANGE AND GLOBAL WARMING?

Climate change is the shift in long-term, global weather patterns due to human action; it's not exclusive to warming or cooling.

Climate change includes any change resulting from different factors, like deforestation or an increase in greenhouse gases. Global warming is one type of climate change, and it refers to the increasing temperature of the surface of Earth.

"Global warming" refers to the long-term warming of the planet. Global temperature shows a well-documented rise since the early 20th century and most notably since the late 1970s. Worldwide, since 1880 the average surface temperature has gone up by about 0.8 °C (1.4 °F), relative to the mid-20th-century baseline (of 1951-1980).

"Climate change" encompasses global warming, but refers to the broader range of changes that are happening to our planet. These include rising sea levels, shrinking mountain glaciers, accelerating ice melt in Greenland, Antarctica and the Arctic, and shifts in flower/plant blooming times. These are all consequences of the warming, which is caused mainly by people burning fossil fuels and putting out heat-trapping gases into the air. The terms "global warming" and "climate change" are sometimes used interchangeably, but strictly they refer to slightly different things.

[Source: NASA http://climate.nasa.gov/faq/]

8.1.2 Climate change: Observed impacts, vulnerability and exposure

The main characteristics of climate change include rising temperatures, changes in rainfall patterns, melting of glaciers and sea ice, sea-level rises and an increased intensity and/or frequency of extreme events. These changes in physical processes have impacts on biological and socioeconomic factors such as shifts in crop-growing seasons, food production and food security, changes in disease vectors, shifting boundaries of forests and other ecosystems and extreme events such as flooding, droughts and landslides.

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°C to 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 functionalities of ecosystems, declining crop yields, floods during the wet season and a reduction in the off-season water supply are other possible impacts.

Threats to all wild species are increasing and include stressors such as over exploitation, land conversion, habitat loss and pollution. Climate change is likely to act synergistically with these stressors, leading to major impacts on protected areas (PAs) and species.

CORAL REEFS

Coral reefs are critical to the fisheries and protect coasts from wave action and erosion (Middleton 1999; Ruddle et al 1988). However, they are undergoing rapid destruction (due to a number of factors including destructive fishing techniques and reef mining for calcium carbonate production, ocean acidification due to higher CO_2 levels in the atmosphere, siltation as a result of deforestation, sedimentation, marine pollution with contaminants, freshwater dilution, subaerial exposure and disease) (Glynn 1996; Middleton 1999; Pennisi 1998; UNEP 1999), and global warming and climate change are posing an additional emerging and severe threat to already stressed coral reefs. The rising sea level and changed weather patterns, such as altered El Niño and La Niña events, are already affecting coral reefs. In 1998, the tropical sea surface temperatures (SSTs) were the highest on record (the culmination of a 50 year trend), and coral reefs suffered the most extensive and severe bleaching (loss of symbiotic algae) and death on record. As a result of this El Niño event, 16 per cent of the world's coral reefs and 50 per cent of those in the Indian Ocean were destroyed (Wilkinson 2004). As such, reef communities have been altered in the region. Although healthy reefs are likely to be able to adapt to projected sea level changes, coral reefs that are already stressed by other human activities and threats will not (UNISDR/UNDP 2012a, 2012b).

MANGROVES

Mangroves are restricted to the intertidal zone along the coasts and are becoming increasingly depleted due to anthropogenic pressures. They are also extremely vulnerable to the effects of climate change, such as rising sea levels, resulting in loss of habitat and changes in salinity, changes in precipitation and wave climates and an increase in the frequency of natural disasters. The 6000 km^2 extent of mangrove forest called the Sunderbans (literally, beautiful forests), a UNESCO World Heritage Site, along the coast of India and Bangladesh is the largest such forest in the world (Allison 1998). As a result of rising sea levels, 75 km^2 (1.25 percent) of the mangroves in this tract along the shores of the two countries has been lost due to inundation (http.www//assets.panda.org/downloads/wwfparksbro.pdf). A UNESCO document titled 'Case Studies on Climate Change and World Heritage' (published in 2007) stated that a 45-centimetre (18-inch) rise in the sea level (which is likely by the end of the 21st century according to the IPCC), combined with other stresses on the Sunderbans, could lead to the destruction of three-quarters of its mangroves. Mangrove forests are home to a number of species such as the critically endangered tiger, the Eurasian otter, five species of marine turtle and the estuarine crocodile and to large numbers of crustaceans and fishes. With a 1-m rise in the sea level, the Sunderbans are likely to disappear, which may result in the extinction of the tiger as well as the other species in these habitats (Smith et al 1998).

SEA GRASSES

Higher water temperatures resulting from climate change will affect the growth, reproduction and general metabolism of sea grasses, while increased acidity will affect their productivity (Bjork et al 2008; Short and Neckles 1999). Increased numbers of storms will also result in physical damage to sea grass meadows and increase the turbidity of the water, affecting the availability of light for photosynthesis (Bjork et al 2008).

SAND DUNES

Sand dunes are cleared for many reasons. Structures such as beach huts and beach restaurants are often built illegally, destroying sand dunes. There is a great danger that sand dunes will be levelled or damaged when artificial green belts are established or mangrove replanting is undertaken. When

exotic species such the whistling pine (*Casuarina equisetifolia*) are planted, additional problems, such as the prevention of marine turtles from nesting, also ensue (Choudhury et al 2003).

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 (*Lepidochelys olivacea*) along the coasts of Odisha, Andhra Pradesh and Kerala as a result of sand and mineral mining on beaches (Choudhury et al 2003). Recreation is a major use of sand dunes and beaches, these being used extensively by tourists. Excessive trampling of sand dune vegetation causes death of the flora and can result in erosion of dune sites (UNISDR/UNDP 2012a, 2012b).

SALT MARSHES

Salt marshes are areas where water is retained for some time. They therefore act as areas where inland pollutants are stored. Excess nutrients—from the agriculture sector—are a particular problem in salt marshes because they lead to eutrophication. Industrial pollutants may contain toxic chemicals such as mercury, lead and aluminium, which cause lethal and chronic risks to the flora, the fauna and humans.

Salt marshes get filled with dredged material to create roads, residential communities and businesses. The resulting habitat destruction alters the flooding regime, elevation soil type and plant and animal communities. Ideally, salt marshes shift with changing environmental conditions. Many salt marshes are being 'squeezed' between the rising sea and fixed flood defence walls. 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 (UNISDR/UNDP 2012a, 2012b; http://des.nh.gov/organization/commissioner/pip/factsheets/cp/documents/cp-08.pdf).

COASTAL WETLANDS, INCLUDING ESTUARIES, DELTAS, SALT MARSHES AND MUDFLATS

Coastal wetlands are associated with deltas, estuaries, lagoons and sheltered bays (Bird 1992). They are affected by rising sea levels and sedimentation. The Great Rann of Kutch, in Gujarat is a huge

area of seasonal salt lakes that supports large populations of various species, including the largest population of the greater flamingo (*Phoenicopterus roseus*) in Asia (Ali 1985; Bapat 1992), and is the only place where Indian wild asses (*Equus hemionus khur*) may be observed. With a sea level rise, these salt marshes and mudflats are likely to be submerged (Bandyopadhyay 1993), which will result in a reduced extent of the habitat available for breeding flamingoes and lesser floricans (*Sypheotides indicus*) (Sankaran et al 1992) and a loss of habitat for wild asses. Changes in river water discharges resulting from climate change may also affect the wetlands associated with deltas. As such, plant and animal species that inhabit these coastal wetlands are also threatened. Mudflats in the intertidal zone are habitats of several migratory birds, which are also threatened by climate change (UNISDR/UNDP 2012a).

WAVE CLIMATES

Ocean currents are driven by heat and salinity (which together determine density) and are, as such, affected significantly by global warming. This will have repercussions for the weather patterns and climates of continents (particularly coastal regions), which are maintained by wave currents. Changes in near-shore currents can also have profound impacts on coastal ecosystems through altered transport and retention of sediments and nutrients (UNISDR/UNDP 2012a).

8.1.3 How can climate change be managed? Climate change mitigation and adaptation!

Climate change, or global warming, is caused by increases in the concentrations of greenhouse gases in the atmosphere. There are two ways in which climate change can be managed. One is to reduce the emission of these gases (mitigation). The other way is to change or adapt our lifestyles to live with it.

The main greenhouse gases, according to the UNFCCC, are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6).

CLIMATE CHANGE MITIGATION

Mitigation is a human (anthropogenic) intervention that is designed to reduce the sources of emission or enhance the sinks of greenhouse gases. This can be through the use of energy-efficient technologies in manufacturing industry, transport and construction. Increased sequestration (capturing) of carbon dioxide by plant life can also reduce the greenhouse gas concentration in the atmosphere. So afforestation and community plantations can help sequester carbon dioxide.

The aim of the UNFCCC was to mitigate and stabilize the emission of greenhouse gases in the atmosphere. The text of the convention reads thus:

> *The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.*[1]

The Kyoto Protocol, an instrument that was designed within the UNFCCC, set a commitment figure for emission reduction for developed countries. It states:[2]

> *The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012.*

1 The text of the convention can be read at http://unfccc.int/files/essential_background/convention/background/application/pdf/convention_text_with_annexes_english_for_posting.pdf

2 The text of the Kyoto Protocol can be read at http://unfccc.int/resource/docs/convkp/kpeng.pdf

Reduced Emissions from Deforestation and Forest Degradation (REDD) is one programme that was introduced for mitigation at the Conference of Parties (CoP) held at Copenhagen in Denmark in 2009. Through REDD, developed countries can financially support developing-country partners in increasing their green cover. The Copenhagen Accord reads thus:[3]

> *We recognize the crucial role of reducing emission from deforestation and forest degradation and the need to enhance removals of greenhouse gas emission by forests and agree on the need to provide positive incentives to such actions through the immediate establishment of a mechanism including REDD-plus, to enable the mobilization of financial resources from developed countries.*

CLIMATE CHANGE ADAPTATION (CCA)

Climate change is altering ecological systems, biodiversity, genetic resources, and the benefits derived with ecosystem services.

Human and natural systems have a capacity to cope with adverse circumstances but, with continuing climate change, adaptation will be needed to maintain this capacity (IPCC, 2012)

Adaptation is "the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities. In natural systems, human intervention may facilitate adjustment to expected climate and its effects..."

Adaptation involves reducing risk and vulnerability; seeking opportunities; and building the capacity of nations, regions, cities, the private sector, communities, individuals, and natural systems to cope with climate impacts, as well as mobilizing that capacity by implementing decisions and actions (Tompkins et al., 2010)

Natural systems have the potential to adapt through multiple autonomous processes (e.g., phenology changes, migration, compositional changes, phenotypic acclimation, and/or genetic changes), and humans may intervene to promote particular adjustments such as reducing non-climate stresses or through managed migration (see Section 4.5). But successful adaptation will depend on our

3 The text of the Copenhagen Accord can be read at http://unfccc.int/resource/docs/2009/cop15/eng/l07.pdf

ability to allow and facilitate natural systems to adjust to a changing climate, thus maintaining the ecosystem services on which all life depends.

Adaptation requires adequate information on risks and vulnerabilities in order to identify needs and appropriate adaptation options to reduce risks and build capacity. In framing an approach to adaptation, it is important to engage people with different knowledge, experience, and backgrounds in tackling and reaching a shared approach to addressing the challenges (Preston and Stafford Smith, 2009; Tompkins et al., 2010; Fünfgeld and McEnvoy, 2011; Eakin et al., 2012) Initially, identifying needs was most often based on impact assessments (or risk-hazard approaches), but social vulnerability or resilience assessments are increasingly being used (Fünfgeld and McEnvoy, 2011; Preston et al., 2011b).

Adaptation needs refer to circumstances requiring information, resources, and action to ensure safety of populations and security of assets in response to climate impacts. Adaptation options are the array of strategies and measures available and appropriate to address needs. Because identifying needs and selecting and implementing options require the engagement of individuals, organizations, and governments at all levels, a range of actors need to be involved in these processes to avoid the risks of maladaptation.

Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.

- Anticipatory adaptation takes place before impacts of climate change are observed—this is also referred to as proactive adaptation.
- Autonomous adaptation does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems, and this is also referred to as spontaneous adaptation.
- Planned adaptation is the result of a deliberate policy decision based on awareness that conditions have changed or are about to change and that action is required to return to, maintain or achieve a desired state.

So, what does adaptation mean in terms of action?[4]

Identifying needs stemming from climate risks and vulnerabilities provides a foundation for selecting adaptation options. Over the years, a number of categories of options have been identified. These options include a wide range of actions that are organized into three general categories:

STRUCTURAL/PHYSICAL:

- **Engineered and built environment:** Sea walls and coastal protection structures, flood levees and culverts, water storage and pump storage, sewage works, improved drainage, beach nourishment, flood and cyclone shelters, building codes, storm and waste water management, transport and road infrastructure adaptation, floating houses, adjusting power plants and electricity grids
- **Adaptation suing technological interventions:** New crop and animal varieties, genetic techniques, traditional technologies and methods, efficient irrigation, water saving technologies, including rainwater harvesting, conservation agriculture, food storage and preservation facilities, hazard mapping and monitoring technology, early warning systems, building insulation, mechanical and passive cooling, renewable energy technologies, second-generation biofuels
- **Ecosystem-based adaptation:** Ecological restoration , including wetland and floodplain conservation and restoration, conserving biological diversity, afforestation and reforestation, conservation and replanting mangrove forest, bushfire reduction and prescribed fire, green infrastructure (e.g., shade trees, green roofs), controlling overfishing, fisheries co-management, assisted migration or managed translocation, ecological corridors, ex situ conservation and seed banks, community-based natural resource management, adaptive land use management
- **Adaptation through increasing supply of key services:** Social safety nets and social protection, food banks and distribution of food surplus, municipal services including water and sanitation, vaccination programs, essential public health services, including reproductive health services and enhanced emergency medical services, international trade

4 Source: Noble et al 2014

ECOSYSTEM-BASED ADAPTATION

Ecosystem-based adaptation (EBA)—which is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change—is becoming an integral approach to adaptation. Often, when faced with climate-related threats, first consideration is given to engineered and technological approaches to adaptation. However, working with nature's capacity and pursing ecological options, such as coastal and wetland maintenance and restoration, to absorb or control the impact of climate change in urban and rural areas can be efficient and effective means of adapting.

The use of mangroves and salt marshes as a buffer against damage to coastal communities and infrastructure has been well researched and found to be effective both physically and financially in appropriate locations. They can also provide biodiversity co-benefits, support fish nurseries, and have carbon sequestration value.

An example of adaptation in an urban area can be that New York City has a well-established program to enhance its water supply through watershed protection that is cost-effective compared to constructing a filtration plant.

However, there are trade-offs relating to land use and the availability of space for people and social, economic, and environmental activities. For example, providing an effective wetland buffer for coastal protection may require emphasis on silt accumulation possibly at the expense of wildlife values and recreation. Moreover, it is considered that ecosystem-based approaches are often more difficult to implement as they usually require cooperation across institutions, sectors, and communities, and their benefits are also spread across a similarly wide set of stakeholders.

Nevertheless, ecosystem based adaptation seems to be the most sustainable option of climate change adaptation.

SOCIAL

- **Adaptation through imparting relevant education:** Awareness raising and integrating into education, gender equity in education, extension services, sharing local and traditional knowledge, including integrating into adaptation planning, participatory action research and social learning, community surveys, knowledge-sharing and learning platforms, international conferences and research networks, communication through media
- **Adaptation through enhancing the information base:** Hazard and vulnerability mapping, early warning and response systems, including health early warning systems, systematic monitoring and remote sensing, climate services, including improved forecasts, downscaling climate scenarios, longitudinal data sets, integrating indigenous climate observations, community-based adaptation plans, including community-driven slum upgrading and participatory scenario development
- **Adaptation through behavioral change:** Accommodation, household preparation and evacuation planning, retreat and migration, which has its own implications for human health and human security, soil and water conservation, livelihood diversification, changing livestock and aquaculture practices, crop-switching , changing cropping practices, patterns, and planting dates, silvicultural options, reliance on social networks

INSTITUTIONAL

- **Adaptation through Economic instruments:** Financial incentives including taxes and subsidies, insurance including index-based weather insurance schemes, catastrophe bonds, revolving funds, payments for ecosystem services, water tariffs, savings groups, microfinance, disaster contingency funds, cash transfers
- **Adaptation through Laws and regulations:** Land zoning laws, building standards, easements, water regulations and agreements, laws to support disaster risk reduction, laws to encourage insurance purchasing, defining property rights and land tenure security, protected areas, marine protected areas, fishing quotas, patent pools and technology transfer,
- **Government policies and programs:** National and regional adaptation plans, including mainstreaming climate change; sub-national and local adaptation plans, urban upgrading programs, municipal water management programs, disaster planning and preparedness, city-

level plans, district-level plans, sector plans, which may include integrated water resource management, landscape and watershed management, integrated coastal zone management, adaptive management, ecosystem-based management, sustainable forest management, fisheries management, and community-based adaptation

SELECTING ADAPTATION OPTIONS:

Considerations when selecting adaptation options:

- Effective in reducing vulnerability and increasing resilience
- Efficient (increase benefits and reduce costs)
- Equitable, especially to vulnerable groups
- Mainstreamed /integrated with broader social goals, programs, and activities
- Stakeholder participation, engagement, and support
- Consistent with social norms and traditions
- Legitimacy and social acceptability
- Sustainable (environmental and institutional sustainability)
- Flexible and responsive to feedback and learning
- Designed for an appropriate scope and time frame
- Likely to avoid maladaptive traps
- Robust against a wide range of climate and social scenarios
- Resources available (including information, finance, leadership, management capacity
- Need for transformative changes considered
- Coherence and synergy with other objectives, such as mitigation

Adaptation can contribute to the well-being of populations, the security of assets and the maintenance of eco-system goods, functions and services now and in the future. Adaptation is place- and context-specific. Adaptation can reduce the risks of climate change impacts, but there are limits to its effectiveness, especially with greater levels and rates of climate change. Taking a longer-term

perspective in the context of sustainable development increases the likelihood that more immediate adaptation actions will also enhance future options and preparedness.

Mitigation, in the near-term and through the century, can substantially reduce climate change impacts in the latter decades of the 21st century and beyond. Benefits from adaptation can be realized even now in addressing current risks and can be realized in the future for addressing emerging risks.

Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. Substantial emission reduction over the next few decades can reduce climate risks in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term and contribute to climate-resilient pathways for sustainable development.

Many adaptation and mitigation options can help address climate change, but no single option is sufficient by itself. Effective implementation depends on policies and cooperation at all scales and can be enhanced through integrated responses that link adaptation and mitigation with other societal objectives.

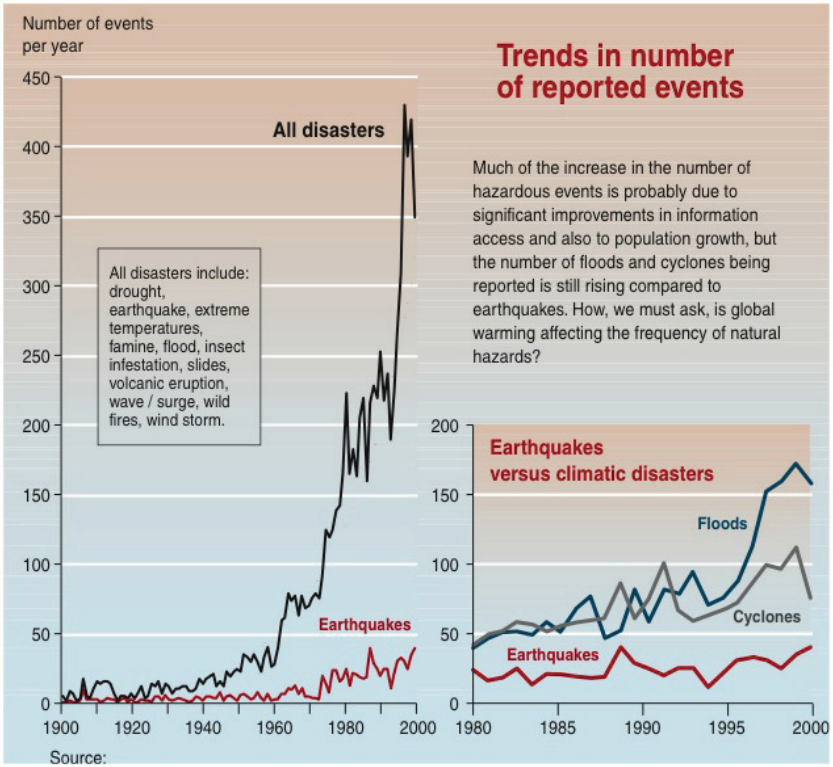


Figure 1: Trends in natural disasters (Source: Centre for Research on the Epidemiology of Disasters)

EMERGING TRENDS IN DISASTER IMPACTS, HAZARDS AND VULNERABILITY PATTERNS

- More than 90 per cent of natural disaster-related deaths are in developing countries.
- The global trend is of fewer deaths but higher economic losses due to disasters.
- Hazards and vulnerability are constantly shaped by dynamic and complex socioeconomic and ecological processes and get compounded by stresses within individual societies.

8.2 Disaster and risk reduction

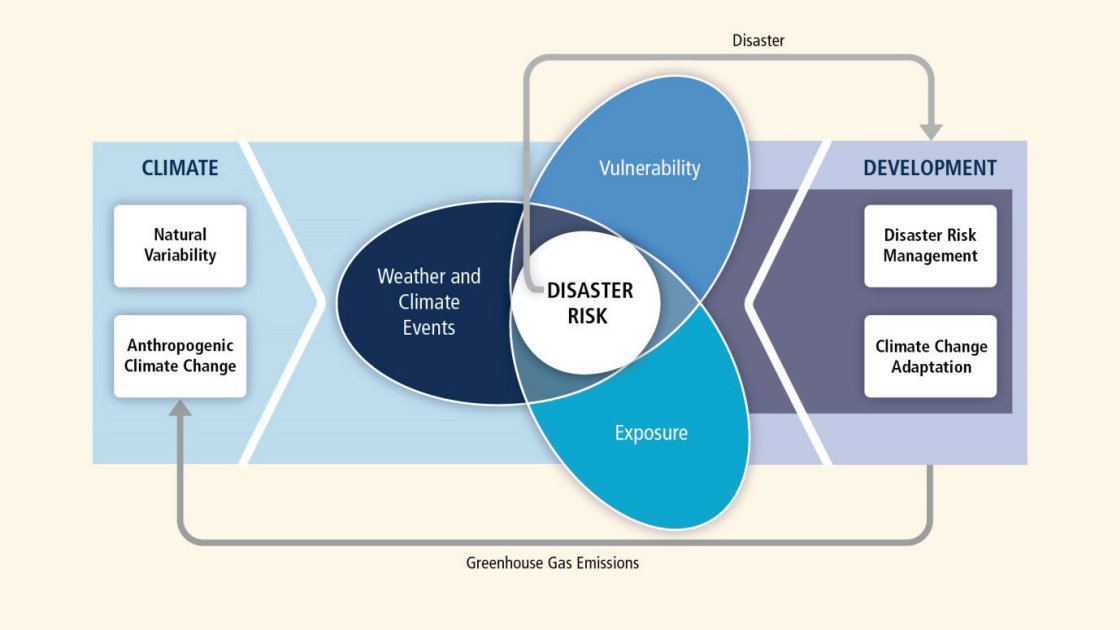
8.2.1 Basics of Disaster risk reduction

The term 'disaster,' meaning 'bad star' in Latin, is defined as an impact of a natural or human-made hazard that causes human suffering or creates human needs that the victims cannot meet without assistance. The word's root is from astrology and implies that when a star is in a bad position, a bad event is about to happen. In a recent document published by the United Nations Development Programme (UNDP) in the Americas, a disaster is defined as 'a social crisis situation occurring when a physical phenomenon of natural, socio-natural or anthropogenic origin negatively impacts vulnerable populations ... causing intense, serious and widespread disruption of the normal functioning of the affected social unit.'

India's Disaster Management Act 2005 defines 'disaster' as 'a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or man-made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such nature or magnitude as to be beyond the coping capacity of the community of the affected area.' Officially, the United Nations defines 'disaster' as 'the occurrence of sudden or major misfortune which disrupts the basic fabric and normal functioning of the society or community.'

With growing populations and infrastructure, the world's exposure to natural hazards is witnessing a steep increase. This is particularly true as the fastest population growth is in coastal areas (with greater exposure to floods, storms and tidal waves). To make matters worse, any land remaining available for urban growth is generally risk prone, for instance, floodplains or steep slopes subject to landslides. The accompanying graphs show a steep increase in the frequency of disasters in recent years. This raises several questions.

- Is the increase due to a significant improvement in access to information?
- What part does population growth and infrastructure development play?
- Is climate change behind the increasing frequency of natural hazards?



There are many reasons for the escalation in the frequency of disasters, such as new settlement patterns, population growth, increased rural-to-urban migration, emerging poverty levels and trends, the impact of development processes, new forms of vulnerabilities related to technological and industrial developments, emergence of virulent biological threats, ecological degradation, phenomena such as El Niño/La Niña, climate change and the potential for rising sea levels, affecting the patterns and intensity of hydro-meteorological hazards.

8.2.2 Types of natural and non-natural disasters

Disasters are often classified according to their causes (natural vs human-made) and speed of onset (sudden vs slow)

CLASSIFICATION BY CAUSE

Natural disasters. These types of disasters are caused by biological, geological, seismic, hydrologic or meteorological conditions or processes in the natural environment, e.g., cyclones, earthquakes, tsunami, floods, landslides and volcanic eruptions.

Human-made disasters. These are disasters or emergency situations of which the principal, direct causes are identifiable human actions, deliberate or otherwise. Apart from technological disasters, this mainly involves situations in which civilian populations suffer casualties and loss of property, basic services and means of livelihood as a result of war, civil strife or other conflicts, or policy implementation. In many cases, people are forced to leave their homes, giving rise to congregations of refugees or externally and/or internally displaced persons as a result of civil strife, an airplane crash, a major fire, an oil spill, an epidemic, terrorism, etc.

CLASSIFICATION BY SPEED OF ONSET

Sudden onset. The disaster happens with little or no warning, and there is minimal time to prepare, for example, an earthquake, a tsunami, a cyclone, a volcanic eruption.

Slow onset. These adverse events are slow to develop: first, the situation develops; the second level is an emergency; the third level is a disaster. Examples are droughts, civil strife and epidemics.

8.2.3 The disaster continuum and the context of coastal and marine biodiversity conservation

Disaster management can be defined as the body of policy and administrative decisions and operational activities that pertain to the various stages of a disaster at all levels. There are three key stages of activity in disaster management.

1. BEFORE A DISASTER STRIKES (PRE-DISASTER)

Activities taken to reduce human and property losses caused by the hazard and ensure that these losses are also minimized when the disaster strikes. Risk reduction activities are taken up in this stage. They are termed mitigation and preparedness activities.

Stable and healthy coastal and marine habitats such as mangroves, coral reefs and sea grasses are key in ensuring the pre-disaster mitigation and preparedness activities against coastal disasters.

2. DURING A DISASTER (DISASTER OCCURRENCE)

Activities taken to ensure that the needs of affected people are met and suffering is minimized. Activities carried out during this stage are called emergency response activities.

3. AFTER A DISASTER (POST-DISASTER)

Activities undertaken for early recovery and efforts undertaken to ensure that the earlier vulnerable conditions do not prevail again. These are called response and recovery activities.

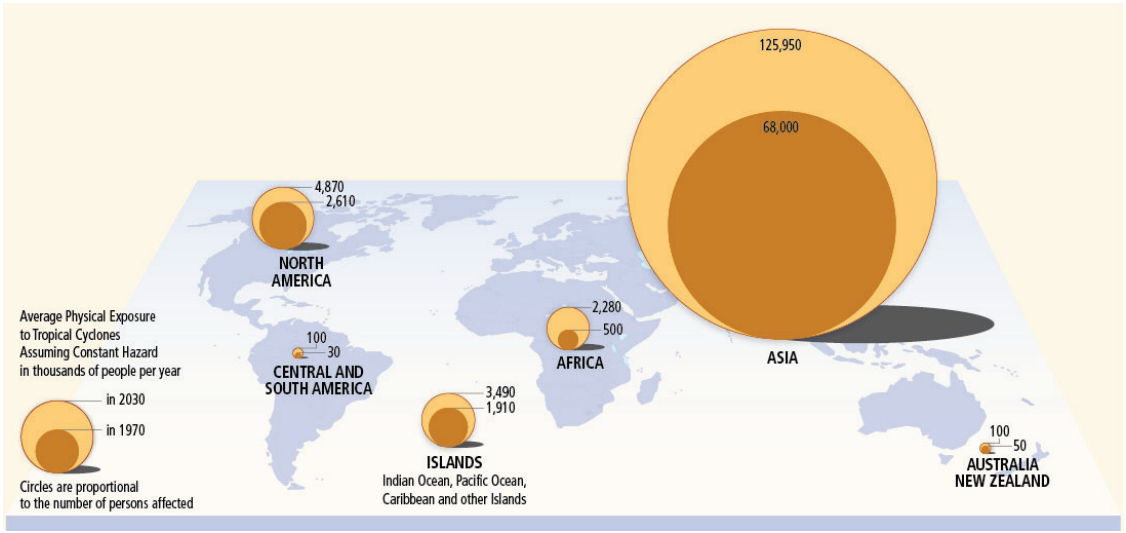


Figure: Average physical exposure to tropical cyclones assuming constant hazards [Source: SREX report 2012]

CATEGORIES OF DISASTERS

i. Water and climate related disasters	a. Floods and drainage management b. Cyclones c. Tornadoes and hurricanes d. Hailstorm Cloud burst e. Heat wave and cold wave f. Snow avalanches g. Droughts h. Sea erosion i. Thunder and lightening j. Tsunami

ii. Geological related disasters	a. Landslides and mudflows b. Earthquakes c. Dam failures/ Dam bursts d. Minor fires
iii. Chemical, industrial and nuclear related disasters	a. Chemical and industrial disasters b. Nuclear disasters
iv. Accident related disasters	a. Forest fires Urban fires Mine flooding b. Oil spills c. Major building collapse d. Serial bomb blasts e. Festival related disasters f. Electrical disasters and fires g. Air, road and rail accidents h. Boat capsizing i. Village fire
v. Biological related disasters	a. Biological disasters and epidemics b. Pest attacks c. Cattle epidemics d. Food poisoning

Source: High Powered Committee Report-1999
Note: After 2004, Tsunami has also been included in the list of disasters.

According to the United Nations International Strategy for Disaster Risk Reduction (2004), a disaster is a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts that exceeds the ability of the affected community or society to cope using its own resources.

URBANIZATION AND DISASTERS

- One out of every two people now lives in a city. This proportion will go on rising—by 2030, 5 billion of the planet's expected 8.1 billion population will be urban.
- One in three of the urban population lives in marginal settlements or crowded slums with inadequate access to clean water, sanitation, schools, transport and other public services. This is relevant for many of our Tier 1 and Tier 2 cities.
- One city dweller in four lives in absolute poverty. By 2030, two-thirds of humankind will live in cities and 3 billion in slums.
- Eight of the 10 most populous cities on the planet are vulnerable to earthquakes. Six of the 10 are vulnerable to floods, storm surges and tsunamis.
- Ineffective land-use planning, inadequate enforcement of building codes and faulty construction standards put millions at risk.
- By 2015, 33 cities will have at least 8 million residents. Of these, 21 are in coastal areas and are particularly vulnerable to meteorological hazards driven by climate change, e.g., Dhaka, Shanghai, Manila, Jakarta and Mumbai.
- Cities with weak governance and small- and medium-sized urban areas are more vulnerable to disasters as they have weaker capacities to manage urban growth, deforestation and destruction of coastal systems.

A 'disaster' occurs when a 'hazard' impacts on 'vulnerable' people. The combination of hazards, vulnerability and inability to reduce the potential negative consequences of risk results in disasters.

The vulnerability of local communities increases due to the negative impacts of climate change and therefore leaves these communities at a higher risk of disasters. Similarly, a community that is more prone to recurring disasters will be more vulnerable to the impacts of climate change.

8.2.4 Hazard profile of India

India is one of the 10 most disaster-prone countries in the world. The country is prone to disasters due to a number of factors, both natural and human induced, including adverse geoclimatic conditions, topographic features, environmental degradation, population growth, urbanization, industrialization and nonscientific development practices. These factors, either by themselves or by accelerating the intensity and frequency of disasters, are responsible for a heavy toll of human lives and for disrupting the support system in the country.

The basic reason for the high vulnerability of the country to natural disasters is its geographical features. The five distinctive regions of the country, i.e., the Himalayan region, the alluvial plains, the desert, the hilly part of the peninsula and the coastal zone, have their own specific problems. While the Himalayan region is prone to disasters such as earthquakes and landslides, the plains are affected by floods almost every year. The desert is affected by droughts, while the coastal zone is susceptible to cyclones.

The geotectonic features of the Himalayan region and adjacent alluvial plains make the region susceptible to earthquakes, landslides, water erosion, etc. Peninsular India is considered to be the most stable portion, but occasional earthquakes in the region show that geotectonic movements are still going on within its depth.

Floods top the list of disasters in India on an annual basis. The protection mechanisms in the country against these floods are inadequate. The western part of the country, including Rajasthan, Gujarat and some parts of Maharashtra, are hit very frequently by droughts. Around 68 per cent of the land area in India is prone to drought. Of this, 35 per cent receives rainfall of 750–1125 mm a year and is considered drought prone, and 33 per cent receives less than 750 mm and is considered chronically drought prone. If the monsoon is poor, drought spreads to other parts of the country as well.

India is exposed to 10 per cent of the world's tropical cyclones. About 71 per cent of this area is in 10 states (Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu, Andhra Pradesh, West Bengal, Kerala, Orissa, Puducherry).

Other factors such as the increasing pressure exerted by the population, deteriorating environmental conditions, deforestation, unscientific and unplanned development, faulty agricultural practices and grazing, unplanned urbanization and construction of large dams, are also responsible for the increased impacts and frequency of disasters in the country.

In recent years, India has been witnessing an ascending trend in the occurrence of heat and cold waves, especially in the wake of the climate change phenomenon. Uttar Pradesh and Bihar rank the highest in terms of casualties on account of cold waves in India, primarily due to a slow pace of development and a lack of adequate and appropriate shelters for workers and farmers.

Thunderstorms and hailstorms usually affect the central, northern, northeastern and northwestern parts of the country.

India has been divided into four seismic zones according to the maximum intensity of earthquake expected. Of these, Zone V is the most active one, comprising all of Northeast India, the northern portion of Bihar, Uttarakhand, Himachal Pradesh, Jammu and Kashmir, Gujarat and the Andaman and Nicobar Islands. Six major earthquakes struck different parts of India between1995 and 2010.

As far as man-made disasters are concerned, it is estimated that currently there are over 1949 industrial units in India that are considered to represent major accident hazards, besides many more small and medium industrial units.

8.3 Climate change and disaster risk: How they relate to coastal and marine biodiversity and coastal livelihoods

A livelihood is a means of making a living. A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living (Chambers and Conway 1991). In rural areas, a major determinant of livelihood security is the availability of resources, especially natural resources, which include forests/grazing areas, land, water, livestock and other animal resources, as well as access to these resources through a conducive natural resource governance system. Access to information and knowledge on the use of natural resources, through peer learning or through intergenerational knowledge transfer, is equally crucial for livelihood security.

A livelihood is sustainable that can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets and provide sustainable livelihood opportunities for the next generation and that contributes net benefits to other livelihoods at the local and global levels and in the short and long term (Chambers and Conway 1991).

This translates into a two-way relationship between livelihoods and the ecosystem. A livelihood is environmentally sustainable when the natural resources and ecosystem services are being utilized for livelihood activities at a rate and in a manner that do not pose any threats to the natural ecosystems and the ecosystem services. A livelihood is socially sustainable when it is able to cope with stress and shocks and retain its ability to continue

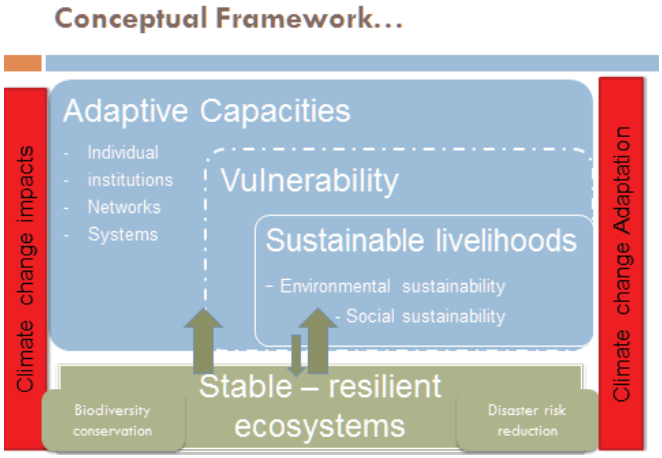


Figure 4: Conceptual framework detailing elements of climate change adaptation and their interrelationship with biodiversity conservation and disaster risk reduction

and improve (Chambers and Conway 1991). There is a need to include the impacts of stresses and shocks or disasters and the coping capacities of human communities in the conceptual planning of livelihood sustainability.

Climate-related hazards affect the lives of poor people directly through impacts on livelihoods, reductions in crop yields or destruction of homes. They affect their lives indirectly through, for example, increased food prices and food insecurity.

The livelihoods of the rural poor are, therefore, closely affected, in one or the other way, by three major factors, viz, climate change, disruption/loss of ecosystem services and disasters. In the recent past, climate change has emerged as one of the most serious threats to the existence of human societies, impacting communities with far-reaching consequences for their lives and livelihoods, especially in the developing countries. Climate studies show us that the best possible scenario of greenhouse gas emission control will still leave us with an at least 1.8°C temperature rise by 2100. This means that while on one hand mitigation is an important aspect of managing climate change, countries must start planning towards adaptation, i.e., develop strategies to cope with this temperature rise on the other hand.

Impacts from recent climate-related extremes, such as heat waves, droughts, floods, cyclones and wildfires, include alteration of ecosystems, disruption of food production and the water supply, damage to infrastructure and settlements, morbidity and mortality, and consequences for mental health and human well-being. For countries at all levels of development, these impacts are consistent with a significant lack of preparedness for current climate variability in some sectors (IPCC).

The goal of CCA planning is to find local or locally adapted sustainable solutions for robust and diversified livelihood options, especially in climate-sensitive sectors such as agriculture, forestry and tourism. In the coastal areas, the need for adaptation is intensified due to the unique challenges faced by the livelihoods in these areas in terms of the higher risk of natural disasters, the high concentration of the human population along the coastline, the stronger role of women in the fisheries sector, the concentration of polluting industries on the coast (at the expense of natural coastal habitats, adding to the vulnerability of the local communities), etc.

Therefore, adapting to climate change is of high relevance for protecting the livelihood security of communities in coastal areas and the overall well-being of such areas.

According to the Millennium Ecosystem Assessment (MEA 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 (UNDP 2011a) estimates that by 2100 about 90 per cent 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 has called for greater protection and enhancement of ecosystem services.

The 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 disaster risk reduction (DRR) strategies (Krishnan and Soni 2011).

8.4 Synergies and trade-offs between climate change, disaster risk, coastal and marine biodiversity and coastal livelihoods

8.4.1 Why should we discuss synergies and trade-offs?

Though the objective of both CCA and DRR is reducing the vulnerability of local communities, some CCA and disaster risk interventions may unintentionally leave people even more vulnerable than before to the impacts of natural disasters.

This is not because of a lack of understanding of the interlinkages between climate change and disasters. At the framework level, the international conventions and national policies on climate and disaster do recognize the linkages between CCA and DRR. There is also no dearth of scientific evidence that different elements of biodiversity and ecosystem services are the foundation of livelihoods of human communities (MEA 2005) and reduce the vulnerability of human communities to the negative impacts of climate change and disasters (IPCC 2007). The challenge, however, lies in identifying the activities and strategies that may be mutually beneficial (interlinkages) or may diminish the efforts of the other sectors (trade-offs) in a particular context. It may not be possible to develop a global equation on the interlinkages between different sectoral strategies as the linkages may be highly context-specific.

For environmental sustainability, livelihoods can be categorized broadly into three categories based on the level of utilization of the natural resource base. The first category is that of those livelihood activities that ensure no harm to natural resources, the second category of livelihood activities is where the livelihood activities strive to maintain the existing natural resource base, and the third category capitalizes on the opportunities created by climate variability and change. Livelihood activities falling under these three categories bring synergies with CCA efforts, while all other activities that negatively affect the quantity or quality of biodiversity and other ecological resources will disrupt the ecosystem balance and subsequently decrease the ability of the ecosystems to regulate the disaster risk, which renders livelihoods socially unsustainable.

This delicate relationship between livelihoods and ecosystem stability is further stressed when the ecosystems and human communities are impacted by climate change and variability. The greatest

impact of climate change is on biodiversity and disrupts ecosystem services. However, the impacts of climate change on ecosystems and their services will not be distributed equally around the world. Drylands, mountain regions and Mediterranean regions are likely to be more vulnerable than others (Gitay et al 2001), and ecosystem degradation is greatest in these regions (Hassan et al 2005, cited from IPCC 2007). The threat is also greater in communities and areas that have a high dependence on the natural resources for their lives and livelihoods. Rural populations living in hilly areas of developing countries are, therefore, among the most vulnerable groups of communities due to their high vulnerability and low adaptive capacities.[5] Many marine and coastal ecosystems no longer deliver the full suite of ecosystem services that humans have come to rely upon (Mengerink et al 2009) due to the existence of trade-offs between the activities of different sectors. Trade-offs can be minimized if the primary goal of all the activities in the marine and coastal ecosystems is maintaining a sustainable flow of ecosystem services (MEA 2005).

8.4.1 The root cause: Trade-offs between different ecosystem services

Stable and diverse ecosystems provide multiple services, which interact in multiple ways. This makes the ecosystem services related to each other either negatively or positively. Some ecosystem services co-vary positively (an increase in one service means another also increases), and others co-vary negatively (an increase in one service means another decreases). Focusing on one ecosystem service in isolation from the possible impacts on other critical services provided by the same ecosystem leads to a situation of conflict and management failure (Elmqvist et al 2011).

Marine and coastal ecosystems around the world are experiencing an increasing demand for their diverse ecosystem services, which are required for different sectors such as fisheries, tourism, biodiversity conservation, CCA, DRR and so on. The viability of many activities of these sectors is dependent on the services provided by the same ecosystem. In such situations, progress toward one objective, such as increasing fish production, has often been at the cost of other objectives, such as conserving biological diversity or improving water quality (MEA 2005), and this is known as a 'trade-off'. These trade-offs exist even within the 'green sector.'

5 Adaptive capacity' is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities or to cope with the consequences (IPC AR4 Glossary, 2007).

Significant co-benefits, synergies and trade-offs exist between mitigation and adaptation and among different adaptation responses. Interactions occur both within and across regions (very high confidence). Increasing efforts to mitigate and adapt to climate change imply an increasing complexity of interactions, particularly at the intersections among water, energy, land use and biodiversity, but there are few tools available to understand and manage these interactions. Examples of actions with co-benefits include (1) improving energy efficiency and developing cleaner energy sources, leading to reduced emissions of health-damaging, climate-altering air pollutants; (2) reducing energy and water consumption in urban areas through greening of cities and recycling water; (3) practicing sustainable agriculture and forestry; and (4) protection of ecosystems for carbon storage and other ecosystem services.

8.4.2 Synergies and trade-offs with DRR and CCA

A number of studies indicate that sustainable strategies for DRR help improve livelihoods (Pomeroy et al 2006). DRR strategies involve enhancement of the adaptive capacity of the coastal population, which also increases the livelihood options through better communication and awareness (Pomeroy et al 2006; IPCC 2012). The coastal population, with enhanced adaptive capacities, is also less vulnerable to the negative impacts of climate change.

While most of the DRR activities are synergistic with the objectives of marine and coastal protected areas and the livelihoods of coastal communities, there are certain activities with trade-offs, such as shelterbelt plantation on the shoreline with *Casuarina equisetifolia* for cyclone protection (NDMA 2008), which reportedly has adverse effects on the nesting of sea turtles by causing beaches to shrink (Balu 2008). Ironically, it has also not been possible so far to establish the effectiveness of thin shelterbelt plantations as bio-shields (Forbes & Broadhead 2007). This example supports the need to build scenarios of ecosystem service trade-offs, which will help prioritize activities on the basis of their impacts on ecosystem services.

Threats to marine and coastal biodiversity are further enhanced in light of the observed and predicted impacts of climate change. Climate change will have heightened negative impacts on the coastal ecosystems by increasing the risk of natural disasters such as coastal flooding and other extreme events (IPCC 2012). CCA is an important management strategy for reducing the vulnerability of people and infrastructure to the negative impacts of climate change. CCA

interventions reduce the threats to habitats and tourism infrastructure and therefore enhance tourism opportunities (Parry et al 2007). However, trade-offs can be seen with the adaptation options, such as modification of land use for agricultural practices and aquaculture, which may lead to habitat loss and degradation, spread of invasive alien species and coastal pollution—changes that may result in loss of fisheries, affecting local livelihoods and ultimately leaving the coastal communities even more vulnerable to the negative impacts of climate change and natural disasters than before.

Similarly, some protective hard infrastructure raised as CCA options (such as seawalls, floodgates, tidal barriers and saltwater-intrusion barriers) have been reported to be ineffective in extending protection, rather enhancing the risk of natural disasters and contributing to habitat loss due to coastal squeeze (Knogge et al 2004; Rochelle-Newall et al 2005). Such CCA strategies, termed 'mal-adaptation' (Burton 1996), may compromise biodiversity and the stability of an ecosystem in the long term and not only increase the risk of disasters but also diminish the livelihood opportunities of the population and make it more vulnerable to climate change.

8.4.3 Possible synergies and trade-offs in CCA and livelihoods

CCA must enhance the adaptive capacities of people through socially and environmentally sustainable livelihoods and resilient ecosystems on one hand and recognize any possible trade-offs between livelihood strategies and biodiversity and ecosystem resilience.

Studies forecast that climate change will adversely affect many ecosystems, particularly coastal and marine ecosystems, and that the most vulnerable areas are coastal areas. The implications of stress from climate change on people's livelihood systems are not widely understood. Knowledge about the special forms of vulnerability of people living in coastal ecosystems is sparse. However, it is predicted that the coastal population, particularly the poor, are relatively more vulnerable to adverse impacts of climate change due to their low adaptive capacities and greater dependence on climate-sensitive sectors, such as fisheries, for their livelihoods and the heightened risk of natural disasters and extreme weather events.

Trade-offs can be seen when CCA strategies increase the vulnerability of communities to disaster risk, via long-term negative impacts on biodiversity. Similarly, some livelihood interventions can unintentionally leave people even more vulnerable than before to the impacts of climate change.

For example, development of rural infrastructure such as village roads in hilly terrain, aiming at CCA, may lead to recurring disasters if the landslide hazard of that hill is not taken into account. Another area of trade-offs can be in the forestry and horticulture sector, where large-scale single-species plantations, especially with exotic species, may increase the risks of soil erosion, exotic pest invasions and soil nutrient imbalance.

Apart from adaptation-focused activities, there are certain mitigation efforts that may have a negative impact on risk reduction efforts. The new opportunities in carbon emissions trading[6] encourage raising plantations (mostly of exotic species) on the available land, very often in the form of monocultures. This phenomenon may disrupt the ecosystem structure and services in that landscape on one hand and take away the opportunity to use that land for more sustainable adaptation options on the other hand. Trade-offs can also be seen when the risk of disasters increases due to other sectoral activities, which may hamper adaptation efforts in an ecosystem. For example, plantation or construction activity on a steep slope may lead to soil erosion and landslides in hilly areas, leading to increased risks for the livelihood security and overall development of the area.

The aforementioned CCA/mitigation strategies may compromise biodiversity and ecosystem stability in the long term and not only increase the risk of disasters but also diminishes the livelihood opportunities of the population, making them further vulnerable to climate change.

6 Emissions trading is a process where developed countries that have emission reduction targets can buy emission reduction certificates from developing countries that do not have targets for emission reduction.

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Further Resources

BBC Human Planet ep 1 of 8 Oceans pt 14 HD nature documentary, http://www.youtube.com/watch?v=Mugl3av42Bk

Concerned Citizens Commission Report: 'Mumbai Marooned'; also National Geographic channel documentary, https://www.youtube.com/watch?v=uvIuroTz8Gw

Website of Indo-German Biodiversity Programme, http://www.indo-germanbiodiversity.com/index.php?r=project/view&id=2

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IPCC Fifth Assessment Report - Working Group II - Climate Change 2014: Impacts, Adaptation, and Vulnerability. https://www.youtube.com/watch?v=jMIFBJYpSgM

Climate Change 2013: The Physical Science Basis. The IPCC has produced a video on its Fifth Assessment Report (AR5). The first part on the Working Group I contribution to AR5 is now available. The other parts will be released with the successive approvals of the other two Working Group contributions and the Synthesis Report in the course of 2014. https://www.youtube.com/watch?v=6yiTZm0y1YA