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Wildlife Institute of India

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On behalf of:
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Curriculum on

Coastal and Marine Biodiversity and Protected Area Management

Module 2
Coastal and marine biodiversity and Ecosystems Services in the overall environment and development context

For Field-Level MPA Managers

Imprint

Training Resource Material:

Coastal and Marine Biodiversity and Protected Area Management for Field-Level MPA Managers

Module 1: An Introduction to Coastal and Marine Biodiversity and Ecosystem Services
Module 2: Coastal and Marine Biodiversity and Ecosystems Services in the Overall Environment and Development Context
Module 3: Mainstreaming Coastal and Marine Biodiversity into Overall Development and Environmental Planning
Module 4: Coastal and Marine Protected Areas and Sustainable Fisheries Management
Module 5: Governance, Law and Policies for Managing Coastal and Marine Ecosystems, Biodiversity and Protected Areas
Module 6: Assessment and Monitoring of Coastal and Marine Biodiversity and Relevant Issues
Module 7: Effective Management Planning of Coastal and Marine Protected Areas
Module 8: Communicating Coastal and Marine Biodiversity Conservation and Management Issues

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Module 2
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For Field-Level MPA Managers

Summary

This is the most comprehensive and time-intensive module of the course, setting the foundation of the issues of coastal and marine conservation in the overall development context. This module facilitates participants looking into the overall development agenda via Global Sustainable Development Goals, the concepts of sustainability, sustainable livelihoods and its interlinkages with the ecosystem services. The module takes a deeper look into the economic values, and threats to coastal and marine biodiversity and focuses in detail on the climate change and disaster risk reduction and their interrelationship with the coastal and marine biodiversity conservation. To make the learning easy for participants, this module comprises two very interesting training methods—ecological footprint game, and two simulation games on a fictitious countries—Bakul, and Ceebano.

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Acronyms

CBD	Convention on Biological Diversity
CMS	Convention on Migratory Species
EIA	Environmental Impact Assessment
EMP	Environment Management Plan
FAO	Food and Agriculture Organization
GCBA	Generational cost benefit analysis
NBAP	National Biodiversity Action Plan
NEP	National Environment Policy
SEA	Strategic Environmental Assessment
SLEIAA	State Level Environmental Impact Assessment Authority

Learning outcomes

After completing this module, the participants are able to

- appreciate the concept of sustainability
- appreciate the role that biodiversity elements play in providing livelihoods to the coastal communities
- Understand the value of ecosystems and different elements of it, and outline the economic benefits that coastal and marine biodiversity provides to different sectors
- summarise the threats that different coastal and marine habitats and species face
- demonstrate the role of coastal and marine biodiversity in climate change adaptation and disaster risk reduction
- critically analyse the synergies and trade-offs between climate change adaptation, disaster risk reduction, coastal livelihoods and coastal marine biodiversity conservation.

Key messages

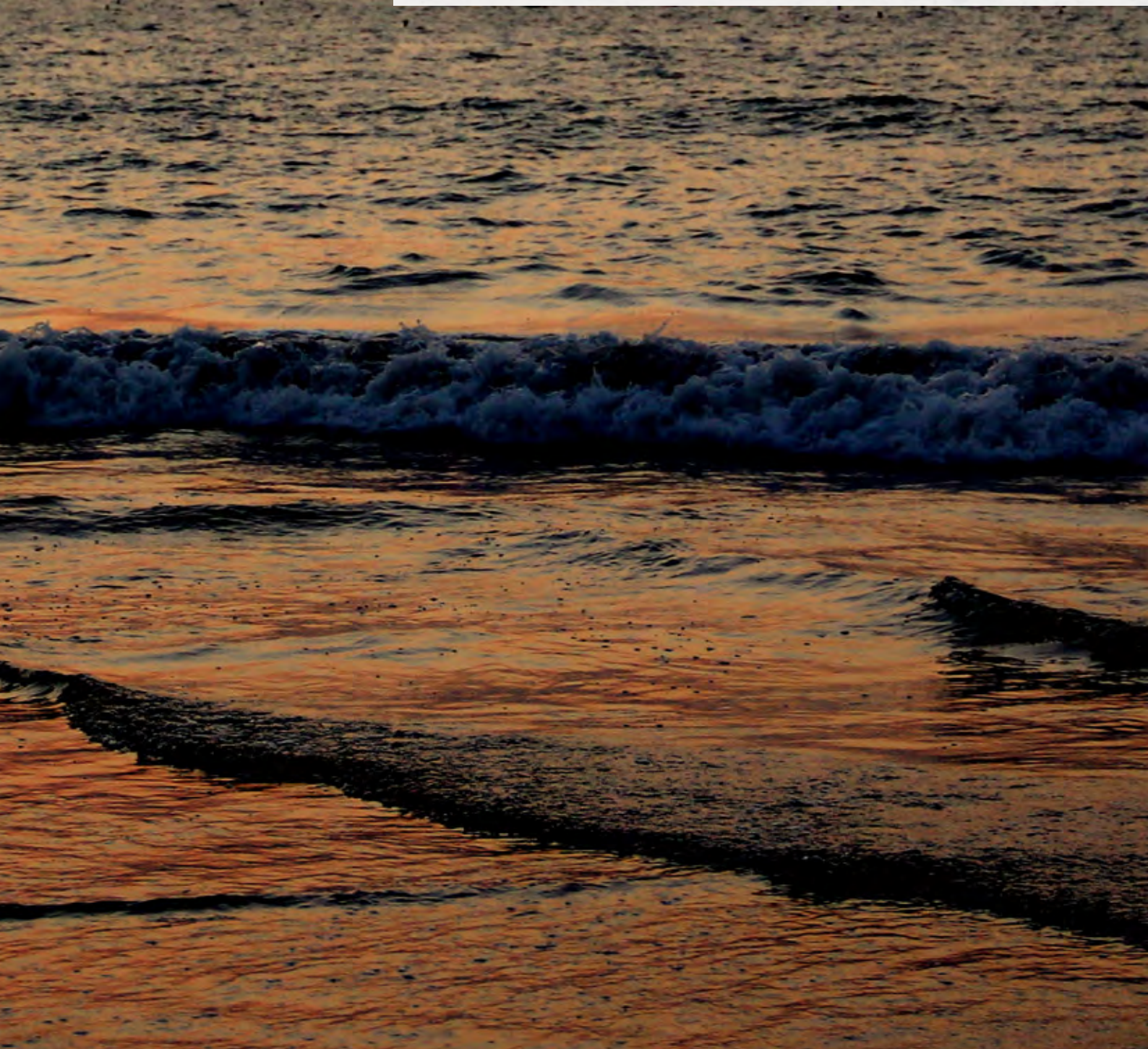
- The eight Millennium Development Goals (MDGs) – which range from halving extreme poverty to halting the spread of HIV/AIDS and providing universal primary education, all by the target date of 2015 – form a blueprint agreed to by all UN member countries and all leading development institutions of the world. MDGs have galvanised unprecedented efforts on a global scale to meet the needs of the world's poorest.
- The MDGs have been replaced by the Sustainable Development Goals from 2015. At the Rio+20 meeting, two decades after the Earth Summit in Rio de Janeiro in 1992, it was decided to institute Sustainable Development Goals (SDGs) from 2015. Targets for achieving these goals have been set for either 2020 or 2030. Eradicating poverty was, once again, seen as the greatest challenge to humankind. Changing unsustainable patterns of production and consumption and promoting sustainable ones were major priorities, and managing the natural resource base was seen as essential to achieving such sustainable practices.
- It is estimated that nearly 250 million people live within a swathe of 50 km from the coastline of India who are dependent on the rich coastal and marine resources. Therefore, the ecological services of the marine and coastal ecosystems of India play a vital role in India's economic growth and the welfare of citizens.
- Today, human activities are threatening the seas and coasts through overfishing, destructive fishing practices, pollution and waste disposal, agricultural runoff, invasive alien species and habitat destruction. Global climate change will make it worse. Sea levels are already rising and will rise further, water temperature will increase, oceans will acidify, and there will be more storms and natural disasters of a severe nature.
- Approximately 60% (15 out of 24) of the ecosystem services evaluated in the Millennium Ecosystem Assessment (including 70% of regulating and cultural services) are being degraded or used unsustainably. The loss of biodiversity in terms of habitat, species and genetic diversity is enormous.
- The consequences of the biodiversity loss and resulting loss of ecosystem services has far reaching impact on livelihoods and the overall wellbeing of human communities.
- Valuing ecosystem services would provide policy-makers with a strong rationale to improve coastal and marine ecosystem management and invest in conservation for its risk management value and economic benefits. In order to fully leverage ecological and economic knowledge of ecosystems and services, there is a need to generate and provide access to better data regarding ecosystem services.
- According to the Intergovernmental Panel on Climate Change (IPCC), the UN body set up to assess climate change, climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean 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 forcings, such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use.

- The main characteristics of climate change include rising temperatures, changes in rainfall pattern, melting of glaciers and sea ice, sea level rise and an increased intensity and/or frequency of extreme events. These changes in physical processes have impacts on biological and socio-economic factors such as shifts in crop growing seasons, food production and food security, changes in disease vectors, shifting boundaries of the forests and other ecosystems, and extreme events like flooding, droughts and landslides.
- Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. Substantial emissions reductions 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.
- The goal of climate change adaptation (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.
- 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.
- 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 negatively impact coastal and marine biodiversity and habitats and consequently 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 flow of ecosystem services.

2.1 Overall Development Context

2.1.1 Millennium development goals:

At the turn of the millennium eight development goals were set before the world taking 1990 as the base year. Called the Millenium Development Goals, these were established at the Millennium Summit of the United Nations in 2000, following the adoption of the United Nations Millennium Declaration.



The eight MDGs – which range from halving extreme poverty to halting the spread of HIV/AIDS and providing universal primary education, all by the target date of 2015 – form a blueprint agreed to by all UN member countries and all the leading development institutions of the world. MDGs have galvanised unprecedented efforts on a global scale to meet the needs of the world's poorest. The eight MDGs are:

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality by two thirds for children under five (between 1990 and 2015)
5. Improve maternal health
6. Combat HIV and AIDS, malaria and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development

2.1.2 What are the Sustainable Development Goals?

The sustainable development goals (SDGs) are a new, universal set of goals, targets and indicators that UN member states will be expected to use to frame their agendas and political policies over the next 15 years. The SDGs follow, and expand on, the Millenium Development Goals (MDGs), which were agreed on by governments in 2000 and are due to expire at the end of this year.

Why do we need another set of goals?

There is broad agreement that while the MDGs provided a focal point for governments on which to hinge their policies and overseas aid programmes to end poverty and improve the lives of poor people – as well as provide a rallying point for NGOs to hold them to account – they have been criticised for being too narrow.

The eight MDGs – reduce poverty and hunger; achieve universal education; promote gender equality; reduce child and maternal deaths; combat HIV, malaria and other diseases; ensure environmental sustainability; develop global partnerships – failed to consider the root causes of poverty, or gender inequality, or the holistic nature of development. The goals made no mention of human rights, nor specifically addressed economic development. While the MDGs, in theory, applied to all countries, in reality, they were considered targets for poor countries to achieve, with finance from wealthy states. Every country will be expected to work towards achieving the SDGs.

As the MDG deadline approaches, around 1 billion people still live on less then $1.25 a day - the World Bank measure on poverty - and more than 800 million people do not have enough food to eat.

SDGs relevant to coastal and marine biodiversity

Goal 12: Ensure sustainable production and consumption.

Target 12.4: By 2020, achieve environmentally sound management of chemicals and all wastes

throughout their life cycle and signifi cantly reduce their release to air, water and soil to minimize their adverse impacts on human health and the environment. Marine pollution occurs when harmful impacts arise from the entry into the ocean of chemicals; particles; or industrial, agricultural and residential waste or the spread of invasive organisms. Most marine pollution originates from the land. It often comes from farm runoff, which contains fertilizers and pesticides. The ocean can also be contaminated by excessive inputs of nutrients such as untreated sewage and other biological waste. This is a primary cause of eutrophication of surface waters, in which excess nutrients, usually nitrogen or phosphorus, stimulate the growth of algae.

Goal 13: Take urgent action to combat climate change and minimize its impacts.

At the UN climate change conference in Copenhagen in 2009, political leaders agreed to limit the temperature rise to 2°C to contain the catastrophic impacts of climate change. Failure to do so could, among other consequences, raise sea levels by up to 1 m, flooding low-lying coastal areas, including mega cities such as New York and Mumbai, which are located in such areas.

Target 13.1: Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.

Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

Target 14.1: By 2025, reduce marine pollution of all kinds, particularly from land-based activities.

Target 14.2: By 2020, manage and protect marine and coastal ecosystems, including by

strengthening their resilience.

Target 14.3: Address the impacts of ocean acidification.

Target 14.4: By 2020, regulate fishing, end overfishing, illegal fishing and destructive fishing

practices and implement management plans to restore fish stocks.

Target 14.5: By 2020, conserve at least 10 per cent of coastal and marine areas.

Target 14.6: By 2020, prohibit certain forms of fisheries subsidies.

Target 14.7: By 2030, increase the economic benefits to least developed countries from the sustainable use of marine resources, including through management of fisheries, aquaculture and tourism.

Target 14.a: Increase scientific knowledge, develop research capacities and transfer marine technology to improve ocean health and enhance the contribution of marine biodiversity to the development of developing countries.

Target 14.b: Provide access to marine resources and markets to small-scale artisanal fishers.

Target 14.c: Ensure the full implementation of international laws.

See more at https://sustainabledevelopment.un.org/sdgsproposal.html.

2.1.3 What are the 17 SDG goals?

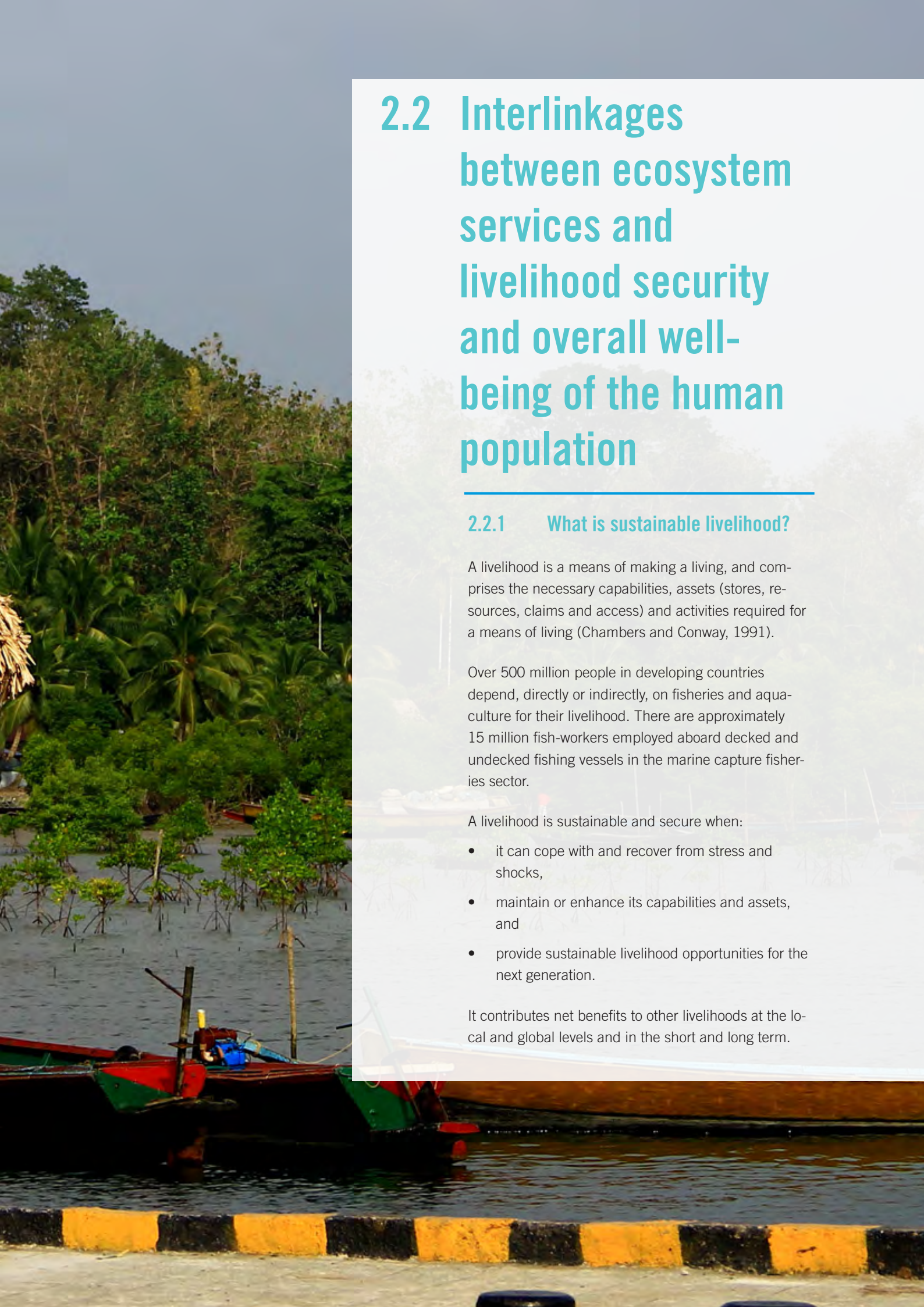
1. End poverty in all its forms everywhere
2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture
3. Ensure healthy lives and promote wellbeing for all at all ages
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5. Achieve gender equality and empower all women and girls
6. Ensure availability and sustainable management of water and sanitation for all
7. Ensure access to affordable, reliable, sustainable and modern energy for all
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all
9. Build resilient infrastructure, promote inclusive and sustainable industrialisation, and foster innovation
10. Reduce inequality within and among countries
11. Make cities and human settlements inclusive, safe, resilient and sustainable
12. Ensure sustainable consumption and production patterns
13. Take urgent action to combat climate change and its impacts (taking note of agreements made bythe UNFCCC forum)
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertifi cation and halt and reverse land degradation, and halt biodiversity loss
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17. Strengthen the means of implementation and revitalise the global partnership for sustainable development

2.1.4 How were the goals chosen?

Establishing post-2015 goals was an outcome of the Rio+20 summit in 2012, which mandated the creation of an open working group to come up with a draft set.

The open working group, with representatives from 70 countries, had its first meeting in March 2013 and published its final draft, with its 17 suggestions, in July 2014. The draft was presented to the UN general assembly in September.

Alongside the open working group, the UN conducted a series of “global conversations”, which included 11 thematic and 83 national consultations, and door-to-door surveys. It also launched an online My World survey asking people to prioritise the areas they’d like to see addressed in the goals. The results of the consultations have fed into the working group’s discussions.



2.2 Interlinkages between ecosystem services and livelihood security and overall well-being of the human population

2.2.1 What is sustainable livelihood?

A livelihood is a means of making a living, and comprises the necessary capabilities, assets (stores, resources, claims and access) and activities required for a means of living (Chambers and Conway, 1991).

Over 500 million people in developing countries depend, directly or indirectly, on fisheries and aquaculture for their livelihood. There are approximately 15 million fish-workers employed aboard decked and undecked fishing vessels in the marine capture fisheries sector.

A livelihood is sustainable and secure when:

- it 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.

It contributes net benefits to other livelihoods at the local and global levels and in the short and long term.

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.

The livelihood is socially sustainable, when it is able to cope with stress (declining resources, climate variability) and shocks (natural disasters), and retain its ability to continue and improve, or in other terms, when it is less vulnerable to the stresses and shocks.

Both aspects of livelihood sustainability – social and environmental – are fundamentally affected by the type, amount and sustainability of the ecosystem services. The consequences of biodiversity loss and ecosystem disruption, therefore, are often harshest for the rural poor, who are highly dependent on local ecosystem services for their livelihood and who are often the least able to access or afford substitutes when these become degraded. These impacts are highest in mountain and coastal communities; these ecosystems are also one of the most vulnerable as far as the negative impacts of climate change are concerned. In fact, the Millennium Ecosystem Assessment has confirmed that biodiversity loss poses a significant barrier to meeting the needs of the world's poorest, as set out in the United Nations Millennium Development Goals

Marine fish and invertebrates are among the last sources of wild food on the planet, providing over 2.6 billion people with at least 20% of their average per capita protein intake. Moreover, the world's oceans host 32 of the 34 known phyla on Earth and contain somewhere between 500,000 and 10 million marine species. Species diversity is known to be as high as 1,000 per square metre in the Indo-Pacific Ocean, and new oceanic species are continuously being discovered, particularly in the deep sea. It is therefore not surprising that the genetic resources in the oceans and coasts are of actual and potential interest for commercial uses.

Coastal livelihoods activities in India: Fisheries, aquaculture, honey collection (Sundarbans), Mangrove resptimber products related livelihoods

See more at: http:// www.mangrovesforthefuture.org/countries/members/india/#sthash. ADBzs6Q7.dpuf

2.2.2 Importance of the Ocean as a Life-Support System for Human Societies (IOC/UNESCO, 2011)

Importance / Issues	
Communities	
Territories & Settlements	More than 40% of the world's population (more than 2.8 billion people) live within 100 kilometres of the coast. Rapid urbanisation will lead to more coastal mega-cities containing 10 million or more people. Thirteen of the world's 20 megacities lie along coasts and nearly 700 million people live in low lying coastal areas less than ten metres above sea level. In Asia, the coastal mega-cities of Chennai (2005: population 6.9 million), Dhaka (12.4 million), Karachi (11.6 million), Calcutta (14.3 million) and Mumbai (18.2 million) are located only a few metres above sea level. One quarter of Africa's population is located in resource-rich coastal zones and a high proportion of gross domestic product (GDP) is exposed to climate influenced coastal risks. In West Africa, the 500 kilometres of coastline between Accra (Ghana) and the Niger delta (Nigeria) is expected to become a continuous urban megalopolis of more than 50 million inhabitants by 2020. In North Africa, the Nile Delta is one of the most densely populated areas of the world and is highly vulnerable to sea-level rise. It is estimated that by 2050, adverse effects associated with global climate change will result in the displacement of between 50 and 200 million people globally.
Small Island Developing States (SIDS)	SIDS are among the most vulnerable nations to changing climate and ocean and coastal degradation. Activities within the ocean and coastal sector in SIDS are important sources of income and foreign exchange. For example, in the Seychelles, coastal tourism contributes 46 to 50% of GDP, 70% of foreign income and employs 20% of the population. In Cape Verde, tourism is the most important economic resource. In Pacific SIDS, fishing can provide between 30 and 80% of exports and GDP – an advantage of the very large Exclusive Economic Zones (EEZs) and the economic values they are able to capture; e.g. transboundary and highly migratory fisheries such as the tuna fishery. In the Caribbean and Pacific islands, more than 50% of the population lives within 1.5 kilometres of the coast. Almost without exception, international airports, roads and capital cities in the small islands of the Indian and Pacific Ocean and the Caribbean are sited along the coast, or on tiny coral islands. The tsunami of December 2004 in the Indian Ocean caused massive loss of life, severe damages to the physical infrastructure of many small islands estimated at USD 470 million, amounting to 62% of the GDP in the Maldives.
Economic Activities (main 4 sectors)	
Fisheries & Aquaculture	In 2009, capture fisheries and aquaculture production was approximately 145 million tonnes, of which marine capture production was 78.6 million tonnes. Almost 81%, or 118 million tonnes, of world fish production was destined for human consumption and provided about 4.2 billion people with more than 15% of their average per capita intake of animal protein. Fish used for human consumption grew by more than 90 million tonnes in the period 1960-2009 (from 27 to 118 million tonnes). The share of fishery and aquaculture production entering international trade increased from 25% in 1976 to about 39% in 2009. In 2008 the value of world exports reached a record value of USD 102 billion, declining by 6% in 2009. Aquaculture now provides 47% of global fish used for human consumption and has been the fastest growing food sector for many years. Employment in fisheries and aquaculture has grown substantially in the last three decades, with an average rate of increase of 3.6% per year since 1980. In 2008, 44.9 million people were employed in capture fisheries or in aquaculture, at least 12% of whom were women. For each person employed in capture fisheries and aquaculture production, approximately three jobs are produced in secondary activities, with an estimated total of more than 180 million jobs in the entire fish industry. Employment in the fisheries and aquaculture sectors has grown faster than the world's population and faster than employment in traditional agriculture.

	Importance / Issues
	Communities
Tourism	While the growth of tourism has been accompanied by significant challenges – for instance, in terms of Greenhouse Gas (GHG) emissions, water consumption, discharge of untreated water, waste generation, damage to local terrestrial and marine biodiversity, and threats to the survival of local cultures and traditions – tourists are driving the greening of the sector, as seen by the recent 20% annual growth rate enjoyed by ecotourism; about six times the industry- wide rate of growth. Travel and tourism are human-resource intensive, employing 230 million people or 8% of the population of developing countries, and it is estimated that one job in the core tourism industry creates about one and a half additional or indirect jobs in the tourism-related economy. In the Seychelles, coastal tourism contributes 46 to 50% of GDP, 70% of foreign income and employs 20% of the population. In Cape Verde, tourism is the most important economic resource. The downside of tourism which many coastal nations are pursuing as the 'engine of growth' includes capital intensive infrastructure, inadequate services for waste disposal and inadequate enforcement of environmental or coastal regulations on construction and waste minimisation, placing serious pressures on the near shore marine ecosystem. Tourism has also frequently been found to displace local people from their livelihoods while others benefit from the new activity. This reinforces the need for sound planning, regulation and enforcement.
Ports & Infrastructure/ Maritime Transport	Ports and associated infrastructure provide significant employment and economic benefits to local areas, and also act as the hub for the majority of incoming and outgoing ocean commerce. International shipping transports more than 90% of global trade and is therefore a crucial underpinning of sustainable development. Both developing and developed countries benefit from seaborne trade. The nature of shipping is such that developing countries can and do become major participants in the industry itself generating income and creating wealth by so doing. Short-sea-shipping, which encompass the movement of cargo and passengers mainly by sea, without directly crossing an ocean, could play a vital role in developing countries' future transport systems by creating low carbon supply chains and Green Economy jobs. The development of short-sea-shipping can help to reduce the growth of road transport, establish a balance between modes of transport, bypass bottlenecks and contribute to green transports as well as improved safety and have general positive effects on human health and local ecosystems. Measures adopted by IMO, or under development, have put shipping companies and the industry in general under increasing scrutiny and have increased expectations regarding reduction of ships' emissions, including GHGs, prevention of the spread of invasive species through ballast water and hulls, and decreased pollution from ships. While the contribution of shipping to GHG emissions is only 2.7% at present, rapid growth of the global economy including exports means this proportion is increasing relative to many other sources. In July 2011, IMO formally adopted treaty obligations to reduce GHG emissions from international shipping.

Importance / Issues	
Communities	
Energy	In 2009, offshore fields accounted for 32% of worldwide crude oil production. It should rise to 34% in 2025 (that is, 23 million barrels per day) 4 and over 4,000 wells drilled in the Gulf of Mexico at all depths. New technologies will allow greater exploitation of oil and gas at increasing depths in the future. Oil spills from oil tankers operating at sea world-wide account for only 7.7% of oil entering the marine environment. Marine energy technologies which exploit the energy of the tides, waves and currents of the sea, as well as temperature and salinity gradients, for the generation of electricity is an emerging source of renewable energy that in principle, exists in all the world's regions. It is however exploitable in practice only at sites that are close to demand centres and where, at the same time, damage to local ecosystems can be contained. As a result, marine technologies are the least developed of the renewable energy technologies and would require much further research and public investment to become cost-efficient and scalable. Offshore wind on the other hand will be a major influence on future renewable energy development. As of October 2010, 3.16 gigawatts of offshore wind power capacity was operational, mainly in Northern Europe. More than 16 gigawatts of additional capacity will be installed before the end of 2014 and the UK and Germany will become the two leading markets. Offshore wind power capacity is expected to reach a total of 75 gigawatts worldwide by 2020, with significant contributions from China and the US. The ever increasing demand for marine space to accommodate energy as well as other uses will require the establishment of planning and zoning processes such as marine spatial planning within nations' EEZ.
Ecosystem Service	
Provisioning Services	In addition to producing half of the oxygen in the earth's atmosphere, marine phytoplanktons produce the organic matter that determines the carrying capacity of the ecosystem which sustains the food web up to fish and marine mammals, and ultimately human consumption. Biodiversity and habitat protection and restoration are of fundamental importance to maintaining resilience of ocean ecosystems.
Regulating services	57% of atmospheric carbon captured by living organisms is captured by marine organisms, and of this between 50 and 71% is captured by the ocean's vegetated habitats including mangroves, salt marshes, sea grasses and seaweed, so-called blue forests, which cover less than 0.5% of the seabed. Currently the ocean absorbs more than 26% of the carbon dioxide emitted to the atmosphere from human activities, resulting in increased acidity of the ocean. Oceans play a key role in atmospheric and climate regulation, while coastal areas provide flood protection, and erosion control for low lying communities, and act as a sink for waste and nutrient disposal. With climate change, a warmer ocean would tend to evaporate more water vapour into the air and to warm the atmosphere, increasing air temperature gradients and, consequently winds. In turn, winds push horizontally against the sea surface and, in combination with the Coriolis effect due to the earth's rotation, drive ocean surface current and upwelling patterns. In parallel, differences in the density of surface waters (driven by the balance between precipitation, run-off, and evaporation), drive the vertical or 'thermohaline' circulation of the deeper oceans. Through this ocean circulatory system, the oceans and atmosphere distribute heat and regulate global climate. Sustained observations of ocean climate change and variability will provide insight into the future climate factors underpinning local sustainable development all over the globe, including far from the coast.
Cultural services	Coastal areas and marine resources are of substantial cultural and historic significance to the communities that inhabit and use them. In developing countries and SIDS, they sometimes provide not only the main sources of food, including protein and important nutrients from fish, but have been providing settlement areas for millennia for many communities in developing countries and SIDS. The aesthetic benefit of coastal areas and marine resources provides corresponding tourism benefit in many cases, and although difficult to value in economic terms, is the basis upon which some tourism is founded.

2.2.3 Human well-being, ecosystem services and livelihood sustainability

The Millennium Ecosystems Assessment uses the concept of well-being, which is far more inclusive than livelihood (See Figure).

The consequences of the biodiversity loss and resulting loss of ecosystem services has far reaching impact on livelihoods and overall wellbeing of human communities. Human well-being has multiple constituents, including basic material for a good life, freedom and choice, health, good social relations, and security. Well-being is at the opposite end of a continuum from poverty, which has been defined as a "pronounced deprivation in well-being."The constituents of well-being, as experienced and perceived by people, are situation-dependent, reflecting local geography, culture, and ecological circumstances.

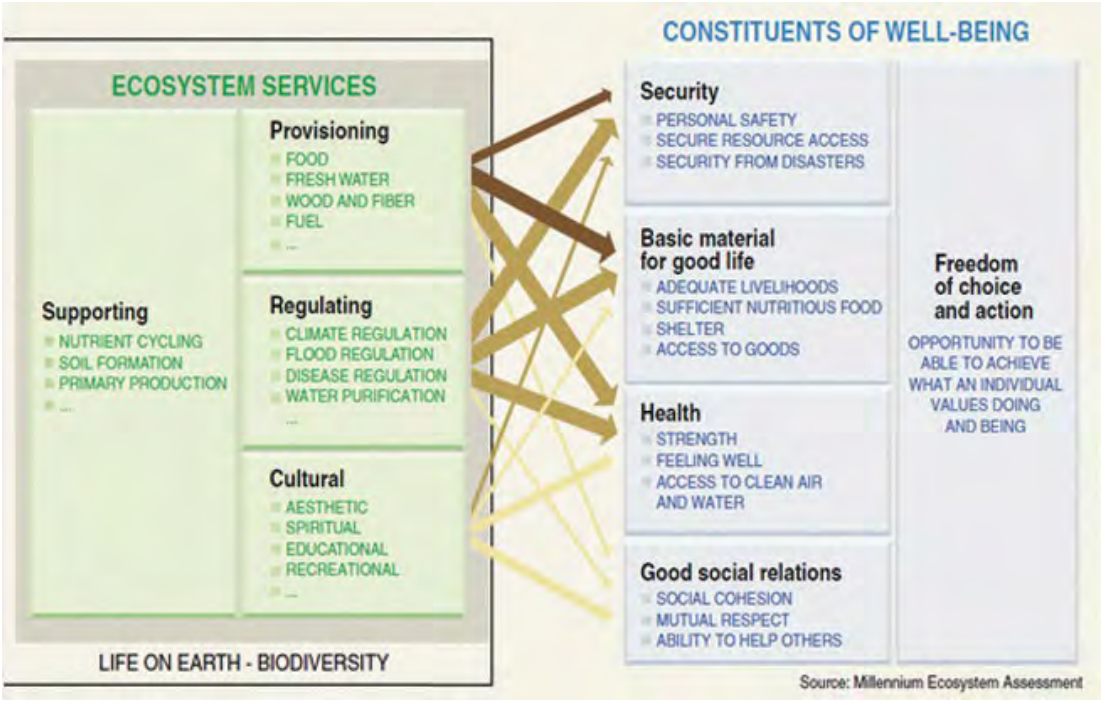


Figure 2.1: Ecosystem Services and Human Well-being (Source: MEA 2005)

Surrounded by the Indian Ocean, the Arabian Sea and the Bay of Bengal, India has over 7500 km of coast-line, which spans 13 maritime mainland states and union territories (UTs). India has a variety of coastal and marine ecosystems that are storehouses of biodiversity. From an economic perspective, these coastal and marine ecosystems are of great importance in that they provide a wide range of ecosystem goods and services. Approximately 20 per cent of India's population lives in coastal areas, with a large proportion based in coastal urban centres such as Mumbai, Chennai and Kolkata. For those who live along the coastal belts, the fi sheries sector is vital, providing employment to over 6 million people, and accounts for 1.07 per cent of India's total GDP.

See more at http://www.mangrovesforthefuture.org/countries/members/india/#sthash.ADBzs6Q7.dpuf.

Approximately 60 per cent (15 out of 24) of the ecosystem services evaluated in the Millennium Ecosystem As- sessment (including 70 per cent of regulating and cultural services) are being de-graded or used unsustainably. Loss of biodiversity, in terms of habitat, species and genetic diversity, is enormous.

The ecosystem services that have been degraded over the past 50 years include capture fisher-ies, water supply, waste treatment and detoxification, water purification, natural hazard protection, regulation of air quality, regula- tion of regional and local climate, regulation of soil erosion, spiritual

Fresh drinking water is increasingly derived from marine waters in many parts of the world. The Arabian Gulf has about half of the world's desalination capacity, with a combined seawater desalination volume exceeding 11 million m3/day. Some countries are especially dependent on desalination, e.g. 90% of Kuwait's potable water comes from the sea. As desalination technology becomes more affordable and available to developing nations and SIDS, we expect to see its adoption increased around the world, thereby decreasing fresh water shortages and increasing the need to ensure marine waters are clean. At the same time, saline residues from desalination can have local negative impacts on marine ecosystems so proper management regimes need to be put in place to minimise these effects. Desalination also tends to be very energy intensive underscoring the need for nations that depend on desalination to also aggressively pursue low carbon energy strategies.

Source: IOC/UNESCO, IMO, FAO, UNDP. (2011). A Blueprint for Ocean and Coastal Sustainability. Paris: IOC/UNESCO

fulfilment, and aesthetic enjoyment. The use of two ecosystem services – capture and fresh water fisheries – is now well beyond levels that can be sustained even at current demands, much less future ones. At least one quarter of important commercial fish stocks are overharvested (high certainty). The quantity of fish caught by humans increased until the 1980s but is now declining because of the shortage of stocks.

According to UNEP reports, FROM 5 per cent to possibly 25 per cent of global freshwater use exceeds long-term accessible supplies. It is now met either through engineered water transfers or overdraft of groundwater supplies (low to medium certainty). Some 15-35 per cent of irrigation withdrawals exceeds supply rates and are therefore unsustainable (low to medium certainty).

Of the 24 ecosystem services, only 4 have been enhanced in the past 50 years, three of which involve food production — crops, livestock, and aquaculture. Terrestrial ecosystems were on average a net source of CO2 emissions during the 19th and early 20th centuries due to widespread deforestation, but became a net sink around the middle of the last century due to reforestation efforts. Thus, in the last 50 years, the role of ecosystems in regulating global climate through carbon sequestration has also been enhanced.

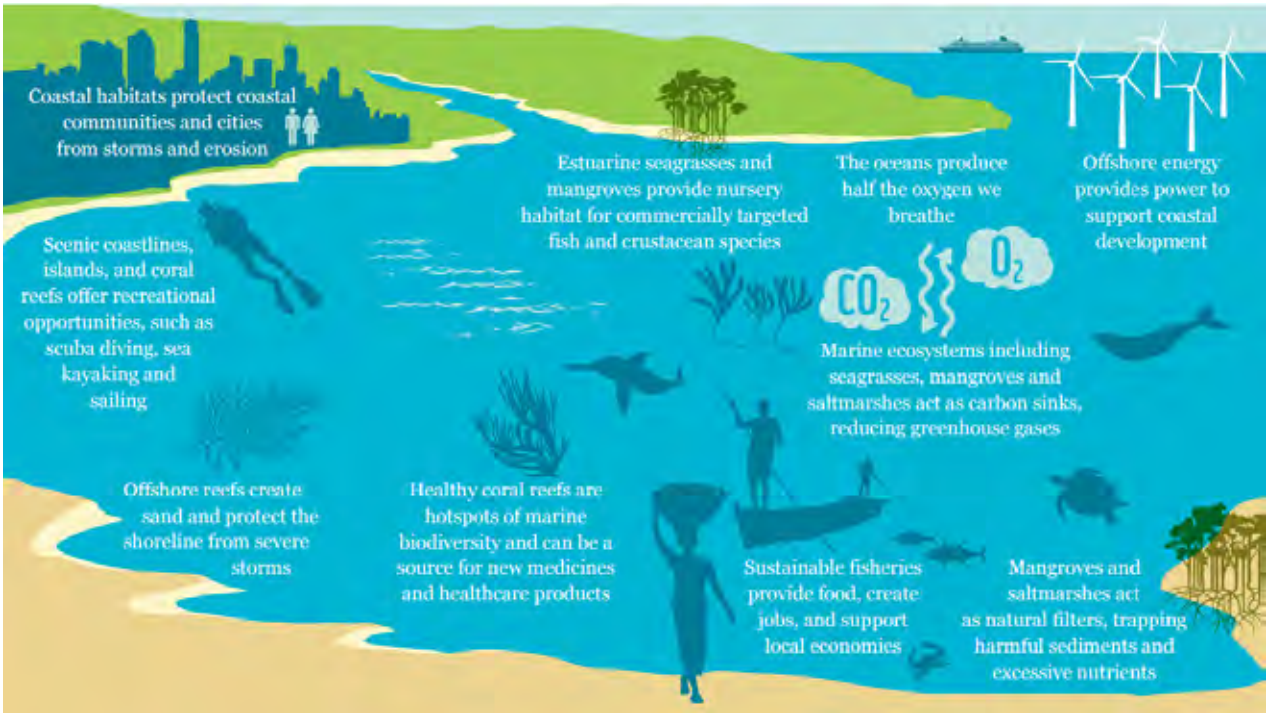


Figure 2.2: Ecosystem goods and services provided by the ocean (UNEP 2011).

Valuing the ocean:

The Boston Consulting Group in collaboration with the Global Change Institute and WWF recently estimated that the ocean generates economic benefits worth at least US$2.5 trillion per year.

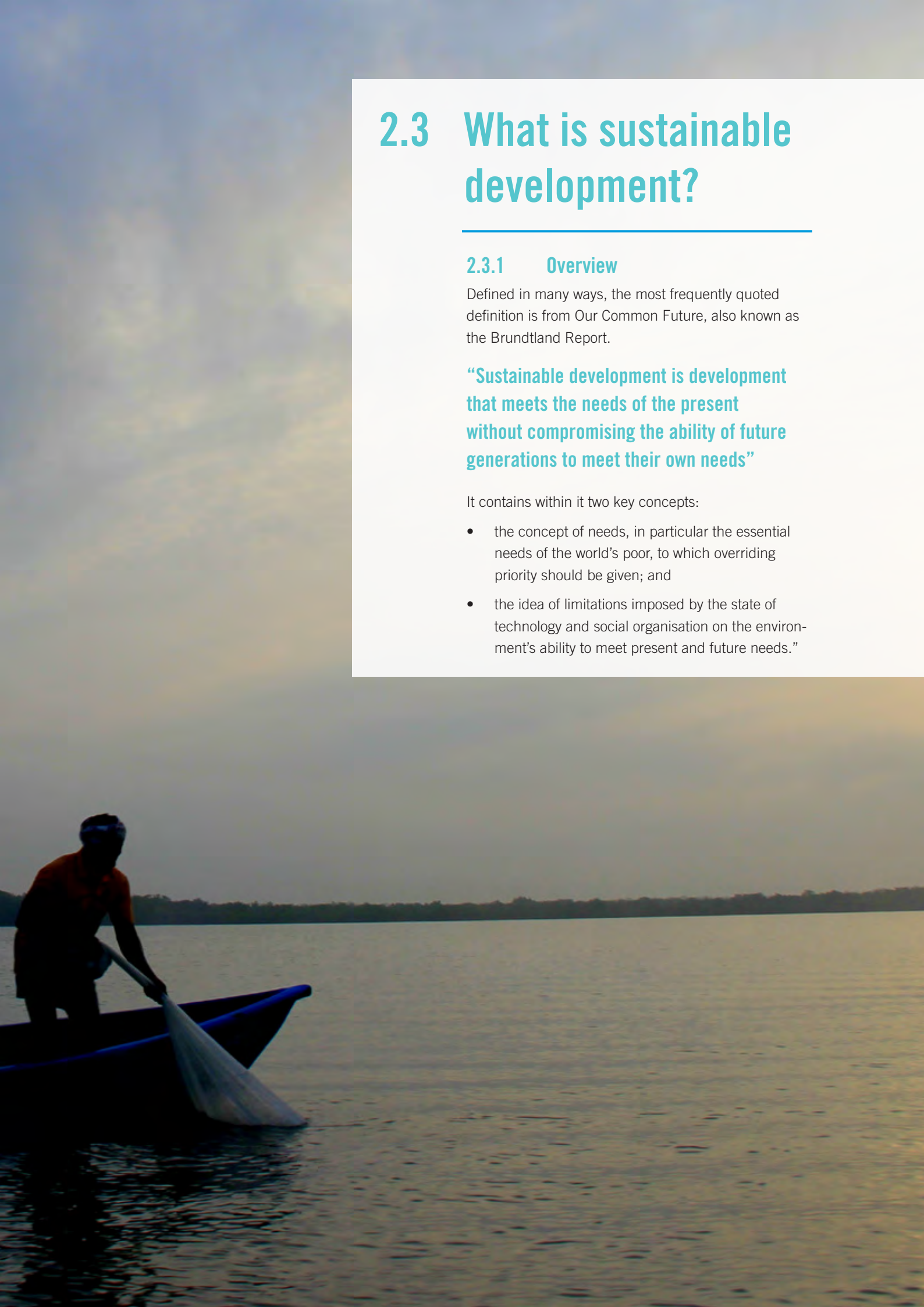
The total value of the ocean's underpinning assets is at least US$24 trillion (Hoegh-Guldberg et al., 2015[1]). Underpinning the value estimates are direct outputs (e.g. fishing), services enabled (e.g. tourism, education), trade and transportation (coastal and oceanic shipping) and adjacent benefits (e.g. carbon sequestration, biotechnology)(BCG, 2015). More than two-thirds of this value relies on healthy ocean conditions.

However, the values highlighted are considered to be vast underestimates. The study did not attempt to assess the value of less well understood ecosystems such as seamounts and deep-sea habitats. Moreover, the study did not consider the role the ocean plays in atmospheric regulation, carbon storage and planetary temperature control – nor its incalculable spiritual and cultural values. The ocean is, of course, infinitely valuable: without it, life on Earth simply could not exist. It also has an intrinsic value, irrespective of human perceptions. Valuation tools are not about putting a price tag on our ocean assets so they can be commoditized, but about enabling decision-makers to make smarter choices so present and future generations can continue to enjoy the benefits of a healthy ocean.

See more at http://www.mangrovesforthefuture.org/countries/members/india/#sthash.ADBzs6Q7.dpuf.

Given the kind ongoing trend of exploitation of marine resources, WWF came up with One Planet Perspective that provides a framework for making better choices for the marine environment.

1 Hoegh-Guldberg, O. et al. 2015. Reviving the Ocean Economy: the case for action - 2015. WWF International, Gland, Switzerland., Geneva, 60 pp.



2.3 What is sustainable development?

2.3.1 Overview

Defined in many ways, the most frequently quoted definition is from Our Common Future, also known as the Brundtland Report.

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

It contains within it two key concepts:

- the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and
- the idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs."

Economics and Human Development

- 1.1 billion people surviving on less than $1 per day of income; 70% in rural areas where they are highly de- pendent on ecosystem services
- Inequality has increased over the past decade. During the 1990s, 21 countries experienced a decline in their rankings in the Human Development Index

Access to Ecosystem Services

- An estimated 852 million people were undernourished in 2000-02, up 37 million from the period 1997-99 Per capita food production has declined in sub-Saharan Africa
- Some 1.1 billion people still lack access to improved water supply, and more than 2.6 billion lack access to improved sanitation
- Water scarcity affects roughly 1-2 billion people worldwide

In the next section, we will explore the concept of current and future needs and its link with the possible availability of resources for future generations via the concept of Ecological Footprint

2.3.2 What is ecological footprint?

The simplest way to define ecological footprint would be to call it the impact of human activities measured in terms of the area of biologically productive land and water required to produce the goods consumed and to assimilate the wastes generated.

The concept of ecological footprint was originated by Dr. Bill Rees

1. **Which things are included in your Ecological Footprint** To produce Your Food:
   - Croplands and orchards
   - Forests
   - Pastures and rangelands
2. **Your energy requirements:**
   - Fuel for your vehicles
   - Cooking food
3. **Your housing requirements**:
   - Bricks, Cement, Land
   - Electricity, water
4. **Fertilisers and pesticides**
   - Land required for production plant

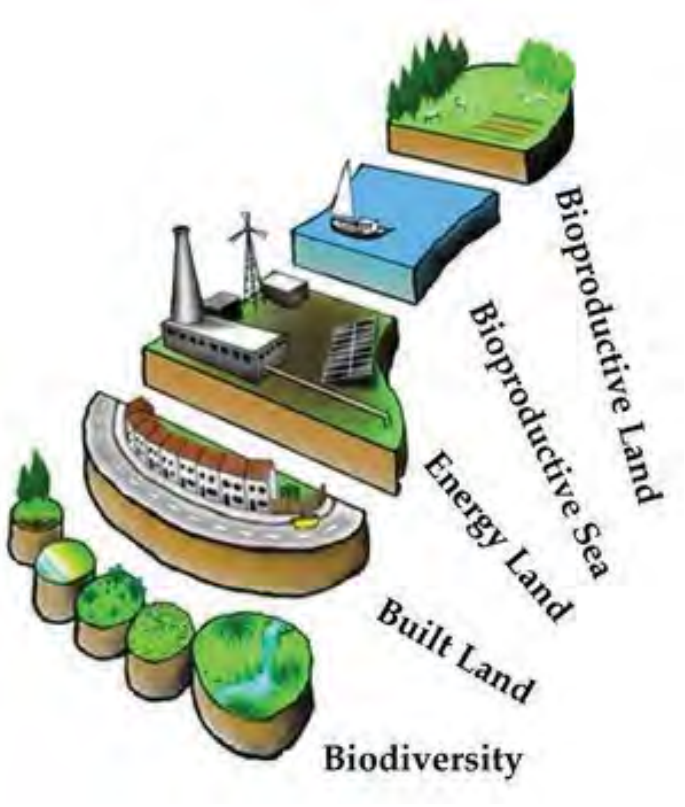


Figure 2.3: Ecological footprint
(Source: http://www.overshootday.org/kids-and-teachers-corner/what-is-an-ecological-footprint-2/

5. **Drugs and medicines**
    - Production plant
    - Raw material

6. **Packaging and refrigerating the food**
    - Packaging material
    - Packing and refrigeration plant

7. **Waste you generate**
    - Paper
    - Plastic
    - Glass
    - Biological waste

2.3.3 Can you calculate how big your ecological footprint is?

We can measure most of the resources we consume and many of the wastes we generate These measurements can be converted to corresponding areas of productive land or sea.

2.3.4 Why would we want to know how big our footprint is?

- To facilitate system analysis and to understand the availably and types of ecosystem services being used by human beings
- To understand the relationship of organisms with the ecosystem elements
- To have a realistic estimate of the Human demand Vs Ecological supply

Example 1: A cooked meal of fish and rice would require bioproductive land for the rice, a bioproductive sea or river for the fish, and forested 'energy' land to re-absorb the carbon emitted during the processing and cooking.

Example 2: Driving a car requires built land for roads, parking, and so on, as well as a large amount of forested 'energy' land to re-absorb the carbon emissions from petrol use. In addition, energy and materials are used for construction and maintenance.

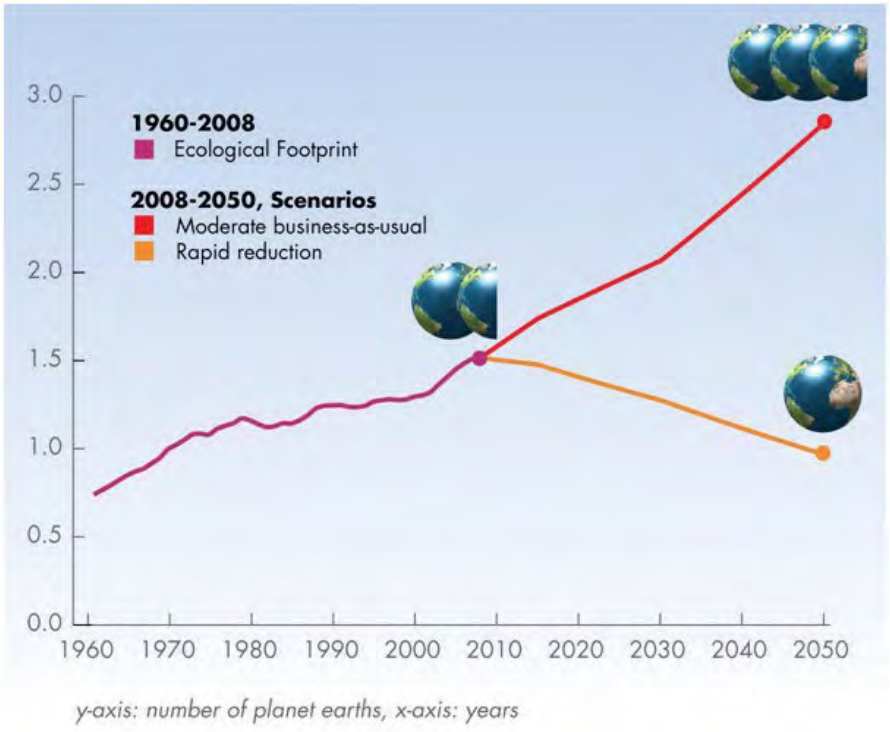


Figure 2.4: Ecological footprint, from 1960 to 2050

2.3.5 How do countries compare on ecological footprint?

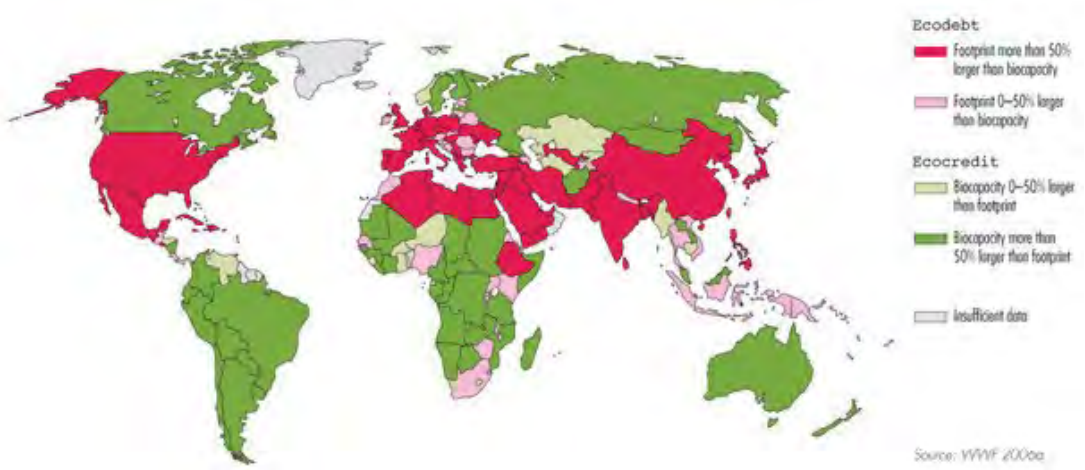


Figure 2.5: Ecological creditors and debtor

(Source: http://www.footprintnetwork.org/en/index.php/GFN/page/the_ecological_footprint_how_countries_compare)

2.3.6 How can we reduce our ecological footprint?

Reduce the use of fossil fuel

Buy organic food

Use less packaging

Buy fresh instead of processed food

Eat less meat

Eat food grown locally, rather than transported

http://www.footprintnetwork.org/en/index.php/GFN/page/personal_footprint/

Water Footprint

- http://www.waterfootprint.org/Reports/Hoekstra2008-Ecological-versus-WaterFootprint.pdf
- http://environment.nationalgeographic.com/environment/freshwater/change-the-course/water-footprint-calculator/
- http://www.watercalculator.org/

Carbon Footprint

- http://www.carbonfootprint.com/calculator.aspx

2.4 Economic activities on the coast

With the presence of ports, and with access to refineries and fuel linkages, industrial clusters have developed along the coast.

Traditionally there have also been industrial complexes related to export-oriented industries along the coast. However, with the promulgation of the Special Economic Zones Act (SEZA-2005) there is a focus on the creation of such zones on the coast.

If ships are needed to sail the seas, they need to be built and also dismantled when they have completed their years of sailing. The Indian coast has centres for shipbuilding and ship-breaking.

The four major centres of shipbuilding are in Kochi, Kolkata, Mumbai and Vishakhapatnam.

The most important ship-breaking centre is at Alang in Gujarat. Valinokkam in Tamil Nadu used to be a ship- breaking centre, but not anymore as the activities have been stopped for environmental reasons.

India is the third largest Salt producing Country in the World after China and USA, with Global annual production of about 230 million tones. Main sources of salt in India are sea brine, lake brine, sub-soil brine and rock salt deposits. The major salt producing marine centres are along the coast of Gujarat, Tamil Nadu, Andhra Pradesh, Maharashtra, Orissa, West Bengal, as well as inland Salt Works in Rajasthan, salt works in Rann of Kutch, rock Salt Deposits at Mandi in the State of Himachal Pradesh.[2]

Ports led to trade, which in turn led to the creation of urban centres. Chennai, Kolkata and Mumbai are three major metropolitan coastal centres that have developed over centuries. These centres in turn have been a hub for manufacturing and commerce and have led to the establishment of other urban centres along the coast.

Coastal tourism is growing to be a significant component of tourism in India. States that have been promoting coastal tourism are: Goa, Kerala, Maharashtra, Tamil Nadu, Odisha, West Bengal, Andhra Pradesh, Karnataka, Andaman and Nicobar islands and Lakshadweep islands.

The total tourism picture for the country in 2013 reveals the following:

Box: Important Facts About Tourism, 2014

• No of foreign tourist arrival in India	7.68 million
Annual growth rate	10.2%
• No of Indian National Departures from India	18.33 million
Annual growth rate	10.3%
• No of Domestic Tourist Visits to all States/UTs	1282 million
Annual growth rate	11.9%
• Foreign Exchange Earning from Tourism	
In INR terms	INR 1,23,320 Crore (#)
Annual Growth Rate	14.5%
In US$ terms	US$ 20.24 billion (#)
Annual Growth Rate	9.7%

Source: India Tourism Statistics at a Glance 2014. www.tourism.nic.in

Fishery is an important sector in India — it provides employment to millions of people and contributes to the country's food security. With a coastline of over 7,000 km, an Exclusive Economic Zone (EEZ) of over 2 million sq km, and with extensive freshwater resources, fisheries play a vital role. At present, fisheries and aquaculture contribute 1.07 per cent to the national GDP, and 5.30 per cent to agriculture and allied activities, while the aver- age annual value of output during the Tenth Five Year Plan (2002-2007) was Rs 31,682.50 crore[3].

2 Source: http://saltcomindia.gov.in/industry_india.html?tp=Salt).

3 Source: http://eprints.cmfri.org.in/7424/1/432-_FISHING_CHINNES__2007.pdf

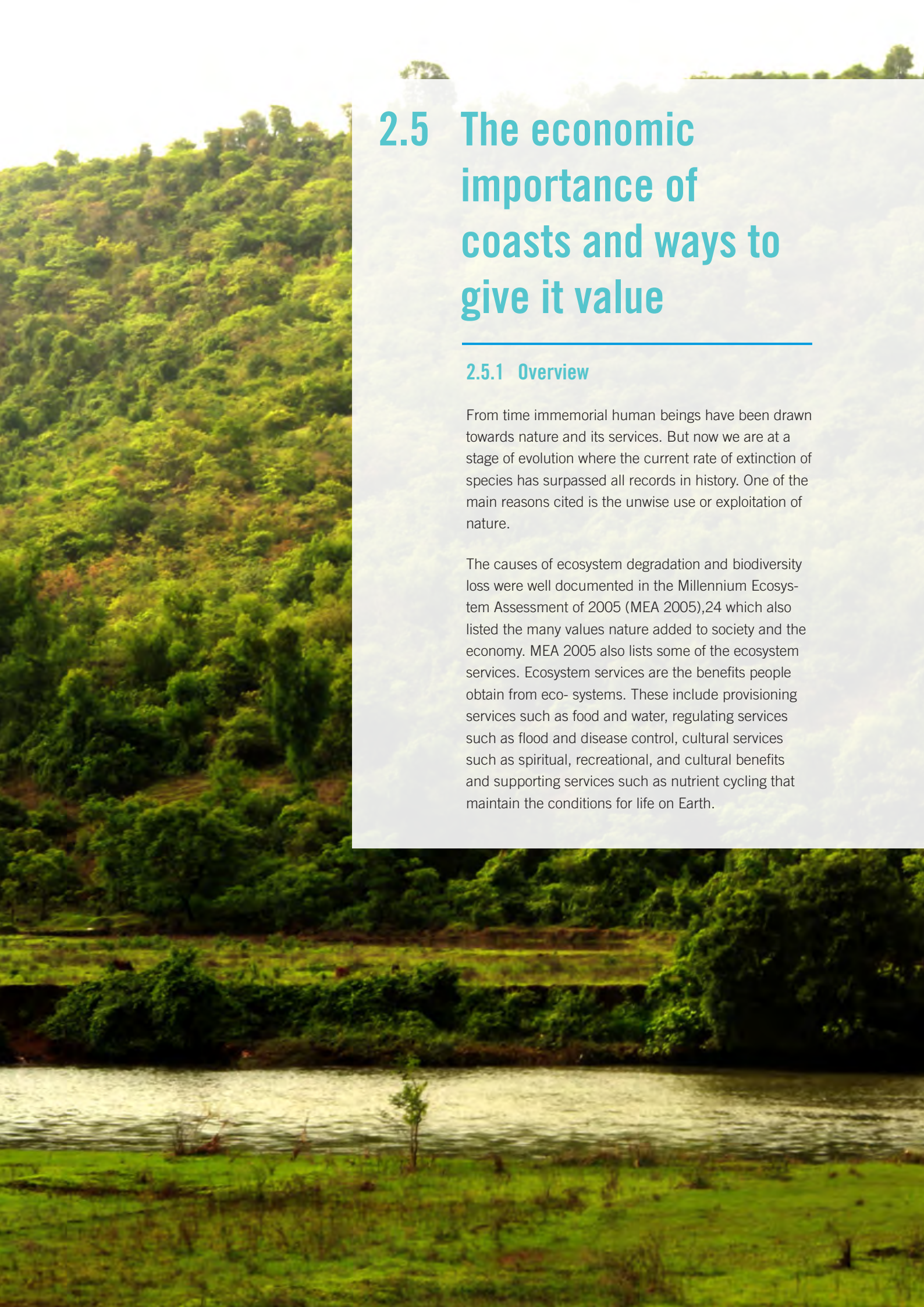
Marine Fisheries contributes to food security and provides direct employment to over 1.5 million fisher people besides others indirectly dependent on the sector.

According to the census conducted by the Central Marine Fisheries Research Institute (CMFRI) in 2010, there are 3,288 marine fishing villages and 1,511 marine fish landing centres in 9 maritime states and 2 Union territories. The total marine fisherfolk population is about 4 million comprising 864,550 families.

India is endowed with an extensive coastline of about 6,000 kms along nine coastal states — Gujarat, Maharashtra, Karnataka, Goa and Kerala on India's western coast and Tamil Nadu, Andhra Pradesh, Odisha and West Bengal on the eastern coast. These nine states have in all 12 major and 179 minor ports.

Of the 12 major ports, six are located on the west coast (Kandla, Mumbai, Jawarlal Nehru, Mormugao, Kochi, New Mangalore) and six on the east coast (Chennai, Tuticorin, Paradip, Vizag, Kolkata, Haldia).

The economic liberalisation opened up the possibility of establishing power plants in the private sector. Due to its relatively quicker gestation and power production reliability, thermal power plants were preferred. The coasts became the preferred destination for establishing these power plants, since it was easier to supply fuel – be it coal, oil, naphtha or natural gas – along the coast.



2.5 The economic importance of coasts and ways to give it value

2.5.1 Overview

From time immemorial human beings have been drawn towards nature and its services. But now we are at a stage of evolution where the current rate of extinction of species has surpassed all records in history. One of the main reasons cited is the unwise use or exploitation of nature.

The causes of ecosystem degradation and biodiversity loss were well documented in the Millennium Ecosystem Assessment of 2005 (MEA 2005),24 which also listed the many values nature added to society and the economy. MEA 2005 also lists some of the ecosystem services. Ecosystem services are the benefits people obtain from eco- systems. These include provisioning services such as food and water, regulating services such as flood and disease control, cultural services such as spiritual, recreational, and cultural benefits and supporting services such as nutrient cycling that maintain the conditions for life on Earth.

On the question of why there is a need for measuring the value of nature, the most imperative answer would be that the aim of defining and measuring the value of the natural environment are to better inform management choices, and/or influence human behaviour.

Valuing ecosystem services would provide policy-makers with a strong rationale to improve coastal and marine ecosystem management and invest in conservation for its risk management value and economic benefits. In order to fully leverage ecological and economic knowledge of ecosystems and services, there is a need to generate and provide access to better data regarding ecosystem services.

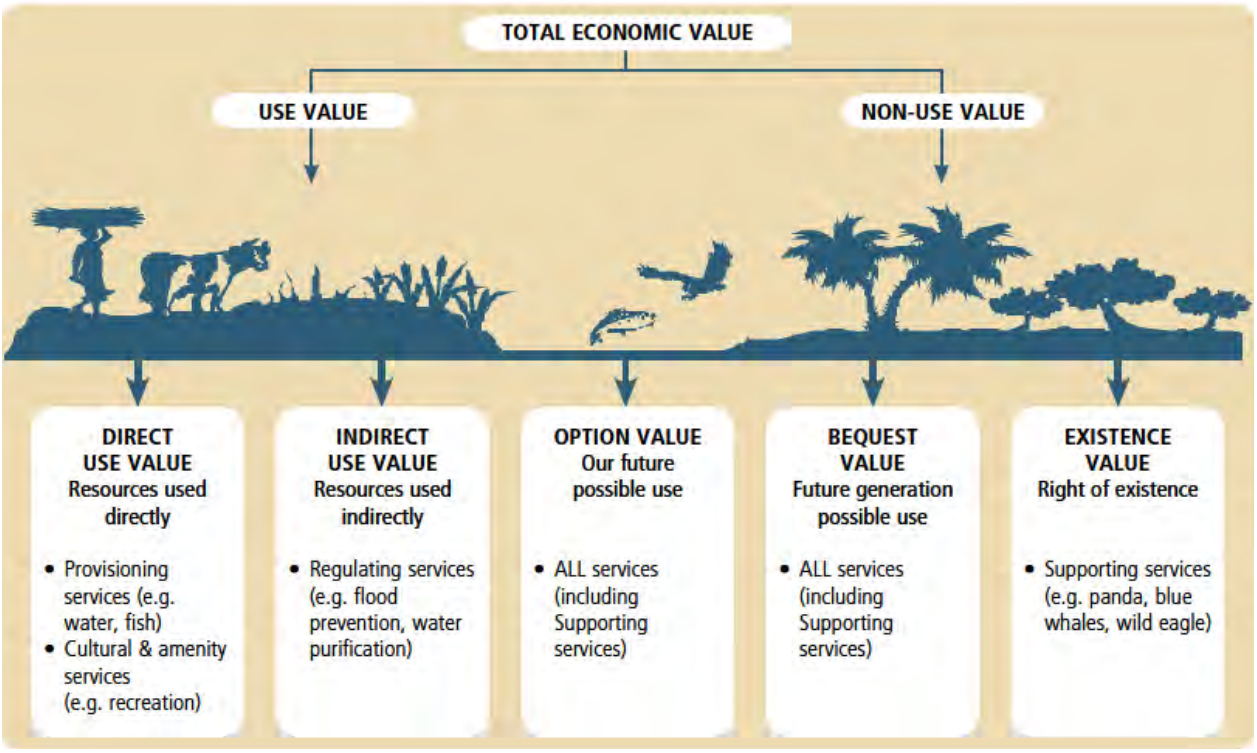


Figure 2.6: Ecosystems goods and services and their value

Marine and coastal resources provide millions of impoverished people across the globe with livelihoods and range of critical ecosystem services like biodiversity, culture to carbon storage to flood protection. Coastal and marine ecosystems are among the most productive ecosystems in the word, provide many services to human society and are of great economic value (UNEP, 2006). The Indian coasts support about 30% of the total 1.2 billion human populations.

Source: (TII, 2014).

2.5.2 Economic value of biodiversity and its valuation

Economic valuation offers a way to compare the diverse benefits and costs associated with ecosystems by attempting to measure them and expressing them in a common denominator — typically a monetary unit. The main framework used is the Total Economic Value (TEV) approach. The breakdown and terminology vary slightly from analyst to analyst, but generally include (i) direct use value, (ii) indirect use value, (iii) option value, and (iv) non-use value. The first three are generally referred to together as 'use value'.

Environmental valuation is largely based on the assumption that individuals are willing to pay for environmental gains and, conversely, are willing to accept compensation for some environmental losses. The individual demonstrates preferences, which, in turn, place values on environmental resources. That society values environmental resources is certain; monetizing the value placed on changes in environmental assets such as coastal areas and water quality is far more complex. Environmental economists have developed a number of market and non- market-based techniques to value the environment.

2.5.2.1 Direct use values

Direct use values refer to ecosystem goods and services that are used directly by humans. These include the value of consumptive uses such as harvesting of food products, timber for fuel or construction, and medicinal products and hunting of animals for consumption, and the value of non-consumptive uses such as the enjoyment of recreational and cultural activities that do not require harvesting of products. Direct use values are most often enjoyed by people visiting or residing in the ecosystem itself.

2.5.2.2 Indirect use values

Indirect use values are derived from ecosystem services that provide benefits outside the ecosystem itself. Examples include natural water filtration which often benefits people far downstream, the storm protection function of mangrove forests which benefits costal properties and infrastructure, and carbon sequestration which benefits the entire global community by abating climate change.

2.5.2.3 Option values

Option values are derived from preserving the option to use in the future ecosystem goods and services that may not be used at present, either by oneself (option value) or by others/heirs (bequest value). Provisioning, regulating, and cultural services may all form part of option value to the extent that they are not used now but may be used in the future.

2.5.3.4 Non-use values

Non-use values refer to the enjoyment people may experience simply by knowing that a resource exists even if they never expect to use that resource directly themselves. This kind of value is usually known as existence value (or, sometimes, passive use value).

2.5. 3 Valuation techniques[4]

There are three families of valuation techniques: market based techniques, revealed preference and stated preference.

2.5.3.1 Market-based techniques

These use evidence from markets in which environmental goods and services are traded, markets in which they enter into the production functions for traded goods and services, or markets for substitutes or alternative resources.

Example: *To understand the economic benefits generated from coastal and marine habitats and ecosystems in Bohol Marine Triangle (BMT) in the Philippines as a basis for sustaining the use of natural resources in the area. BMT area has rich biodiversity and the local community is dependent on the coastal and marine resources of the area. The study combined market-based valuation of economic activities (fisheries, tourism, gleaning, and seaweed farming) and value transfer methods for non-marketed impacts (biodiversity conservation, flood protection, fish nursery function). The accumulated total net benefit for the BMT natural resources over a 10-year period was found to be US$11.54 million (with a 10% discount rate). This led to officials in allocating resources for maintaining the ecosystems of BMT.*

2.5.3.2 Revealed preference methods

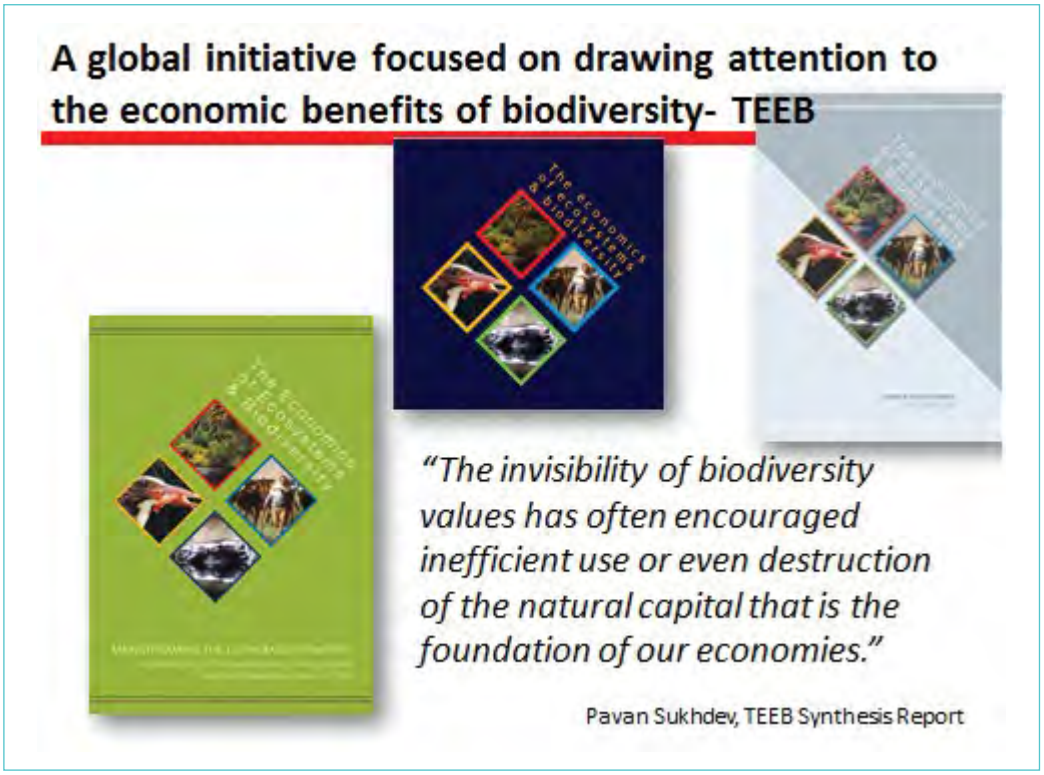
These are based on deducing the value of ecosystem services by interpreting observed human behaviour.

Example: *The decision-makers were faced with the issue of eutrophication in the Stockholm archipelago. They carried out the analysis of the benefits and costs of reducing the eutrophication in the Stockholm archipelago. For this evaluation, it was assumed that a reduction in eutrophication would lead to an increase in water transparency, which would increase both ecological health and human enjoyment of the area. It was also assumed that a 40 per cent reduction in nitrogen load was needed to achieve a one-metre increase in transparency, through a combination of measures including increased sewage water treatment and reduced fertilizer use. The total costs of such measures were estimated to be SEK 57 million per year. The benefits of the reduction of eutrophication were estimated to be about SEK 60 million per year for recreational benefits (travel cost method) and SEK 500 million per year for all conservation benefits (contingent valuation method). However, the analysis indicates that the costs of reducing eutrophication could be justified purely by the recreation values and that when taking a full range of values into account the benefits could outweigh the costs by a ratio of 8:1 or more.*

2.5.3.3 Stated preference techniques

These methods are based on surveys in which people give valuation responses in hypothetical situations. Some of the popular valuation methods are contingent valuation, choice experiments, value transfer.

4 Source: UNEP-WCMC (2011) Marine and coastal ecosystem services: Valuation methods and their application. UNEP-WCMC Biodiversity Series No. 33. 46 pp. http://www.unep.org/dewa/Portals/67/pdf/Marine_and_Coastal_Ecosystem.pdf]



The Economics of Ecosystems and Biodiversity (TEEB)

Key Concepts:

- Natural resources make important contributions to long-term economic performance and should be considered economic assets.
- We cannot manage what we do not measure. The loss of ecosystem services is often overlooked because most of them, such as soil retention or spiritual values, are public goods and services.
- Subsidies to fisheries, fossil fuel industries, and other potentially harmful activities should be measured and reported annually; the perverse components of these subsidies should be tracked, reduced, and eventually phased out altogether.

Three stages:

- Demonstration, the identification and measurement of the flow of ecosystem services and their values.
- Appropriation, capturing some or all of the demonstrated and measured values of ecosystem services so as to provide incentives for their sustainable provision.
- Benefit sharing, appropriation mechanisms are designed in such a manner that the captured ecosystem services benefits are distributed to those who bear the costs of conservation.

[Source: Sukhdev, P. 2011. Putting a Price on Nature: The Economics of Ecosystems and BiodiversitySolutions. Vol 1, No. 6. pp. 34-43 - http:// www.thesolutionsjournal.com/node/823]

Put a Value on Nature! Pavan Sukhdev TED Talk

http://www.youtube.com/watch?v=oU9G2E_RYJo

TEEB-India

The Ministry of Environment and Forests, Government of India formally initiated the TEEB study in February 2011. The Minister stated the ministry's commitment to developing a framework for green national accounts by 2015, facilitated by TEEB India. Consultations in February 2011 and September 2011 led to identification of three biophysical sectors critical to India. Findings from investigating these sectors were presented in an initial assessment and scoping report at COP11, Hyderabad, India (October 2012). The report lays out high level methodology for doing an ecosystem based economic valuation. Current efforts are to bring policy relevance to further investigations for TEEB in India, and increase its technical scope from economic valuation to a broader recognition of natural capital.

Ecosystem: Forests, Inland wetlands, Coastal and marine ecosystems

- TEEB India process aims to recognise and harness the economic valuation of biodiversity and ecosystem services
- Action at three levels:
  - Policy making
  - Business
  - Citizen awareness

Three stages:

- Demonstration, the identification and measurement of the flow of ecosystem services and their values.
- Appropriation, capturing some or all of the demonstrated and measured values of ecosystem services so as to provide incentives for their sustainable provision.
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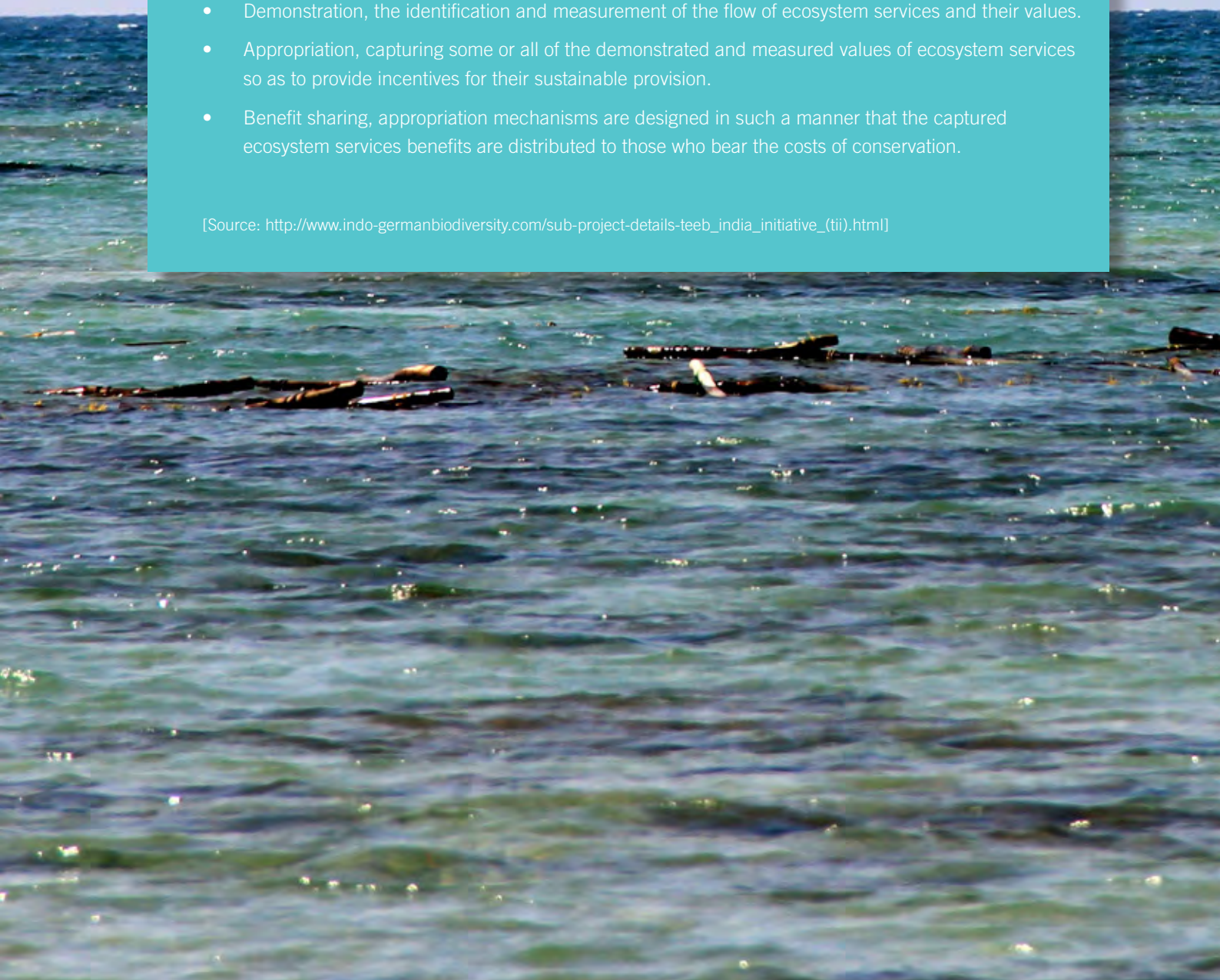
[Source: http://www.indo-germanbiodiversity.com/sub-project-details-teeb_india_initiative_(tii).html]

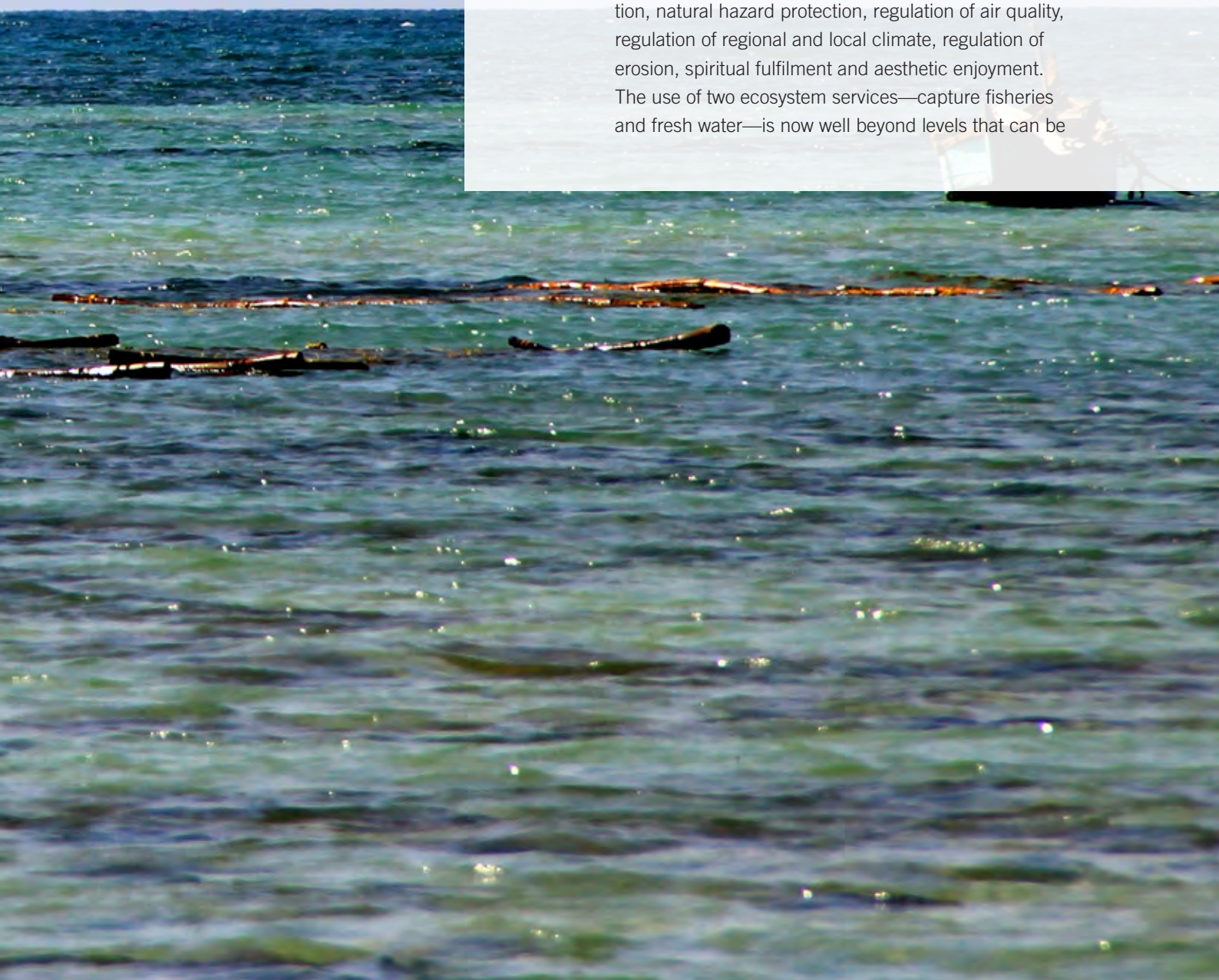


2.6 Loss of biodiversity and ecosystem services

2.6.1 Current status of biodiversity loss:

Approximately 60 per cent (15 out of 24) of the ecosystem services evaluated in the Millennium Ecosystem Assessment (including 70 per cent of regulating and cultural services) are being degraded or used unsustainably. Loss of biodiversity at habitat, species and genetic levels is enormous.

The ecosystem services that have been degraded over the past 50 years include capture fisheries, water supply, waste treatment and detoxification, water purification, natural hazard protection, regulation of air quality, regulation of regional and local climate, regulation of erosion, spiritual fulfilment and aesthetic enjoyment. The use of two ecosystem services—capture fisheries and fresh water—is now well beyond levels that can be



sustained even at current demands, much less future ones. At least one quarter of important commercial fish stocks are over- harvested (high certainty). The quantity of fish caught by humans increased until the 1980s but is now declining because of the shortage of stocks.

From 5 per cent to possibly 25 per cent of global freshwater use exceeds long-term accessible supply. It is now met either through engineered water transfers or overdraft of groundwater supplies (low to medium certainty). Some 15–35 per cent of irrigation withdrawals exceed supply rates and are therefore unsustainable (low to medium certainty).

Out of 24, only four ecosystem services have been enhanced in the past 50 years, three of which involve food production: crops, livestock and aquaculture. Terrestrial ecosystems were on average a net source of CO_2 emissions during the nineteenth and early twentieth centuries due to widespread deforestation, but became a net sink around the middle of the last century due to reforestation efforts. Thus, in the last 50 years, the role of ecosystems in regulating global climate through carbon sequestration has also been enhanced.

According to the findings of Millennium Ecosystem Assessment"

- Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history.
- This has resulted in a substantial and largely irreversible loss in the diversity of life on earth.

Unprecedented change in ecosystems

- More land was converted to cropland in the 30 years after 1950 than in the 150 years between 1700 and 1850. 20 per cent of the world's coral reefs were lost and 20 per cent degraded in the last several decades.
- 35 per cent of the mangrove area has been lost in the last several decades Amount of water in reservoirs quadrupled since 1960.
- Withdrawals from rivers and lakes doubled since 1960.

Unprecedented change: Biogeochemical Cycles since 1960:

- Flows of biologically available nitrogen in terrestrial ecosystems doubled. Flows of phosphorus tripled.
- > 50 per cent of all the synthetic nitrogen fertiliser ever used has been used since 1985.
- 60 per cent of the increase in the atmospheric concentration of CO2 since 1750 has taken place since 1959.

Significant and largely irreversible changes to species diversity

- The distribution of species on earth is becoming more homogenous. Humans have increased the species extinction rate by as much as 1,000 times over background rates typical over the planet's history (medium certainty).
- 10–30 per cent of mammal, bird and amphibian species are currently threatened with extinction (medium to high certainty).

The loss of marine biodiversity is increasingly impairing the ocean's capacity to provide food and other market and non-market services, and the trend of biodiversity loss is accelerating on a global scale. Coastal habitats are under pressure, with approximately 20% of the world's coral reefs lost and another 20% degraded. Mangroves have been reduced to 30 to 50% of their historical cover12, impacting biodiversity, habitat for inshore fisheries, and carbon sequestration potential. 29% of seagrass habitats are estimated to have disappeared since the late eighteen hundreds. Over 80% of the world's 232 marine ecoregions reported the presence of invasive species which is the second most significant cause of biodiversity loss on a global scale and the marine bio-invasion rates have been reported as high as up to one invasion every nine weeks. As with non-point source pollution, the challenge is as much institutional inertia as it is scientific consensus in terms of dealing with loss of biodiversity and habitat, and increasing both protection and restoration efforts.

2.6.2 Habitat Loss

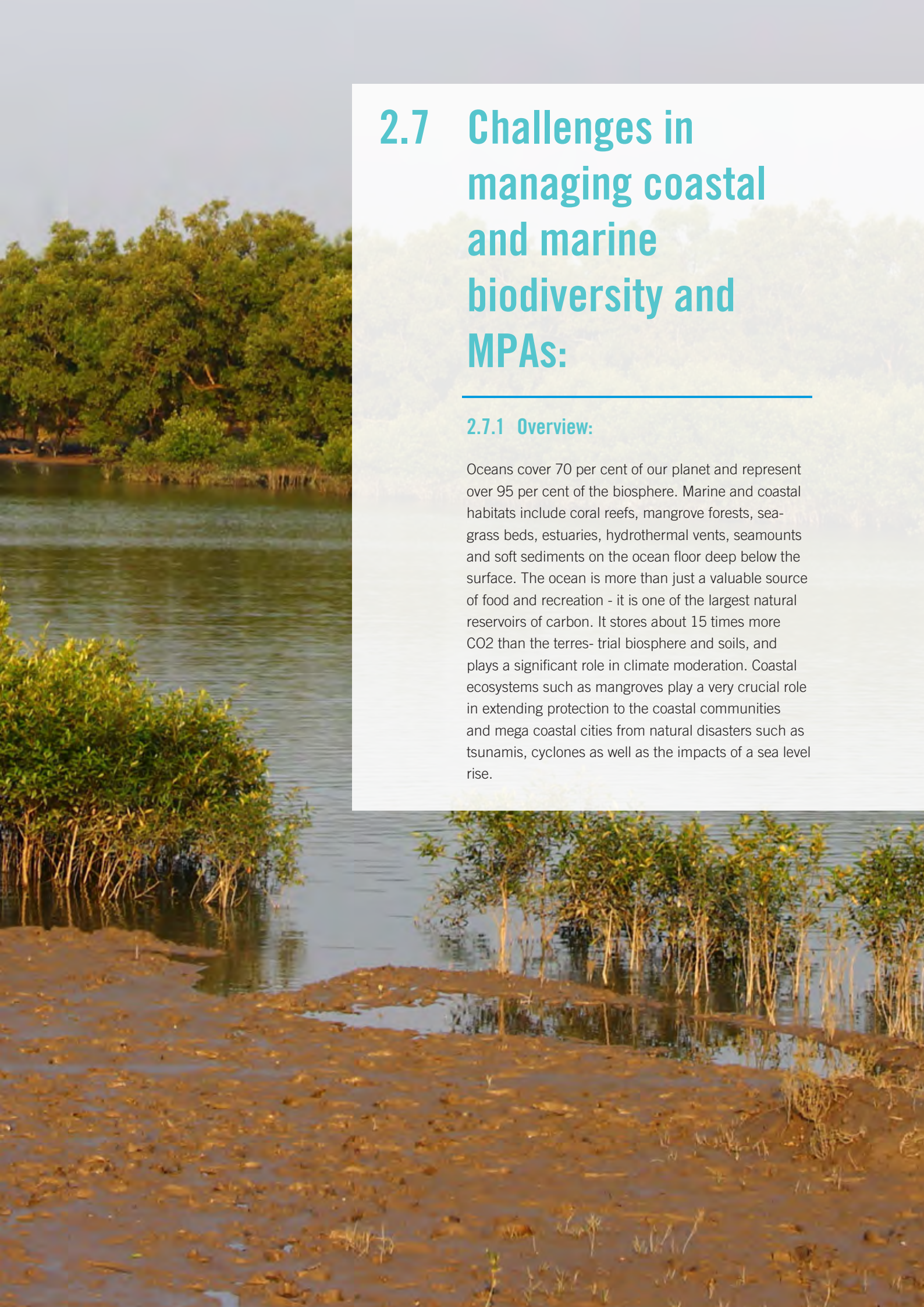
- 20-50 per cent of more than half of the world's 14 biomes surface areas have already been converted to crop- lands.
- Some 60 per cent of the world's major rivers have been fragmented by dams and diversions. Coral reefs
    - 60 per cent are already destroyed or on the verge of destruction Southeast Asia.
- High altitude mountain forest. Tropical forest.
- Mangroves
    - 40 and 70 per cent in Africa
    - 70 per cent in Asia
        - 85 per cent in India
        - 87 per cent in Thailand.

2.6.3 Species Extinctions

- 130 species disappear from the earth each day.
- Between 10 and 20 per cent of all species will be driven to extinction in the next 20 to 50 years.
- The current and impending rate of human-caused extinctions - 100 to 1,000 times the background extinction rate.

2.6.4 Erosion of Genetic Diversity

- Example: In China, the number of local rice varieties being cultivated has declined from 46,000 in the 1950s to slightly more than 1,000 in 2006.
    - In some 60 to 70 per cent of the areas where wild relatives of rice used to grow, it is either no longer found or the area devoted to its cultivation has been greatly reduced.
- 21 per cent of the world's 7,000 livestock breeds (amongst 35 domesticated species of birds and mammal) are classified as being at risk.



2.7 Challenges in managing coastal and marine biodiversity and MPAs:

2.7.1 Overview:

Oceans cover 70 per cent of our planet and represent over 95 per cent of the biosphere. Marine and coastal habitats include coral reefs, mangrove forests, sea-grass beds, estuaries, hydrothermal vents, seamounts and soft sediments on the ocean floor deep below the surface. The ocean is more than just a valuable source of food and recreation - it is one of the largest natural reservoirs of carbon. It stores about 15 times more CO2 than the terres- trial biosphere and soils, and plays a significant role in climate moderation. Coastal ecosystems such as mangroves play a very crucial role in extending protection to the coastal communities and mega coastal cities from natural disasters such as tsunamis, cyclones as well as the impacts of a sea level rise.

This tremendous wealth of biodiversity and ecosystem services is not infinite. Today, human activities are greatly threatening the seas and coasts through overfishing, destructive fishing practices, pollution and waste disposal, agricultural runoff, invasive alien species, and habitat destruction. Global climate change will make it worse. Sea levels will rise, water temperature will increase, oceans will acidify, and there will be more storms and natural disasters[5].

Coastal habitats are under pressure, with approximately 20 per cent of the world's coral reefs lost and another 20 per cent degraded. Mangroves have been reduced to 30 to 50 per cent of their historical cover, impacting biodiversity, habitat for inshore fisheries, and carbon sequestration potential. 29 per cent of seagrass habitats are estimated to have disappeared since the late eighteen hundreds Let's take a closer look at how these stress factors generate impacts on the coastal and marine ecosystems and consequently on the life and livelihoods of coastal communities.

The DPSIR framework, represents a systems-analysis view – the driving forces of social and economic development exert pressures on the environment. As a consequence, the state of the environment changes. This leads to impacts on, for example, human well-being and ecosystem health that can lead to a response in social controls on human activity. This in turn feeds back onto either the driving forces, the pressures, the state of the environment or the impacts directly, through adaptation or through curative action.

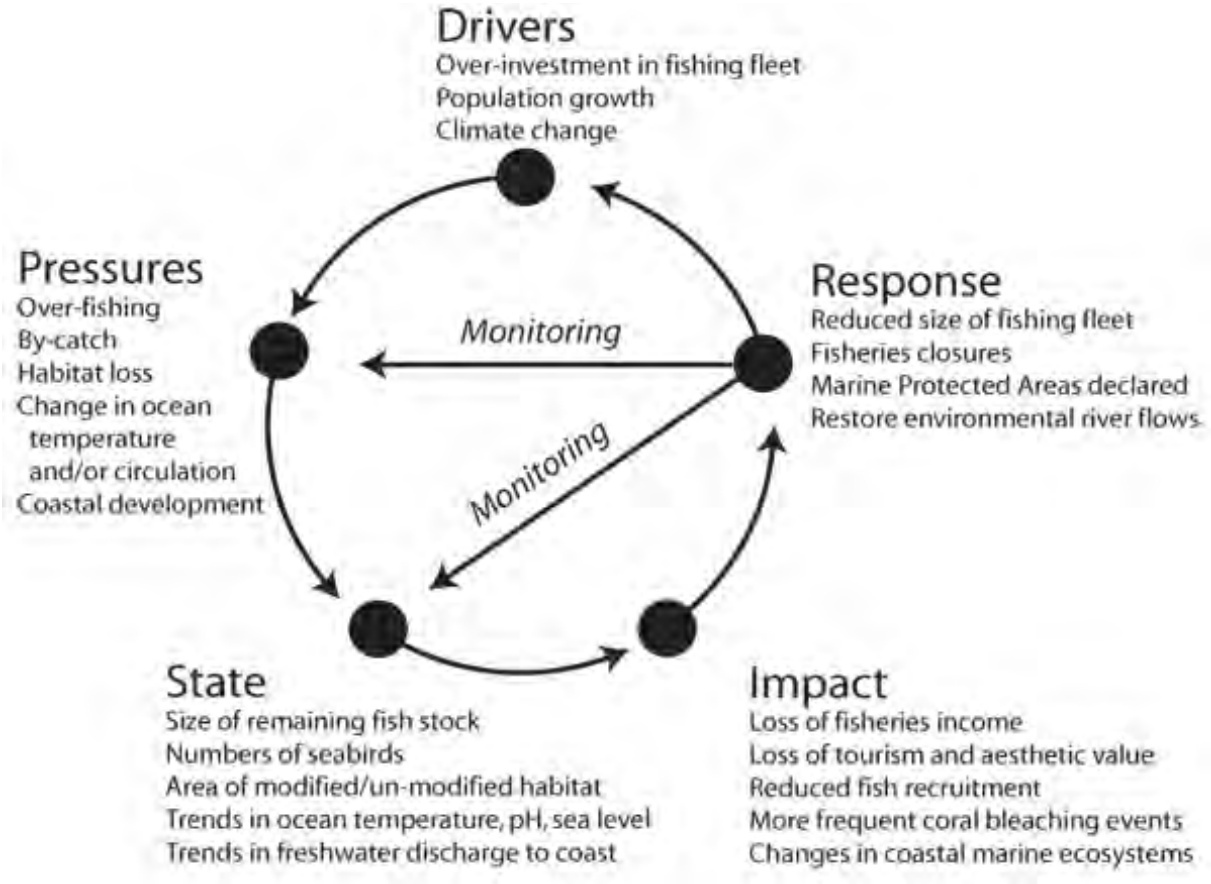


Figure 2.7: DPSIR Framework in the context of coastal and marine ecosystems.
source : http://www.worldoceanassessment.org/?page_id=6

5 Source: IYB CBD Factsheet on Marine and Coastal Biodiversity https://www.cbd.int/undb/media/factsheets/undb-factsheet-marine-en.pdf

2.7.2 Unsustainable fishing

There are many inter-related issues affecting the sustainability of fisheries, including overcapacity in fishing fleets and a related increase in illegal, unregulated and unreported (IUU) fishing, a failure to take into consideration ecosystem effects of fishing into management plans (e.g. bycatch, discards, destructive fishing practices), lack of incentives-based management, weak monitoring, control and surveillance capacity and inability and/or unwillingness to accept short-term costs for long-term benefits. The continuing contribution of fisheries to sustainable development depends on the health of functioning, productive ecosystems and on their optimal utilisation.

Coastal fish farming is increasing and will continue to increase and expand in the marine environment as the demand for food fish increases and as freshwater becomes more limited. Mariculture with fed species, if not managed properly, could impact on biodiversity and ecosystem functions through the release of nutrients beyond the recycling capacity of ecosystems and through the release of farmed species, diseases and chemicals. The improvement in, and expansion of, green technologies for mari-culture together with adoption of an ecosystem approach to aquaculture that includes identification and management of risks, can ensure sustainable increase in fish production from the seas.

About 80 per cent of world fish stocks, for which assessment information is available, are fully ex-ploited or overexploited and thus require effective and precautionary management

According to the United Nations Food and Agriculture Organization (FAO), Fishing may alter or affect:

- the target resource (especially if it is overfished);
- species associated with or dependent on the target resource (such as predators or prey);
- trophic relationships within the ecosystem in which the fishery operates; and
- habitats in which fishing occurs.

The benefits lost to fishing nations as a consequence of overfishing are in the order of USD 50 billion per annum.

Overfishing and excessive fishing can reduce the spawning biomass of target species below desired levels such as maximum sustainable or economic yields.

When there is sustained overfishing, changes in species composition and biodiversity can occur with a progressive reduction of large, long-lived and high value predator species and an increase in small, short-lived and lower value pelagic prey species, a process described as 'fishing down the food chain'. Intensive fishing can also reduce genetic diversity of wild populations.

Non-selective fishing gear that is not modified to exclude or otherwise deter the entanglement of non-target spe cies may take a significant bycatch of juvenile fish, benthic animals, marine mammals, marine birds, vulnerable or endangered species. These are often discarded dead. While bycatch and discard problems are usually measured in the potential loss of human food, the increased risk of depletion for particularly vulnerable or endangered species (e.g. small cetaceans, turtles) can be significant.

Ghost fishing can occur when certain gear such as pots or gillnets have either been lost or abandoned at sea and, although untended, continue to catch and kill fish until the gear falls apart.

Impacts on the sea floor can result from the intense use of trawls and other mobile bottom gear (e.g. dredges) and can change the sea floor structure, microhabitats, and benthic fauna. The activity is particularly damaging in sensitive environments, par- ticularly in the case of long-term trawling/dredg-ing in the same area.

Fishing with dynamite and poisons can have severe and broad-reaching impacts, particularly on coral reefs.

Global Fisheries watch data website and video
http://www.globalfishingwatch.org
https://www.youtube.com/watch?v=fn2JXmCUo30

2.7.3 Tourism

Tourism is a double-edged activity. It has the potential to contribute in a positive manner to socio-economic achievements but, at the same time, its fast and sometimes uncontrolled growth can be the major cause of degradation of the environment and loss of local identity and traditional cultures[6]

Coastal tourism is a key component of coastal and marine economies. It is, in many countries, the fastest growing area of contemporary tourism, which has placed increasing pressure on the coast. These are often areas in which uses may already be highly concentrated in the form of agriculture, human settlements, fishing, industry, etc.

Tourism provides 43% of jobs in French coastal regions, generating more revenue than fishing or shipping

(UNEP 2009)

A lack of land-use planning and building regulations in many destinations has led to sprawling developments along coast-lines, leading to habitat fragmentation. The sprawl includes tourism facilities themselves and supporting infrastructure such as roads, housing, parking, service areas and waste disposal. Habitat degradation is an- other negative impact of tourism development. For example, coastal wetlands are often drained and filled and mangroves cut due to a lack of more suitable sites for construction of tourism facilities and infrastructure. Apart from this, many tourism activities such as anchoring, snorkeling or sport fishing and tourism related littering can cause direct harm to species (e.g. marine mammals) and degradation of marine habitats with subsequent impacts on coastal erosion and fisheries.

The Convention on Biological Diversity (CBD) website contains a very good case study on this topic, which can be accessed here http://www.cbd.int/doc/case-studies/tour/cs-tour-pa-01-en.pdf

Tourists and suppliers, often unknowingly, can bring in species (insects, wild and cultivated plants and diseases) that are not native to the local environment, which can cause enormous disruption and even destruction of eco- systems. Although an important tool for environmental education and increasing awareness, wildlife viewing can stress the animals and alter their natural behaviour when tourists come too close and create noise, e.g. with their mo- torised vehicles and lights.

According to the Millennium Ecosystem Assessment, at a conservative estimate, they cover some seven per cent of the earth's surface and deliver 45 per cent of the world's natural productivity and ecosystem services of which the benefits are estimated at USD20 trillion a year (Source: www.maweb.org).

In the past, demand for land, as well as poor understanding of the services provided by wetlands, has resulted in viewing such wetlands as wastelands and hence there has been 'extensive 'reclamation' and conversion into other land use, especially for settlements and industries. Today, the importance of wetlands, especially in terms of the ecosystem services that they provide, is increasingly understood and appreciated.

6 Source: Convention on Biological Diversity (CBD)

Source: Convention on Biological Diversity

To ensure stability on the water, most large commercial vessels have ballast tanks that can be filled with water or emptied to safely balance the weight distribution of their load or to compensate for reductions in cargo or fuel. However, ballast water taken on board in one port may be released in another port, inadvertently releasing non-native species that the water may contain.

Ballast water management in the Great Lakes

Invasive plants and animals from foreign freshwater ports are those most likely to thrive in the fresh waters of the Great Lakes. Ballast water exchange, where ships' crews exchange coastal port water in ships' ballast tanks with oceanic salt water during the voyage, is used to reduce the risk of species invasions by physically removing coastal organisms from the tanks. Second, the high salinity of the ocean water would be inhospitable for many coastal organisms that had not been removed from tanks.

Third, any marine organisms drawn into the ballast tanks along with salt water in mid-ocean are unlikely to survive if released in a coastal port. Used globally, ballast water exchange is particularly effective for reducing the risk of invasion to freshwater ports such as those in the Great Lakes.

Between 1959 and 2010, at least 56 non-native aquatic species were reported in the Great Lakes, with 34 of them attributed to transoceanic shipping. For example, ballast water is the original vector by which Zebra and Quagga mussels, Tubenose and Round gobies, spiny water fleas and Blood Red Shrimp were transported to the Great Lakes. Since their original introduction, these aquatic invaders have spread further through river systems and from lake to lake by other means such as on fishing equipment, in bait buckets, or on the hulls of recreational boats that may not have been cleaned properly.

Between 1989 and 1993, ballast water exchange was voluntary. In 1993, it became mandatory for ships destined for the Great Lakes to exchange ballast water loaded at or near a port with salt water from mid-ocean (at least 200 miles offshore and in water at least 2000 m deep).

In 2006, Canada added a new measure for ships with empty ballast tanks to help prevent the arrival of non-native species. In addition to mid-ocean ballast water exchange, the new regulations require that empty tanks be flushed or rinsed in mid-ocean to make sure any leftover organisms are also given the salt water treatment.

These regulations are supported by intensive inspection and compliance efforts. All vessels entering the St. Lawrence Seaway from outside Canada's Exclusive Economic Zone are inspected by Transport Canada or the U.S. Coast Guard under a unique binational inspection programme when they reach the Port of Montreal. Annually, no more than 3 per cent of vessels are non-compliant, and all of these ships are required to take corrective actions before proceeding. The programme has been heralded around the world as a model of effective management and bilateral regulatory cooperation.

Source: Government of Canada, Fisheries and Oceans,
http://www.dfo-mpo.gc.ca/science/publications/article/2011/06-13-11-eng.html

2.7.4 Loss of native habitats and species and threat from invasive alien species

Alien invasive species are alien species that invade new habitat; that is, they become established in natural or semi-natural ecosystems or habitats, are agents of change and threaten native biological diversity.

Over 80 per cent of the world's 232 marine eco-regions reported the presence of invasive alien species which is the second most significant cause of biodiversity loss on a global scale; and marine bio-invasion rates have been reported to be as high as up to one invasion every nine weeks (IOC/UNESCO, IMO, FAO, UNDP, 2011). Ballast water from the ships plays a major role in the spread of invasive species. Visit Module 5 for information on impacts of ballast water on spreading invasive alien species and the possible solution.

In order to find a solution to the problem of alien invasive, the Global Invasive Species Programme (GISP) has been designated as an international thematic focal point for invasive alien species under the clearing-house mechanism of the CBD.

2.7.5 Pollution

More than 80 per cent of all marine pollution originates from land-based sources which are primarily industrial, agricultural and urban. Pollution in all its forms – air, water, chemical, sewage and municipal solid waste – ultimately enters the ocean through water channels. The disposal of waste is also a serious constraint to sustainable development. Agricultural practices, coastal tourism, port and harbour developments, damming of rivers, urban development and construction, mining, fisheries, aquaculture, and manufacturing, among others, are all sources of marine pollution threatening coastal and marine habitats. The occurrence of marine and coastal hypoxic areas or 'dead zones' has been increasing at a massive rate in recent years.

In addition to land based and marine pollution, plastic materials and other litter are widespread in the ocean. Much of the trash that enters the ocean is made up of plastics: plastic bags, food packaging, and straws and lids from our to-go cups. In the ocean, these plastics break down into tiny, toxic particles that are ingested by marine life, which in turn is consumed by us. This plastic may be from tourists or from the municipal waste of local populations dumped in the coastal waters or from ships dumped in the open sea.

2.7.6 Marine debris[7]

Solid materials, typically waste, that has found its way to the marine environment is called marine debris. Plastic and synthetic materials are the most common types of marine debris and cause the most problems for marine animals and birds. At least 267 different species are known to have suffered from entanglement or ingestion of marine debris, including seabirds, turtles, seals, sea lions, whales and fish.

The scale of contamination of the marine environment by plastic debris is vast. It is found floating in all the world's oceans, everywhere, from polar regions to the equator. The seabed, especially near coastal regions, is also contaminated – predominantly with plastic bags. Plastic is also ubiquitous on beaches everywhere from populous regions to the shores of very remote uninhabited islands.

7 This section is adapted from the following publication of Greenpeace: http://www.greenpeace.org/austria/Global/austria/dokumente/Studien/meere_Plastic_Debris_Study_2006.pdf

2.7.6.1 Sources of marine debris

It has been estimated that around 80 per cent of marine debris is from land-based sources and the remaining 20 per cent is from ocean based sources. The sources can be categorised into four major groups:

- **Tourism related litter at the coast:** This includes litter left by beach goers such as food and beverage packaging, cigarettes and plastic beach toys.
- **Sewage related debris:** This includes water from storm drains and combined sewer overflows which discharge waste water directly into the sea or rivers during heavy rainfall. These waste waters carry with them garbage such as street litter, condoms and syringes.
- **Fishing related debris:** This includes fishing lines and nets, fishing pots and strapping bands from bait boxes that are lost accidentally by commercial fishing boats or are deliberately dumped into the ocean.
- **Wastes from ships and boats:** This includes garbage which is accidentally or deliberately dumped overboard.
- **Huge volumes of non-organic wastes, including plastics and synthetics**, are produced in more developed, industrialised countries. Conversely, in less developed and more rural economies, generally a much smaller amount of these non-biodegradable persistent wastes are produced. However, in the future, as less developed countries become more industrialised, it is likely that they will also produce more plastic and synthetic wastes and this will increase further the threat of pollution of the marine environment.

2.7.6.2 Harm to marine wildlife

Countless marine animals and sea birds become entangled in marine debris or ingest it. This can cause them serious harm and often results in their death.

Entanglement in marine debris

Marine debris which is known to cause entanglement includes derelict fishing gear such as nets and mono-filament lines and also six-pack rings and fishing bait box strapping bands. This debris can cause death by drowning, suffocation, strangulation, starvation through reduced feeding efficiency, and injuries. Particularly affected are seals and sea lions, probably due to their very inquisitive nature of investigating objects in their environment. Entanglement rates in these animals of up to 7.9 per cent of a population have been recorded.

Furthermore, in some instances entanglement is a threat to the recovery of already reduced population sizes. An estimated 58 per cent of seal and sea lion species are known to have been affected by entanglement including Hawaiian monk seals, Australian sea lions, New Zealand fur seals and other species in the Southern Ocean.

Whales, dolphins, porpoises, turtles, manatees and seabirds have all been reported to have suffered from entanglement. Many different species of whale and turtle have been reported to have been tangled in plastic. Manatees have been found with scars or missing flippers due to entanglement. species of seabirds are also known to have been affected. Derelict fishing gear also causes damage to coral reefs when nets or lines get snagged by the reef and they break off.

Finally, discarded or lost fishing nets and pots can continue to trap and catch fish even when they are no longer in use. This phenomenon is known as ghost fishing and can result in the capture of large quantities of marine organisms. Consequently, it has become a concern with regard to conservation of fish stocks in some areas and has resulted in economic losses for fisheries.

Ingestion of marine debris

Ingestion of marine debris is known to particularly affect sea turtles and seabirds but is also a problem for marine mammals and fish. Ingestion is generally thought to occur because the marine debris is mistaken for prey and most that is erroneously ingested is plastic of different types including plastic bags, plastic pellets and fragments of plastic that have been broken up from larger items. The biggest threat from ingestion occurs when it blocks the digestive tract or fills the stomach, resulting in malnutrition, starvation and possibly death.

Studies show that a high proportion (about 50 to 80%) of sea turtles found dead, are known to have ingested marine debris. This can have a negative impact on turtle populations. In young turtles, a major problem is dietary dilution in which debris takes up some of the gut capacity and threatens their ability to take on necessary quantities of food. For seabirds, 111 out of 312 species are known to have ingested debris and it can affect a large percentage of a population (up to 80%). Moreover, plastic debris is also known to be passed to the chicks in regurgitated food from their parents. One harmful effect from plastic ingestion in birds is weight loss due, for example, to a falsely sated appetite and failure to put on adequate fat stores for migration and reproduction.

Potential invasion of alien species

Plastic debris which floats on the oceans can act as rafts for small sea creatures to grow and travel on. Plastic can travel for long distances and therefore there is a possibility that marine animals and plants may travel to areas where they are non-native. Plastic with different sorts of animals and plants have been found in the oceans in areas remote from their source. This represents a potential threat for the marine environment should an alien species become established. It is postulated that the slow speed at which plastic debris crosses oceans makes it an ideal vehicle for this. The organisms have plenty of time to adapt to different water and climatic conditions.

2.7.6.3 Marine debris around the world

Many studies have been carried out in different countries and oceans estimating the quantity of plastic on beaches, the sea floor, in the water column, and on the sea surface. Most of these studies have focused, partially for reasons of practicality, on large (macro) debris. A limited body of literature also exists concerning small to microscopic particles (micro debris).The results show that marine debris is ubiquitous in the world's oceans and shorelines. Higher quantities are found in the tropics and in the mid-latitudes compared to areas towards the poles. It has been noted that high quantities are often found in shipping lanes around fishing areas and in oceanic convergence zones.

Floating marine debris: Studies on different areas of the marine environment reported quantities of floating marine debris that were generally in the range of 0-10 items of debris per sq km . Higher values were reported in the English Channel (10-100+ items/sq km) and Indonesia (more than 4 items in every sq m). Floating micro debris has been measured at much higher levels: the North Pacific Gyre, a debris convergence zone, was found to contain maximum levels, that when extrapolated represent, near to a million items per square kilometre.

Seafloor debris: Research has shown that marine debris was present on the seafloor in several locations in European waters, and also in the United States, Caribbean and Indonesia. In European waters, the highest quantity recorded was 101,000 items/sq km and in Indonesia the equivalent of 690,000 items/sq km .

Shoreline Debris: Surveys of shorelines around the world have recorded the quantity of marine debris either as the number of items per km of shoreline or the seven number of items per square metre of shoreline. The highest values reported were for Indonesia (up to 29.1 items per m) and Sicily (up to 231 items per m).

2.7.6.4 Solutions

There are a number of global, international and national initiatives in place that are aimed at protecting the oceans from marine debris. The most far reaching of these is the International Convention for the Prevention of Pollution from Ships (MARPOL).

Other measures to address marine debris include manual clean-up operations of shorelines and the sea floor as well as school and public education programmes.

While the above measures are important for preventing or reducing the problem of marine debris, the ultimate solution to waste prevention is to implement a responsible waste strategy, with the concept of "Zero Waste" . Such a strategy encompasses waste reduction, reuse and recycling as well as producer responsibility and ecodesign. Ultimately, this would mean reduction of the use of plastics and synthetics such that they are only used where absolutely necessary and where they have been designed for ease of recycling within the existing recovery infrastructure. It is possible that biodegradable plastics could be used where plastic was deemed necessary but could not be seen as an environmentally sound alternative unless they are known to break down rapidly to non-hazardous substances in natural environments.

Source: http://www.projectaware.org/project/ugly-journey-our-trash

2.8 Coastal squeeze

Coastal squeeze is the term used to describe what happens to coastal habitats that are trapped between a fixed landward boundary, such as a sea wall and rising sea levels and/or increased storminess. The habitat is effectively 'squeezed' between the two forces and diminishes in quantity and/or quality.

Prominent sites to observe coastal squeeze are the mega coastal cities, where seawalls are constructed to protect property along retreating beaches. These seawalls confine the wave energy and intensify erosion by concentrating the sediment transport processes in an increasingly narrow zone. Eventually, the beach disappears, leaving the seawall directly exposed to the full force of the waves, and wherever the seawall is not present in this zone, water enters cities leading to urban flooding situations.

One recent estimate found that at least 40 per cent of the global oceans are 'heavily affected' by human activities. This has a direct impact on sustainable development, with the majority of human settlements located on or near the coasts. Many of these 'stresses' to coastal and marine biodiversity develop either due to insufficient information that different agencies working in the coastal areas have on coastal geology and processes, or are intentional due to commercial interests.

See a case study here

http://repository.tudelft.nl/view/ir/uuid%3Ae23ef22d-172a-4c22-9a2b-477d8d294466/

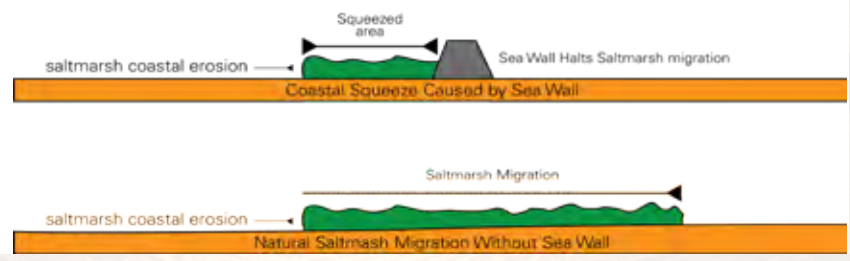


Figure 2.8: Coastal Squeeze. (Source: https://www.geocaching.com/geocache/GC5T0XC_ukme-viking-outcasts-niu?guid=d99fd978-0c97-4820-b621-7dd4d328ae76)

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

2.9.1 Overview

According to the Millennium Ecosystem Assessment, climate change is likely to become one of the most significant drivers of biodiversity loss by the end of the century. It will create new hazards such as glacier recession, sea level rise and extreme weather events in frequency and intensity, never seen before. Greater rainfall in some areas will trigger more floods and landslides, with consequent disruption to agriculture, urban settlements, commerce and transport. Climate change will, therefore, further aggravate the existing disaster risks and vulnerabilities and expose millions of people never affected before to risks, around the world.

A projected sea-level rise of 88 cm over the 21st century could lead to the loss of 13 per cent of mangrove area in 16 pacific island countries or territories, with losses as high as 50 per cent on some islands.

In addition to affecting individual species and ecosystem health, climate change will also impact ecosystem services. These include provisioning services such as food and raw materials, which may improve in the short term in boreal regions and decline elsewhere; regulating services such as flood control and coastal protection which are expected to be particularly impacted by the degradation of coral reefs and wetlands; and cultural services including traditional livelihoods.

A study by the World Bank revealed that coral reef degradation attributable to climate change in Fiji is expected to cost between USD 5 million and USD 14 million a year by 2050.

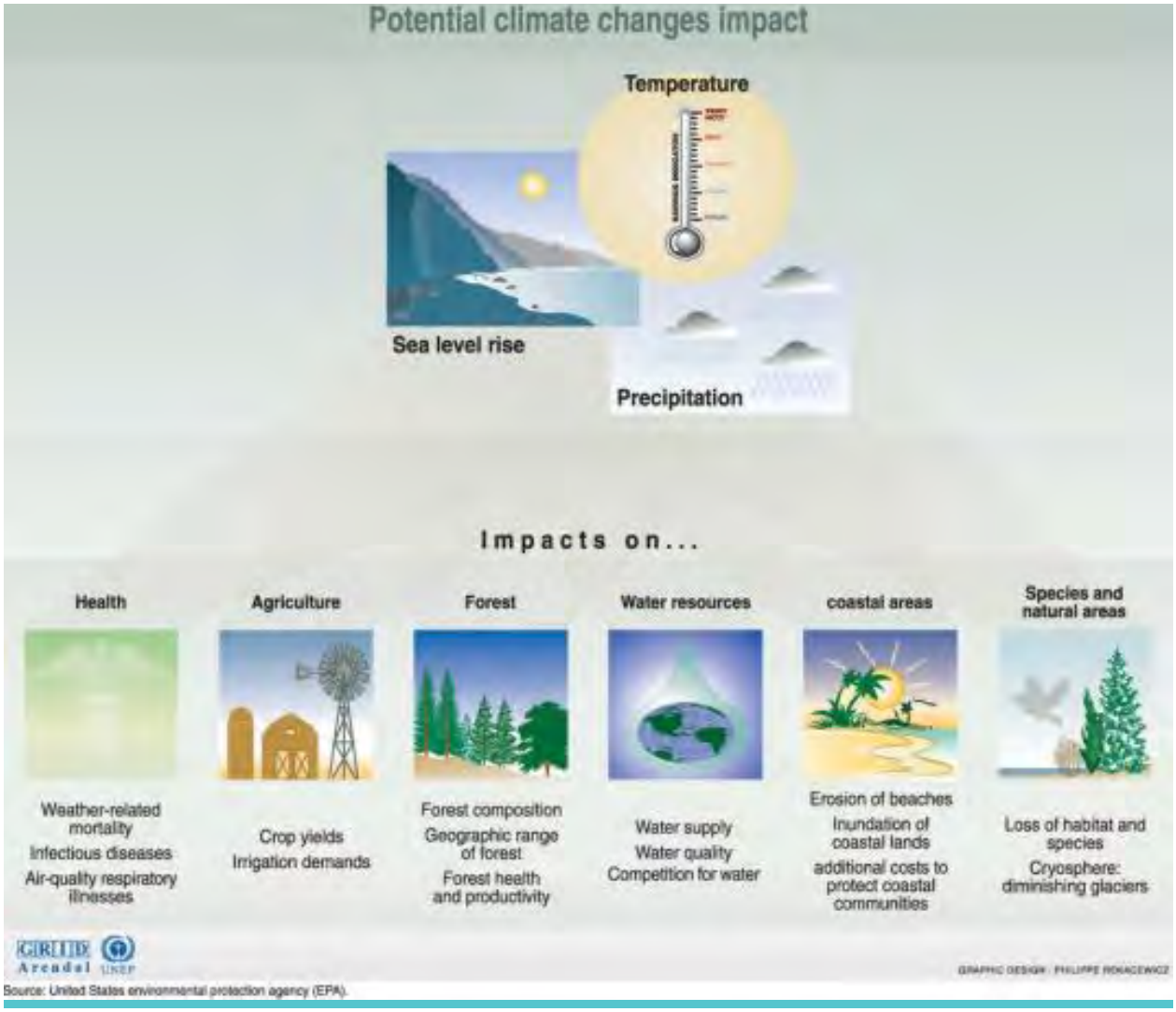


Figure 2.9: Potential climate change impacts. Graphic courtesy of Philippe Rekacewicz, UNEP/GRID-Arendal. Source: United States Environmental Protection Agency (EPA).

First, there is ample evidence that climate change affects biodiversity. On the other hand, biodiversity can support efforts to reduce the negative effects of climate change. Conserved or restored habitats can remove carbon dioxide from the atmosphere, thus helping to address climate change by storing carbon (for example, reducing emissions from deforestation and forest degradation). Moreover, conserving intact ecosystems, such as mangroves, for example, can help reduce the disastrous impacts of climate change such as flooding and storm surges.

2.9.2 Basic science of climate change

In the atmosphere, CO2 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 CO_2 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.

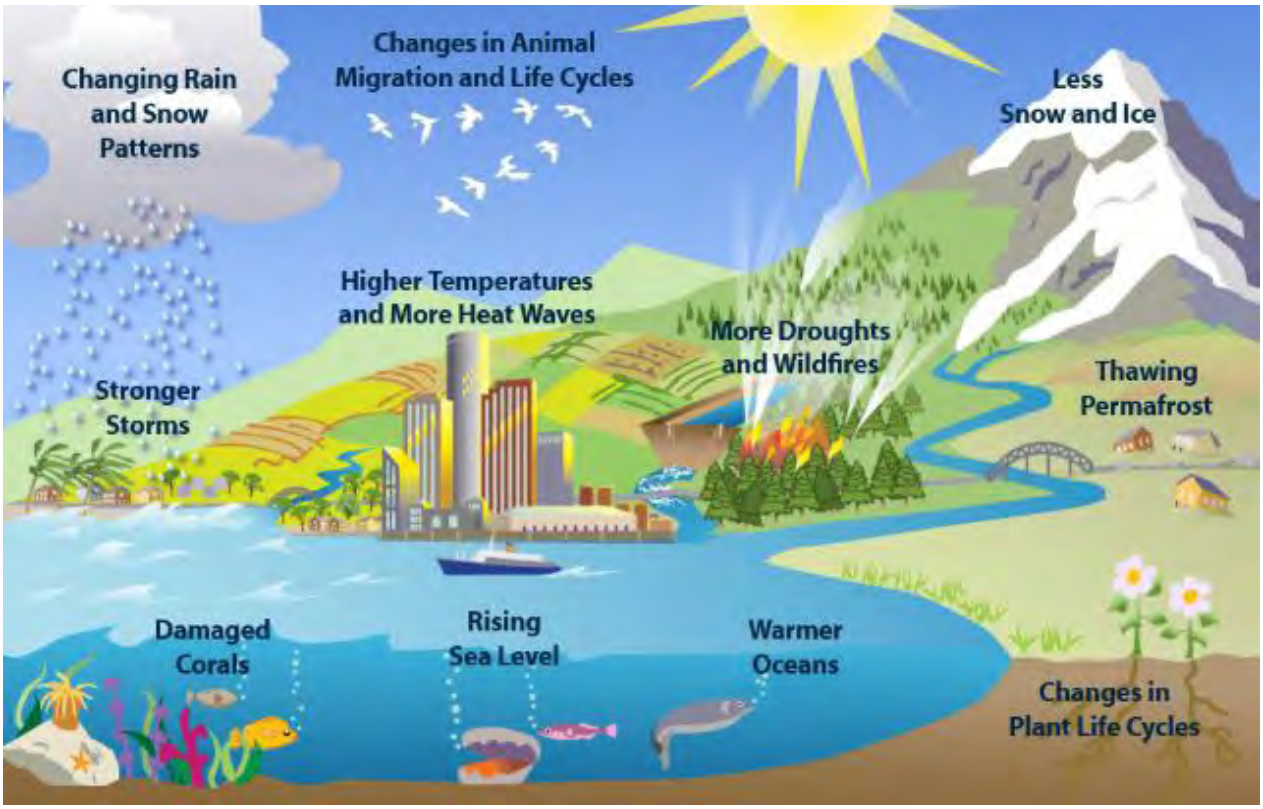


Figure 2.10: Signs of climate change [Source: https://www3.epa.gov/climatechange/kids/scientists/clues.html]

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).

Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems. In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans. Impacts are due to observed climate change, irrespective of its cause, indicating the sensitivity of natural and human systems to changing climate.

Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800,000 years.

Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century.

Changes in many extreme weather and climate events have been observed since about 1950. Some of these changes have been linked to human influences, including a decrease in cold temperature extremes, an increase in warm temperature extremes, an increase in extreme high sea levels and an increase in the number of heavy precipitation events in a number of regions (IPCC, 2014).

Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes. It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century. Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions. The global ocean will continue to warm during the 21st century. Heat will penetrate from the surface to the deep ocean and affect ocean circulation (IPCC, 2013).

IPCC (2014) studies have confirmed, continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Climate change will amplify existing risks and create new risks for natural and human systems. Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks (IPCC, 2014).

Some key terms[8]

- **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.
- **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. 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.'

8 adapted from IPCC (2012)

2.9.3 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 hey refer to slightly different things.

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

2.9.4 Climate change: Observed impacts, vulnerability and exposure

(Source: IPCC 2014a and 2014b)

2.9.4.1 General impacts:

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.

According to the fifth report of the IPCC, in recent decades, climate change has caused impacts on natural and human systems on all continents and across the oceans.

- In many regions, changing precipitation or melting snow and ice is altering hydrological systems, affecting water resources in terms of quantity and quality.
- Many terrestrial, freshwater and marine species have shifted their geographic ranges, seasonal activities, migration patterns, abundance and species interactions in response to ongoing climate change.
- Climate change has negatively affected wheat, maize, rice and soybean yields in many regions and in the global aggregate.
- There has been increased heat-related mortality and decreased cold-related mortality in some regions as a result of warming.

Changes in many extreme weather and climate events have been observed since about 1950. Some of these changes have been linked to human influences, including a decrease in cold temperature extremes, an increase in warm temperature extremes, an increase in extreme events, high sea levels and an increase in the number of heavy precipitation events in a number of regions.

'Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes.' Vulnerability, therefore, is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity (IPCC 2007). The lower the adaptive capacity of a system, the higher will be its vulnerability to the negative impacts of climate change.

Vulnerability is also governed by the stability and resilience of local ecosystems. The more stable and resilient an ecosystem is, the lesser vulnerable the communities will be. Therefore, protection, restoration or establishment of biologically diverse ecosystems that provide important goods and services may constitute important adaptation measures to increase the adaptive capacities of the population. Maintaining biodiversity is an important component of adaptation as biodiversity contributes to the provision of many ecosystem services.

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.

Fluctuating weather patterns are inducing changes in the distributions and ranges of species and are disrupting the natural balances 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, which can have insidious implications for human health.

2.9.4.2 Impact on coral reefs[9]:

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 CO2 levels in the atmosphere, siltation as a result of deforestation, sedimentation, marine pollution with contaminants, freshwater dilution, subaerial exposure and disease), 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. 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.

2.9.4.3 Impact on Mangroves[10]

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. As a result of rising sea levels, 75 km2 (1.25 percent) of the mangroves in this tract along the shores of the two countries has been lost due to inundation. A UNESCO document 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.

2.9.4.4 Impact on 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[11]; Short and Neckles 1999[12]). 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[13]).

9 Source: UNISDR/UNDP (2012).

10 Source: UNISDR/UNDP (2012).

11 Björk M., Short F., Mcleod, E. and Beer, S. (2008). Managing Seagrasses for Resilience to Climate Change. Gland, Switzerland: IUCN. 56pp

12 Short, F. T. and H. A. Neckles (1999). The effects of global climate change on seagrasses. Aquatic Botany 63: 169–196.

13 Björk M., Short F., Mcleod, E. and Beer, S. (2008). Managing Seagrasses for Resilience to Climate Change. Gland, Switzerland: IUCN. 56pp

2.9.4.5 Impact on 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[14]).

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[15]). 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).

14 Björk M., Short F., Mcleod, E. and Beer, S. (2008). Managing Seagrasses for Resilience to Climate Change. Gland, Switzerland: IUCN. 56pp

15 Choudhury, B. C., Pandav B, Tripathy, B., and Andrews H. A., Sea Turtle Conservation: Eco (Turtle) friendly Coastal Development, Centre for Herpetology/ MCBT, Mammalapuram, Tamilnadu, India, 2003

2.9.4.6 Impact on 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).

2.9.4.7 Impact on Coastal wetlands, including estuaries, deltas, salt marshes and mudflats

Coastal wetlands include deltas, estuaries, lagoons and sheltered bays. They are affected by rising sea levels and sedimentation. With a sea level rise, these salt marshes and mudflats are likely to be submerged (Bandyopadhyay 1993[16]), 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).

2.9.4.8 Impact on 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).

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

Climate change, 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 (SF6).

2.9.5.1 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.

16 Bandyopadhyay, B.K., S.R. Pezeshki, R.D. DeLaune, and C.W. Lindau. 1993. Influence of soil oxidation-reduction potential and salinity on nutrition, N-15 uptake, and growth of Spartina patens. Wetlands 13:10–15.

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.

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

> *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.*

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:

> *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.*

2.9.5.2 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[17])

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. But successful adaptation will depend on our ability to allow and facilitate natural systems to adjust to a changing climate, thus maintaining the ecosystem services on which all life depends.

17 Tompkins, E.L., W.N. Adger, E. Boyd, S. Nicholson-Cole, K. Weatherhead, and N. Arnell, 2010: Observed adaptation to climate change: UK evidence of transition to a well-adapting society. Global Environmental Change, 20(4),627-635.

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 Smith, 2009[18];Tompkins et al., 2010[19]; Fünfgeld and McEnvoy, 2011[20]; Eakin et al., 2012[21]) Initially, identifying needs was most often based on impact assessments (or risk-hazard approaches), but social vulnerability or resilience-assessments are increasingly being used.

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?

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 using 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

18 Preston, B. and M. Stafford-Smith, 2009: Framing Vulnerability andAdaptive Capacityv Assessment: Discussion Paper. CSIRO Climate Adaptation National Research Flagship Working Paper No. 2, CSIRO Marine and Atmospheric Research, Aspendale, Victoria, Australia, 52 pp.

19 Tompkins, E.L., W.N. Adger, E. Boyd, S. Nicholson-Cole, K. Weatherhead, and N. Arnell, 2010: Observed adaptation to climate change: UK evidence of transition to a well-adapting society. Global Environmental Change, 20(4),627-635.

20 Fünfgeld, H. and D. McEvoy, 2011: Framing Climate Change Adaptation in Policy and Practice. VCCCAR Working Paper 1, VCCCAR Project: Framing Adaptation in the Victorian Context, Victorian Centre for Climate Change Adaptation Research (VCCCAR), Melbourne, Australia, 65 pp

21 Eakin, H., E.L. Tompkins, D.R. Nelson, and J.M. Anderies, 2012: Hidden costs and disparate uncertainties: trade-offs in approaches to climate policy. In: Adapting to Climate Change: Thresholds, Values, Governance [Adger, W.N., I. Lorenzoni, and K.L. O'Brien (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 212-226.

- **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, *exsitu* 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.

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

Video of "Climate Change 2014: Synthesis Report",
a report of the Intergovernmental Panel on Climate Change
https://www.youtube.com/watch?v=fGHOdAwM-QE

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 ecosystem 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 ts 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.

2.9.5.3 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.

2.10 Disaster Risk Reduction

2.10.1 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, socionatural 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.'

List of various disasters

(Source: High Powered Committee Report-1999) Available from http://www.undp.org/content/dam/india/docs/disaster_management_in_india.pdf

i.	Water and climate related disasters	a)	Floods and drainage management
		b)	Cyclones
		c)	Tornadoes and hurricanes
		d)	Hailstorm
		e)	Cloud burst
		f)	Heat wave and cold wave
		g)	Snow avalanches
		h)	Droughts
		i)	Sea erosion
		j)	Thunder and lightening
		k)	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
		b)	Urban fires
		c)	Mine flooding
		d)	Oil spills
		e)	Major building collapse
		f)	Serial bomb blasts
		g)	Festival related disasters
		h)	Electrical disasters and fires
		i)	Air, road and rail accidents
		j)	Boat capsizing
		k)	Village fire
v.	Biological related disasters	a)	Biological disasters and epidemics
		b)	Pest attacks
		c)	Cattle epidemics
		d)	Food poisoning

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.

2.10. 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)

2.10.2.1 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.

2.10.2.2 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.

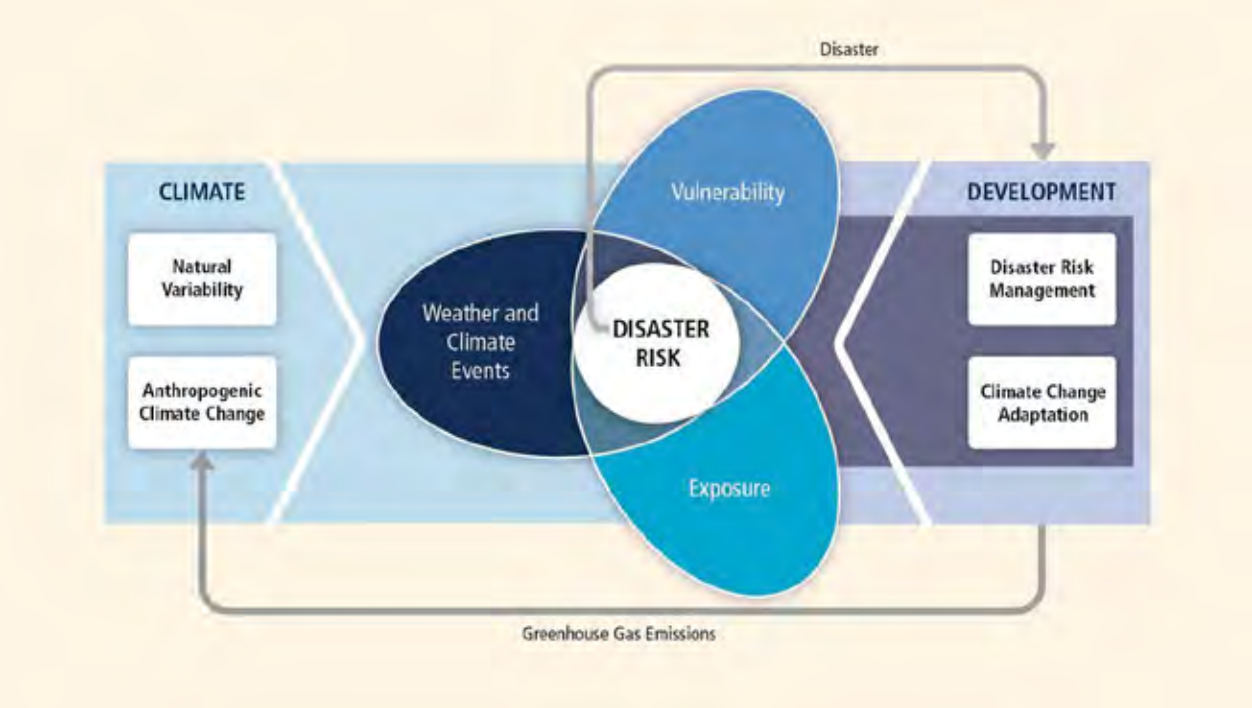


Figure 2.12: Trends in natural disasters (Source: Centre for Research on the Epidemiology of Disasters)

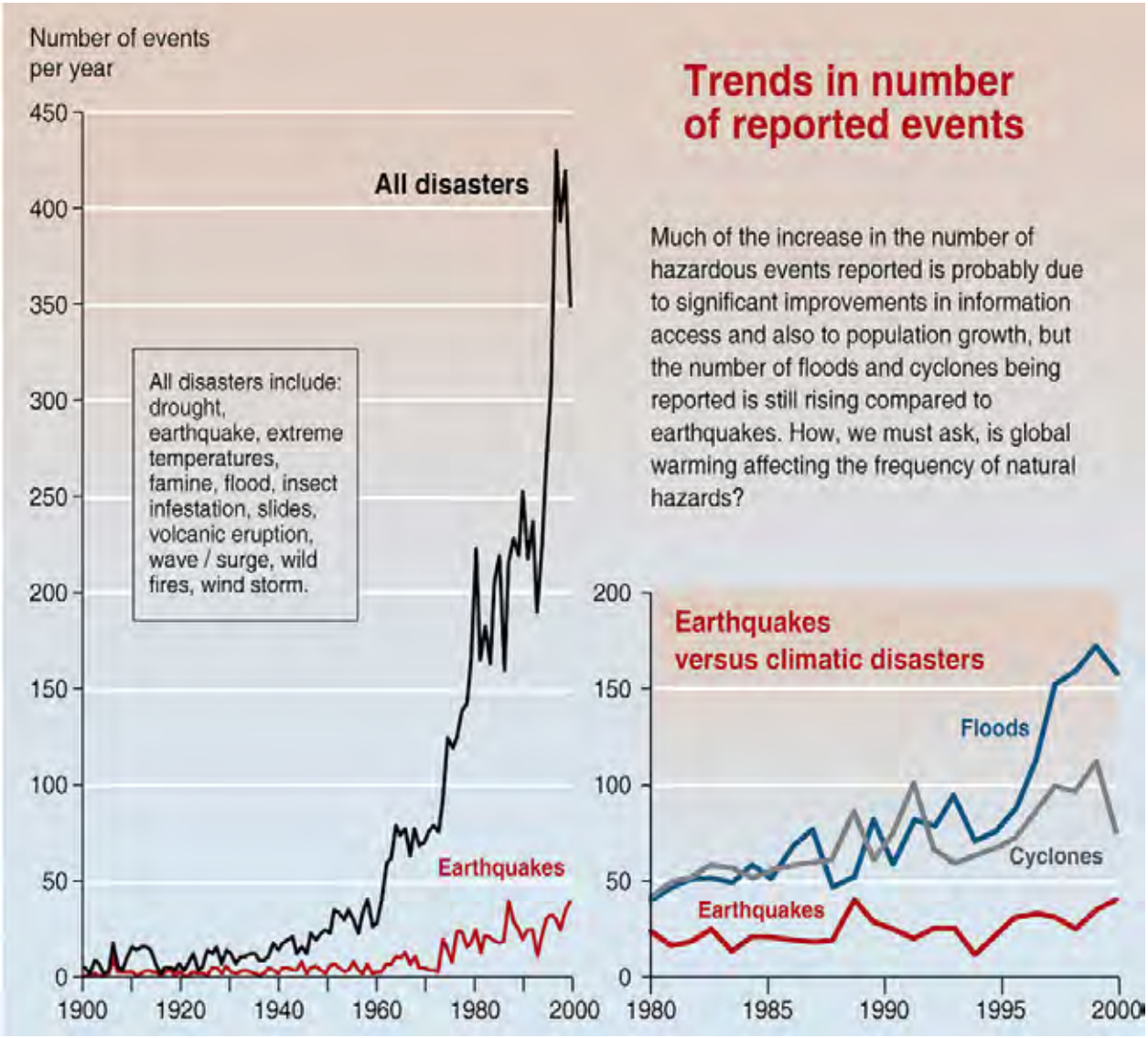


Figure 2.13: Trends in natural disasters. (2005). In UNEP/GRID-Arendal Maps and Graphics Library. Retrieved October 3, 2011 from http://maps.grida.no/go/graphic/trends-in-natural-disasters.

2.10.3 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.

2.10.4 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.

2.10.4 .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.

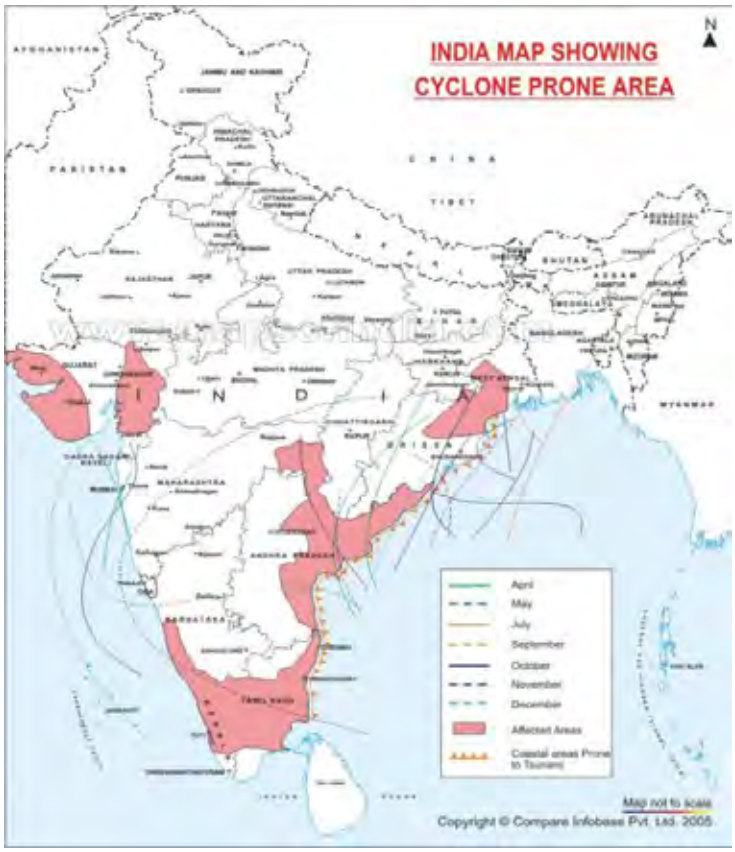
2.10.4.2. During a disaster (disaster occurrence)

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.

2.10.4.3. 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.

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.



[Source: https://socialissuesindia.wordpress.com/2014/01/06/climatic-vulnerable-of-indias-coastal-regions/]

2.10.5 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.

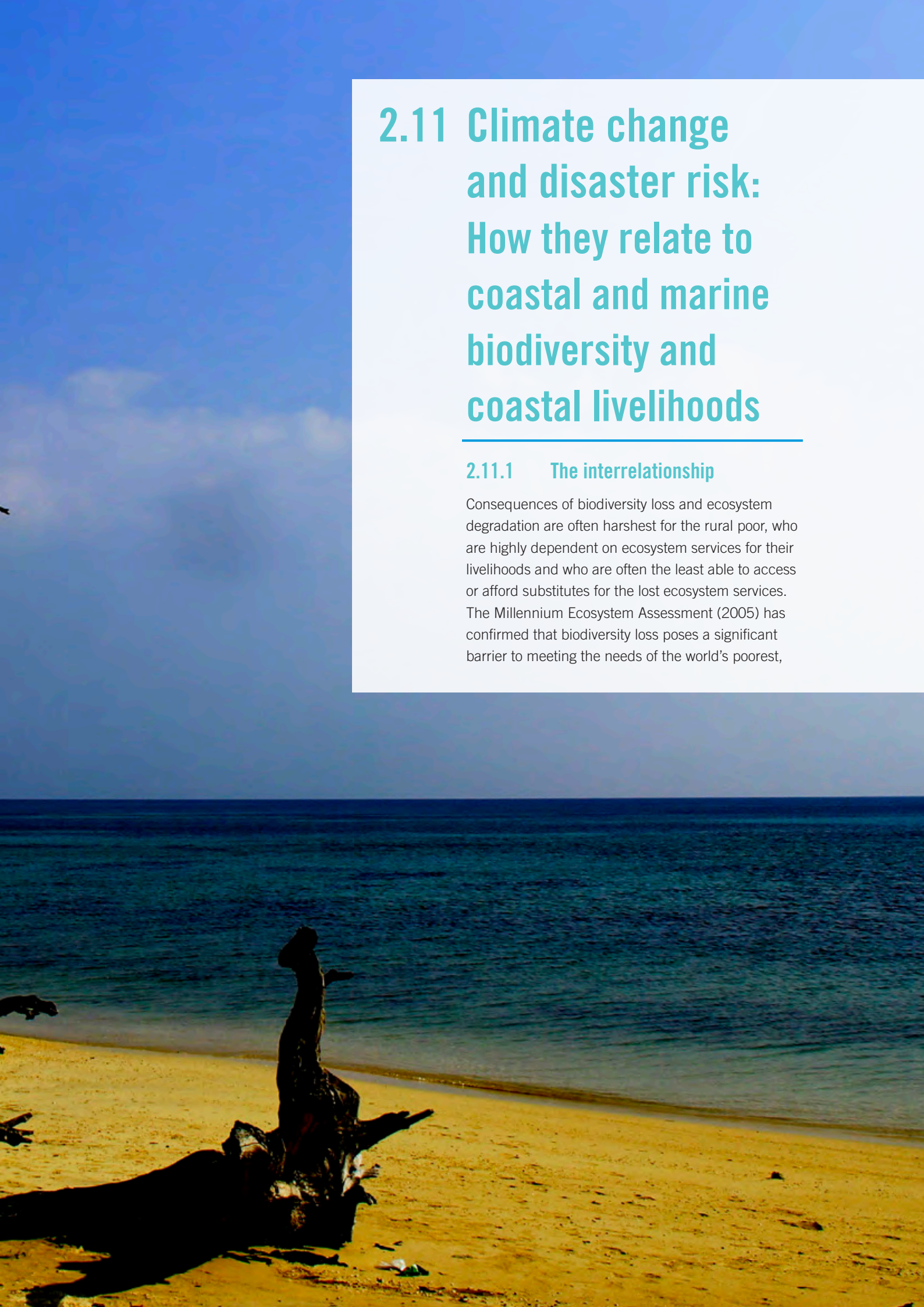
India is exposed to 10 per cent of the world's tropical cyclones. About 71 per cent of this area is in 10 states (Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu, Andhra Pradesh, West Bengal, Kerala, Orissa, Puducherry). Other factors such as the increasing pressure exerted by the population, deteriorating 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 between 1995 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.



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

2.11.1 The interrelationship

Consequences of biodiversity loss and ecosystem degradation are often harshest for the rural poor, who are highly dependent on ecosystem services for their livelihoods and who are often the least able to access or afford substitutes for the lost ecosystem services. The Millennium Ecosystem Assessment (2005) has confirmed that biodiversity loss poses a significant barrier to meeting the needs of the world's poorest,

as set out in the United Nations Millennium Development Goals (now replaced with the Sustainable Development Goals (SDGs). Impacts of biodiversity loss and ecosystem degradation are highest in mountain and coastal communities, and these ecosystems are also one of the most vulnerable ecosystems as far as the negative impacts of climate change are concerned.

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

The livelihoods of rural poor are, therefore, greatly affected, in one or the other way by three major factors — climate change, 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 on their lives and livelihoods, especially in developing countries. Climate studies show that the best possible scenario of controlling the greenhouse gases emissions will still leave us with at least 1.8 degrees Celsius temperature rise by 2100, which means that while on the one hand mitigation is an important aspects of managing climate change, countries must start planning towards adaptation, i.e. strategies to cope with this temperature rise on the other hand.

Value of Ecosystem Services in Disaster Risk Management: Some Examples

- In the Maldives, degradation of protective coral reefs necessitated the construction of artificial breakwaters at a cost of US$ 10 million per kilometer (SCBD, 2009[22]).
- In Vietnam, the Red Cross began planting mangroves in 1994 with the result that, by 2002, some 12,000 hectares of mangroves had cost US$1.1 million for planting but saved annual levee maintenance costs of US$ 7.3 million, shielded inland areas from a significant typhoon in 2000, and restored livelihoods in planting and harvesting shellfish (Reid and Huq, 2005[23]; SCBD, 2009[24]).
- In the United States, wetlands are estimated to reduce flooding associated with hurricanes at a value of US$ 8,250 per hectare per year, and US$ 23.2 billion a year in storm protection services (Costanza et al., 2008[25]).
- In Orissa, India, a comparison of the impact of the 1999 super cyclone on 409 villages in two tahsils with and without mangroves showed that villages that had healthy stands of mangroves suffered significantly less loss of lives than those without (or limited areas) healthy mangroves, even though all villages had the benefit of early warnings and accounting for other social and economic variables (Das and Vincent, 2009[26]).

22 SCBD, 2009: Connecting Biodiversity and Climate Change Mitigation and Adaptation. Report of the second ad hoc technical expert group on biodiversity and climate change, Secretariat of the Convention on Biological Diversity, Montreal, Canada

23 Reid, H. and S. Huq, 2005: Tropical forests and adaptation to climate change: In search of synergies. In: Climate Change – Biodiversity and Livelihood Impacts [Robledo, C., M. Kanninen, and L. Pedroni, (eds.)]. Center for International Forestry Research, Indonesia

24 SCBD, 2009: Connecting Biodiversity and Climate Change Mitigation and Adaptation. Report of the second ad hoc technical expert group on biodiversity and climate change, Secretariat of the Convention on Biological Diversity, Montreal, Canada

25 Costanza, R., O. Pérez-Maqueo, M.L. Martinez, P. Sutton, S.J. Anderson, and K. Mulder, 2008: The value of coastal wetlands for hurricane protection. Ambio,37(4), 241-248.

26 Das, S. and J.R. Vincent, 2009: Mangroves protected villages and reduced death tolls during Indian super cyclone. Proceedings of the National Academy of Sciences,106(18), 7357-7360.

Disaster, Biodiversity and Climate Change: Is there a real connection?

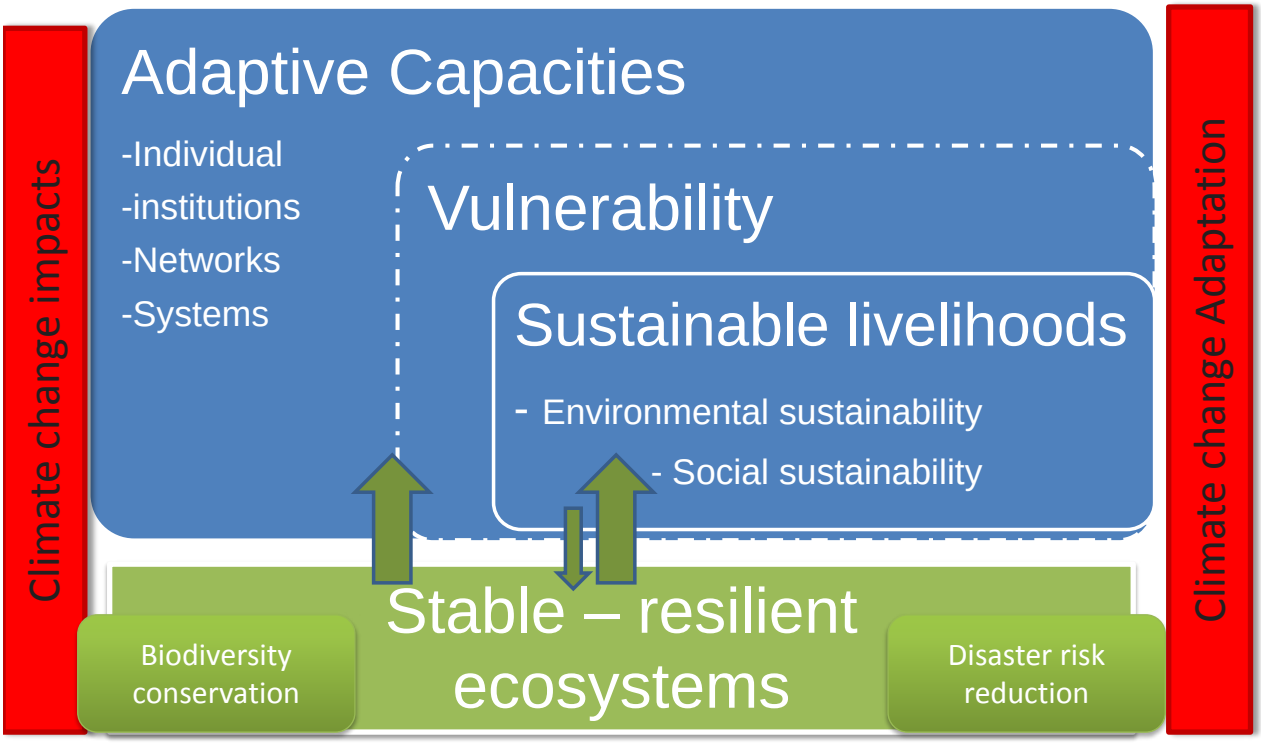


Figure 2.14: Conceptual Framework to understand interrelationship between ecosystems, climate change and sustainable livelihood (Source: Khera, 2012)

Impacts from recent climate-related extremes, such as heat waves, droughts, floods, cyclones, and wildfires, include alteration of ecosystems, disruption of food production and 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 climate change adaptation planning is to find local or locally adapted sustainable solutions for robust and diversified livelihood options, especially in climate-sensitive sectors like agriculture, forestry, tourism etc. In the coastal areas, the need for adaptation becomes further high due to the unique challenges that these areas face for their livelihoods in terms of higher risk of natural disasters, high concentration of human population on the coastline, stronger role of women in the fisheries sector, 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 livelihood security of communities in coastal areas and overall well-being of such areas.

2.11.2 Synergies and Trade-offs: climate change, disaster risk, coastal and marine biodiversity and rural livelihoods

Though the objective of both climate change adaptation and disaster risk reduction is reducing the vulnerability of the local communities, some climate change adaptation and disaster risk interventions may unintentionally leave people more vulnerable than before to the impacts of natural disasters and vice versa.

This is not because of lack of understanding of the interlinkages between climate change and disasters. At the framework level, international conventions and national policies on climate and disaster do recognise the linkages between climate change adaptation and disaster risk reduction. 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 also 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 various sectoral strategies as the linkages may be highly context specific.

For environmental sustainability, livelihoods can be categorised broadly into three categories based on the level of utilisations of natural resource base. The first category can be of those livelihood activities that do not harm natural resources; the second category of livelihood activities would be where the livelihood activities strive to maintain the existing natural resource base. And the third category capitalises on the opportunities created by climate variability and change. Livelihood activities falling under these three categories bring synergies with climate change adaptation 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 decreases the ability of the ecosystems to regulate the disaster risk. This renders the 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 disruption of ecosystem services. However, the impacts of climate change on ecosystems and their services will not be distributed equally around the world. Dry lands, mountain regions and Mediterranean regions are likely to be more vulnerable than others (Gitay et al., 2001[27]) and ecosystem degradation is largest in these regions (Hassan et al., 2005[28], cited from IPCC 2007). The threat is also greater in communities and areas that have a high dependency on the natural resources for their lives and livelihoods. Rural populations living in the coastal areas of developing countries are, therefore, among the most vulnerable group of communities due their high vulnerability and low adaptive capacities.

27 Gitay, H., S. Brown, W. Easterling and B. Jallow, 2001: Ecosystems and their goods and services. Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken and K.S. White, Eds., Cambridge University Press, Cambridge, 237-342.

28 Hassan, R., R. Scholes and N. Ash, Eds., 2005: Ecosystems and Human Well-being: Volume 1: Current State and Trends. Island Press, Washington, District of Columbia, 917 pp.

2.11.3 Synergies and trade-offs with disaster risk reduction and climate change adaptation

A number of studies indicate that sustainable strategies for disaster risk reduction help improve livelihoods (Pomeroy et al 2006). Disaster risk reduction 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[29]; 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[30]), which reportedly has adverse effects on the nesting of sea turtles by causing beaches to shrink (Balu 2008[31]). Ironically, it has also not been possible so far to establish the effectiveness of thin shelterbelt plantations as bio-shields (Forbes & Broadhead 2007[32]). This example supports the need to build scenarios of ecosystem services trade-offs, which will help prioritise activities based on 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). Adaptation 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[33]). 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 more vulnerable to the negative impacts of climate change and natural disasters than before.

29 POMEROY, R.S., RATNER, B.D., HALL, S.J., PIMOLJINDA, J. & VIVEKANANDAN, V. 2006. Coping with disaster: Rehabilitating coastal livelihoods and communities. Marine Policy 30(6): 786-793.

30 NDMA. 2008. Management of Cyclones. National Disaster Management Authority, Government of India. 190 pp.

31 BALU, A. 2008. The World Bank funded coastal shelterbelt project threatens sea turtle nesting habitats in Tamil Nadu, India. Indian Ocean Turtle Newsletter 7: 23-25

32 FORBES, K. & BROADHEAD, J. 2007. The Role of Coastal Forests in the Mitigation of Tsunami Impacts. FAO.

33 PARRY, M.L., CANZIANI, O.F., PALUTIKOF, J.P., VAN DER LINDEN, P.J. & HANSON, C.E. (Eds.) 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press. 1000 pp. Also available at www.ipcc.chs.

Similarly, protective hard infrastructure raised as CCA option (such as seawalls, floodgates and 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[34]; Rochelle- Newall et al 2005[35]). Such CCA strategies, termed as mal-adaptation (Burton 1996[36]), may compromise biodiversity and ecosystem stability in the long term; they not only increase disaster risk, but also diminish livelihood opportunities of the population and make them more vulnerable to climate change.

2.11.4 Marine and coastal protected areas and livelihood security

Coastal communities, especially those in the developing countries, depend largely on fisheries for their livelihoods (Pérez 2010[37]; Koziell 2001[38]). With the increasing population, the need for fish catch is also increasing. Marine and coastal protected areas play a crucial role in maintaining the fish population in the sea and help meet the increasing demand for fish and support coastal livelihoods. These protected areas, if partially or entirely closed to fishing, have proved to be very effective in association with conventional fisheries management in rebuilding damaged fish stocks and in giving all stocks some stability. In several regions, fish stocks have increased rapidly following the establishment of marine protected areas (MPAs). Far from hurting the fishing industry, MPAs have led to enhanced catches, hence providing a direct economic benefit. The larger stocks inside the reserves export their offspring to fishing grounds through ocean currents. Juveniles and adults may also emigrate from the re- serves, so boosting fisheries nearby (Kelleher 1999[39]).

Certain livelihood activities negatively affect marine and coastal habitats and species and thus hinder the sustainability of MPAs. The use of two ecosystem services “capture fisheries and freshwater” is now well beyond levels that can be sustained even at current demands, much less future ones (MEA 2005).

34 KNOGGE, T., SCHIRMER, M. & SCHUCHARDT, B. 2004. Landscape-scale socio-economics of sea-level rise. Ibis 146: 11-17.

35 ROCHELLE-NEWALL, E., KLEIN, R.J.T., NICHOLLS, R.J., BARRETT, K., BEHRENDT, H., BRESSER, T.N.H., CIESLAK, A., DE BRUIN, E.F.L.M., EDWARDS, T., HERMAN, P.M.J., LAANE, R.P.W.M., LEDOUX, L., LINDEBOOM, H., LISE, W., MONCHEVA, S.,MOSCHELLA, P.S., STIVE, M.J.F. & VERMAAT, J.E. 2005. Global change and the European coast: Climate change and economic development. In: Vermaat, J.E., Ledoux, L., Turner, K. & Salomons, W. (Eds.) Managing European Coasts: Past, Present and Future Environmental Science Monograph Series. New York: Springer. Pp. 239-254.

36 BURTON, I. 1996. The growth of adaptation capacity: Practice and policy. In: Smith, J.B., Bhatti, N., Menzhulin, G., Benioff, R.,Budyko, M., Campos, M., Jallow B. & Rijsberman, F. (Eds.) Adapting to Climate Change. New York: Springer. Pp. 55-67.

37 PÉREZ, A.A., FERNÁNDEZ, B.H. & GATTI, R.C. (Eds.) (2010). Building Resilience to Climate Change: Ecosystem-Based Adaptation and Lessons from the Field (No. 9). IUCN.

38 KOZIELL, I. 2001. Diversity not Adversity: Sustaining Livelihoods with Biodiversity. IIED.

39 KELLEHER, G. 1999. Guidelines for Marine Protected Areas. Gland: IUCN.

The role of the shipping industry in spreading invasive alien species is known to threaten several ecosystems (IOC/UNESCO, IMO, FAO and UNDP 2011). Tourism is emerging as another important livelihood activity among coastal communities. The values of tourism increase when the areas receive some degree of protection. Marine and coastal protected areas, therefore, are instrumental in bringing income to the coastal communities in the form of tourism. Coastal tourism is a double-edged activity: on one hand it has the potential to contribute to socio-economic achievements and, on the other hand, its fast and uncontrolled growth can be the major cause of degradation of the coastal environment and loss of local identity and traditional cultures (SCBD 2004).

A very important issue, when discussing trade-offs, is the perceived loss of livelihood opportunity of the coastal populations due to restricted resource use in a marine protected area. The designation and expansion of protected areas apparently have also brought associated social and ecological costs and can threaten the long-term viability of the protected areas themselves (Pimbert and Jules 1997[40]). This lack of livelihood security and loss of trust ultimately undermine conservation objectives as the rates of extraction intensify in areas surrounding the marine and coastal protected areas.

2.11.5 Possible synergies and trade-offs in Climate Change Adaptation and Livelihoods

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

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

Trade-offs can be seen when climate change adaptation strategies may increase the vulnerability of communities to disaster risk, via long-term negative impacts on biodiversity. Similarly, some livelihood interventions can unintentionally leave people more vulnerable than before to the impacts of climate change. For example, rural infrastructure development such as village roads in hilly terrain, aiming at climate change adaptation may lead to recurring disasters, if the landslide hazard of that hill is not taken into account. Another area of trade-off can be in the forestry and horticulture sector, where large-scale single-species plantations, especially with exotic species may run into the risk of soil erosion, exotic pest invasion 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 trading encourage raising plantations on the available land, which consist of mostly exotic species, and very often in the form of monoculture. This phenomenon may disrupt the ecosystem structure and services in that landscape on the 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 disaster risk may increase 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 landslide in the hill areas, leading to increased risks for livelihood security and overall development of the area.

The above climate change adaptation/mitigation strategies may compromise biodiversity and ecosystem stability in the long term. This not only increases disaster risk, but also diminish livelihood opportunities of the population, making them further vulnerable to climate change.

40 PIMBERT, M.P. & JULES, N.P. 1997. Parks, people and professionals: Putting 'participation' into protected area management. Pp. 297-330 In: GHIMIRE, K.B. & PIMBERT, M.P. (Eds.) Social Change and Conservation: Environmental Politics and Impacts of National Parks and Protected Areas. London: Earthscan.

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

Stable and bio-diverse ecosystems provide multiple services, which interact in multiple ways. This makes the ecosystem services relate 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 ecosystems services provided by the same ecosystem leads to a situation of conflict and management failure (Elmqvist et al 2011)[41].

41 PIMBERT, M.P. & JULES, N.P. 1997. Parks, people and professionals: Putting 'participation' into protected area management. Pp. 297-330 In: GHIMIRE, K.B. & PIMBERT, M.P. (Eds.) Social Change and Conservation: Environmental Politics and Impacts of National Parks and Protected Areas. London: Earthscan.

Marine and coastal ecosystems around the world are experiencing an increasing demand for their diverse ecosystem services, required for different sectors such as fisheries, tourism, biodiversity conservation, climate change adaptation, disaster risk reduction, 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 towards 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'.

Significant co-benefits, synergies, and trade-offs exist between mitigation and adaptation and among different adaptation responses; interactions occur both within and across regions. Increasing efforts to mitigate and adapt to climate change imply an increasing complexity of interactions, particularly at the inter- sections among water, energy, land use, and biodiversity, but tools to understand and manage these interactions remain limited. Examples of actions with co-benefits include (i) improved energy efficiency and cleaner energy sources, leading to reduced emissions of health-damaging climate-altering air pollutants; (ii) reduced energy and water consumption in urban areas through greening cities and recycling water; (iii) sustainable agriculture and forestry; and (iv) protection of ecosystems for carbon storage and other ecosystem services.

Way forward:

Stable ecosystems are the foundation for achieving the goals of reduced vulnerability, and higher adaptive capacities towards climate and disaster risk reduction. In the coastal ecosystems, the role of biodiversity and ecosystem services is further critical due to high dependence of communities on natural resources for livelihoods. Adopting an ecosystem approach in the overall development planning should be top priority for the region. Conservation of ecosystems and biodiversity provide multiple benefits in the long run, and will automatically minimise the trade-offs between actions of various sectors. Adopting 'no regrets' measures, such as planting mangroves to stabilise coastal land and climate-proofing key investments, can go a long way towards reducing vulnerability.

Sectoral studies on assessing the combined vulnerability (DFID 2004) and cumulative risk due to climate change and disasters, and identifying sector-specific synergies and trade-offs and their long-term impact on the coastal and marine ecosystems are immediately needed in the country. This will not only help each sector identify climate related disaster risk to their activities but will also facilitate the state governments in prioritising coastal conservation action at the vulnerable locations and eco-systems.

It is important that the education and trainings of relevant stakeholders include this concept, so that a strong support system is created that ensure the success of various government interventions. The school and college curriculum must include coastal and marine biodiversity issues as an integrated concept in the subject of environmental/ ecological sciences. Climate change and disaster management trainings must have coastal and marine biodiversity management as an integrated concept, and vice versa.

It is high time to invest in infrastructure, human capacity and information networks at international, national and regional levels, which are required for efficient vulnerability and risk assessment, early warning and preparedness planning in the region and also timely rehabilitation and reconstruction work.

Many marine and coastal ecosystems no longer deliver the full suite of ecosystem services upon which humans have come to rely (Mengerink et al 2009) due to the existence of trade-offs between the activities of different sectors. Trade-offs can be minimised if the primary goal of all the activities in the marine and coastal ecosystems is maintaining a sustainable flow of ecosystem services. An inclusive approach to marine and coastal protected area management, comprising the following pathways could possibly lead to sustainable management of marine and coastal protected areas in general and enhancing support from the coastal communities in particular.

Placing ecosystem services at the centre of all the strategic development planning in marine and coastal ecosystems may support decision-makers in framing policies, plans and programmes with 'biodiversity in mind'.

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Further Resources

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

Thousands of sharks visit a sea mount - Blue Planet: A Natural History of the Oceans - BBC https://www.youtube.com/watch?v=4XXJs6vCTzc

Explore Oceans on Earth - Hindi https://www.youtube.com/watch?v=0ypp-XxBs8Y