Training Resource Material:

Communicating Coastal and Marine Biodiversity Conservation and Management Through the Media

Module 1

Introduction to biodiversity and ecosystem services

For Media Professionals, Students and Trainers

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

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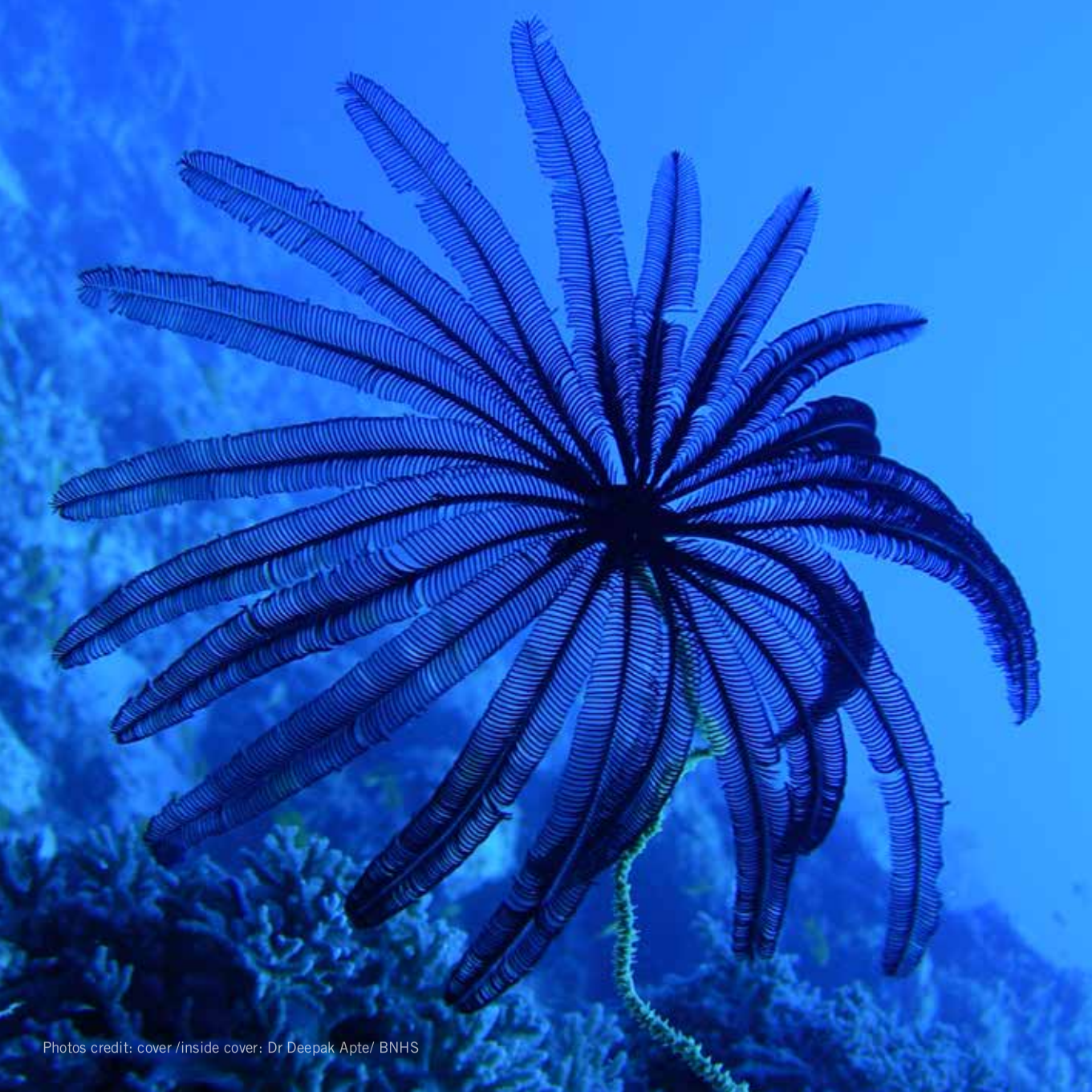

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Summary

This module provides the basic introduction to the concept of biodiversity and it's interconnectedness with human beings. Concept of ecosystems services is the central focus of this module. The module provides details of different facets of the concept of biodiversity and different examples of coastal and marine habitats and species. It also touches upon the concept of conservation shortcuts such as keystone species, knowledge of which is a must for media processionals.

Imprint

Training Resource Material:
Communicating Coastal and Marine Biodiversity Conservation and Management Through the Media

Module 1: Introduction to biodiversity and ecosystem services
Module 2: Setting the context: Why are the coasts important?
Module 3: Coastal and marine protected areas
Module 4: Governance, law and policy framework for coastal and marine biodiversity
Module 5: Why do we not hear more about the coast?
Module 6: Mainstreaming coastal and marine biodiversity into overall development and environmental planning
Module 7: Interlinkages between coastal and marine biodiversity, climate change, natural disasters and coastal livelihoods

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Acronyms

ABNJ	Areas Beyond National Jurisdiction
BNHS	Bombay Natural History Society
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on the conservation of Migratory Species of wild animals
EEZ	Exclusive economic zone
ENVIS	Environmental Information System
ERSST	Extended Reconstructed Sea Surface Temperature
GEF	Global Environment Facility
IDWH	Integrated Development of Wildlife Habitat
ISRO	Indian Space Research Organisation
IUCN	International Union for Conservation of Nature
MARBEF	Marine Biodiversity and Ecosystem Functioning
MEA	Millennium Ecosystem Assessment
MoEFCC	Ministry of Environment, Forests & Climate Change
MPA	Marine protected area
NCSCM	National Centre for Sustainable Coastal Management
NOAA	National Oceanic and Atmospheric Administration
NPTEL	National Programme on Technology Enhanced Learning
SAC	Space Applications Centre
SACON	Salim Ali Centre for Ornithology and Natural History
SST	Sea Surface Temperature
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNISDR	United Nations International Strategy for Disaster Reduction
WWF	World Wide Fund for Nature

Learning outcomes

After completing this module, the participants will be able to

- explain the term 'biodiversity' and describe different aspects of the concept
- explain the term 'ecosystem services' and outline different types of ecosystem services
- express the difference between terrestrial and coastal marine ecosystems
- illustrate different types of coastal and marine habitats and summarize the threats they face.

Key messages

1. 'Biological diversity' or biodiversity refers to the diversity of life in all its forms and at all levels of organization.
2. The levels of biodiversity are the diversity within a species (genetic diversity), the diversity of species (species diversity) and the diversity of habitats (habitats diversity). Each of the three levels can be described further: What types of elements are there and in what numbers (compositional biodiversity), how they are arranged (structural biodiversity) and what role they play in the system (functional biodiversity).
3. Ecosystems provide a variety of benefits to people, including provisioning, regulating, cultural and supporting services, known as 'Ecosystem Services.'
4. Biodiversity is the foundation of resilient ecosystems supporting a vast array of 'functions.' Genetic, species (animal and plant) and habitat diversities have important roles to play in provision of ecosystem services.
5. Changes in biodiversity can influence all these functions (e.g., pollination, nutrient cycling) and the products arising out of these (e.g., food, medicinal plants).

6. When it comes to measuring and monitoring biodiversity, there are two ways of doing it: The first is to measure actual processes (functional biodiversity), e.g., regeneration rates and patterns, rates of productivity, species interaction. However, this would be difficult and time consuming. The second one is, therefore, the way out and uses surrogates (known as conservation shortcuts), which is simpler and based on certain assumptions that the conservation benefits of surrogate species extend to a larger set of species and/or habitats. Therefore, measuring a surrogate species would provide us an idea of how the ecosystem is doing. Some famous surrogates are Tigers, Turtles, Whale Sharks, etc.
7. There are several types of coastal and marine ecosystems in India: inland freshwater wetlands, inland brackish water wetlands, estuarine wetlands, coastal mudflats, sand dunes, rocky shores, mangrove forests, coral reefs and other coastal and marine ecosystems.
8. Marine and terrestrial ecosystems are different with respect to the aquatic medium in which all marine organisms exist. There are no discrete boundaries in marine ecosystems as seen on land.

Key terms

Biological diversity; genetic, species and ecosystem diversity; keystone, umbrella, indicator and flagship species; provisioning, regulating, supportive and cultural ecosystem services; mangroves, wetlands, seagrasses and coral reefs.

1.1 Basic concepts of biodiversity

1.1.1 Definitions of biodiversity

Biological diversity refers to the diversity of life in all its forms and at all levels of organization.

According to the Convention on Biological Diversity (CBD) of 1992, biological diversity means the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. This includes diversity within species, between species and of ecosystems.

Biologist E.O. Wilson has a more detailed definition (Wilson 1988): 'The variety of life at every hierarchical level and spatial scale of biological organizations: genes within populations, populations within species, species within communities, communities within landscapes, landscapes within biomes, and biomes within the biosphere.'

1.1.2 Three levels of biodiversity

Biodiversity can be described at three levels: the diversity within a species (genetic diversity), the diversity of species (species diversity) and the diversity of ecosystems (habitat or ecosystem diversity).

GENETIC DIVERSITY

Genetic diversity refers to the variation of genes within a species. This includes genetic variation between distinct populations of the same species or variation within a population.

Genetic diversity plays a very important role in species' survival and adaptability to changing environmental conditions. Genetic variations enable changes to occur in an organism's anatomy or physiology between generations that are subsequently instrumental in adaptation and survival.

A species that has a high genetic diversity will have more variation that can respond in many different ways, which is essential for surviving in case of external stress, such as disturbances, natural disasters, disease spread, pollution, climate variability and climate change.

SPECIES DIVERSITY

Species diversity refers to the variety of species within a given context, which can be a geographical region/location/ecosystem or a marine space. The two main factors taken into account, when measuring diversity, are richness and evenness.

Richness is a measure of the number of different kinds of organisms present in a particular area. For example, the number of different fish species present in communities A and B in Figure 1 is three, so the richness of both communities is three. However, diversity depends not only on richness, but also on evenness. Evenness compares the similarity of the population size of each of the species present. The relative abundance of the three species is more even in community A than in B, so community A has a higher evenness than B. Therefore, the product of richness and evenness shows that overall 'species diversity' is higher in community A.

Species-diverse ecosystems are more likely to be stable because there is a higher chance of availability of another species to take up the functions of the species that may be lost due to environmental change, disasters or any other reason. High species diversity also means less empty niches in the ecosystem and therefore less chances of invasion by exotic species.[1] Disease spread in a diverse ecosystem is relatively low and less severe due to a proportionately lower number of hosts available for the parasite.

1 See 'Species diversity and invasion resistance in a marine ecosystem.' Available at http://noss.cos.ucf.edu/papers/Stachowicz%20et%20al%201999.pdf

Figure 1.1: Species diversity and its inter-relationship with species numbers (richness) and evenness (spread)

HABITAT DIVERSITY

"Ecosystem" means a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.

A community consists of the assemblage of populations of plants and animals that occupy an area and their interactions with each other and their environment.

"Habitat" means the space where an organism or population naturally occurs.

Habitat diversity refers to the distribution and abundance of habitats in a given geographical space. A region possessing a wide variety of habitats supports a much greater diversity of species than one in

which there are few different habitats. The presence of a variety of habitats also supports a different set of species exhibiting different genetic variations in that region/space.

Ecosystem diversity is a term that incorporates both habitat and community diversity.

An increase in the number of habitats and/or, an increase in their structural complexity leads to increased species diversity. Different ecosystems maintain different material and energy cycles with interconnected threads with other ecosystems and habitats. Maintaining ecosystem and habitat diversity therefore is crucial for ensuring overall health of all ecosystems.

1.1.3 Three forms of biodiversity

The levels of biodiversity have been already discussed in the previous section. Each of the three levels can be described further: What types of elements are there and in what numbers (composition), how they are arranged (structure) and what role they play in the system (function).

COMPOSITIONAL BIODIVERSITY

Compositional biodiversity describes the type of biodiversity elements (at all the levels, viz, gene, species and habitat) present in an area. Examples can be genetic composition of populations, identity and relative abundances of species in a natural community, and kinds of habitats and communities distributed across the landscape.

STRUCTURAL BIODIVERSITY

Structural biodiversity describes the variety of arrangement of these components, i.e., the variety of ways in which different habitats, species or genes are arranged over space (spatial biodiversity) or time (temporal biodiversity). Examples of spatial biodiversity can be different species assemblages in different patches in a wetland.

Similar to spatial heterogeneity, temporal fluctuations in environmental factors also regulate the biodiversity of a specific space. An example for the importance of time in relation to biodiversity is the dependency of fish breeding patterns on water availability or changing water temperature, as well as seasonal flooding events, which are necessary for entire ecosystem functionalities. These temporal fluctuations support different species over different seasons/timescales and have a critical influence on ecosystem dynamics.

FUNCTIONAL BIODIVERSITY

Functional biodiversity is the variety of biological processes, functions or characteristics of a particular ecosystem. Functional biodiversity, therefore, describes the enormous variety of processes that occur due to interaction of different species with each other and the interactions of the species with their physical environment. These processes include the climatic, geologic, hydrologic, ecological and evolutionary processes that generate biodiversity and continuously change it, e.g., nutrient cycling, pollinations, predation, parasitism and germination.

Functional biodiversity is one of the main factors determining the long-term stability of an ecosystem and its ability to recover from major disturbances.

India Biodiversity Portal:

A unique repository of information on India's biodiversity. The Portal aims to provide open and free access to biodiversity information. The portal enables widespread participation by all citizens in contributing to and accessing information on Indian biodiversity.

http://indiabiodiversity.org/

1.2 Conservation shortcuts

There are two ways to measure and monitor biodiversity:

1. Measuring actual processes (functional biodiversity), e.g., pollination rate and pattern, rates of productivity, species interaction. However, this would be difficult and time consuming.
2. Using surrogates, which is simpler and based on certain assumptions that the conservation benefits of surrogate species extend to a larger set of species and/or habitats. These are called 'conservation shortcuts.'

There are different views on the use of these surrogates or conservation shortcuts. More information is available at http://www.pnas.org/content/97/11/5954.long

Some conservation shortcuts are keystone species, umbrella species, indicator species and flagship species.

1.2.1 Keystone species

A keystone species has a disproportionately large impact on its community or ecosystem relative to its abundance. A classic example is a starfish (*Pisaster ochraceus*) occurring in the rocky intertidal of the Pacific Northwest: It is an efficient predator of the Common Mussel, *Mytilus californicus*. This mussel is able to compete for resources better than other species and thus reproduce faster. Predation by the starfish keeps the mussel population at moderate levels, allowing other macro invertebrates to persist in that ecosystem. The removal or decline of the starfish population will inadvertently increase the mussel population, resulting in a decline of other macro invertebrate species. The starfish is therefore the 'keystone species' of this ecosystem, which helps in maintaining high species diversity in this intertidal community.

Read more examples here http://www.vigyanprasar.gov.in/Radioserials/keystone2.pdf

1.2.2 Umbrella species

Some species can also be very important for conservation if they are associated with many types of habitats and ecosystems that span large geographical spaces.

These species are called umbrella species and are defined as **'a species whose conservation confers protection to a large number of naturally co-occurring species' in several ecosystems and habitats.** Monitoring this one species and managing the ecosystem for its continued success results in the maintenance of a high-quality habitat for other species in the area. Sea turtles are a very good example of umbrella species for coastal marine ecosystems.

1.2.3 Indicator species

Indicator species are organisms whose presence, absence or abundance reflects a specific environmental condition. Indicator species can signal a change in the biological condition of a particular ecosystem, and may therefore be used as a proxy to diagnose the health of an ecosystem. These species are very valuable in conservation planning and management, as these can be used to indicate the status of an environmental condition, identify a disease outbreak, or monitor pollution or climate change. For example, corals are used as indicators of marine processes such as siltation, seawater rise and sea temperature fluctuation. In the Philippines, indicator species are used to assess the status of marine and coastal biodiversity, including population trends in Whale Sharks, Humpback Whales and Irrawaddy Dolphins.

1.2.4 Flagship species

Flagship species are popular, charismatic species that serve as symbols and rallying points to stimulate conservation awareness and action. A flagship species acts as an ambassador for less-recognized or less-beloved animals and organisms in a habitat. For example, the Polar bears are a flagship species for biodiversity conservation in the Arctic region. Interestingly, the Polar bears are also 'climate change flagship species.' Flagship species may or may not be keystone species or good indicators of biological processes.

There are some species that can be both a keystone species and an umbrella species, such as Elephants, Turtles and Whale Sharks, while other species can be flagship species as well as keystone species, such as the Tiger, turtles and mangroves.

Photo credit: Dr K Sivakumar

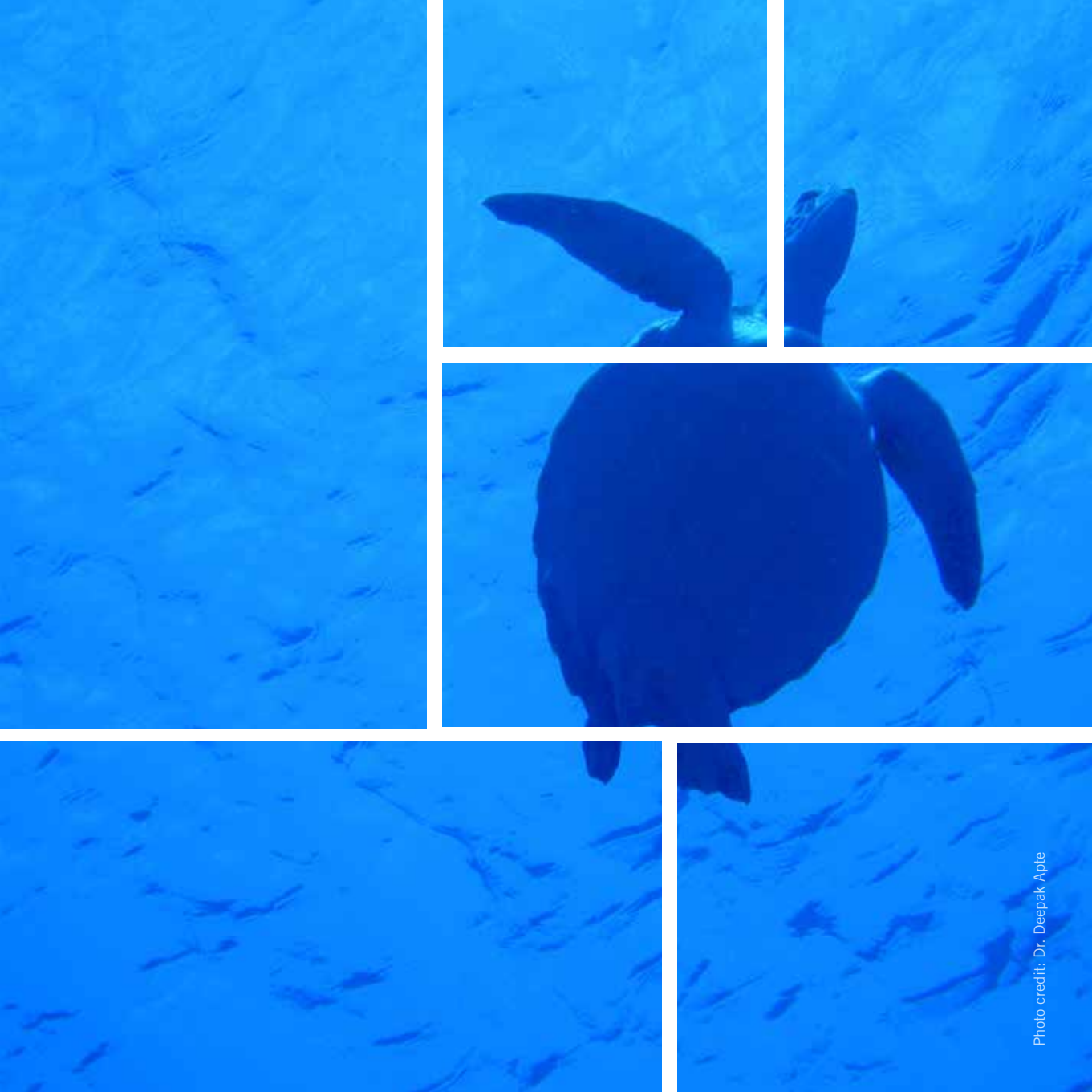


Photo credit: Dr. Deepak Apte

1.3 Why is biodiversity important?

ECOSYSTEM SERVICES: PROVISIONING, REGULATING, SUPPORTING AND CULTURAL ECOSYSTEM SERVICES

Ecosystems provide a variety of benefits to people, including provisioning, regulating, cultural and supporting services. These benefits are termed as "Ecosystem Services". **Ecosystem services are the benefits people obtain from ecosystems.** They illustrate the link between interactions of species with each other and with the physical environment, as well as the usefulness of these functions for the well-being of people, in terms of wealth, nutrition and security.

Changes in biodiversity can influence all these functions (e.g., pollination, nutrient cycling) and products arising out of these (e.g., food, medicinal plants). The concept of ecosystem services is becoming popular as a way to encourage discussion about the dependence of people on nature and what this means both socially and economically.

Marine ecosystems are important to humankind both ecologically and economically, providing numerous vital goods and services, and supporting the processes that sustain the entire biosphere. Marine ecosystem services are provided at the global scale (for example. oxygen production, nutrient cycles, carbon capture through photosynthesis and carbon sequestration) and at the regional and local scales (for example stabilising coastlines, bioremediation of waste and pollutants, and a variety of aesthetic and cultural values). Marine services also include several important economic benefits such as food provision and tourism (http://www.eea.europa.eu/publications/10-messages-for-2010-2014-2).

The Millennium Ecosystem Assessment (MEA) of 2005 was a global exercise carried out to assess the ecological impact of biodiversity. In its report finalized in 2005, the MEA lists the ecosystem services arising from biological diversity.

http://www.millenniumassessment.org

1.3.1 PROVISIONING SERVICES

Provisioning services are the products people obtain from ecosystems. Such as food (agriculture and horticulture crops, livestock, fish), medicines, fuel, fibre, freshwater, minerals, and genetic resources.

Fish (including shellfish) provide essential nutrition for three billion people and half the animal protein and minerals to 400 million people in the poorest countries.

1.3.2 REGULATING SERVICES

Regulating services are the benefits people obtain from regulation of ecosystem processes including air quality maintenance, climate regulation, carbon sequestration or storage, regulation of diseases, plant pest and disease control, water purification, natural hazard and disaster risk reduction (mitigating the threat from cyclones, storm surges, floods), pollination etc. **The presence of coastal ecosystems such as mangroves and coral reefs can reduce the damage caused by hurricanes or large waves.**

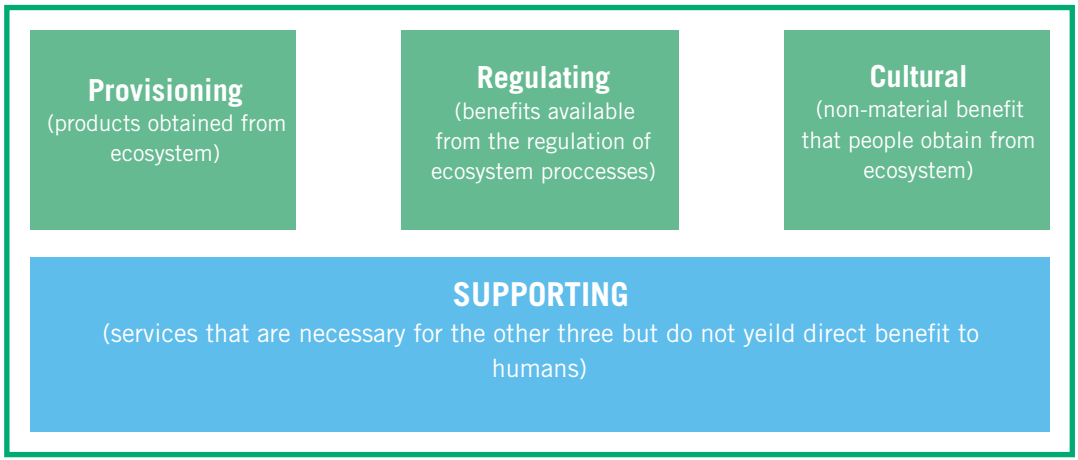
1.3.3 CULTURAL SERVICES

Cultural services are the nonmaterial benefits people obtain from ecosystems such as spiritual enrichment, religious and cultural value (sacred sites), knowledge systems, educational values, aesthetic values, social relations (in urban green spaces), and recreation and ecotourism. Spiritual and religious values refers to religious bonds to sacred landscapes, groves and species which are often connected to different religions.

1.3.4 SUPPORTING SERVICES

Supporting services are those that are necessary for the production of all other ecosystem services, such as biomass production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling and provisioning of the habitat.

They differ from provisioning, regulating and cultural services in that their impacts on people are often indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people.



Following table provides a quick overview of various ecosystem services along with examples and the relative importance in terms of contribution by various coastal and marine ecosystems. The classification in the first column is adapted from Beaumont et al (2007).

An overview of various ecosystem services provided by coastal and marine ecosystems										
SERVICE	**EXAMPLES**	**ECOSYSTEMS**								
		Mangroves	Coral reefs	Seagrass beds	Coastal lagoons	Submerged rocks	Tidal flats	Salt marshes	Sandy beaches	Estuaries
Provisioning Services										
Food	Fish, shellfish	H	H	M	M	H	L			H
	Seaweed		L			H				
	Nontimber forest products	H								
Raw materials	Timber, firewood, charcoal	H								
	Various pharmaceuticals from seaweed		L			H	H			
	Biochemicals, natural medicines, pharmaceuticals	H								
	Construction material (coral blocks)		M							
Others	Freshwater	M			M					
	Genetic resources	H	H	L	M	L				M

An overview of various ecosystem services provided by coastal and marine ecosystems

SERVICE	EXAMPLES	ECOSYSTEMS								
Regulating services										
Gas and climate regulation	Regulation of local air quality	H								
	Regulation of global climate	H	M	M	L			M		
Disturbance prevention (flood and storm protection, erosion control)	Reduction of wave energy reaching coastline; control of storm surge, wind break	H	H	M		M	M	M	H	
Bioremediation of waste	Water purification and waste treatment	H		M	M		H	H	M	H
Cultural services										
Leisure and recreation	Recreation and ecotourism	H	H	L	L	M	M	L	H	
Cultural heritage and identity	Ethical and spiritual values	H	H						M	
Cognitive values	Education and inspirational values	H	H			M	H		H	
Existence values	Existence—present and potential future benefits	H	H	H	H	M	M	M	H	
Supporting services										
Biologically mediated habitat	Habitat	H	H	M	M	L	L			
Nutrient cycling	Nutrient cycling	H	H	H	H		M	M		
	Carbon sequestration	H	H	H	L			H		
Life support	Primary production	H	L	H	H	M	L	M		
	Water cycling	H			M			L	L	

[H=High Importance; M= Medium Importance; L= Low Importance]

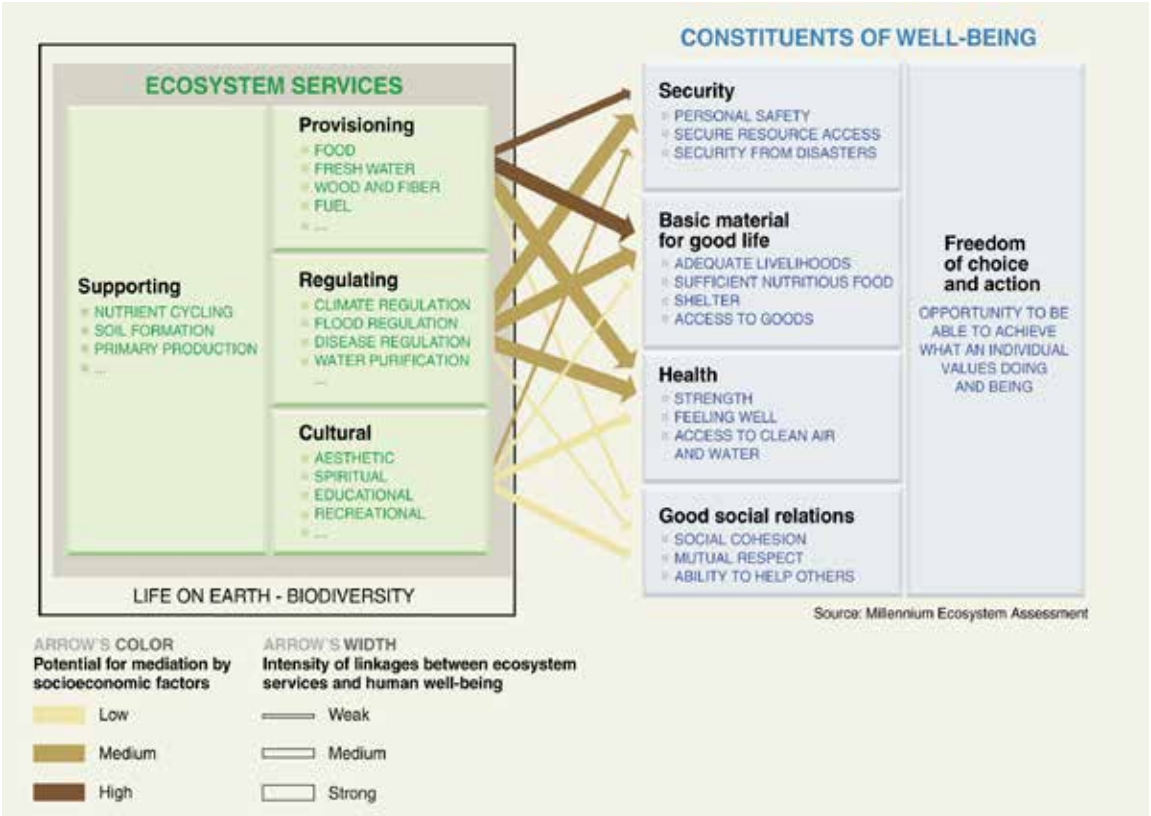


Figure 1.2: Ecosystem Services and constituents of human well being

From landscape to seascape

1.4 Coastal and marine ecosystems in the context of biomes

Ecological communities of living things, such as microorganisms, plants and animals form as a result of the physical surroundings, including land, air and water in an area.

The aquatic biome can be broken down into two basic regions, freshwater and coastal-marine.

Fresh Water is a basic requisite of life on mother earth, and is available in aquifers under the ground and on surface as rivers and lakes. Freshwater has a low salt concentration — usually less than 1 per cent. Plants and animals in freshwater regions are adjusted to the low salt content and will not be able to survive in areas of high salt concentration (i.e, ocean).

Classification of biomes

Aquatic biomes

Freshwater
- Ponds and lakes
- Rivers and streams
- Wetlands

Coastal
- Mangroves
- Tidal mudflats
- Lagoons
- Sandy beaches
- Rocky shores
- estuaries
- wetlands

Marine
- Oceans
- Coral reefs
- Seagrasses
- Deep sea

Desert biome
- Hot and dry deserts
- Semi-arid deserts
- Coastal deserts
- Cold deserts

Grasslands
- Steppes
- Prairies
- Pampas
- Savannas

Forests
- Tropical forests
- Deciduous forests
- Alpine forests
- Boreal forests or Taiga

Coastal and Marine regions

Oceans and major seas cover 70.8 per cent or 362 million sq km of the earth, with a global coastline of 1.6 million km. Coastal and marine ecosystems are found in 123 countries around the world. Marine ecosystems are strongly connected through a network of surface and deep-water currents, and they are among the most productive ecosystems in the world. Following is an overview of selected coastal and marine ecosystems:

1.4.1 MANGROVES

Mangroves are trees or plants which grow in the area between the land and water, and bridge the terrestrial and marine environments. Mangroves are tidal forest ecosystems in sheltered brackish to saline environments. Mangrove forests are found from the highest level of spring tides down almost to mean sea level on sheltered sedimented shores throughout the tropics. They occur in fully saline waters but also penetrate considerable distances into estuaries. Mangroves are genetically extremely diverse providing an important habitat for numerous marine and terrestrial species, including nurseries for commercial species.

They dominate approximately 75 per cent of the world's coastline. Indian mangrove vegetation covers about 6,749 km^2 . The entire mangrove habitats are situated in three zones: (1) East Coast, about 4700km^2 , (2) West Coast, about 850 km^2, and (3) Andaman and Nicobar Islands about 1190 km^2 These zones have been further categorized into Deltaic, Coastal, and Island habitats. It is estimated that worldwide 48 to 90 species of mangroves exist, and India with rich mangrove species diversity inhabits 82 species of mangroves.

Mangroves provide a variety of benefits. They are a source of firewood, wood products such as timber and posts; non-wood produce such as fodder, honey, wax, tannin, dyes; and plant materials for thatching. Mangrove wetlands and forests can act as a shelter belt against cyclones, and even tsunamis. *In Orissa state, villages surrounded by mangrove forests survived the fury of the super cyclone in 1999, unlike other villages; similarly villages in Cuddalore and*

Nagapattinam districts of Tamil Nadu that were buffered by mangroves suffered relatively less damage in the 2004 Indian Ocean tsunami. They also prevent coastal erosion. The most important role of mangroves is the relative quiet conditions they provide which serve as nursery grounds for a number of commercially important fish, prawn, crabs and molluscs. The mangrove food web is complex and enhances the fishery production of nearby coastal waters by exporting nutrients and detritus. They also provide habitats for wildlife ranging from migratory birds to estuarine crocodiles (e.g. Bhitarkanika National Park), tigers (Sunderbans), etc

The Sundarbans is the largest single block of tidal halophytic mangrove forest in the world with ~60 per cent located in Bangladesh and the rest (~40%) in India. It is a UNESCO World Heritage Site.

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, resulting in loss of habitat and an increase in the frequency of natural disasters.

Mangroves - Guardians of the Coast: A film by 'Mangroves for the Future'
https://www.youtube.com/watch?v=4SY7X9zdZ-U

Guardians of our Coast showcases the fascinating web of life that surrounds these tidal forests. The movie highlights the unique collaboration between governments, regional and local institutions, NGOs and local communities, in efforts to save these vulnerable ecosystems and restore them to their former glory.

1.4.2 WETLANDS

'Wetland' means an area of marsh, peatland or water, natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters, and includes all inland waters such as lakes, reservoirs, tanks, backwaters, lagoons, creeks, estuaries and man-made wetlands and the zone of direct influence on wetlands, that is to say the drainage area or catchment region of the wetlands

Wetlands have the highest species diversity of all ecosystems. Many species of amphibians, reptiles, birds (such as ducks and waders), can be found in the wetlands.

India, with its annual rainfall of over 130 cm, varied topography and climatic regimes, supports and sustains diverse and unique wetland habitats. Natural wetlands in India consists of the high-altitude Himalayan lakes, followed by wetlands situated in the flood plains of the major river systems, saline and temporary wetlands of the arid and semi-arid regions, coastal wetlands such as lagoons, backwaters and estuaries, mangrove swamps, coral reefs, and so on. Wetlands in India occupy 58.2 million ha, including areas under wet paddy cultivation.

Gosabara-Mokar wetland area is located in Porbandar district in the Saurashtra region of Gujarat, which covers an area of 2,316 km2 with a total human population of 5,86,060 people. The three talukas in the district comprises a total of 182 villages. Porbandar district has been carved out from Junagadh district. The Arabian Sea in the west, Devbhumi-Dwarka district in north, Jamnagar in the east and Junagadh in south form the boundaries of Porbandar district.

Gosabara-Mokar is a unique mosaic wetland ecosystem harbouring 112 species of resident and migratory bird. It is a natural lagoon modified by construction of large check dam to control intrusion of sea water. During high tide, sea water enters in a part of the lagoon making it a unique habitat of saline and freshwater mosaic. Large and shallow spread of water in the wetland attracts large number and variety of migratory birds including some globally threatened species such as the Greater Spotted Eagle, Dalmatian Pelican and Peregrine Falcon, making it a wetland of International Importance. Gosabara hosts more than 1 lakh birds of 112 species belonging to 17 families, indicating the excellent ecological health of this wetland ecosystem. The Lesser Flamingo has the largest population at Gosabara. The Northern Pintail is the most dominant among ducks. Two species of cranes are found here—Common Crane and Demoiselle Crane. The Black-tailed Godwit is dominant among the shore birds. A record 27 Mallards have been counted in Gosabara. There are two waders that breed in Gosa Bara—the Collared Pratincole and Kentis Plover. The first one is called 'Mota Tejpar' and the latter 'Dhongili'. Both are ground nesting birds. Other shore birds include the Black-tailed Godwit, Spotted Redshank, Common Redshank, Golden Plover, Marsh Sandpiper, Curlew Sandpiper and Wood Sandpiper.

The area qualifies as a potential Ramsar Site from Gujarat according to a SACON (MoEFCC) report.

1.4.3 MUDFLATS

These are important sub-environments found on the fringe of estuaries and in low relief sheltered coastal environments. Both terrestrial and marine environments contribute to the final grained sediments of the inter-tidal mudflats. Mudflats are a major sink of trace metals and organic matter (Siraswar and Nayak, 2011) The Indian coastline has extensive mud flats covering an area of more than 38,000 km^2. Most of the larger river mouths are concentrated in the northeast and northwest coastal areas and hence the muddy coasts of India are mainly located in these areas. India's non-vegetated mud flats have a total area of about 22300 km^2, 90% of which are located in the state of Gujarat in the north-west of the country.

1.4.4 ROCKY SHORES

Rocky shores provide good refuge for numerous life forms such as frog shells, periwinkles, oysters, barnacles, cowries, crabs, starfi shes, sea urchins and a variety of algae and sea weeds. Rocky shores covered with algal beds are ideal substrate for many intertidal species.

1.4.5 SANDY BEACHES

In this habitat, animals are adapted for burrowing. Bivalves, olive shells, worms, arthropods, sand anemones, and crabs prefer this habitat. High variation in the composition of the sand profile of different beaches results in great faunal diversity among the beaches.

1.4.6 LAGOONS

A lagoon is a shallow water body along the low lying coast separated from the ocean by a barrier but also connected to the ocean by one or a few restricted inlets. They usually form on gently sloping coasts where barrier islands can form off the coast and are generally shallow. Lagoons include coastal and atoll lagoons. There are 8 major lagoons on the East Coast and 9 on the West Coast. Major lagoons on the East Coast are Bende, Chilka, Gulf of Mannar, Muthupet, Muthukadu, Nizampatnam, Pennar and Pulicat. Lagoons on the West Coast are Asthamudi,

Ettikulum, Lagoons of Bombay Coast, Lagoons of Lakshadweep atolls, Paravur, Murukumpuzha, Talapady, Veli and Vembanad. Lagoon ecosystems are also getting adversely affected by the urbanization, industrialization and aquaculture activities in the same ways as estuarine ecosystems (Saxena, 2012).

1.4.7 ESTUARIES

Estuaries mark the transitional zone between the lower tidal region of a river and the marine environment. Estuaries are areas where freshwater streams or rivers merge with the ocean. This mixing of waters with such different salt concentrations creates a very interesting and unique ecosystem. Microflora like algae, and macroflora, such as seaweeds, marsh grasses, and mangrove trees (only in the tropics), can be found here. Estuaries support a diverse fauna, including a variety of worms, oysters, crabs and waterfowl.

They are sheltered coastal water bodies which act as nutrient traps, shelter and nursery for a wide variety of marine life forms. They are very important from commercial, industrial and recreational point of view. A total of 14 major, 44 medium and 162 minor rivers draining fresh water into the sea through about 53 estuaries in India. Several of Indian estuaries have become danger prone zones . The estuarine ecosystems are under heavy anthropogenic pressures mainly due to urbanization and industrialization. Dumping of sewage, inflow of municipal waste water and industrial effluents into these water bodies are causing extensive damage to these ecosystems. The aquaculture activities around estuaries have also resulted in heavy accumulation of heavy organic and inorganic pollutants. (Alok Saxena, 2012)

1.4.8 OCEANS

The largest of all the ecosystems, oceans are very large bodies of water that dominate the earth's surface. Like ponds and lakes, ocean regions are separated into separate zones: intertidal, pelagic, abyssal, and benthic. All four zones have a great diversity of species.

The intertidal zone is where the ocean meets the land—sometimes it is submerged and at other times exposed, as waves and tides come in and out. Because of this, the communities are con-

stantly changing. On rocky coasts, the zone is stratified vertically. Where only the highest tides reach, there are only a few species of algae and mollusks. In these areas usually submerged during high tide, there is a more diverse array of algae and small species, such as herbivorous snails, crabs, sea stars and small fishes. At the bottom of the intertidal zone, which is only exposed during the lowest tides, many invertebrates, fishes and seaweed can be found. The intertidal zone on sandier shores is not as stratified as in the rocky areas. Waves keep mud and sand constantly moving, thus very few algae and plants can establish themselves—the fauna include worms, clams, predatory crustaceans, crabs and shorebirds.

The pelagic zone includes those waters further from the land, basically the open ocean. The pelagic zone is generally cold though it is hard to give a general temperature range since, just like ponds and lakes, there is thermal stratification with a constant mixing of warm and cold ocean

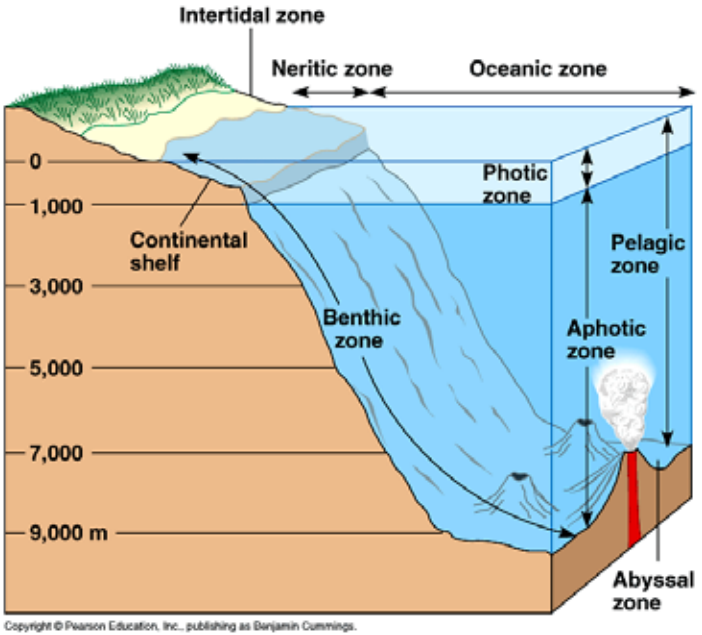


Figure 1.3: Ocean zones

currents. The flora in the pelagic zone include surface seaweeds. The fauna include many species of fish and some mammals, such as whales and dolphins. Many feed on the abundant plankton.

The benthic zone is the area below the pelagic zone, but does not include the very deepest parts of the ocean (see abyssal zone below). The bottom of the zone consists of sand, silt, and/or dead organisms. Here temperature decreases as depth increases toward the abyssal zone, since light cannot penetrate through the deeper water. Flora are represented primarily by seaweed while the fauna, since it is very nutrient-rich, include all sorts of bacteria, fungi, sponges, sea anemones, worms, sea stars and fishes.

The deep ocean is the abyssal zone. The water in this region is very cold (around 3° C), highly pressured, high in oxygen content, but low in nutritional content. The abyssal zone supports many species of invertebrates and fishes. Mid-ocean ridges (spreading zones between tectonic plates), often with hydrothermal vents, are found in the abyssal zones along the ocean floors. Chemosynthetic bacteria thrive near these vents because of the large amounts of hydrogen sulfide and other minerals they emit. These bacteria are thus the start of the food web as they are eaten by invertebrates and fishes.

1.4.9 CORAL REEFS

Corals are invertebrate animals belonging to a large group of colourful and fascinating animals called Cnidaria. Each individual coral animal is called a polyp, and most live in groups of hundreds to thousands of genetically identical polyps that form a ‘colony’.

Coral are generally classified as either “hard coral” or “soft coral”. Soft corals, which include seas fans, sea feathers and sea whips, don’t have the rock-like calcareous skeleton like the others, instead they grow wood-like cores for support and fleshy rinds for protection. Soft corals also live in colonies, that often resemble brightly coloured plants or trees. Hard corals extract abundant calcium from surrounding seawater and use this to create a hardened structure for protection and growth. There are around 800 known species of hard coral, also known as the

‘reef building’ corals. Coral reefs are therefore created by millions of tiny polyps forming large carbonate structures.

Most corals contain algae called zooxanthellae, which are plant-like organisms. The zooxanthellae living in the soft tissue of a coral polyp use sunlight to produce food through photosynthesis and create a byproduct that the coral can use as food. Thus, in a symbiotic relationship, zooxanthellae provide corals with food and provide it with the colour; in return, the coral provides the zooxanthellae with shelter and nutrients.

Coral reefs are often called ’rainforests of the sea‘ as they are highly diverse ecosystems because of the variety of niches provided by the reef structures.

There are three principal reef types:

Fringing reef – directly attached to a shore, or borders it with an intervening shallow channel or lagoon;

Barrier reef – a reef separated from a mainland or island shore by a deep channel or lagoon; and

Atoll reef – this more or less circular or continuous barrier reef extends all the way around a lagoon without a central island.

In India, the reefs are distributed along the east and west coasts at restricted places and all the three major reef types (atoll, fringing and barrier) occur.

Off the mainland coast of India, the Gulf of Kachchh in the northwest, and Palk Bay and Gulf of Mannar in the southeast, are the two major areas where coral reefs are found.

There are patches of reef growth on the west coast, for example coral reefs at Ratnagiri and Malvan. The Andaman and Nicobar Islands have fringing reefs around many islands, and a long barrier reef (329 km) on the west coast. In the Lakshadweep, there are 10 atolls with 36 islands. All the atolls are surrounded by prolific reefs.

The commonest corals are Plate coral or Bowl coral (e.g. *Turbinaria mesenterina*), Branching coral (*Acropora spp*), Brain coral (e.g. *Symphyllia spp.*), Moon corals (e.g. *Favia spp.*).

The most important ecosystem services that coral reefs deliver are to tourism, fisheries and shoreline protection. Coral reefs are critical to the fisheries and protecting coasts from wave action and erosion. However, they are undergoing rapid destruction (due to a number of factors including destructive fishing techniques; reef mining for calcium carbonate production; siltation as a result of deforestation; sedimentation; marine pollution with contaminants; freshwater dilution and sub-aerial exposure and disease, and climate change is posing an additional and severe threat to already stressed coral reefs. Although healthy reefs are likely to adapt to projected sea level changes, coral reefs that are already stressed by other human activities and threats will not (UNISDR/UNDP 2012a, 2012b) [Savarkar 2014, ENVIS publication]

Photos credit: Dr. Deepak Apte/ BNHS, and Dr. Sarang Kulkarni/ IISDA

1.5 Key coastal and marine species

The faunal diversity of India—terrestrial, freshwater, brackish water and marine—is represented by 92,037 species, of which 2,577 belong to Protista and 89,460 to Animalia, including 31 phyla of invertebrates and chordates. These numbers account for 7.50 per cent of the total in the world. Among these are 31 species of marine mammals.

1.5.1 MARINE ALGAE

Marine Algae are macro plants growing in marine environment. Marine algae are also known as seaweeds. They form the main vegetation on reef. The algae are classified in three main group, viz., Green algae, Brown algae and Red algae. The algae not only serve as the main primary producers, but they are also effective indicator to assess any change in the biotic community or environment as a whole.

A recent report identifies a total of 936 species of marine algae from different areas of India (Rao, 2010). The greatest number of species have been recorded in Tamil Nadu (302), followed by Gujarat (202), Maharashtra (159), Lakshadweep (89), Andhra Pradesh (79) and Goa (75). Recent studies conducted by the Botanical Survey of India have recorded 206 species of seaweed in the Andaman and Nicobar Islands

Seaweeds are harvested mainly for raw material for production of agar, alginates and seaweed liquid fertiliser.

1.5.2 SEA GRASSES

Sea grass are found in shallow salty and brackish water in many parts of the world, from tropic to the Arctic Circle. They are called so due to long grass like leaves. They are often confused with sea weeds, but are actually more closely related to the flowering plants that we see on the land. Sea grass have root, stem and leaves and produce flowers and seeds. Although they receive little attention, they are one of the most productive ecosystems in the world. They provide

shelter, food and mating ground for various tiny invertebrates to large fish, crabs, sea turtle etc. They are in threat due to anthropogenic activity. Within seagrass communities, a single acre of seagrass can produce over 10 tons of leaves per year. This vast biomass provides food, habitat, and nursery areas for a myriad of adult and juvenile vertebrates and invertebrates. Further, a single acre of seagrass may support as many as 40,00 fish, and 50 million small invertebrates. Because seagrasses support such high biodiversity, and because of their sensitivity to changes in water quality, they have become recognized as important indicator species that reflect the overall health of coastal ecosystems.

1.5.3 FISH

Fish constitute almost half of the total number of vertebrates in the world. They live in almost all conceivable aquatic habitats. They exhibit enormous diversity of size, shape and biology, and in the habitats they occupy.

The Indian fish population represents 11.72% of species, 23.96% of genera, 57% of families and 80% of the global fishes. There are more than 2,546 species of fishes in the coastal and marine ecosystems of India.

Fishes found in the coral reef ecosystems of India include groups such as the damselfish (more than 76 species), butterfly fish (more than 40 species), parrot fish (more than 24 species), sea bass, groupers and fairy basslets (more than 57 species), cardinal fish (more than 45 species), jacks and kingfish (more than 46 species), wrasses (more than 64 species), comb-tooth blennies (more than 58 species), gobies (more than 110 species), surgeonfish, tangs and unicornfish (more than 40 species) (Ramakrishna et al, 2010). Cryptic and nocturnal species that are confined primarily to caverns and reef crevices during daylight periods constitute another 20 per cent.

1.5.4 REPTILES

Reptiles are the most diverse terrestrial vertebrates with about 12,000 described forms, including about 9,350 currently recognized species and about 3,000 subspecies Out of which, about 100 have re-entered the ocean.

Crocodiles

The saltwater crocodile (*Crocodylus porosus*) is also widely known by the common names, estuarine or Indo-Pacific crocodile, more rarely or informally referred to as the saltie, marine or sea-going crocodile. This species is the largest of all living reptiles, as well as the largest terrestrial and riparian predator in the world. The males of this species can reach sizes up to 6.3 m (20.7 ft) and weigh up to 1,360 kg (3,000 lb). However, an adult male saltwater crocodile is generally between 4.3 and 5.2 m (14 and 17 ft) in length and weighs 400 to 1,000 kg (880–2,200 lb), rarely growing larger. Females are much smaller and often do not surpass 3 m (9.8 ft). As its name implies, this species of crocodile can live in salt water, but usually resides in mangrove swamps, estuaries, deltas, lagoons, and lower stretches of rivers.

Sea turtle

Five of the seven species of sea turtles are known to inhabit Indian coastal waters and islands. These are the Olive ridley (*Lepidochelys olivacea*), Green (*Chelonia mydas*), Hawksbill (*Eretmochelys imbricata*), Loggerhead (*Caretta caretta*) and the Leatherback (*Dermochelys coriacea*) turtles. Except the Loggerhead, the remaining four species nest along the Indian coast. All the five species of sea turtles that occur in Indian coastal waters are protected under Schedule I of the Indian Wildlife Protection Act (1972), as well as listed in Appendix I of Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES) which prohibits trade in turtle products by signatory countries. All species of sea (marine) turtles occurring in the Indo-Pacific region are a priority for conservation under the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and are listed on both Appendices I and II. At present there exists no commercial or international trade of marine turtles or turtle products in India. However, incidental fishing related

Green Sea Turtle (*Chelonia mydas*) (Photo – D. Adhavan)

Olive ridely (*Lepidochelys olivacea*)
(Photo - nationalgeographic.com)

Loggerhead Sea turtle (*Caretta caretta*)
(Photo - http://scubaemporium.blogspot.com/2011/04/loggerhead-sea-turtles-compass-of-sea.html.)

Hawksbill Sea turtle (*Eretmochelys imbricata*)
(Photo - http://www.thinglink.com/)

Leatherback Sea turtle
(*Dermochelys coriacea*) (Photo - en.wikipedia.org)

mortality of marine turtles which is globally well documented, is also a matter of great concern for India.

Though many of the ecological interconnections influencing sea turtle behavior and biology remain unclear, it is known that sea turtles occupy a unique position within the food web. They consume an assortment of prey, including puffer fish, crustaceans, sponges, tunicates, sea grasses, and algae. The unusual life cycle of the animal plays a vital role in transportation of nutrients from the highly productive marine habitats such as sea-grass beds to energy-poor habitats like sandy beaches. This helps reverse the usual flow of nutrients from land to sea.

1.5.5 MOLLUSKS

The molluscs or mollusks compose the large phylum of invertebrate animals known as the Mollusca. Around 85,000 extant species of molluscs are recognized. They are the largest marine phylum, comprising about 23% of all the named marine organisms. Many molluscs also live in freshwater and terrestrial habitats. They are highly diverse, not just in size and in anatomical structure, but also in behavior and in habitat. Cephalopod molluscs, such as squid, cuttlefish and octopus, are among the most neurologically advanced of all invertebrates—and either the giant squid or the colossal squid is the largest known invertebrate species. The gastropods (snails and slugs) are by far the most numerous molluscs in terms of classified species.

Most molluscs are herbivorous, grazing on algae or filter feeders. For those grazing, two feeding strategies are predominant. Some feed on microscopic, filamentous algae, often using their radula as a 'rake' to comb up filaments from the sea floor. Filter feeders are molluscs that feed by straining suspended matter and food particle from water, typically by passing the water over their gills. Most bivalves are filter feeders.

These filter feeding organisms maintains the water quality by filtering the suspended micro particles including micro algae and microorganism. *C. tritonis* is one of the few animals to feed on the crown-of-thorns starfish, *Acanthaster planci* which is a threat to corals.

Helmet shell (*Cassis cornuta*) (Photo - MoEFCC)

Vazhaipoo shell (*Conus milne edwardsi*) (Photo - MoEFCC)

Rajali (*Charonia tritonis*) (Photo - MoEFCC.)

Bear Paw Clam (*Hippopus hippopus*)
(Photo -MoEFCC.)

Chambered nautilus or Elephant trunk shell (*Nautilus pompilius*) (Photo - MoEFCC.)

Giant clam (*Tridacna squamosal*) (Photo - MoEFCC)

Map cowrie (*Cypraea mappa*) ; Schedule 4
(Photo - MoEFCC)

Horse conch shell (*Fasciolara trapezium*); Schedule 4
(Photo - MoEFCC)

(Cypraea talpa; Schedule 4 (Photo - MoEFCC)

Harpulina arausiaca; Schedule 4 (Photo - MoEFCC)

Arthritic spider conch (*Lambis chiragra arthritica*)
(Photo - MoEFCC)

Lambis scorpius (*Spider conch*) (Photo - MoEFCC)

1.5.6 SEA CUCUMBER

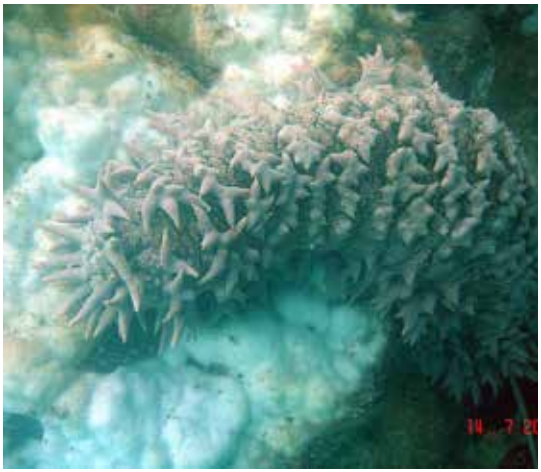
Sea cucumbers are diverse group of worm-like and usually soft-bodied echinoderms found in nearly every marine environment, but are most diverse on tropical shallow-water coral reefs. They range from the intertidal, where they may be exposed briefly at low tide, to the floor of the deepest oceanic trenches. Some of these are about 20 cm in length, though adults of some diminutive species may not exceed a centimeter, while one large species can reach lengths of 5 m (*Synapta maculata*). Several species can swim and there are even forms that live their entire lives as plankton, floating with the ocean currents. These animals are used as delicacy and as a part of folk medicine in Asia. Despite increased exploitation of sea cucumbers, they are still numerous in the wild. Sea cucumbers are nocturnal creatures (active during the night).

Sea cucumbers feed on tiny particles like algae, minute aquatic animals, or waste materials, which they gather in with 8 to 30 tube feet that look like tentacles surrounding their mouths. The animals break down these particles into even smaller pieces, which become fodder for bacteria, and thus recycle them back into the ocean ecosystem.

Sea cucumber (*Euapta godeffryi*)
(Photo - N. Marimuthu)

Sea cucumber (*Stichopus hermanni*)
(Photo - N. Marimuthu)

Sea cucumber (*Holothuria atra*)
(Photo - N. Marimuthu)



Sea cucumber (*Thelenota ananas*)
(Photo - N. Marimuthu)

1.5.7 COASTAL BIRDS AND SEABIRDS

The marine ecosystem offers feeding and breeding ground for a number of birds. Although there is not much diversity among seabirds, a number of seabirds are found regularly in marine and estuarine ecosystems. So far a total of 69 marine bird species have been reported from India (BNHS/ENVIS, 2011).

There are some specialist species that are exclusively dependent on coral reef ecosystems, while a few are generalists that do not depend much on them.

Some common coastal and marine birds:

Greater Flamingo (*Phoenicopterus ruber)*

These famous pink birds can be found in warm, watery regions on many continents. They favor environments like estuaries and saline or alkaline lakes. Considering their appearance, flamingos are surprisingly fluid swimmers, but really thrive on the extensive mud flats where they breed and feed.Shrimplike crustaceans are responsible for the flamingo's pink color. The birds pale in captivity unless their diet is supplemented. Greater flamingos live and feed in groups called flocks or colonies.

Grey-headed Fish-eagle (*Icthyophaga ichthyaetus)*

This bird of pray is found near slow-moving rivers and streams, lakes, reservoirs and tidal lagoons in wooded country, usually in lowlands but ascending locally to 1,525 m. Although widespread, this species is now only locally common and may have a moderately small population, which is thought to be undergoing a moderately rapid population reduction owing to habitat degradation, pollution and over-fishing.

Brown-headed gull (*Chroicocephalus brunnicephalus)*

This is a small gull which breeds in the high plateaus of central Asia from Tajikistan to Ordos in Inner Mongolia. It is migratory, wintering on the coasts and large inland lakes of tropical southern Asia. This gull breeds in colonies in large reedbeds or marshes, or on islands in lakes, nest-

ing on the ground. Like most gulls, it is highly gregarious in winter, both when feeding or in evening roosts. It is not a pelagic species, and is rarely seen at sea far from coasts.

http://bnhsenvis.nic.in/Database/MarineBirdsIndia_837.aspx

1.5.8 MARINE MAMMALS

There are some 120 species of marine mammal to be found in the world and the Indian seas support 25 species of marine mammals. All the marine mammal species reported from Indian waters are protected under the Wildlife (Protection) Act 1972.

The information available on the distribution and abundance of marine mammals in the marine regions of India remains scanty. A lack of capacity among marine mammalogists to conduct surveys and research has been an impediment to progress in research and gaining knowledge about species-level distribution, abundance, biology and ecological characteristics. Marine mammals include representatives of three major orders:

Cetacea (whales, dolphins and porpoises):

Cetaceans are the mammals most fully adapted to aquatic life. Their body is fusiform (spindle-shaped). The forelimbs are modified into flippers. The tiny hindlimbs are vestigial; they do not attach to the backbone and are hidden within the body. The tail has horizontal flukes. Cetaceans are nearly hairless, and are insulated by a thick layer of blubber. As a group, Cetaceans are noted for their high intelligence.

Sirenia (manatees and dugong)

The order Sirenia, has just four species in two families worldwide. The two families are the Dugongidae, the dugong family, and the Trichechidae, or the manatee family. All the four species have become rare due to human exploitation for meat and oil. All the sirenians are completely herbivorous and are confined to shallow waters of coastal areas where higher aquatic plant life is abundant. Dugongs are strictly marine mammals whilst manatees may live in the sea or in estuarine or riverine waters. Manatees can wriggle back to water if put on nearby land.

Dugong (*Dugong dugon*)

Dugongs are one of four living species of the order Sirenia, which also includes three species of manatees. It is the only living representative of the once-diverse family Dugongidae. Dugongs are more closely related to elephants than to marine mammals such as whales and dolphins. They are sometimes referred to as "sea cows" in reference to the fact that they feed almost exclusively on sea grass. Dugongs have long been associated with myths and legends - early sightings of the species by lonely sailors are believed to have led to the legend of the mermaids. Although commercial hunting of dugongs is now banned, the species may still be at risk from traditional hunting and the destruction of sea grass beds by human activities. Dugong play an important ecological role in coastal marine ecosystems, and the status of dugong populations in an area can be used as an indicator of general ecosystem health.

Carnivora (sea otters, polar bears and pinnipeds).

Carnivora is an order of placental mammals that includes about 270 species of bears, cats, dogs, weasels, pinnipeds, and many other meat-eaters. This order is divided into about 11 families. Members of the order Carnivora have a simple stomach and a characteristic tooth pattern that includes the carnassial pair (an enlarged fourth upper premolar and lower first molar); most carnivora have a primitive number of incisors.

As for the marine mammals, the order Carnivora contains pinnipeds (sealions, walrus and seals), the polar bear, and the two otters.

1.6 Coastal and marine ecosystems in India: A statistical overview

According to the Zoological Survey of India, the Indian Ocean accounts for:

29 per cent of the global ocean area;

13 per cent of marine organic carbon synthesis; 10 per cent of capture fisheries;

90 per cent of culture fisheries; 30 per cent of coral reefs;

10 per cent of the mangroves; and

it has 246 estuaries draining a hinterland greater than 2,000 sq km, besides coastal lagoons and backwaters.

Being landlocked in the north, and with the largest portion of it lying in the tropics, the Indian Ocean is a region of high biodiversity, with one of the countries in the region, India, rated as being one of the mega-biodiversity centres of the world.

In the current context of international trade and intellectual property regimes, it is important for all of the Indian Ocean countries to understand their marine biodiversity.

The dissimilarities between the west and east coasts of India are remarkable. The west coast is generally exposed, with heavy surf and rocky shores and headlands, whereas the east coast is generally shelving, with beaches, lagoons, deltas and marshes. The west coast is a region of intense upwelling, associated with the southwest monsoon (May–September), whereas the east coast experiences only a weak upwelling, associated with the northeast monsoon (October–January), resulting in marked differences in hydrographic regimes, productivity patterns and qualitative and quantitative composition of fisheries.

All the islands on the east coast are continental islands, whereas the major island formations in the west coast are oceanic atolls.

According to the Zoological Survey of India, the current inventory of coastal and marine biodiversity of India indicates that a total of 17,795 species from the faunal and floral communities have been reported from the seas around India.

The data reveal that India contributes 6.75 per cent to the global marine biodiversity.

1.7 What are the differences between the terrestrial and the coastal and marine ecosystems?

According to the CBD Aichi Target 11, protected areas should be integrated into the wider landscape and seascape, and relevant sectors, bearing in mind the importance of complementarity and spatial configuration. Here landscape refers broadly to terrestrial ecosystems, whereas seascape refers to marine ecosystems. Wider landscape and seascape includes the array of land and water uses, management practices, policies and contexts that have an impact within and beyond protected areas, and that limit or enhance protected area connectivity and the maintenance of biodiversity. **The methods of managing terrestrial ecosystems cannot be directly applied to marine ecosystems because of a number of causes.** These can be examined under the following broad contexts:

1.7.1 ECOLOGICAL CONTEXT

The fundamental difference between marine and terrestrial areas is the aquatic medium in which all marine organisms live. Water being denser than air (800 times), organisms may be neutrally buoyant, have specialized floatation devices (e.g., swim bladder of fish) or have a high surface area to volume ratio to increase buoyancy. The buoyancy of water offsets the effect of gravity, which is why the largest animal on Earth is a whale, an inhabitant of the marine realm. Terrestrial plants such as trees have to invest large resources in support structures (e.g., wood), whereas aquatic plants invest in fewer resources for support.

Plants, primarily the multicellular flowering forms, are the dominant primary producers on land, releasing oxygen through the process of photosynthesis. On land, plants are mostly sessile, rooted to the ground for their lifetime. In the marine realm, the microscopic unicellular phytoplankton are the dominant primary producers. These drift along with winds and waves, forming blooms where conditions (especially availability of nutrients) are favourable. Thus, on land, the ecosystems can be described as being more internally controlled by the dominant organisms (trees), whereas the organisms of the marine realm are subject to the physics of the surrounding medium, water.

Perhaps the most important ecological point that needs to be considered in managing marine ecosystems is that terrestrial ecosystems have discrete boundaries, while in the case of marine ecosystems, the boundaries are relatively open.

Marine systems are highly dynamic, tightly connected through a network of surface and deep-water currents whose stratifications are broken by upwelling that creates vertical and horizontal heterogeneity. Consequently, the wide range of physical, chemical and geological variations that are found in the sea have given rise to a complex of marine habitats that range from highly productive near-shore ecosystems to the ocean deeps that are inhabited only by specialized organisms.

Aquatic environments are richer in nutrients than equivalent terrestrial ecosystems and hence are able to support more life. However, while light and oxygen can be limiting factors in the aquatic environment, they are seldom so on land. The aquatic realm is relatively more stable than the terrestrial realm with smaller fluctuations in temperature and other variables. Since they live in water, aquatic organisms are seldom exposed to desiccation, while terrestrial organisms are often exposed to desiccation. This is important considering the fact that a large proportion of an organism's body is made up of water.

This issue of boundaries is important in the context of migration of organisms and in the dispersal of organisms in various life stages. This has probably resulted in relatively lower genetic variation between populations and therefore larger effective population sizes. Apart from migration in search of food, marine organisms migrate as the local conditions change; the rate of response to environmental variability is much faster in the case of marine ecosystems compared to terrestrial ecosystems. The boundary issue is also relevant with respect to habitat fragmentation—the sensitivity to habitat fragmentation is much lower in the case of marine ecosystems.

There is also a difference in the rate and importance of anthropogenic pressures. Habitat destruction in the case of terrestrial ecosystems is widespread, whereas it is localized in the case of the marine

realm (estuaries, coral reefs, etc.). More importantly, **in the case of terrestrial ecosystems, habitat destruction is 'visible' as in the cutting down of trees in a forest, whereas while bottom trawling may devastate the benthic habitat of marine ecosystems, it may not be visible unless someone dives in the area** as humans do not live in water and therefore cannot be aware of change in habitat.

1.7.2 SOCIO-ECONOMIC CONTEXT

In the socio-economic context, the different kinds of property rights become relevant in understanding the difference between marine and terrestrial ecosystems. **On land, property rights are reasonably clear: private, public (state) and common property. In contrast, coastal waters and many coastal spaces such as beaches have always been considered open-access, which means that restricting natural resource-based activities such as fishing, seaweed collection and shell collection can be difficult as it will affect thousands of livelihoods.**

At the international level, it was only after the United Nations Convention on the Law of the Sea (UNCLOS) that nations have acted to establish ownership of the seabed and overlying waters by the declaration of territorial waters and an exclusive economic zone (EEZ). While the onus of conservation of living marine resources in the EEZ rests with the coastal state, Section 2 of Part VII of UNCLOS broadly says that states should cooperate with one another in the conservation and management of living marine resources in the high seas. Most recently (2011), the Global Environment Facility project on Areas Beyond National Jurisdiction (ABNJ) was developed to promote efficient and sustainable management of fisheries resources and biodiversity conservation in the ABNJ, considered as the world's last global commons.

More than a third of the world's population lives in coastal areas and small islands that make up just over 4 per cent of Earth's total land area. Fisheries and fish products provide direct employment to 38 million people. Coastal tourism is one of the fastest growing sectors of global tourism and provides employment for many people generating local incomes. Ninety per cent of world trade is through sea shipping.

Marine ecosystems have been important as providers of food for millennia, especially for those living in coastal areas. While the proportion of farmed food with respect to wild-caught food is very high in the case of terrestrial ecosystems, it is capture fisheries that dominate production from the marine environment. In terrestrial environments, it is primary producers and herbivores, the first two levels in a food chain/web that are farmed and consumed, whereas in the case of food from the sea, it is the carnivores or organisms at higher levels in the food chain that are harvested and consumed. Depletion at the higher trophic levels can have a cascading effect on the food chain and food web. This can be considered as the second relevant point of difference between marine and terrestrial ecosystems from a socioeconomic context.

1.7.3 POLITICAL AND SECURITY CONTEXT

Land borders are geographical features such as rivers, seas, mountains and other formations that present natural obstacles to communication and transport. Deliberate (human) movement of plants and animals across borders may be prohibited (in the case of endangered species) and is otherwise usually restricted with quarantine requirements. However, migratory movement of plants or animals via sea is historically unrestricted and also the subject of the Convention on Migratory Species.

With respect to maritime boundaries, under UNCLOS, a coastal state is entitled to a territorial sea not exceeding 12 nautical miles measured from its baselines. Within its territorial sea, the coastal state exercises sovereignty, including over its resources.

In addition, a coastal state may establish an EEZ not extending beyond 200 nautical miles from its baselines, where the coastal state has sovereign rights for, inter alia, marine scientific research and protection and preservation of the marine environment. When two or more coastal countries share a sea or ocean, usually bilateral/multilateral treaties are executed to resolve border disputes.

On land, hunting in border areas can be controlled: hunters chasing their prey may be stopped by clearly demarcated natural or artificial borders which allow their prey to move away but clearly indicate the limit of human movement. On the other hand, fishing may involve chasing fish even across maritime borders as there may not be visible indicators of such borders and the fish are swimming

underwater, out of sight. Similarly, since a reserve demarcated in the ocean realm, unlike that demarcated on land, may not have visible boundaries, trespass (human) may happen.

There is considerable difference in costs in demarcating and monitoring boundaries in terrestrial and marine systems. It is easier to fix boundaries of terrestrial systems and ensure their visibility by, for example, using fences and monitor them by patrolling. In contrast, it is much more difficult to demarcate boundaries of marine ecosystems and make the boundaries visible. The costs of patrolling seas/oceans and enforcing regulations are higher than that for terrestrial ecosystems.

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About the CMPA project

The Project –'Conservation and Sustainable Management of Existing and Potential Coastal and Marine Protected Areas (CMPA)', under the Indo-German Biodiversity Programme, is a technical cooperation project jointly implemented by the Governments of India and Germany (2012-17). The Project is commissioned by the German Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety (BMUB) with funds provided under the International Climate Initiative (IKI), in partnership with the Ministry of Environment, Forests and Climate Change (MoEFCC), Government of India.

The project aims at contributing to conservation of biodiversity through participatory approaches in the management of existing and potential coastal and marine protected areas in India. Project activities are implemented together with the Forest Departments of the project partner states - Gujarat, Goa, Maharashtra and Tamil Nadu, as well as with premier national training institutions.

Our partners

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

The Wildlife Institute of India (WII), Dehradun

WII has a mandate to train Indian Forest Service officers, State Forest Service officers and other key stakeholders such as the Coast Guard and Customs and has recently initiated a one-week refresher course exclusively addressing issues related to integrated management of coastal and marine biodiversity that is targeted at senior forest officials. https://www.wii.gov.in/

Xavier Institute of Communications (XIC), Mumbai

XIC is a professional media centre offering a variety of services in training and production. XIC is an autonomous educational unit of the Bombay St. Xavier's College Society Trust, which comprises St. Xavier's College, the Institute of Management, the Institute of Counseling and the Heras Institute of Indian History and Culture. XIC pilot-tested the curriculum between December 2014 and May 2015 and subsequently decided to integrate the curriculum into its Communication for Development (C4D) diploma course.
www.xaviercomm.org

BMM Department, St. Xavier's College, Mumbai

St. Xavier's College is one of the most prestigious liberal arts colleges in India. The BMM department was established in 2002. The Bachelor in Media Studies, a programme begun by the University of Mumbai in 1999, is being run by St. Xavier's College under the system of academic autonomy. While this is an applied course that seeks to provide industry with qualified media professionals, St. Xavier's believes that an academic grounding is very essential for forming young people for this crucial job of communications.
www.xaviers.edu

St. Paul's Institute of Communication Education (SPICE), Mumbai

St. Paul's Institute of Communication Education (SPICE) is a fast-growing media school in India offering a comprehensive post-graduate diploma in journalism that trains students for a career in print journalism, television journalism and digital journalism. With top-notch media faculty members and excellent infrastructure, SPICE is the go-to destination for Gen Next journalists.
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Department of Communication, Journalism and Public Relations, Gujarat University

The Department of Communication, Journalism and Public Relations was established in 1987–1988. The department plays a vital role in providing media professionals and communication experts to various fields. Two courses are offered by the department, the Master's in Mass Communication and Journalism (MMCJ) and the Master's in Development Communication (MDC).
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