Training Resource Material

Coastal and Marine Biodiversity and Protected Area Management

Module 2
Coastal and Marine Ecosystem Services and their Value

For MPA Managers

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

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

Training Resource Material

Coastal and Marine Biodiversity and Protected Area Management

Module 2

Coastal and Marine Ecosystem Services and their Value

For MPA Managers

Summary

This module facilitates participants looking into the overall development agenda via Global Sustainable Development Goals, the concepts of sustainability, and sustainable livelihoods and its interlinkages with the ecosystem services. Concept of ecosystem services and their value is the central theme of this module.

Imprint

Training Resource Material:
Coastal and Marine Biodiversity and Protected Area Management
for MPA Managers

Module 1: An Introduction to Coastal and Marine Biodiversity
Module 2: Coastal and marine Ecosystem Services and their Value
Module 3: From Landscape to seascape
Module 4: Assessment and monitoring of coastal and marine biodiversity and relevant issues
Module 5: Sustainable Fisheries Management
Module 6: Marine and Coastal Protected Areas
Module 7: Governance, law and policies for managing coastal and marine ecosystems, biodiversity and protected areas
Module 8: Coasts, climate change, natural disasters and coastal livelihoods
Module 9: Tools for mainstreaming: impact assessment and spatial planning
Module 10: Change Management and connectedness to nature
Module 11: Communicating Coastal and Marine Biodiversity Conservation issues
Module 12: Effective management Planning of coastal and marine protected areas

ISBN 978-81-933282-5-5
December 2016

Published by:

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Indo-German Biodiversity Programme
A-2/18, Safdarjung Enclave
New Delhi 110029, India
T +91-11-4949 5353
E biodiv.india@giz.de
W http://www.indo-germanbiodiversity.com

Wildlife Institute of India (WII)
P.O. Box 18, Chandrabani
Dehradun 248001
Uttarakhand, India
T +91-135-2640 910
E dwii@wii.gov.in
W www.wii.gov.in

Indira Gandhi National Forest Academy (IGNFA)
Post Office New Forest,
Dehradun - 248006
Uttarakhand, India
Phone +91-135-2757316
Fax +91-135-2757314
E-Mail : director@ignfa.gov.in

GIZ is a German government-owned not-for-profit enterprise supporting sustainable development.

This training resource material has been developed under the Human Capacity Development component of the project ‘Conservation and Sustainable Management of Coastal and Marine Protected Areas (CMPA)’, under the Indo-German Biodiversity Programme, in partnership with the Wildife Institute of India (WII) and Indira Gandhi National Forest Academy (IGNFA). The CMPA Project has been commissioned by the German Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety (BMUB) with the funds provided under the International Climate Initiative (IKI). The CMPA Project is being implemented in selected coastal states in India and focuses on capacity development of the stakeholders in the forest, fisheries and media sectors.

With guidance of:
Dr. Amita Prasad, Additional Secretary, Ministry of Environment, Forest and Climate Change (MoEFCC) Government of India
Dr. J. R. Bhatt, Advisor, Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India
Dr. Konrad Uebelhör, Director, Indo-German Biodiversity Programme, GIZ India
Dr. V. B. Mathur, Director, Wildlife Institute of India
Dr. Shashi Kumar, Director, Indira Gandhi National Forest Academy, India
Dr. J. Michael Vakily, Team Leader, CMPA Project, Indo-German Biodiversity Programme, GIZ India

Compiled and edited by:
Dr. Neeraj Khera, Senior Advisor, Indo-German Biodiversity Programme, GIZ India
Dr. K. Sivakumar, Scientist F, Wildlife Institute of India

Text and editing contributions from:
Dr. Sarang Kulkarni, Marine Biologist, Indian Institute of Scuba Diving and Aquatic Sports (IISDA), Dr. J.A. Johnson, Scientist D, Wildlife Institute of India; Dr. Ramesh Chinnasamy, Scientist C, Wildlife Institute of India; Dr. D. Adhavan, Project Associate, Wildlife Institute of India; Dr. Pradeep Mehta, Research and Programme Manager, Earthwatch Institute India; Mr. Luke Mendes, Writer, Filmmaker and Media Trainer, Mumbai; Mr. S. Gopikrishna Warrier, Regional Environment Manager, PANOS South Asia; Mr. Darryl D'Monte, Chairperson, Forum of Environmental Journalists of India (FEJI); Dr. Dirk Asendorpf, Journalist and Media Trainer, Germany; Ms Atiya Anis, Communications Expert, Indo-German Biodiversity Programme, GIZ India; Mr. Sanjay Dave, Charkha and Mr. Bharat Patel, MASS Gujarat [case studies of turtle rescue and community plantation of mangroves]; Dr. R. Ramesh and team, NCSCM [ecosystem services, differences between terrestrial and coastal ecosystems, GIS]; Ms Helina Jolly [economic valuation methods and examples]; Dr. S. Senthil Kumar, IGNFA.

Photos by:
Dr. Neeraj Khera, unless otherwise credited

The consequences of biodiversity loss and the resulting loss of ecosystem services have far-reaching impact on livelihoods and the overall well-being of human communities.

Table of contents

Key messages

- Coastal and marine ecosystems provide a wide range of services to human society including supporting, regulating, cultural and provisioning services.
- These services influence human welfare both directly, through human use, and indirectly, via impacts on supporting and regulating services in other environments. But they are increasingly under threat from widespread and growing pressures on marine and coastal resources such as overfishing, water contamination, coastal habitat destruction and general loss of biodiversity.
- The consequences of the biodiversity loss and the resulting loss of ecosystem services has far reaching impacts on livelihoods and the overall well-being of human communities.
- Valuation can be useful and/or relevant at all levels of governance, including strategic policy setting, project appraisals, decision making, day to day management and communication with stakeholders.

2.1 Why is biodiversity important?

Ecosystem services: provisioning, regulating, supporting and cultural ecosystem service

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 stabilizing 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. [1]Ecosystems provide a variety of benefits to people, including provisioning, regulating, cultural and supporting services

2.1.1 Provisioning services

Provisioning services are the products people obtain from ecosystems, such as food (agriculture and horticulture crops, livestock, fish), medicinal and aromatic plants and products, fuel, fibre, fresh water, gums and resins, minerals and genetic resources.

Fish (including shellfish) provides essential nutrition for 3 billion people and at least 50 per cent of animal protein and minerals to 400 million people in the poorest countries.

2.1.2 Regulating services

Regulating services are the benefits people obtain from regulation of ecosystem processes, including air quality maintenance, climate regulation, carbon sequestration, regulation of human diseases, plant pest and disease control, pollination, water purification, natural hazard and disaster

1 Source: http://www.millenniumassessment.org

risk reduction (mitigating the threat from landslides, floods and even tsunamis), pollination etc. The presence of coastal ecosystems such as mangroves and coral reefs can reduce the damage caused by hurricanes or large waves[2].

Pollination: a critical ecosystem service

Animal pollination plays a vital role as a regulating ecosystem service in nature. Pollinators are a source of multiple benefits to people, beyond food provisioning, contributing directly to medicines, biofuels (e.g. canola and palm oil), fibres (e.g., cotton and linen) construction materials (timbers), musical instruments, arts and crafts, recreational activities and as sources of inspiration for art, music, literature, religion, traditions, technology and education.

Read Summary for Policy-makers of this IPBES report:
http://www.ipbes.net/sites/default/files/downloads/pdf/spm_deliverable_3a_pollination_20161124.pdf

2.1.3 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, ecotourism. Spiritual and religious value refers to religious bonds to sacred landscapes, groves and species (Butler, 2006) and is often connected to different religions.

2.1.4 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.

2 Source: [Read a special report on this- SREX https://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf]

Figure 2.1: Coastal Ecosystem Service [http://nca2014.globalchange.gov/report/regions/coasts/graphics/coastal-ecosystem-services]

Coastal ecosystems provide a variety of valuable benefits (ecosystem services) on which humans depend for food, economic activities, inspiration, and enjoyment. This schematic illustrates many of these services situated in a Pacific or Caribbean island setting, but many of them can also be found along mainland coastlines.

Ecosystem Services: A short film by Media students developed under the CMPA Project

https://www.youtube.com/watch?v=8-CFg6s8kes

Following table provides a quick overview of various ecosystem services along with example 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)[3]

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

3 Source: Beaumont, N.J., Austen, M.C., Atkins, J.P., Burdon, D., Degraer, S., Dentinho, T.P., Derous, S., Holm, P.,Horton, T., van Ierland, E., 2007. Identification, definition and quantification of goods and services provided by marine biodiversity: implications for the ecosystem approach. Marine Pollution Bulletin 54,253– 265.

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]

2.2 Overall development scenario

From an economic perspective, the coastal and marine ecosystems are of great importance as 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 coast, the fisheries sector is vital, providing employment to over 6 million people, and accounts for 1.07 per cent of India's total GDP.

The sustainable development goals (SDGs) are a new, universal set of goals, targets and indicators that UN member states are 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).

The Millennium Development Goals (MDGs) consisted of eight international development goals established after the Millennium Summit of the United Nations in 2000, following the adoption of the United Nations Millennium Declaration. The MDGs have been replaced by the Sustainable Development Goals from 2015.

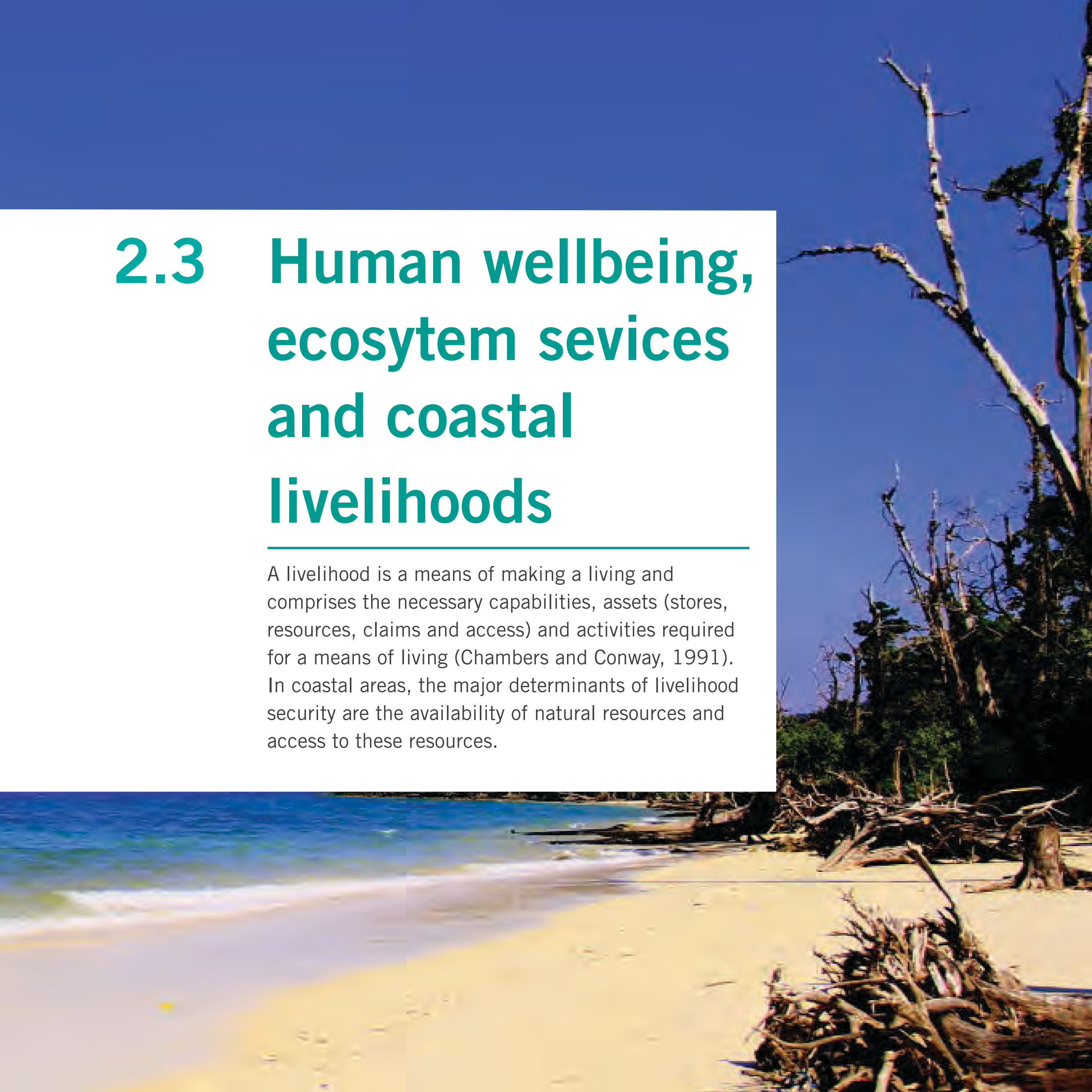
There is broad agreement that while the MDGs provided a focal point for governments on which to hinge their policies and overseas aid programmes to end poverty and improve the lives of poor people – as well as provide a rallying point for NGOs to hold them to account – they have been criticised for being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

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.

What are the 17 SDGs (Sustainable Development 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 well-being 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 by the 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 desertification 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.



2.3 Human wellbeing, ecosytem sevices and coastal livelihoods

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). In coastal areas, the major determinants of livelihood security are the availability of natural resources and access to these resources.

Over 500 million people in developing countries depend, directly or indirectly, on fisheries and aquaculture for their livelihoods[4]. 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 stresses 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[5]. A livelihood is socially sustainable when it is able to cope with stress (declining resources, climate variability) and shocks (natural disasters), and retains its ability to continue and improve or, in other terms, when it is less vulnerable to stresses and shocks. 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.

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 greatest on communities living amidst mountain and coastal ecosystems, these ecosystems being among 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.

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

---

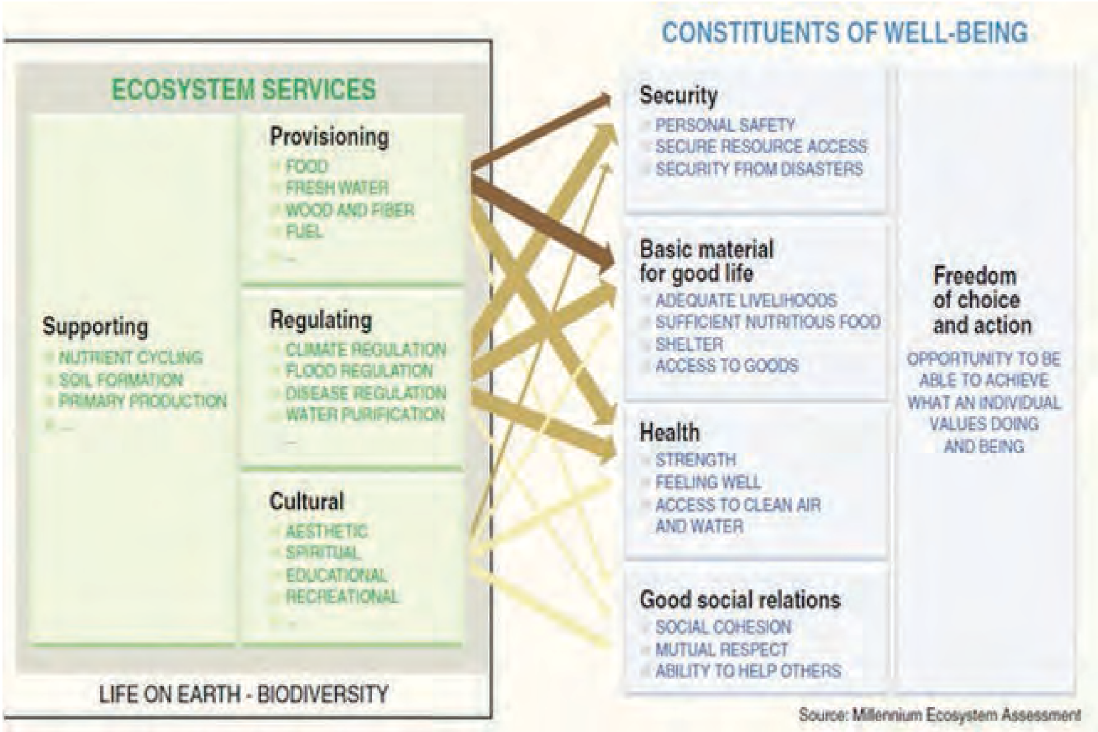
4 Source: Partnership on Climate Change, Fisheries and Aquaculture. 2009. Fisheries and aquaculture in our changing climate. UNEP.

5 Source: Chambers, R., Conway, G.R. 1991. Sustainable Rural Livelihoods: Practical Concepts for the 21st Cetury. Institute of Development Studies DP 296. University of Sussex, Brighton.

The consequences of biodiversity loss and the resulting loss of ecosystem services have far-reaching impacts on the livelihoods and overall well-being of human communities. Human well-being has multiple constituents, including the 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.

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.

Figure 2.2 : Ecosystems and overall well-being of the human population



2.4 Status of ecosystem services

2.4.1 Overview

Approximately 60 per cent (15 out of 24) of the ecosystem services evaluated in the Millennium Ecosystem Assessment (including 70 per cent of the 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 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 climates, regulation of soil erosion, spiritual fulfilment, and aesthetic enjoyment. The use of two ecosystem services capture and freshwater 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.

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 is therefore unsustainable (low to medium certainty).

Of the 24 ecosystem services, only four 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 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.

Many marine and coastal ecosystems no longer deliver the full suite / variety of ecosystem services upon which humans have come to rely (Mengerink et al 2009) due to 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 (Rosenberg 2005; Millennium Ecosystem Assessment 2005).

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.

2.4.2 Current status of coastal and marine biodiversity

Changes being made in ecosystems are increasing the likelihood of nonlinear changes (including accelerating, abrupt and potentially irreversible changes), with important consequences for human well-being:

- Fisheries collapse
- Eutrophication and hypoxia (deprivation of oxygen)
- Disease emergence
- Species introductions and losses
- Climate change and natural disasters

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.

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 inreservoirs 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).

2.4.3 Facts and figures on marine biodiversity:

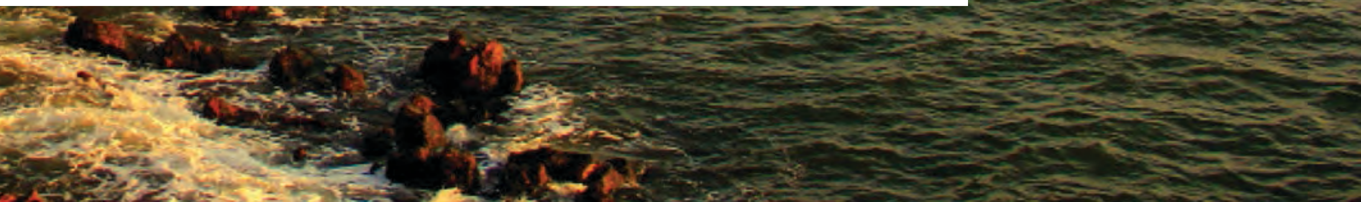
- By the year 2100, without significant changes, more than half of the world's marine species may stand on the brink of extinction.
- Today 60% of the world's major marine ecosystems that underpin livelihoods have been degraded or are being used unsustainably.
- Approximately 12% of the land area is protected, compared to roughly 1% of the world ocean and adjacent seas.
- Ocean acidification may threaten plankton, which is key to the survival of larger fish.
- If the concentration of atmospheric CO2 continues to increase at the current rate, the ocean will become corrosive to the shells of many marine organisms by the end of this century. How or if marine organisms may adapt is not known.
- Ocean acidification may render most regions of the ocean inhospitable to coral reefs, affecting tourism, food security, shoreline protection, and biodiversity.
- Commercial overexploitation of the world's fish stocks is so severe that it has been estimated that up to 13 percent of global fisheries have 'collapsed.'
  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.
- Excessive nutrients from sewage outfalls and agricultural runoff have contributed to the number of low oxygen (hypoxic) areas known as dead zones, where most marine life cannot survive, resulting in the collapse of some ecosystems. There are now close to 500 dead zones covering more than 245,000 km^2 globally, equivalent to the surface of the United Kingdom.
- Between 1980 and 2005, 35,000 square kilometers of mangroves were removed globally. Between 30 and 35 percent of the global extent of critical marine habitats such as seagrasses, mangroves and coral reefs are estimated to have been destroyed.
- Technological change and the emergence of new economic opportunities such as deep sea mining, more intensive fishing, and deeper oil and gas drilling increase risks to areas that historically were not under threat.

Source: http://www.unesco.org/new/en/natural-sciences/ioc-oceans/focus-areas/rio-20-ocean/blueprint-for-the-future-we-want/marine-biodiversity/facts-and-figures-on-marine-biodiversity/

2.5 Challenges in managing coastal and marine biodiversity

2.5.1 Overview and DPSIR Framework

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.[6]



Let’s take a closer look at how these stress factors generate impacts on the coastal and marine eco systems and consequently on the life and livelihoods of coastal communities.

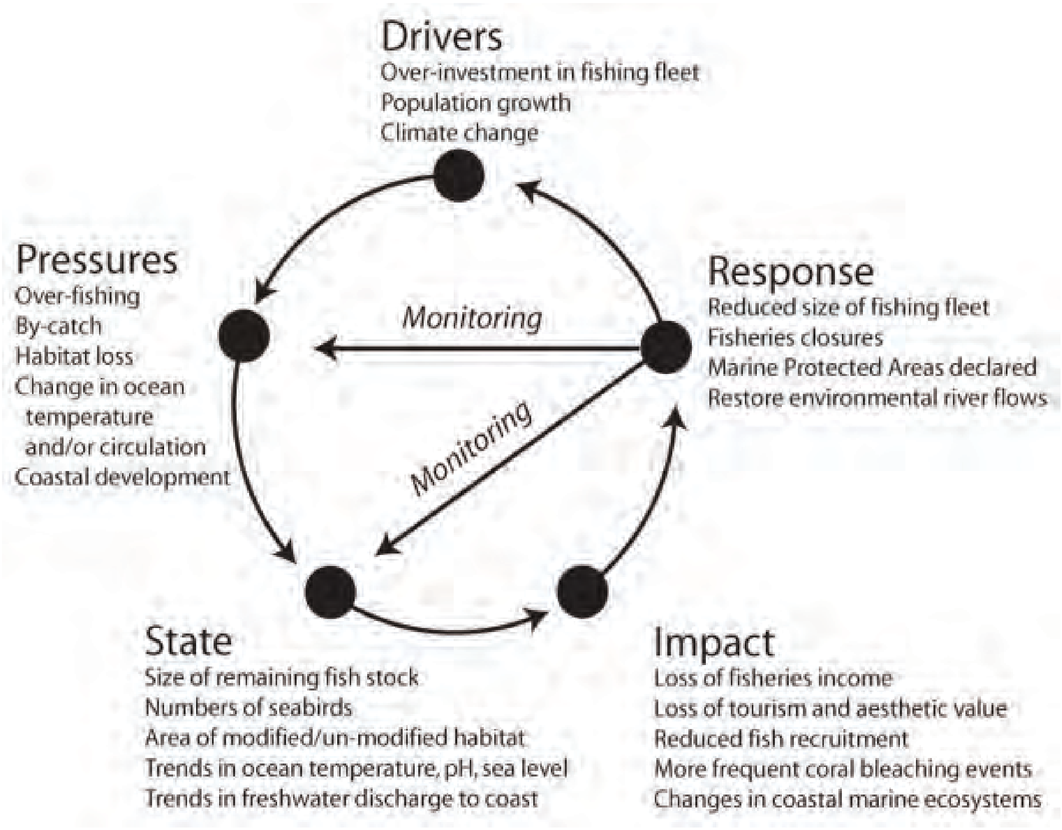


Figure 2.3: DPSIR in the context of coastal and marine ecosystems

[Source: http://www.worldoceanassessment.org/wp-content/uploads/2012/06/DPSIR9.gif]

2.5.2 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 mariculture 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 exploited 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/dredging 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=fn2JXmCUo3O

2.5.3 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 (Convention on Biological Diversity).

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 coastlines, 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.

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.

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

2.5.4 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.

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.

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.

Case Study: 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

2.5.5 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.

2.5.6 Marine debris[7]

Oceans are filled with things that do not belong there, such as huge amounts of consumer plastics, metals, rubber, paper, textiles, derelict fishing gear, vessels, and other lost or discarded items.

Marine debris is defined as any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes. Marine debris is a global problem, and is a threat to our environment, navigation safety, the economy, and human health.

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.

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.

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

- **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 domestic, medical and industrial waste products.
- **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:** Plastic is non-biodegradable and extremely durable. Days, weeks, and even decades in the ocean will do little to break down most plastics. Studies have found that it takes a plastic water bottle nearly 450 years to dissolve at sea. Plastic grocery bags, industrial pellets, and product packaging are all flowing into our waters every day.

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 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 seabirds, whale and turtle have been reported to have been tangled in plastic. Derelict fishing gear also causes damage to coral reefs when nets or lines get snagged by the reef and they break off.

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.

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.

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.

MARINE DEBRIS AROUND THE WORLD

Litter enters the sea from land-based sources, from ships and other installations at sea, from point and diffuse sources, and can travel long distances before being deposited. While plastic typically constitutes a lower proportion of the discarded waste, it represents the most important part of marine litter with sometimes up to 95 % of the waste, and has become ubiquitous even in remote polar regions (Galgani et al 2015).

SOLUTIONS

Tackling marine debris will require behavioral change via a mix of education, incentives, and regulation. Human behaviour needs to change from the current throwaway culture being status quo, and accountability is a fundamental ingredient in this change. Media has an important role to play in explaining the people the negative impacts of marine debris, and making them aware on how intentionally and unintentionally one is contributing to this global problem, and sharing the possible 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.

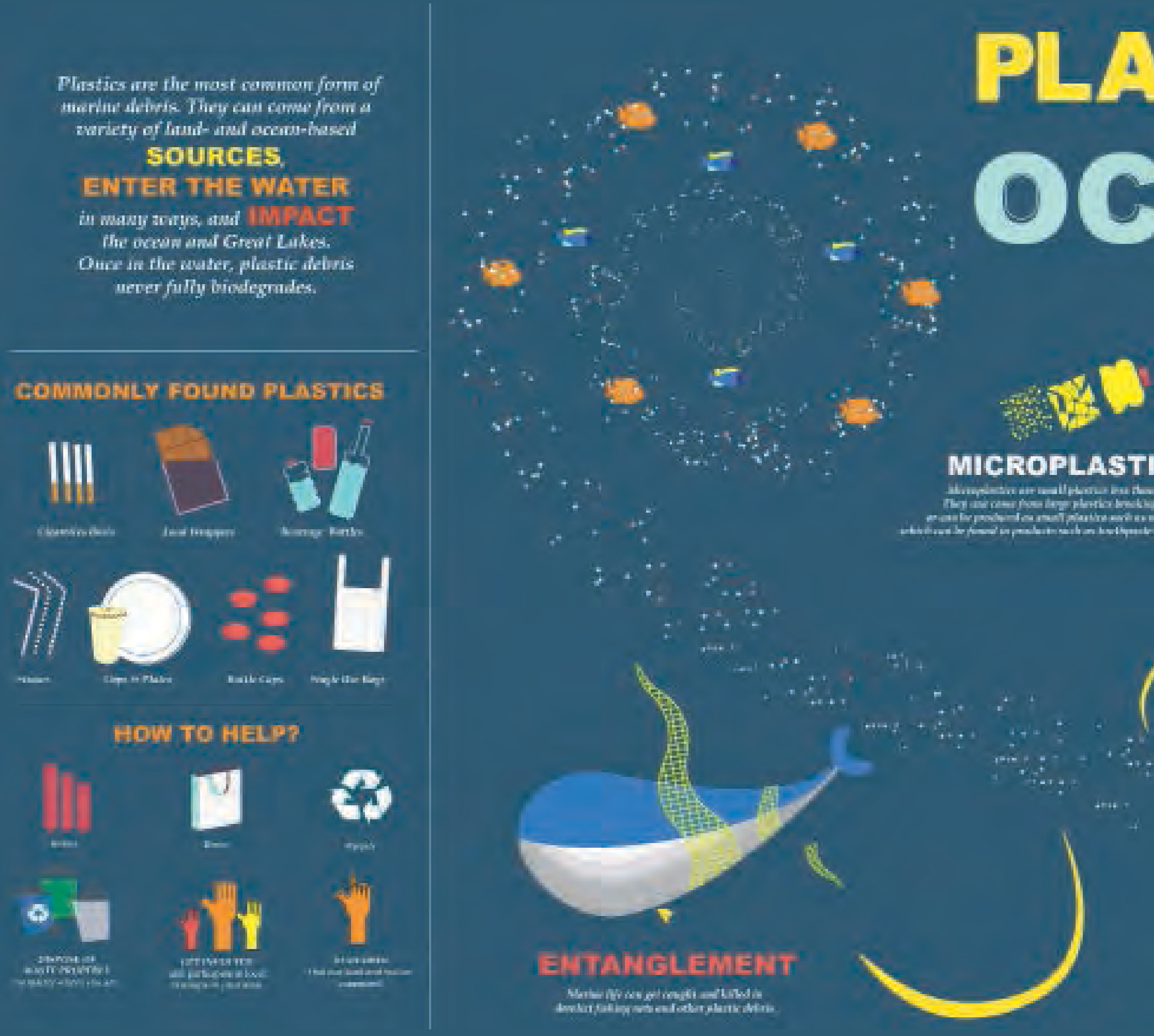
Case Study: Fishing for Litter

Fishing for Litter is a German initiative in cooperation with fisheries associations. Fishermen bring ashore, voluntarily, all the litter that was collected in their nets during the normal fishing operations. There is no financial compensation for this engagement. The disposal logistics, however, are for free. The project started in 2000, in two harbours on the Baltic Sea. Today, six harbours and about 60 fishermen have joined the scheme. They are given special big plastic bags to store the litter collected at sea.

All litter collected is analysed in cooperation with partners from the waste industry in order to investigate its composition, amount and potential recyclability.

Source: MARLISCO

www.marlisco.eu/fishing-for-litter-in-germany.en.html


PLA
OC
Plastics are the most common form of marine debris. They can come from a variety of land- and ocean-based
SOURCES,
ENTER THE WATER
in many ways, and IMPACT
the ocean and Great Lakes.
Once in the water, plastic debris never fully biodegrades.
COMMONLY FOUND PLASTICS
HOW TO HELP?
MICROPLASTI
ENTANGLEMENT
Marine life can get caught and killed in derelict fishing nets and other plastic debris.

ASTICS
IN THE
CEAN
BOATS/NETS
Fishing gear can become marine debris when it is lost or abandoned.
ICS
INGESTION
Animals can easily mistake plastic debris for food.
RAIN & WINDS
LITTERING
Intentional littering or improper disposal of trash can cause marine debris.
STREAMS & STORM DRAINS
https://marinedebris.noaa.gov/

2.5.7 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/

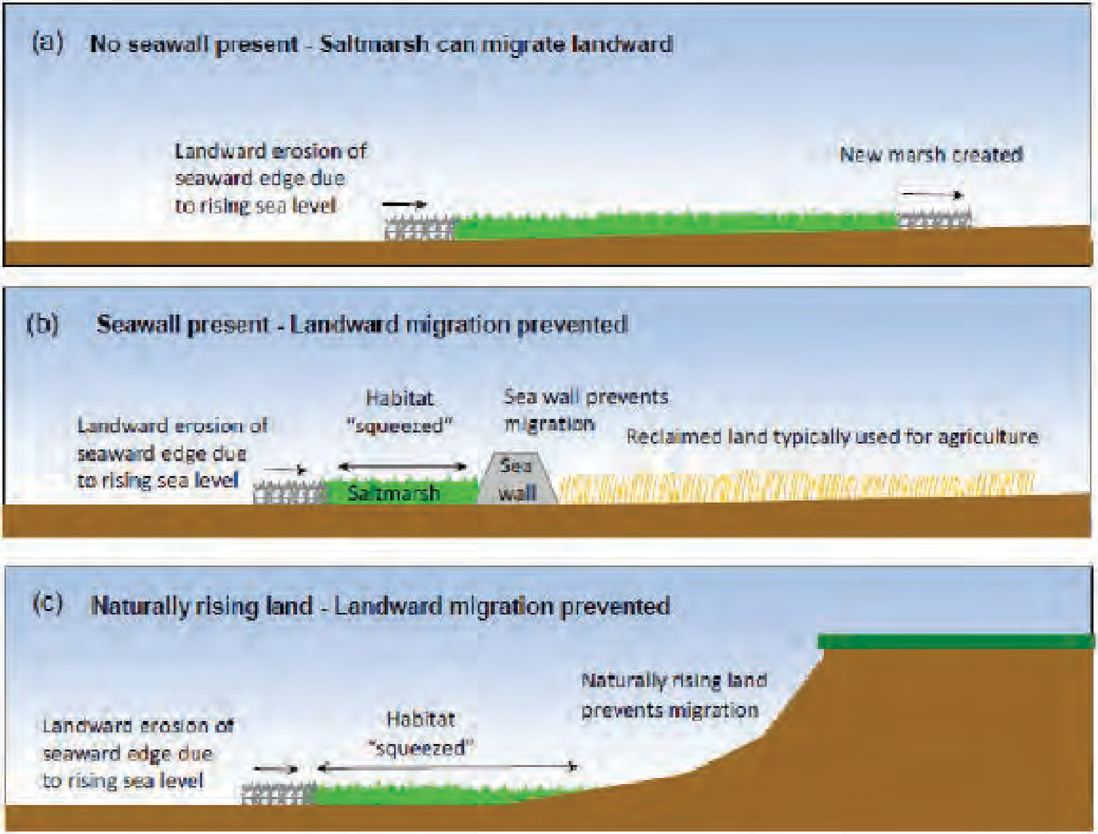


Figure 2.5: A simplified illustration of coastal squeeze as defined by Doody (2012). (a) Unrestricted landward translation of saltmarsh habitat in low lying areas, which maintains coastal habitat extent – sometimes referred to as natural transgression or rollover. (b) Landward translation of saltmarsh is prevented by a sea defence, which results in a reduction in the width of saltmarsh – the most common definition of coastal squeeze. (c) Landward translation of saltmarsh is prevented by rising land, which results in a reduction in the width of saltmarsh – occasionally referred to as 'natural coastal squeeze' by some authors. [Source: Defining coastal squeeze: A discussion (PDF Download Available). Available from: https://www.researchgate.net/publication/259512642_Defining_coastal_squeeze_A_discussion

2.5.8 Vulnerability to climate change and natural disasters

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.

2.6 The root cause of conflicts : Trade-offs and low levels of awareness

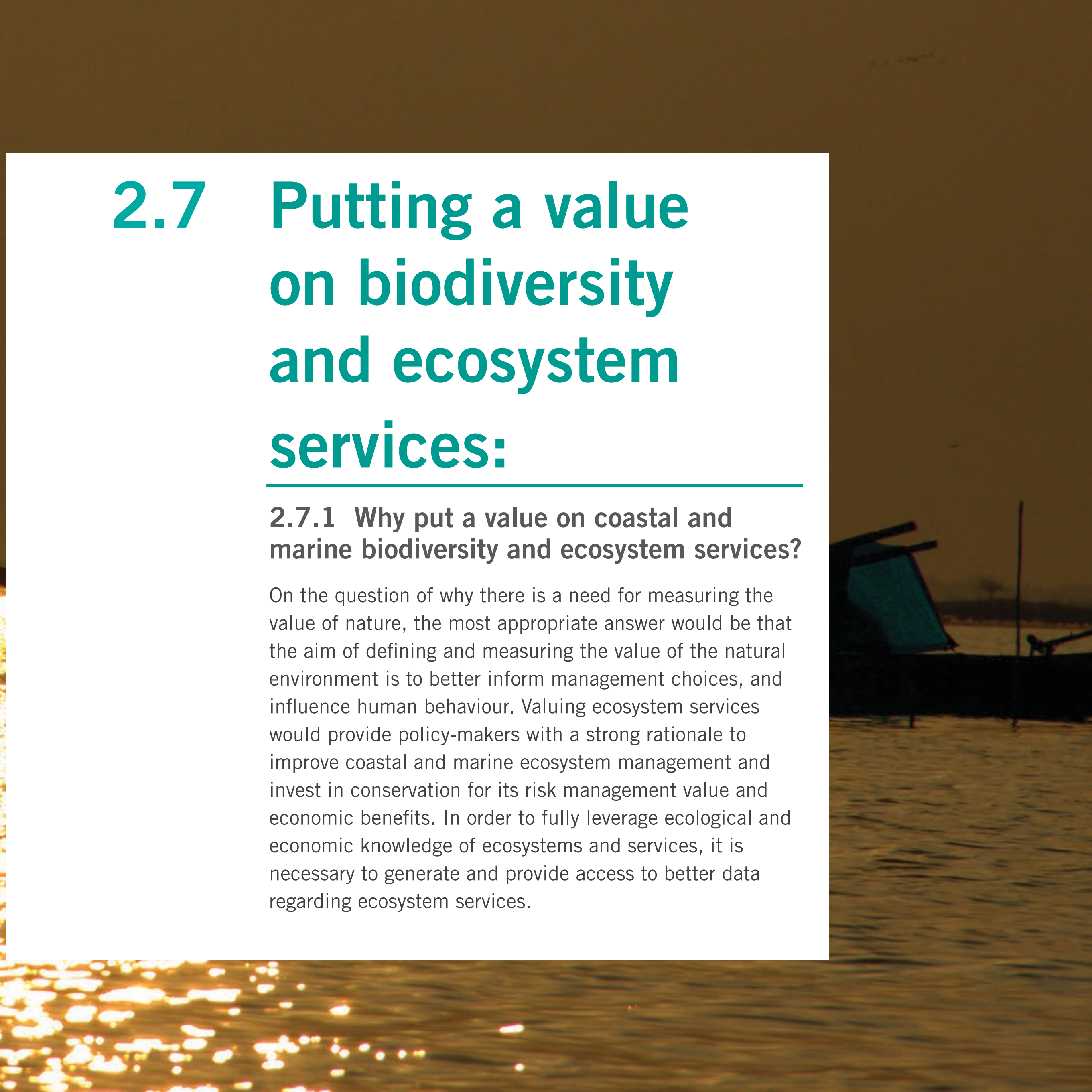
Stable and bio-diverse ecosystems provide multiple services, which interact in multiple ways. Some ecosystem services co-vary positively (an increase in one service means another also increases) and others co-vary negatively (an increase in one service means another decreases). Focusing on one ecosystem 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.

Marine and coastal ecosystems around the world are experiencing an increasing demand for their diverse ecosystem services for different sectors such as fisheries, tourism, biodiversity conservation, climate change, disaster management 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); this is known as a 'trade-off.'

Progress towards one objective such as increasing food production has often been at the cost of other objectives such as conserving biological diversity or improving water quality. A good example of these types of trade-offs is expansion of commercial shrimp farming leading to serious impacts on ecosystems, including loss of vegetation, deterioration of water quality, decline of capture fisheries and loss of biodiversity.

These trade-offs exist even within the 'green sector,' where large scale plantations of exotic species as a measure of carbon sequestration might lead to a situation of land degradation and habitat loss.

Traditional national accounts do not include measures of resource depletion or the degradation of these resources. A country could cut its forests and deplete its fisheries and this would show only as a positive gain in GDP, without registering the corresponding decline in assets (wealth). Losses in the natural world have direct economic repercussions that we systematically underestimate. Making the value of our natural capital visible to economies and society creates an evidence base to pave the way for more targeted and cost-effective solutions (TEEB 2009).



2.7 Putting a value on biodiversity and ecosystem services:

2.7.1 Why put a value on coastal and marine biodiversity and ecosystem services?

On the question of why there is a need for measuring the value of nature, the most appropriate answer would be that the aim of defining and measuring the value of the natural environment is to better inform management choices, and 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, it is necessary to generate and provide access to better data regarding ecosystem services.

Measurement of ecosystem services and their values to humans is rapidly becoming the principal means of communicating the impacts of ecological change on human well-being.

The ultimate aims of defining and measuring the value of the natural environment are to better inform management choices and/or influence human behaviour. There are two main types of reason for valuing ecosystem services:

- To assess the costs and benefits of an action or policy, as an aid to decision making
- To improve our understanding of the value of benefits to society from an ecosystem or series of linked ecosystems.

Ecosystem valuation can assist in a wide range of tasks, including:

- Demonstrating and communicating the importance of an ecosystem;
- Guiding national development plans;
- Policy, programme and project appraisal
- Setting priorities within a sector plan or across different sectors
- Green national and corporate accounting
- Setting a framework to establish market-based instruments such as taxes, charges, fees, fines, penalties, subsidies and incentives and tradable permit schemes
- Determining liability and compensation in environmental litigation.

The choice of valuation method used in a practical situation can depend on the governance scale, decision context, scientific understanding, and various other factors.

2.7.2 What are the values of coastal and marine biodiversity and ecosystem services?

Marine and coastal resources provide millions of impoverished people across the globe with livelihoods and a 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. They provide many services to human society and are of great economic value (UNEP, 2006). The Indian coasts support about 30 per cent of the human population of 1.2 billion (TII, 2014).

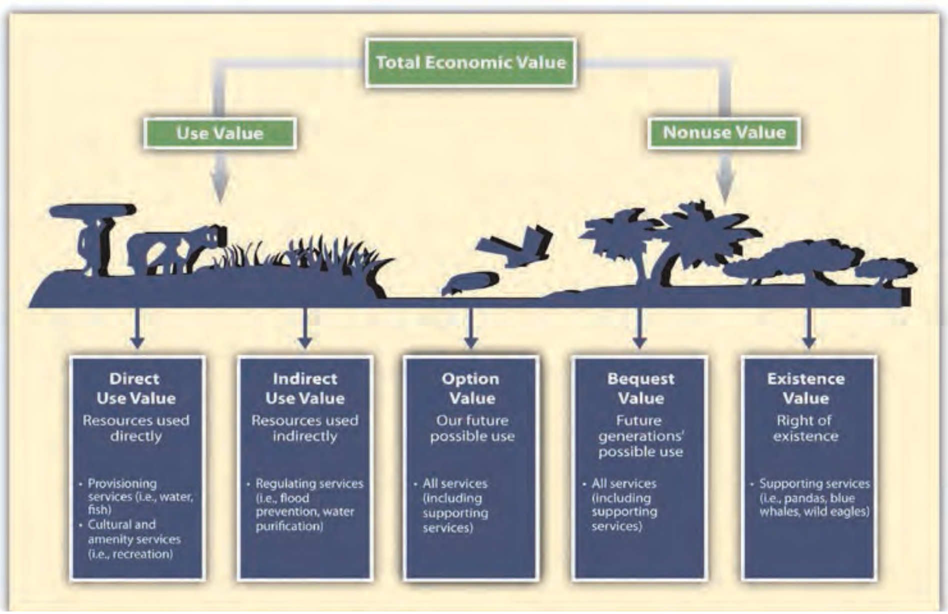


Figure 2.6 : Ecosystem goods and services and their value[8]

8 Source: UN Food and Agricultural Organization, "What Are Ecosystem Services)

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, 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 an ecosystem or residing in it.

INDIRECT USE VALUES

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

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 values to the extent that they are not used now but may be used in the future.

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).

2.7.3 Valuation methods and examples[9]

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 unit — 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. 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.

Bohol Marine Triangle Economic Valuation

On the question of whether to sustain the use of natural resources in the Bohol Marine Triangle (BMT) in the Philippines, a study was proposed to understand the economic benefits generated from coastal and marine habitats and ecosystems there. 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 per cent discount rate).This led to officials in allocating resources for maintaining the ecosystems of BMT.

9 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

Decision-making in the Stockholm archipelago

The decision-makers were faced with the specific issue of eutrophication (loss of dissolved oxygen in the water, due to high organic content) in the Stockholm archipelago. They carried out analysis of the benefits and costs of reducing eutrophication.

The analysis indicated 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.

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

MARKET-BASED TECHNIQUES[10]

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: *The Bohol Marine Triangle (BMT) in the Philippines 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 natural resources of BMT over a 10-year period was found to be US$11.54 million (with a 10 per cent discount rate).*

10 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]

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 an 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 the 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 1-metre increase in transparency, through a combination of measures including increased sewage water treatment and reduced fertiliser 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 indicated 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.*

STATED PREFERENCE TECHNIQUES

These methods are based on surveys in which people give valuation responses in hypothetical situations. Popular valuation methods include contingent valuation, choice experiments and value transfer.

2.7.4 Case studies on economic valuation of coastal and marine biodiversity[11]

MANGROVES OF THAILAND

Ecosystem services: Food production, wood products, coastal protection and fish nurseries

Valuation method: Market and production function approaches

Implications: Mangrove conservation is more beneficial than conversion for shrimp farms, but if non-linearities are taken into account, limited conversion for shrimp farming has relatively little effect on coastal protection.

Barbier et al. (2008)[12] demonstrate the practical importance of taking into account non-linear relationships between value and area. They show that using an average value for the storm protection value of mangroves in an area of Thailand ($1879 per hectare), mangrove conservation clearly dominates conversion for shrimp farms. However, using the marginal values, and therefore taking into account the fact that small reductions in mangrove area have relatively little effect on flood protection values, this result is nuanced: the highest values overall occur if there is, in this case, 20 per cent mangrove conversion for shrimp farms and 80 per cent conservation. Of course there is a strong spatial component to the value – the flood defence value of any given hectare depends strongly on where it is and what people and infrastructure it protects, as well as on the extent of the mangrove nearby: the 20 per cent earmarked for conversion should be carefully chosen to incur the smallest reduction in coastal protection values. Taking non-linear values into account is also very important in determining the appropriate level of mangrove restoration where

11 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]

12 Source: Barbier E.B. et al. (2008) Coastal ecosystem-based management with nonlinear ecological functions and values. Science, 319: 321–323

they have already been destroyed. Barbier (2009)[13] reports restoration costs with a present value of around $9000 per hectare. Considering the average value of flood protection (present value around $11000 per hectare) would suggest that restoration is profitable. Looking at marginal values would reveal the more accurate conclusion that it is profitable up to a point. This reasoning can help ensure that scarce resources for restoration and conservation activities are optimally allocated.

VALUATION FOR GUINEA CURRENT LARGE MARINE ECOSYSTEM

Ecosystem services: Range of the most important services

Valuation method: Market and value transfer approaches

Implications: Demonstration of major benefits from the marine ecosystem accruing to human populations

The Guinea Current Large Marine Ecosystem (GCLME) valuation project[4] aimed to develop an initial assessment of the costs and benefits deriving from conservation at the large scale of an entire LME. The 16 GCLME countries face issues of unsustainable fisheries and marine resource management generally and degradation of marine and coastal ecosystems by human activities. To combat the resulting environmental and social problems, environmental and sustainability concerns must be integrated into policies and decision making, and economic valuation of ecosystem services is one important step towards this. Given time and resource pressures, the benefits of using a value transfer approach were considered to outweigh the costs of possible inaccuracies in this approach. The valuation is based on the current flow of ecosystem services, raising awareness of current flows and providing the background and motivation for conservation initiatives and specific policy options (which may require separate, more detailed cost benefit calculations).

13 Source: Barbier, E.B. (2009) Ecosystems as natural assets. Foundations and Trends in Microeconomics, 4: 611–681

Ecosystem services valued in the study include:

- Fisheries
- Fish nurseries
- Tourism
- Timber and non-timber forest products
- Flood and erosion control
- Sewage treatment
- Drinking water
- Carbon sequestration
- Biodiversity and other non-use

Overall, the 253 million hectare area is estimated to yield annual benefits of $14 billion from marine environments (mostly from fisheries) and $3.5 billion from coastal environments (mostly fish nurseries, coastal protection and tourism). The estimates are used to demonstrate the importance of marine and coastal environments to the human populations living around it, feeding / leading in to work on policy instruments for conservation and resource management. In addition to the aggregate value estimates, some headline calculations are presented with clear policy relevance: for example, it is estimated that 1 hectare of destroyed mangrove ecosystem in the GCLME represents losses of US$32,000 (4 per cent discount rate) to US$38,000 (3 per cent discount rate).

VALUATION FOR THE ‘PLAN BLEU’ IN THE MEDITERRANEAN

Ecosystem services: Six key services

Valuation method: Value added, avoided cost, value transfer

Implications: Demonstration of important benefits, their distribution across countries and also data gaps.

High levels of exploitation and other human activities, coupled with climate change, are threatening sensitive biodiversity and habitats in the Mediterranean. In addition to conservation concerns, the human and economic costs are potentially very significant. To illustrate this, the Plan Bleu has carried out research to establish a first estimation of the annual value of economic benefits flowing from the whole Mediterranean marine environment. Six types of marine ecosystems were studied, each characterised by the biodiversity and surface they cover and the ecological services they provide. The economic valuation of the benefits those ecosystems provide, focused on six ecological services: production of food resources, amenities, support to recreational activities, climate regulation, mitigation of natural risks and waste assimilation.

At the regional level, the aggregate value amounted to over €26 billion in 2005, an average of about €10,000 per square kilometres per year, though this varies significantly across different habitats and areas. And, due to a lack of data, the value of benefits from ecological services provided by marine ecosystems in the Mediterranean was probably underestimated. The distribution of the value by benefit type shows that 68 per cent of the benefits would come from the provision of amenities and recreational support (€18 billion). The distribution of the value of benefits by country shows that eight countries would capture about 90 per cent of the value of benefits provided by marine ecosystems: Italy, Spain, Greece, France, Turkey, Israel, Egypt and Algeria.

VALUATION AND COST-BENEFIT ANALYSIS FOR THE BLACKWATER ESTUARY

Ecosystem services: Several specific services and a composite ‘environmental quality’ benefit

Valuation method: Market, production function and stated preference, in cost-benefit framework

Implications: The benefits of managed realignment scenarios exceed costs when non-market ecosystem service values are taken into account.

Luisetti (2008)[14] uses Cost-Benefit Analysis (CBA) methods to assess four different options for the Blackwater Estuary, in East England, with varying levels of managed realignment and habitat creation: ‘hold the line’, ‘policy targets’ (PT) (meeting existing targets), ‘deep green’ (DG) and ‘extended deep green’ (EDG). Market prices are used to value coastal defence work (costs avoided), fisheries (modelled via a production function) and agricultural land lost (after adjustment for subsidies). Three carbon price estimates are used for the carbon, methane and nitrous oxide fluxes. A stated preference study is used for a ‘composite environmental benefit’ that is intended to cover a wide range of impacts without double-counting: recreation, aesthetics, water quality and biodiversity. The study breaks total value down into use and non-use components, and the aggregation methods allowed for a distance-decay and nonlinear relationship with wetland area. Thus the estimates for the composite environmental benefit showed the diminishing marginal value of provision of additional areas of high environmental quality: in the PT scenario (81.6 hectares wetlands) the value estimate is £6.3 million per year of which £4.4 is use value; in the DG scenario, with 10 times more wetlands, the value is only a little higher at £7.7 million per year, of which £5.8 million is use value, while in the EDG scenario, with 30 times more wetland than PT, value is £8.3 million per year of which £6.4 million is use value. The results of the CBA show that managed realignment can be cost-beneficial if non-marketed benefits are accounted for, particularly for conservation and recreation. With a constant 3.5 per cent discount rate, the highest Net Present Value is the ‘deep green’ scenario (£106 million over 25 years, £192 million over 100 years); much higher values arise using a declining discount rate, making the ‘extended deep green’ scenario preferable (because the lower discounting of long-term future makes it easier for long-

14 Source: Luisetti (2008) A policy analysis for the Blackwater estuary. In Alternative economic approaches to the assessment of managed realignment coastal policy in England (doctoral dissertation). University of East An glia.

term environmental benefits to outweigh near-term costs). The study is well grounded in scientific analyses of fisheries and sediment transport and is exemplary in exploring sensitivities to different time horizons, discount rates, values and assumptions.

WADDEN SEA ESTIMATES OF EXPENDITURE

Ecosystem services: Recreation and tourism

Valuation methods: Expenditure and employment (not estimates of Total Economic Value)

Implications: Demonstrates importance of national park tourism to local/regional economy

WWF (2008)[15] report on the Wadden Sea National Park as an example of a tourist-based economy, with over 10 million tourists per year. They stress the added value arising through tourists' additional expenditures, stating that tourists who visit the area purely because of the national park generate a regional added value of about US$5,050,000, corresponding to 280 full time jobs. Furthermore, tourists for whom the national park plays an important (but not exclusive) role in their choice of destination generated added value of US$131,000,000 or about 5.900 full time jobs. However, these expenditures are related to the national park as a whole, and it is difficult to determine the extent to which specific marine ecosystems services and/or aspects of biodiversity influence tourists' decisions.

15 Source: WWF (2008) The value of our oceans: the economic benefits of marine biodiversity and healthy ecosys tems. Frankfurt am Main: WWF Germany. pp. 21.

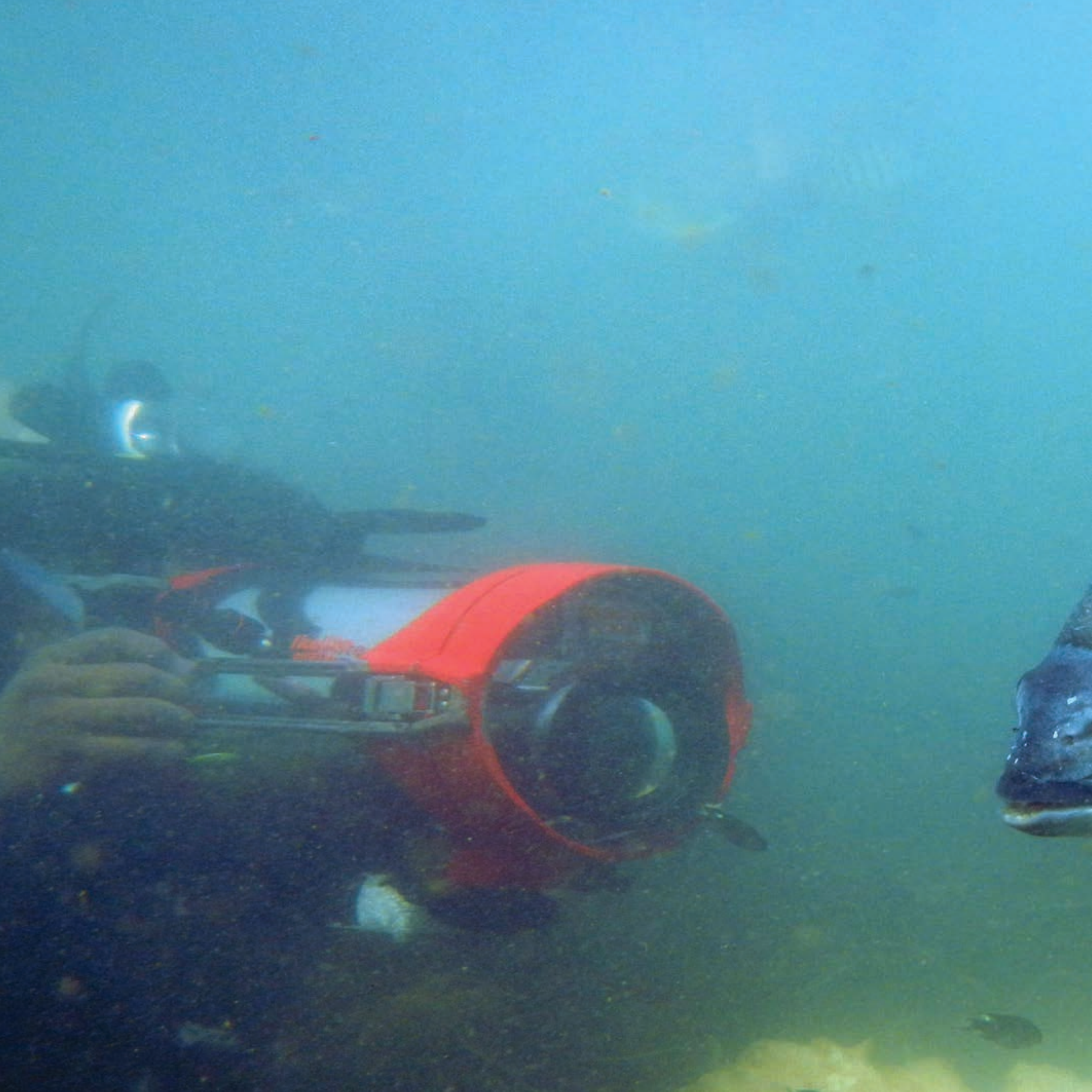



Photo by: Dr. Sarang Kulkarni

2.7.5 Applicability of valuation methods to coastal and marine ecosystem services[16]

Valuation method	Value captured	Points to note	Ecosystem services
Market based approaches: based on market prices and other data			
Market prices	Direct use values	Adjust for costs, subsidies, taxes	Provisioning services, provided these are marketed, e.g. fisheries, aquaculture, renewable energy, aggregates, fossil fuels
Market proxies	Direct use values	Adjust for costs, subsidies, taxes	Where a service is not marketed, one can sometimes use a proxy market value: for example, valuing subsistence fishing at the market value of fish
Production functions	Use values	Data hungry	For example, nursery habitat for fisheries is often valued via a production function
Cost of illness	Varies depending on how health impact is valued	Production function linking change to health impact	Any ecosystem change that impacts on human health or mortality (e.g. wastewater treatment)
Avoided costs	Cost, not value	Presumes replacement would be appropriate	For example, the cost of recreating coastal wetlands to compensate for losses
Revealed preference methods: based on actual behaviour			
Hedonic property pricing	Use values within home	Depends on awareness of impacts	Seascapes, amenities, peace and quiet, general environmental quality
Travel cost	Use values for recreation	Based on visits to a site	Recreation and ecosystem services that contribute to it
Random utility model	Use values for recreation	Based on choice among sites	Recreation and ecosystem services that contribute to it
Stated preference methods: based on hypothetical behaviour			
Contingent valuation	All use and non-use	Based on pricing single option	All services. The only methods able to estimate non-use values. Often used for biodiversity, cultural and heritage values
Choice modelling	All use and non-use	Based on choice from options	Same as for "contingent valuation"

16 Source: UNEP-WCMC (2011) Marine and coastal ecosystem services: Valuation methods and their application. UNEP-WCMC Biodiversity Series No. 33. 46 pp

‘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.

Put a Value on Nature! Pavan Sukhdev TED Talk
http://www.youtube.com/watch?v=oU9G2E_RYJo

Main sources

Andrews, G. Montana State University, USA, http://serc.carleton.edu/NAGTWorkshops/health/case_studies/plastics.html.

Anonymous. 2010. The impacts of plastic pollution in the North Pacific Ocean and possible solutions.

Barbier, E. B., et al. 2008. Coastal ecosystem-based management with nonlinear ecological functions and values. Science 319:321–323.

Barbier, E.B. (2009) Ecosystems as natural assets. Foundations and Trends in Microeconomics, 4: 611–681

CBD Factsheet on Ecosystem Services available at https://www.cbd.int/iyb/doc/prints/factsheets/iyb-cbd-factsheet-ecoservices-en.pdf

Chakraborty, S. B., Costal environment of Midnapore, West Bengal: Potential Threats and Management. Retrieved on 09th September, 2015 from http://re.indiaenvironmentportal.org.in/files/coastal%20environment.pdf

Chambers, R. and Conway, G. 1991: Sustainable Rural Livelihoods: Practical Concepts for the 21st Century'. Discussion Paper 296. Brighton: IDS

Chambers, R. and Conway, G.R. (1991). Sustainable Rural Livelihoods: Practical Concepts for the 21st Century. Institute of Development Studies DP 296, 1991. University of Sussex: Brighton.

Chambers, R., Conway, G. (1991). Sustainable rural livelihoods: Practical concepts for the 21st century. Discussion Paper 296. IDS, Brighton.

FAO. © 2005-2012. Fisheries and Aquaculture topics. Types of ecosystems. Topics Fact Sheets. Text by J.J. Maguire. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 27 May 2005. [Cited 26 September 2012]. http://www.fao.org/fishery/topic/12273/en

FAO. 2005–2012. Fisheries and aquaculture topics. Types of ecosystems. Topics fact sheets. Text by J.J. Maguire. Rome. Updated 27 May 2005. (Cited 26 September 2012) http://www.fao.org/fishery/topic/12273/en

Groom, M.J., Meffe, G.K., Carroll, C.R. and contributors. 2005. Principles of Conservation Biology (third edition). Sinauer Associates.

Gupta, P., (2005). Underground Water Development in India – Trends, Crops (Report). Kellogs-School of Management. Retrieved on 20 September, 2015 from http://www.gopio.net/india_development/Water_Study_NU_2005.pdf

Hunter, M.L. 2002. Fundamentals of Conservation Biology (second edition). Blackwell Science, Malden, MA.

India-WRIS Wiki : Water resource Information System of India. Retrieved on 17th September, 2015 from http://www.india-wris.nrsc.gov.in/wrpinfo/index.php?title=River_Info

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

Joshi, K. K., Marine Biodiversity of India– A Perspective for RFM Central Marine Fisheries Research Institute. Retrieved on 20 September, 2015 from http://eprints.cmfri.org.in/9831/1/ICT_Oriented_Strategic_Extension_for_Responsible_Fisheries_Management_Manual-61-79.pdf

Khera, N. (2013). Sustainable Management of Marine and Coastal Protected Areas: Taking an Inclusive Approach Technologies and their applications in sustainable use and conservation of coastal and marine protected areas in India. In Sivakumar, K. (Ed.) Coastal and Marine Protected Areas in India: Challenges and Way Forward, ENVIS Bulletin: Wildlife & Protected Areas. Vol. 15 Wildlife Institute of India, Dehradun-248001, India. 264-273 pp

Luisetti T, Turner RK, Bateman IJ, Adams C, Fonseca L. 2008. An Ecosystem Services Approach for Assessing Managed Realignment Coastal Policy in England, CSERGE Working Paper. University of East Anglia: Norwich

Mengerink, K., A. Schempp, and J. Austin. (2009). Ocean and coastal ecosystem-based management: implementation handbook. Environmental Law Institute, Washington, D.C., USA. [online] https://www.eli.org/sites/default/files/eli-pubs/d19_03.pdf

Millennium Ecosystem Assessment -MEA. (2005). Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC

Munich, GRIN Publishing. http://www.grin.com/en/e-book/157133/the-impacts-of-plastic-pollution-in-the-north-pacific-ocean-and-possible.

MEA. Marine Fisheries Systems (Chapter 18), http://www.maweb.org/documents/document.287.aspx.pdf.

Parikh et al. 2012. The Economics of Ecosystems and Biodiversity—India. Initial assessment and scoping report. Working document. MoEF.

Plastic debris in the world's oceans: http://www.unep.org/regionalseas/marinelitter/publications/docs/plastic_ocean_report.pdf

Savarkar,V. B. 2013, current status of coastal ecosystem management, disaster risk reduction and climate change adaptation in India. In Sivakumar, K. (ed.) Coastal and marine protected areas in India: challenges and way forward, ENVIS bulletin: wildlife & protected areas. Vol. 15 Wildlife Institute of India, Dehradun-248001, India. 242 - 263 pp.

Sukhdev, P. (2011). Putting a Price on Nature: The Economics of Ecosystems and Biodiversity. Solutions. Vol 1, No. 6. pp. 34-43 - http://www.thesolutionsjournal.com/node/823

Secretariat of the Convention on Biological Diversity. 2009. Connecting Biodiversity and Climate Change Mitigation and Adaptation. Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change. Technical Series No. 41. Montreal. 126 pp.

UNEP Regional Seas Information Series: Technical Analysis for Policymakers on Issues Related to Protection of the Marine and Coastal Environment, http://www.unep.org/regionalseas/publications/series/unep-rsp-info-series.pdf.

UNEP. 2009. Sustainable coastal tourism: An integrated planning and management approach. http://www.unep.fr/shared/publications/pdf/DTIx1091xPA-SustainableCoastalTourism-Planning.pdf, downloaded on 24 September 2012.

UNEP-WCMC (2011) Marine and coastal ecosystem services: Valuation methods and their application. UNEP-WCMC Biodiversity Series No. 33. 46 pp.

Venkataraman, K. and Sivaperuman, C. 2014. Marine Faunal Diversity in India: Taxonomy, Ecology and Conservation. Academic Press, 2014 ISBN 012801962X, 9780128019627. 546 pp.

The Aquatic Biome, http://www.ucmp.berkeley.edu/glossary/gloss5/biome/aquatic.html

Wilson, E.O. (ed.) 1988. Biodiversity. National Academy Press, Washington, DC, USA.

Further Resources:

Bjork, M., Short, F. and Beer M.S. 2008. Managing Seagrasses for Resilience to Climate Change.

Butler, C. D., and Oluoch-Kosura, W. 2006. Linking future ecosystem services and future human well-being.

Parikh et al. 2012. The economics of ecosystems and biodiversity–India. Initial Assessment and Scoping Report. Working Document. MoEFCC publication.

Ramakrishna, Sreeraj, C.R., Raghunathan, C., Sivaperuman, C., Yogesh Kumar, J.S., Raghuraman, R., Immanuel, T. and Rajan, P.T. 2010. Guide to Opisthobranchs of Andaman and Nicobar Islands. 196 pp.

Rao, M.U. 2010. Seaweeds of India. Nat. Symp. Mar. Plants Parangipettai, 5–6 pp.

Roy, A. & Ghosh, A. 2009. Ocean. Published by Sheuli Chatterjee, Sa Explorer's Institute, Kolkata, 256 pp.

Ruddle, K., Morgan, W.B. and Pfaffl in, J.R. 1988. The Coastal Zone: Man's Response to Change. Harwood Academic Publishers, Chur, Switzerland. 555 pp.

Sawarkar, V.B. 2013. Current status of coastal ecosystem management, disaster risk reduction and climate change adaptation in India. In Sivakumar, K. (ed.), Coastal and marine protected areas in India: challenges and way forward. ENVIS Bulletin: wildlife & protected areas. Vol. 15. Wildlife Institute of India, Dehradun-248001, India. pp. 242–263.

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

Sivakumar, K. (ed). Coastal and marine protected areas in India: challenges and way forward. ENVIS Bulletin: wildlife & protected areas. Vol. 15. Wildlife Institute of India, Dehradun-248001, India. Middleton, N. 1999. The Global Casino: An Introduction to Environmental Issues (second edition). Arnold, London, UK. 370 pp.

Smith, J.B., Rahman, A., Haq, S. and Mirza, M.Q. 1998. Considering Adaptation to Climate Change in the Sustainable Development of Bangladesh. World Bank Report. World Bank, Washington, D.C. 103 pp.

UNISDR/UNDP. 2012a. A Toolkit for Integrating Disaster Risk Reduction and Climate Change Adaptation into Ecosystem Management of Coastal and Marine Areas in South Asia. Outcome of the South 44 Asian consultative workshop on Integration of Disaster Risk Reduction and Climate Change Adaptation into Biodiversity and Ecosystem Management of Coastal and Marine Areas in South Asia, held in New Delhi on 6 and 7 March 2012. New Delhi: UNDP. xiii + 173 pp.

UNISDR/UNDP. 2012b. Review Paper—Status of Coastal and Marine Ecosystem Management in South Asia. Inputs of the South Asian Consultative Workshop on Integration of Disaster Risk Reduction and Climate Change Adaptation into Biodiversity and Ecosystem Management of Coastal and Marine Areas in South Asia, held in New Delhi on 6 and 7 March 2012. New Delhi: UNDP. x + 181 pages.

Venkataraman and Sivaperuman. 2014. Marine Faunal Diversity in India (first edition). Taxonomy, Ecology and Conservation. Academic Press Print Book. ISBN 9780128019481. 546pp.

Website of TEEB: http://www.teebtest.org