



Review Article

Indian J Med Res 153, March 2021, pp 382-387

DOI: 10.4103/ijmr.IJMR_695_21

Coastal ecosystem services & human wellbeing

Ahana Lakshmi

National Centre for Sustainable Coastal Management, Anna University Campus, Chennai, Tamil Nadu, India

Received March 2, 2021

Coastal areas are home to diverse ecosystems that provide essential goods and services for human wellbeing. Recognition, understanding and appreciation of the various goods and services provided by coastal ecosystems, especially the provisioning and cultural services are of utmost importance today. Systematic exploration of bioactive compounds from marine flora and fauna and deriving pharmaceuticals and nutraceuticals, as well as promotion of concepts such as the blue gym are essentially linked to human health and sustenance, necessitating measures towards preservation of these ecosystems. They also link Sustainable Development Goals, SDG 3: good health and wellbeing and, SDG-14: life below water.

Key words Coast - cultural services - ecosystem services - health - wellbeing - provisioning

Introduction

The coast is a highly dynamic interface between land and sea influenced by land-based and oceanic processes¹. India has a long coastline of 7516.6 km². About a sixth of India's population lives along the coast as these areas are also the preferred location for a large number of settlements including some Indian megacities. Coastal areas are also well known for their beaches that attract millions for recreation and sport as well as for other ecosystems such as mangrove wetlands (Sundarbans), mudflats, seagrass meadows and coral reefs¹. Coastal ecosystems act as a natural defense against high tides, tsunami and cyclones that have a large destructive potential¹ and provide a number of goods and services that contribute and support human needs³.

A need to better understand various ecosystem services and the ecosystems that provide these services

is accentuated in the recent times, especially due to climate change impacts as well as the COVID-19 pandemic^{4,5}. Hence this review is aimed at looking at the coastal ecosystem services with a focus on their contribution to human health and wellbeing.

Coastal Ecosystems

Ecosystems are functional units in which biotic and abiotic components interact dynamically³. Along the Indian coast (as throughout the world), a variety of ecosystems are seen based on the interaction between local geomorphology and ocean processes. These ecosystems possess rich biodiversity with high productivity and have evolved to exist in a complex of environmental circumstances that include tides, currents and wave action as well as nutrients and other chemicals brought down through riverine inputs¹. Such ecosystems include estuaries, deltas, lagoons, mangrove wetlands, beaches, seagrass meadows,

seaweed beds and coral reefs. The area under various natural coastal wetlands in India as estimated by the Space Application Centre⁶ and are given in Table I. Many of the well known coastal ecosystems, considered ecologically sensitive are protected by the Coastal Regulation Zone (CRZ) Notification (2019)⁷ issued under the Environment (Protection) Act, 1986. These are considered as CRZ - Class I, where minimal disturbance to the environment through development activities is permitted. Such ecosystems, *inter alia*, include mangroves, corals and coral-reefs, sand dunes, mudflats, salt marshes, horse-shoe crab habitats and seagrass beds.

Among the coastal ecosystems, sandy beaches, mangroves, seagrasses and coral reefs are perhaps best known. Mangroves are salt-tolerant coastal trees or shrubs found in tropical and sub-tropical inter-tidal regions, often growing in water-logged regions⁸. Indian mangroves are broadly classified into tide dominated such as mangroves of the Mahanadi delta, river dominated as in the case of Godavari and drowned river-valley seen in Gujarat⁹. After the 1999 super-cyclone that hit Odisha and the 2004 Indian Ocean tsunami that affected large parts of the east coast, the role of mangroves as barriers to storm surges as well as rising sea levels has been better appreciated¹⁰. From Indian mangrove habitats, 46 true mangrove species belonging to 14 families and 22 genera have been recorded¹¹. Seagrasses, submerged marine flowering plants occurring in shallow oceanic and estuarine habitats, and colonizing sandy/muddy substrates (especially in wave-sheltered conditions) are like mangroves, serving as sediment stabilizers^{12,13}. In India, seagrass meadows are extensive in the Gulf of Mannar and Palk Bay, Chilika Lake, Gulf of Kachchh and the lagoons of Lakshdweep Islands. In the Gulf of Mannar alone, 13 of the 14 species found in India have been recorded¹⁴. Sandy beaches are found all along the coast and attract

large crowds for recreation and many stretches also serve as turtle nesting grounds. Biologically active mud flats are another important ecologically sensitive area that are protected under the CRZ. Along the east coast, in certain stretches from Andhra Pradesh to West Bengal, mudflats and mangroves are the habitat for horseshoe crabs, highly valued in medical research¹⁵.

Ecosystem Services

A large number of goods and services are provided by the environment around us, specifically, the various ecosystems. Some of these goods are easily recognized while the recognition for many others which are relatively less apparent has come over time. The former include food, timber and freshwater while the latter include varied services ranging from pollination to disease control and climate regulation. An early valuation¹⁶ for the current economic value of 17 ecosystem services for 16 biomes brought up a value in the range of USD16-54 trillion annually, this was, however, estimated to be a conservative value¹⁷. In 2014, the estimated value for the total global ecosystem services in 2011 was revised to USD125 trillion/yr. These numbers are more for us to understand the value that ecosystems provide and therefore the cost incurred in replacing such services which are otherwise freely available to mankind. Efforts to set a monetary value to the services provided by the various ecosystems is a difficult exercise as each ecosystem may provide certain services locally, and others globally. For example, mangrove ecosystems along a coast may provide the habitat for fish and shellfish that are caught and consumed locally (and hence considered local services) in contrast with the oxygen released by mangrove trees into the atmosphere and the carbon they sequester which are considered global services. The list of services that ecosystems provide can be long and confusing and hence, for meaningful understanding, they need to be classified.

The Millennium Ecosystem Assessment³ describes ecosystem services as the benefits people obtain from ecosystems and categorised the various services from ecosystems into four major groups namely, provisioning, regulating, cultural and supporting services (Figure): (i) Provisioning services include goods such as food, timber, medicines *etc.*; (ii) Regulating services include benefits such as flood control and water purification; (iii) Cultural services are the non-material benefits such as spiritual enrichment as well as recreation and

Table I. Area under coastal wetland ecosystems

Coastal Wetland Ecosystem	Area (in ha)
Lagoon	246044
Creek	206698
Sand/Beach	63033
Intertidal Mudflat	2413642
Salt Marsh	161144
Mangrove	471407
Coral Reef	142003

Source: Ref 6; ha, hectare

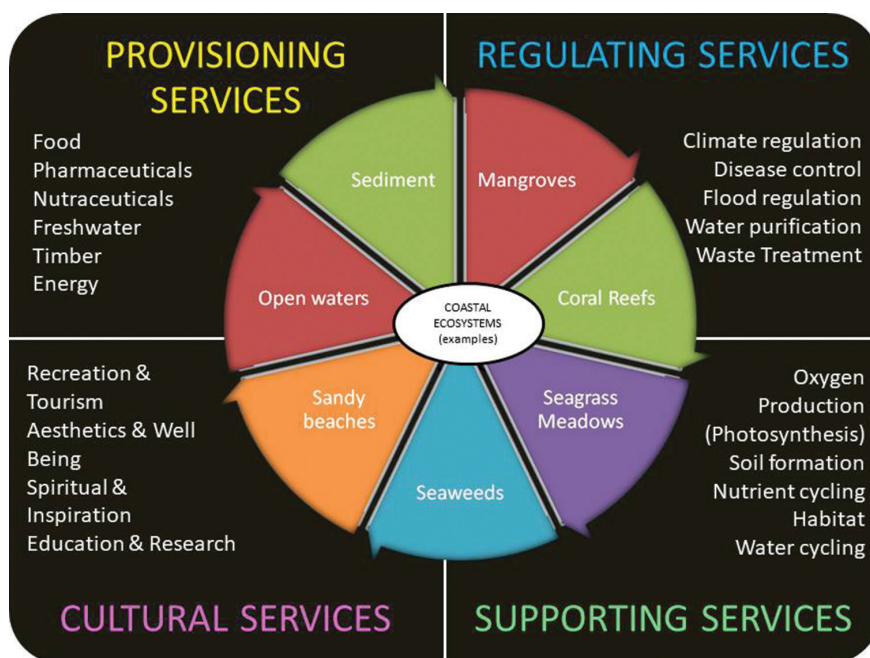


Figure. Ecosystem Services provided by Coastal Ecosystems.

education while; (iv) Supporting services are those that are necessary for the functioning of all other ecosystem services and can range from primary production to nutrient cycling and provision of habitat.

With respect to coastal ecosystem services, some of the key services from a few important coastal ecosystems are presented in Table II.

Subsequently, the global initiative, The Economics of Ecosystems and Biodiversity (TEEB), is an effort towards mainstreaming the values of biodiversity and ecosystem services at all levels of decision making, to take into account the natural capital, which includes all natural assets, living and non-living (<https://naturalcapitalforum.com/>), into a country's wealth calculation. According to the TEEB report¹⁸ ecosystem services may be likened to the dividend received by the society from the natural capital. It therefore stands to reason that to receive a regular dividend and ensure human well-being, natural capital needs to be protected.

Human well-being and ecosystem services

Understanding of the role of ecosystem services highlights the role of natural assets as essential for well-being, and sustainability¹⁶. While all the four groups of ecosystem services play an important role in human health and wellbeing, the provisioning and cultural services appear to take on a higher importance in terms of human health and wellbeing.

Provisioning services: Within this broad category, pharmaceuticals and nutraceuticals are of importance in the context of the current pandemic (also for the known and emerging diseases). The use of compounds extracted from marine animals such as cod and shark liver oil as health supplements is well known¹⁹. Other than being used as supplements, many organisms may also harbour compounds with various pharmacological properties for use as drugs²⁰.

From coastal ecosystems, perhaps the best known animal in medical research is the horse-shoe crab, two species of which are found along the north-eastern coast of India²¹. The blood of these crabs contains important immune cells used in the Limulus Amebocyte Lysate (LAL) test to for detecting endotoxins²². These crabs are however, under threat by over-exploitation²¹. In India, the habitat of these crabs is under threat and is classified as CRZ-I under the CRZ 2019 notification as mentioned⁷.

A number of studies have been carried out in mangroves for bioactive compounds. For example, it is reported that pharmacological investigations of various extracts from the plant *Excoecaria agallocha* have shown antibacterial, antioxidant, anti-diabetic, and anti-nociceptive activities²³. Others report that of 84 mangrove species, only 27 species were traditionally used for similar purposes²⁴. In the case of seagrass, *Halophila* spp. appear to have bioactive compounds^{25,26}. Though many metabolites

Table II. Goods and services available from coastal ecosystems

Coastal Ecosystem	Provisioning	Regulating	Cultural	Supporting
Mangroves	Fish & shellfish, medicines, honey, timber and forest products, fodder, groundwater recharge and discharge	Water quality maintenance, climate regulation, coastal protection through erosion control, flood and flow control, sediment and nutrient retention, shoreline stabilization, carbon sequestration	Ecotourism, spiritual, education and research, inspirational.	Biodiversity reservoir, gene bank, habitat for birds and other animals, maintenance of fisheries, habitat for spawning and juvenile fish, primary production, oxygen generation
Seagrass	Fish & shellfish, as food/fertilizer, medicines	Carbon sequestration, coastal protection, erosion control, water purification, sediment and nutrient retention	Recreation (boating, swimming), ecotourism, education and research	Habitat for fish/maintenance of fisheries, primary production, oxygen generation
Coral Reefs	Building materials, ornamental fish, coral for live trade, raw materials for medicines, seafood products, seaweed (agar, carrageenan) from rocks near reefs, shells (used to make jewellery, lime mortar)	Coastal protection (function like underwater breakwater), nutrient cycling	Education and research, recreation, tourism (e.g. snorkelling, diving)	Habitat for fish and shellfish, maintenance of fisheries
Sandy Beaches	Sand and minerals, water catchment and purification	Coastal protection, erosion control, protection from storm surge and tsunami, prevent seawater intrusion	Tourism, education and research, health benefits (Blue Gym)	Turtle nesting sites, habitat especially for burrowing organisms such as crabs and molluscs

with biological activities have been isolated from macroalgae (seaweeds), few products with real potential have been identified²⁷. This is a point to be documented in that there is potential for pharmaceuticals of marine origin, which is yet to be harnessed in an organised manner to contribute towards better health and wellbeing.

Cultural services: These are ecosystem services such recreation, tourism, spiritual inspiration and education provided by a number of coastal ecosystems. A positive association between self-reported health and living near the coast in England was reported previously²⁸. Worldwide, the move towards the coast is well recorded with increasing population of coastal settlements, especially cities, as many industries are located in close proximity of seaports while others prefer the more equitable climate of coastal locales. Among the coastal ecosystems, beaches perhaps rank at the top in terms of providing relaxation and recreation. In addition, boating in mangroves such as Sunderbans, Coringa or Pichavaram as well as boating in the open sea to observe corals and seagrasses through glass-bottomed

boats²⁹ have become preferred ecotourism options. Similarly, the concept of Blue Flag certified beaches³⁰ is also being promoted. Though these are targeted at specific tourist groups, encouraging visitors to beaches in general can result in improved wellbeing through relaxation and simple recreation; a concept referred to as the Blue Gym^{31,32} which has been shown to improve depleted emotional and cognitive resources.

Many of these coastal ecosystems are under threat from anthropogenic causes such as conversion for development^{33,34}. When ecosystems are lost, not only are the various services diminished or lost, but there is also a reduction in the natural capital when unique assemblages of species are lost. Opportunities to obtain crucial compounds that could form part of the growing armoury of drugs to fight existing and emerging diseases would be lost as well as cultural services that are needed for the wellbeing of people.

Conclusion

High biodiversity within natural assets enables greater resilience to shocks, thus ensuring sustained

ecosystem services³⁵; of these the provisioning and cultural groups of ecosystem services can be seen to link two important Sustainable Development Goals (SDG), SDG-3 (good health and wellbeing, <https://sdgs.un.org/goals/goal3>) and SDG-14 (life below water; <https://sdgs.un.org/goals/goal14>). In summary, it behoves us to conserve and sustainably use the oceans, coastal and marine resources in a manner that ensures healthy lives and promotes wellbeing for all.

Financial support & sponsorship: None.

Conflicts of Interest: None.

References

- Kusky T. The coast: Hazardous interactions within the coastal environment. New York: Facts On File, Inc.; 2008.
- Know India. Available from: <https://knowindia.gov.in/profile/> accessed on March 1, 2021.
- Millennium Ecosystem Assessment. Ecosystems and Human Well-being: Synthesis. Washington DC: Island Press; 2005.
- Lorentzen, HF, Benfield T, Stisen S, & Rahbek C. COVID-19 is possibly a consequence of the anthropogenic biodiversity crisis and climate changes. *Dan Med J* 2020; 67: A205025.
- McNeely JA. Nature and COVID-19: The pandemic, the environment, and the way ahead. *Ambio* 2021; 50 : 767–81.
- Space Applications Centre. National Wetland Atlas. Ahmedabad: Indian Space Research Organisation; 2011.
- Ministry of Environment, Forest and Climate Change, Government of India. *G.S.R. 37(E)-(18/01/2019)- Coastal regulation zone notification*. Available from: <http://moef.gov.in/en/g-s-r-37e-18012019-coastal-regulation-zone-notification-3>, accessed on January 18, 2019.
- Global Mangrove Alliance. *Mangroves*. Available from: <http://www.mangrovealliance.org/mangrove-forests/>, accessed on March 1, 2021.
- Selvam, V. Environmental classification of mangrove wetlands of India. *Curr Sci* 2003; 84 : 757-765.
- Danielsen F, Sørensen MK, Olwig MF, Burgess ND. The Asian tsunami: a protective role for coastal vegetation. *Science* 2005; 310 : 643. doi: 10.1126/science.1118387.
- Ragavan P, Saxena A, Jayaraj RSC, Mohan PM, Ravichandran K, Saravanan S, et al. A review of the mangrove floristics of India. *Taiwania* 2016; 61 : 224-42.
- Barbier EB, Sally DH, Kennedy C, Koch EW, Stier AC, Silliman BR. The value of estuarine and coastal ecosystem services. *Ecological Monographs* 2011; 81 : 169-93.
- Ramesh R, Banerjee K, Paneerselvam A, Lakshmi A, Krishnan P, Purvaja R. Legislation and policy options for conservation and management of seagrass ecosystems in India. *Ocean Coast Manag* 2018; 159 : 46-50.
- Kannan L, Thangaradjou T, Anantharaman P. Status of seagrasses of India: Seaweed research and utilisation. *Seaweed Res Util* 1999; 21 : 25-33.
- Kumar V, Roy S, Sahoo AK, Behera BK, Sharma AP. Horseshoe crab and its medicinal values. *Int J Curr Microbiol App Sci* 2015; 4 : 956-64.
- Costanza R, d'Arge R, de Groot R, Fraber S, Grasso M, Hannon B, et al. The value of the world's ecosystem services and natural capital. *Nature* 1997; 387 : 253-60.
- Costanza R, de Groot R, Sutton P, van der Ploeg S, Anderson SJ, Kubiszewski I., et al, Changes in the global value of ecosystem services. *Glob Environ Change* 2014; 26 : 152-8.
- The Economics of Ecosystems and Biodiversity. *Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB*. Available from: <http://teebweb.org/publications/teeb-for-synthesis/>, accessed on March 1, 2021.
- Griffing GT. Mother was right about cod liver oil. *Medscape J Med* 2008; 10 : 8.
- Malve H. Exploring the ocean for new drug developments: Marine pharmacology. *J Pharm Bioallied Sci* 2016; 8 : 83-91.
- Mishra JK. Horseshoe Crabs, Their eco-biological status along the Northeast coast of India and the necessity for ecological conservation. *Biology and Conservation of Horseshoe Crabs* 2009; 89-96.
- Krisfalusi-Gannon J, Ali W, Dellinger K, Robertson L, Brady TE, Goddard MKM, et al. The role of horseshoe crabs in the biomedical industry and recent trends impacting species sustainability. *Front Mar Sci* 2018; 5 : 185.
- Vinoth R, Kumaravel S, Ranganathan R. Therapeutic and traditional uses of mangrove plants. *JDDT* 2019; 9 : 849-54.
- Nabeelah Bibi S, Fawzi MM, Gokhan Z, Rajesh J, Nadeem N, Kannan RRR, et al. Ethnopharmacology, phytochemistry, and global distribution of mangroves-A comprehensive review. *Mar Drugs* 2019; 17 : 231.
- Yuvaraj N, Kanmani P, Satishkumar R, Paari A, Pattukumar V, Arul V. Seagrass as a potential source of natural antioxidant and anti-inflammatory agents. *Pharm Biol* 2012; 50 : 458-67.
- Bel Mabrouk S, Reis M, Sousa ML, Ribeiro T, Almeida JR, Pereira S, et al. The Marine Seagrass *Halophila stipulacea* as a Source of Bioactive Metabolites against Obesity and Biofouling. *Mar Drugs* 2020; 18 : 88.
- Smit, AJ. Medicinal and pharmaceutical uses of seaweed natural products: A review. *J Appl Phycol* 2004; 16 : 245-62.
- White MP, Alcock I, Wheeler BW, Depledge MH. Coastal proximity, health and well-being: Results from a longitudinal panel survey. *Health & Place* 2013; 23 : 97-103.
- The Hindu. *A chance to view underwater treasures*. Available from: <https://www.thehindu.com/news/national/tamil-nadu/a-chance-to-view-underwater-treasures/article27037013.ece>, accessed on March 1, 2021.

30. ANI News. *International Blue Flag hoisted at 8 beaches across the Country*. Available from: <https://pib.gov.in/Pressreleaseshare.aspx?PRID=1684105>, accessed on February 28, 2021.
31. Depledge MH, Bird WJ. The Blue Gym: Health and wellbeing from our coasts. *Mar Pollut Bull* 2009; 58 : 947-8.
32. White M, Pahl S, Wheeler B, Fleming L, Depledge M. The 'Blue Gym': What can blue space do for you and what can you do for blue space? *J Marine Biol* 2016; 96 : 5-12.
33. Mangroves for the future. *India*. Available from: <http://www.mangrovesforthefuture.org/countries/members/india/>, accessed on March 1, 2021.
34. The Logical Indian. *India's Coastal, Marine Ecosystems Under Increasing Threat Due To Overexploitation Of Resources: IUCN*. Available from: <https://thelogicalindian.com/environment/indias-coastal-marine-ecosystems-under-threat-21555>, accessed on March 1, 2021.
35. Dasgupta P. *The economics of biodiversity: The Dasgupta review*. London: HM Treasury; 2021.

For correspondence: Dr Ahana Lakshmi, National Centre for Sustainable Coastal Management, Anna University Campus, Chennai 600 025, Tamil Nadu, India
e-mail: ahanalakshmi@gmail.com