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Marine and Coastal Biomes and Habitats: Types and Services

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Abstract: People are dependent on the ocean and coasts and their resources for their survival and well-being. Coastal and marine ecosystems are amongst the most productive ecosystems in the world and provide many services to human society. Most services derived from marine and coastal ecosystems are being degraded and used unsustainably and therefore are deteriorating faster than other ecosystems. The highly threatened nature of marine and coastal ecosystems and the demand for their services highlight the need for a local, regional, and global response. It is an urgent need to protect the world's aquatic ecosystems for future generations. This can be accomplished by reducing emissions, preventing the use of harmful chemicals, and removing fish from the food chain. The health of the ocean can only be maintained by reducing greenhouse gas emissions, and by enhancing the carbon sequestration. This can mitigate the ocean warming, acidification, de-oxygenation, sea level rise, impacts of extreme weather events and destruction of sensitive ecosystems at a global scale. Improved capacity to predict the consequences of change of drivers in marine and coastal ecosystems would aid decision-making at all levels. The aim of this review was to update recent information from the available literature relating with marine and coastal biomes and habitats with respect to types, services, major threats, and recommendations for conservation.

Keywords: Ecosystem, Estuary, Habitats, Mangroves, Marine biome, Mudflats, Seagrass, Wetlands

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Introduction

Aquatic biomes are water-based biomes and are important component of the biosphere. An aquatic ecosystem is a community of species that live together, interact, and to some extent rely on one another. Aquatic biome is immersed in water, water-based, a group of living things, and has a distinct, more or less self-sufficient community. Based on the concentration of salt content, aquatic biomes are divided into two subcategories; freshwater biomes (rivers, lakes and ponds) and marine biomes (oceans, seas, etc.) (https://www.clearias.com/aquatic-biomes-marine-and-freshwater-biomes/, 2023).

Marine ecosystem is the interaction between the living (plants and animals) and non-living things within the marine culture. It covers more than 70% of the Earth's surface and provides habitat for flora and fauna ranging from seashores

to the deep seabed. It is a home for millions of species. In marine ecosystem, each living organism is dependent on each and creates a beautiful food chain of marine culture. All the biotic and abiotic components play an important role in maintaining proper balance in the ecosystem (https://www.earthreminder.com/marine-ecosystem-characteristics-types/, 2020).

UNEP (2006) stated that humankind depends on the oceans and coasts for its survival, with one third of the world's population living in coastal areas, approximately 4% of Earth's total land area. Global changes and other drivers are causing degradation or loss of ecosystem services. Changes to ecosystem services such as food security and employment of nearly 38 million people in the fisheries industry will cause impacts that will reach far beyond the coastal zone. People are integral parts of ecosystems and human well-being depends on 'ecosystem services', which are the benefits that people obtain from ecosystems (UNEP-WCMC, 2011).

Balasubramanian (2011) recorded that the ocean is a major source of food, energy, mineral resources, and also controls the global climate. It is essential for all aspects of human well-being and livelihood. It provides key services like climate regulation, through the energy budget, carbon cycle and nutrient cycle. The ocean is the home of biodiversity ranging from microbes to marine mammals that form a wide variety of ecosystems in open pelagic and coastal ocean (Bindoff *et al*., 2019).

Coastal and marine ecosystems provide many important services to society. They are also subject to continuous anthropogenic impacts which are intensified by climate change. The high recreational benefits associated with coastal and marine ecosystems as well as the positive correlation between these values and the environmental quality can provide an economic justification for implementing conservation strategies (Torres and Hanley., 2016). Marine ecosystem with its total biomass far exceeds of all fresh water ecosystems put together. As being the largest reservoir of water, oceans strongly influence climate by regulating the hydrological cycle on the earth.

The coastal and marine ecosystems include coral reefs, sea grass meadows, mangroves, mudflats, and coastal wetlands, each supporting a unique diversity of species and genes. It provides ecosystem services that make up the planet's natural capital. The major threats to the sustainability of marine and coastal protected ecosystems include land-based pollution and eutrophication, overfishing, destructive fishing, illegal, unreported and unregulated fishing, alteration of physical habitats, invasions of exotic species, global climate change and natural disasters (WII, 2014).

Woodward and Wui (2001) reported that the vulnerable coastal and marine ecosystems provide major resources to the region's peoples supporting a diverse and stabilizing natural system. However, the pace of coastal development and increasing pollution loads threaten the sustainability of the marine and coastal resources and the continued exploitation of the significant reserves of offshore oil and gas provide the potential for both economic prosperity and an increased risk of environmental degradation (Muir, 2013; Evangelia *et al*., 2017).

According to Lecerf *et al*. (2021), to maintain the health of marine life, the climate regulating functions and ecosystem services provided by the ocean, it is essential to reduce greenhouse gas emissions, and to enhance the carbon sequestration (Geta, 2022). Khera *et al*. (2015) stated that marine and coastal ecosystems are of several types such as: inland fresh water wetlands; inland brackish water wetlands; estuarine wetlands; coastal mudflats; sand dunes; rocky shores; mangrove forests; coral reefs; and marine areas. Populations in the marine realm have been found to be genetically more homogenous and therefore, effective population sizes are larger (Popat, 2023).

Coastal and marine ecosystems provide a wide range of services to human society which influence human welfare both directly, through human use, and indirectly, via impacts on supporting and regulating services in other environments. These systems are 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 (Khera and Sivakumar, 2016; Cooley *et al*., 2022).

Kennedy *et al*. (2002) documented that, the world's oceans are comprised of diverse habitats that support a wealth of marine wildlife. They also provide humans with a wide variety of goods and services including foods, recreational opportunities, and transportation corridors. A strong commitment to answering the challenge of effective stewardship of our marine resources will ensure that the full range of benefits of marine ecosystems will be enjoyed by generations to come (NAS, 2008; Mclean and Tsyban, 2018).

The aim of this review was to update recent information from the available literature relating with 'marine and coastal biomes and habitats' with respect to types, services, major threats, and recommendations for conservation.

This review was carried out by collecting information on relevant research findings with the help of Internet search engines like Google, Google Scholar, PubMed, ScienceDirect, and ResearchGate and other published articles, reports, and monographs. Published articles have been reviewed and the related information was gathered for this current study. The keywords used for reviewing the literature were the ones that refer to the issues concerning the 'marine and coastal biomes and habitats'. For literature search, keyword "marine and coastal biomes and habitats" is combined with: types, services, coastal biomes, marine biomes, major threats, and conservation.

Types of Marine and Coastal Biomes:

Riyas (2023) noted that coastal and marine biomes are bodies of water with salt concentrations that are equivalent to or greater than that of seawater. Marine ecosystems, which live in salty waters, are the largest of the Earth's aquatic ecosystems. Marine biomes are aquatic biomes found in the ocean's saline water. The three major marine biomes are neritic, oceanic, and benthic. Beaches, coastal and marine ecosystems, coastal areas, coastal waters, coral reefs, deep sea/open ocean, estuarine ecosystem, intertidal zones, inland and transitional waters, lagoon, mangrove ecosystems, Marine Protected Areas, and wetlands are the examples of marine biomes.

According to Khera *et al*. (2015), saltwater biomes are broadly classified into two categories: Coastal biomes (Mangroves, Tidal mudflats, Lagoons, Sandy beaches, Intertidal rocky shores, Estuaries) and Marine biomes (Oceans, Coral reefs, Seagrasses, Deep sea).

Coastal biomes:

❖ *Mangroves*:

- Tidal forest ecosystems in sheltered brackish to saline environments.
- Found from the highest level of spring tides down to mean sea level on sheltered shores with sediment.
- Dominate approximately 75 per cent of the world's coastline.
- Occur in fully saline waters and estuaries.
- Constitutes a bridge between terrestrial and marine ecosystems.
- Globally important ecological, environmental and socio-economic resource.
- Extremely fragile land-water interface highly susceptible to global change.

- Threats: Industrial, residential, agricultural, leisure developments and, for the establishment of ponds for fish and prawns aquaculture.
- Benefits of mangroves:

✓ Source of firewood, wood products (timber and posts); non-wood produce (fodder, honey, wax, tannin, dyes); and plant materials for thatching.

✓ Act as a shelter belt against cyclones, and even tsunamis.

✓ Habitat for marine species, with nurseries for commercial species.

✓ Provide crucial economic livelihoods and coastal protection.

✓ Prevent coastal erosion.

✓ Nurseries for commercially important fish, prawn, crabs and molluscs.

✓ Enhances the fishery production of nearby coastal waters by exporting nutrients and detritus.

✓ Habitats for wildlife (migratory birds, estuarine crocodiles, tigers etc.

❖ *Tidal mudflats*:

- Coastal mud-lands or mudflats contain mostly mud organisms.
- Mud with fine texture, adhesive quality and deposited under turbulence of sea water.
- Critical habitat for migrating shorebirds and many marine organisms (horseshoe crab and a variety of clam species).
- Highly productive with diverse species diversity.
- Feeding and nesting habitats to numerous species of birds, fish, molluscs, crustaceans, and other ecologically and commercially important organisms.
- Threats: Mudflats, salt marshes, mangroves, and seagrasses are commonly destroyed for port and other industrial and infrastructure development or maintenance dredging. Contamination by heavy metals, polychlorinated biphenyls (PCBs), and other persistent organic pollutants (POPs).
- Benefits: Food provisioning (fisheries catch); shoreline stabilization; protection from floods and soil erosion; processing of pollutants; stabilization of land by trapping sediments; buffering land from storms; and feeding grounds for wading birds, wildfowl, etc.

❖ *Lagoons*:

- Shallow water body along the low lying coast separated from the ocean by a barrier but also connected to the ocean by one or a few restricted inlets.
- Form on gently sloping coasts where barrier islands can form off the coast and are generally shallow.
- Include coastal and atoll lagoons. Diverse and productive ecosystems.
- Threats: Urbanization, industrialization, aquaculture practices, sea levels, and sedimentation.
- Benefits: Commercial and subsistence fishing. Food provision (Fish, shellfish), nutrient recycling, carbon sequestration, recreation, tourism, and cultural significance, Habitat, Life Support, Primary production, Water cycling.

❖ *Sandy beaches*:

- Represent 31% of the world's ice-free shoreline.
- Formed by accumulation of sand particles driven by wind or water current.
- Classified on the basis of sand structures, wave action, surf zone and the sand grain size.
- Benefits: Reduction of wave energy reaching coastline; control of storm surge, wind break; water purification and waste treatment; recreation and ecotourism; water cycling;

habitat for dune vegetation, benthic fauna and sea birds; and nesting areas for marine turtles..

- Threats: Human disturbances, infrastructure and geological constraints reduce shoreline movement and cause coastal squeeze and morphological changes in sandy beaches.

❖ *Intertidal Rocky shores* (*Apte and Bhave., 2010*):

- Span the intertidal and shallow sub-tidal zones of the temperate coasts.
- Characterised by strong environmental gradients, and are exposed to marine and atmospheric climate regimes.
- Made up of with eroded cliffs; wave cut platforms and vertical cliffs.
- Tidal pools which harbours rich diverse life in high density.
- Dominated by calcareous mussels, seaweeds, coralline algae, polychaetes, molluscs, bryozoans and sponges.
- Organisms have adaptations to keep from being swept away by crashing waves. E. g. Seaweeds, Barnacles, Sea stars, etc.
- Threats: Climate change, ocean warming, ocean acidification, extreme heat exposure during low tide emersion.
- Benefits: Biodiversity; Food; Biological regulation; Atmospheric and climate regulation; Flood/storm protection; Cultural and amenity, Nutrient cycling and fertility.

❖ *Estuaries*:

- An estuary is a semi-enclosed coastal body of water that has a free connection with the open sea at one side and a river on the other side.
- The river-sea interface that provides high habitat heterogeneity and supports high biodiversity across freshwater and sub-tidal zones.
- Forms the transitional zones called 'ecotone' between the sea and rivers and possess unique biological make up.
- Complex ecosystem of high productivity, combining salt marshes and mud flats with deeper water and linking fresh water communities with oceans.
- Comprises three zones such as: polyhaline zone (low salt), mesohaline zone (medium salt) and oligohaline zone (fully saline).
- Functions both on planktonic based and detrital based food web.
- The physicochemical properties have large variation and form a stressful environment for organisms living there.
- Biota of Estuaries: Plants (Phytoplankton, marginal marsh vegetation, mud-flat algae, epiphytic plants growing on the marginal marsh vegetation) and animals (Oysters, crabs, clams, lobsters, worms, waterfowl).
- Benefits: Fishing grounds; breeding habitat for shrimp, prawn, oysters and fishes; sheltered harbours for ships and their traffic; water as a coolant in power generation plants.
- Ecosystem services: Food; Fibre, timber, and fuel; Medicines and other resources; Biological regulation; Freshwater storage and retention; Hydrological balance; Atmospheric and climate regulation; Human disease control; Waste processing; Flood/storm protection; Erosion control; Cultural and amenity; Recreational; Aesthetics; Education and research; Biochemical; and Nutrient cycling and fertility.
- Threats: Urbanization, industrialization, dumping of sewage, inflow of municipal waste water, industrial effluents, aquaculture, and accumulation of heavy organic and inorganic pollutants.

Marine biomes:

❖ *Oceans*:

- Largest ecosystems that dominate the earth's surface.
- Regions are separated into intertidal, pelagic, abyssal, and benthic zones.
- All four oceanic zones have the richest diversity of species.
- Intertidal zone (where the ocean meets the land) is sometimes submerged and at other times exposed, as waves and tides come in and out.
- Because of low tide and high tide, the communities are constantly changing.
- Rocky coasts: Stratified vertically with a few species of algae, molluscs (herbivorous snails), crabs, sea stars and small fishes. Bottom with many invertebrates, fishes and seaweed can be found.
- Sandy coasts: Not stratified and waves keep mud and sand constantly moving. Few algae and plants can establish themselves. Fauna include worms, clams, predatory crustaceans, crabs and shorebirds.
- Pelagic zone/Open Ocean: Zone with a thermal stratification with a constant mixing of warm and cold ocean currents. It include neritic zone: the productive coastal waters, and oceanic zone: deep waters of the open ocean. Flora includes surface seaweeds. Fauna: Fishes, mammals (whales and dolphins).
- Benthic zone: Area below the pelagic zone, but without deepest parts of the ocean/abyssal zone. Benthic zone is further subdivided into sublittoral zone, bathyal zone, abyssal zone, and deep ocean trenches. Consists of sand, silt, and/or dead organisms. Extends from the seashore to the deepest parts of the sea. Temperature decreases as depth increases toward the abyssal zone. Flora: seaweed. Fauna: Bacteria, fungi, sponges, sea anemones, worms, sea stars and fishes.
- Deep Ocean/Abyssal zone: Water is very cold, highly pressured, high in oxygen content, but low in nutritional content. Supports many species of chemosynthetic bacteria, invertebrates, and fishes.
- Economically and environmentally important, but are vulnerable to human activities and global and climate changes.
- Threats: Oil spills and their ecological disasters; marine dumping of wastes; dredging wastes; overfishing; ocean acidification; population displacement; mangrove destruction; by-catch; whaling; overfishing and exploitation; climate change; sea temperature rise; invasive species; and ocean dead zones.

❖ *Coral Reefs*:

- A coral reef is an underwater limestone structure formed by corals, which are microscopic invertebrate organisms.
- Widely distributed in warm shallow waters.
- Formed by colonies of coral polyps (marine animals belonging to Class Anthozoa of Phylum Cnidaria).
- Corals release calcium carbonate (limestone) to construct an exterior skeleton.
- Corals live in colonies, and the skeletal material accumulates over time to form a reef.
- Examples of corals: *Acropora* spp., *Porites* spp., *Diploastrea*, *Heliopora*, *Goniastrea retiformis* and *Lobophyllia corymbosa*.
- Found as barriers along continents (e.g., the Great Barrier Reef off Australia), fringing islands and atolls.
- Nutrition via photosynthesis and by extending tentacles to obtain plankton from the water.
- Associated fauna: Microorganisms, invertebrates, fishes, sea urchins, octopuses and sea stars.
- Types of coral reefs:

- ✓ Fringing reef: Attached to a shore with an intervening shallow channel or lagoon.
- ✓ Barrier reef: A reef separated from island shore by a deep channel or lagoon; and
- ✓ Atoll reef: Circular or continuous barrier reef extends all the way around a lagoon without a central island.
- Corals which produce a hard skeleton are called stony corals.
- Types of corals:
- ✓ Stony corals: Finger corals, Fungus coral, Brain coral, Tube coral, Rose coral, Stag horn coral, Lettuce-leaf coral.
- ✓ Soft corals: Sea fan, Bushy soft coral, Sea feather, Black coral.
- Types of coral reefs: Shore reefs/ Fringing reefs, Barrier reefs, Atolls (Deep sea atolls and Shelf atolls); Table reefs, The Faro, Micro atolls, Knolls, Patch reefs etc.
- Ecosystem services: Tourism; fisheries; shoreline protection; recreational opportunities for diving, snorkelling, and viewing; habitat/nursery functions for commercial and recreational fisheries; shelter and feeding grounds for the marine worms, urchins, sponges, sea fans, molluscs, crabs, shrimps, sea anemones and fish; supports the planktons.
- Threats: Coastal development, over exploitation and destructive fishing practices, land and marine based pollution.

❖ *Seagrasses*:

- Common throughout the tropical and temperate coastal waters of the Asian and the Pacific Region.
- Associated with mangrove habitats in coastal waters and with coral reefs in deeper waters.
- Trap the fine sediments that remain suspended after passing through estuarine and mangrove areas.
- Seagrass beds are depositional areas and provide a mechanism for clearing waters of sediment.
- Ecosystem services: Habitats and food sources for marine fauna (e. g. tiger prawns); food and flood regulation; sustainable fishing, recreation and shoreline protection.
- Threats: Coastal development, elevated sedimentation, destructive fishing methods, land based pollution, thermal discharge, petroleum product spills, dredge and fill operations, cyclones and strong waves, grazing, acidification, increased sediment load in the water, construction of harbours and jetties, dredging and discharge of effluents.

❖ *Deep Sea*:

- Found in the darkest and deepest parts of the ocean.
- Environment is harsh with no sunlight and extreme pressure, making it a challenge for marine species to survive.
- Include all waters below the 200-m isobaths, underlying benthos, and provide habitats for highly diversified and specialised biota.
- Home to many unique and bizarre species (anglerfish, giant squid).
- Includes over 90% of the world's oceans and is most diverse ecosystems in the world.
- Inhabiting various animal species in the seabed up to 1000 meters depth underwater.
- Sunlight is one of the big challenges to penetrate at the seafloor; however, the species have adapted the marine environment of this region.
- Water is very cold (around 3° C), highly pressured, high in oxygen content, but low in nutritional content.
- Chemically synthesized sulphur bacteria form the basis of the food web.

- Fauna: Commercial fishes, squids, fishes, elephant seals, sperm whales, crabs, worms, sharks.
- Deep-sea organisms use the nutrients and oxygen but the CO_2 is not available for use by plants in photosynthesis due to lack of light.
- Economic valuation provided by deep-sea services can contribute to a better governance of ocean waters, with emphasis on fisheries management.
- Ecosystem services: Food; fibre, timber, and fuel; atmospheric and climate regulation; education and research; nutrient cycling and fertility; overfishing; climate change; regulating the earth's climate by storing vast amounts of carbon dioxide; cycling of carbon and other nutrients.
- Threats: Bottom trawling; marine pollution, oil and gas exploration, more intensive fishing, cable laying, mineral resource exploration, large-scale deep-sea mining.

Major Threats to the Sustainability of Marine and Coastal Habitats:

- Alteration of physical habitats
- By-catch and discards: Unintentional catch of marine wildlife (sea turtles, porpoises, albatross, crabs, starfish and fish)
- Climate change, Coral mining, Destructive fishing
- Direct physical damage to coastal and marine ecosystems
- Disruption and modification of habitats
- Dumping of wastes – plastic and other wastes
- Global climate change, Illegal, unreported and unregulated fishing
- Invasions of exotic species
- Land-based pollution and eutrophication, Mangrove destruction
- Natural disasters, Ocean acidification, Ocean dead zones
- Oil spills and their ecological disasters
- Overexploitation, Overfishing
- Pollution (land and sea based sources)
- Population displacement
- Recreational use of Marine Protected Areas
- Sea temperature rise
- Unsustainable exploitation of resources, Whaling

Recommendations for Conservation of Marine and Coastal Habitats:

- Classification of coastal areas according to use (fisheries, recreational, agricultural and industrial).
- Community participation for conservation.
- Control of industrial and municipal effluent into coastal waters.
- Control of maritime pollution.
- Designation of special conservation areas in which all development activities would be prohibited.
- Environmental Impact Assessment (EIA) for coastal development activities.
- Establishment of parks, reserves and conservation areas.
- Integrated Coastal Zone Management.
- International Conventions on Marine Wetland.
- National seawater quality monitoring system.
- Ocean Monitoring.
- Partnerships between Resource Managers and local communities.
- Protection for a cross-section of habitats around the entire coastline.
- Regulation of By-catch and discards.

- Remote sensing and GIS databases for Marine Resources: Background information on site characteristics, biodiversity, key species, etc.
- Restricting fishing capacity: Catch limits, seasons, closed areas and size limits.
- Strengthening of water quality standards.
- Treatment facilities for sewage, industrial wastewater and excretion.

Conclusion

Results of this study indicate that, marine and coastal ecosystems provide major resources to the region's peoples supporting a diverse and stabilizing natural system. The pace of coastal development and increasing pollution loads threaten the sustainability of the marine and coastal resources. Overexploitation of the marine resources provides the potential for economic prosperity, with an increased risk of environmental degradation. Coastal wetlands, seagrass beds, coral reefs and the sea surface are key habitats that are especially vulnerable to physical damage and chemical pollution. The control of marine pollution, establishment of integrated coastal management programmes at local, national and international level, and community participation is recommended for the protection and sustainable development of the coastal and marine environment.

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