

1. Marine Biodiversity and Environment – An Overview

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Marine biodiversity encompasses the rich and diverse array of life in the oceans, including ecosystems, species, and genetic diversity. Covering about 70% of the Earth's surface, oceans are home to millions of species, many of which remain undiscovered. Marine ecosystems play a fundamental role in sustaining life on Earth, offering invaluable ecological, economic, and social benefits. These ecosystems, ranging from coral reefs and mangrove forests to the deep ocean and polar seas, provide essential services such as carbon sequestration, coastal protection, food sources, and climate regulation. Marine life spans an incredible range of organisms, from microscopic viruses and plankton to massive marine mammals, each uniquely adapted to their specific environment. The diversity of marine habitats is staggering, with species thriving in environments as varied as the sunlit surface waters to the dark depths of the ocean, where pressures and temperatures are extreme. Of the estimated 500,000 to 2 million marine species, only about 242,000 have been formally described. This indicates that a vast majority of marine life remains unexplored, particularly in the remote deep-sea regions and the polar seas. As new technologies and exploration methods continue to advance, thousands of new species are discovered each year, further highlighting the immense, untapped biodiversity of the world's oceans. The ongoing discovery of these species underscores the need for greater exploration and, most importantly, for comprehensive conservation efforts to protect these ecosystems and their inhabitants. The extraordinary wealth of marine biodiversity is not only crucial for the health of the oceans but is also essential to the well-being of all life on Earth, making its preservation a top priority for global sustainability.

Marine ecosystems offer a wealth of vital services that are essential for the well-being of both the environment and human societies. These services include food provision, climate regulation, primary production, nutrient cycling, and cultural benefits. The rich biodiversity within these ecosystems is the cornerstone of their health, driving the many functions that sustain life and economies. Biodiversity plays a central role in supporting key industries such as fisheries, tourism, and coastal protection. Marine species provide food security for billions of people, particularly in coastal and island communities, while also supporting livelihoods through fisheries and aquaculture. Additionally, the oceans contribute to the production of bioactive compounds, which are invaluable in developing medicines and pharmaceuticals. Phytoplankton, seaweeds, and seagrasses are integral in sequestering carbon, helping mitigate the impacts of climate change. These organisms absorb significant amounts of carbon dioxide from the atmosphere, reducing the overall carbon footprint. Beyond their role in carbon capture, coastal habitats such as mangroves, salt marshes, and coral reefs act as natural buffers, protecting shorelines from erosion, storms, and sea-level rise. Marine biodiversity is also a key driver of nutrient cycling, which sustains the health of ecosystems and ensures the

productivity of marine food webs. By maintaining the balance of nutrients in the water, marine species support both ecosystem stability and the productivity of fisheries. Furthermore, marine ecosystems are vital for recreational activities, contributing to tourism industries that generate billions of dollars globally. Activities such as diving, whale watching, and beach tourism rely on healthy, biodiverse oceans and are an important source of income for many regions. Genetic diversity within marine species is crucial for the adaptation of populations to changing environmental conditions. It enhances the resilience of aquaculture systems, ensuring the sustainable production of seafood. As the oceans continue to face threats from human activities and climate change, preserving genetic diversity is essential for ensuring the long-term health and productivity of marine ecosystems. The protection and conservation of marine biodiversity are critical for safeguarding the myriad services these ecosystems provide. From supporting food security and economic livelihoods to mitigating climate change and protecting coastal communities, marine ecosystems are indispensable to both the environment and human society.

Biodiversity is commonly measured by species richness but extends across multiple levels of biological organization, from genetic diversity to entire ecosystems. Within an ecosystem, biodiversity encompasses three key components viz., composition (the variety of species and genetic traits), structure (the physical organization of habitats and communities), and function (the ecological processes that sustain life). These elements form a hierarchical framework that operates across various spatial and temporal scales. Ecoregions, which are large marine areas characterized by distinct oceanographic, geological, and ecological features, provide a valuable basis for conservation and management efforts. These regions help identify priority areas for biodiversity protection and sustainable resource use. Adapted from terrestrial biodiversity frameworks, the ecoregion-based approach integrates biodiversity science with ecosystem-based management, ensuring that conservation strategies account for ecological connectivity, habitat dynamics, and species interactions. By applying this comprehensive framework, researchers and policymakers can better assess biodiversity patterns, track environmental changes, and implement effective marine management practices that support ecological resilience and long-term sustainability.

Compositional elements represent the identity and diversity of life within an ecosystem, encompassing physiographic regions, habitats, species, and genetic variants. These elements define the richness and variety of biological components that contribute to ecosystem complexity and resilience. Structural elements focus on the spatial organization of both biotic and abiotic components, including habitat distribution, population structures, and genetic traits. The arrangement of species within an ecosystem, the connectivity between habitats, and the physical features of the environment all play crucial roles in maintaining biodiversity and ecosystem stability.

Functional elements refer to the dynamic processes and disturbances that shape biodiversity over time. These include environmental factors such as climate variability, ocean currents, and nutrient cycling, as well as ecological interactions like predation, competition, and symbiosis. Additionally, demographic factors such as population growth, migration, and

reproductive strategies, along with genetic mechanisms like mutation and gene flow, contribute to biodiversity's adaptability and evolution. Human activities are also integral functional elements, as they significantly influence biodiversity at all levels. Anthropogenic impacts, such as habitat modification, pollution, overfishing, and climate change affect the composition, structure, and functionality of ecosystems. Understanding these interactions is essential for developing effective conservation and management strategies that promote ecological balance and long-term sustainability.

Role of marine ecosystems in advancing SDGs

Marine biodiversity and healthy marine ecosystems are fundamental to achieving the UN Sustainable Development Goals (SDGs). Not only do they directly support SDG 14 (Life Below Water), but they also contribute to several other goals. Marine biodiversity is instrumental in alleviating poverty (SDG 1) and ensuring food security (SDG 2) through livelihoods and sustainable fisheries. It fosters economic growth (SDG 8), contributes to clean water access (SDG 6), and plays a vital role in enhancing human health (SDG 3). Furthermore, it promotes sustainable consumption (SDG 12) and underscores the importance of integrated conservation due to the interconnectedness of marine and terrestrial ecosystems (SDG 15). Protecting marine biodiversity is not only essential for building resilience but also for safeguarding human well-being and advancing the 2030 Agenda.

Challenges confronting marine biodiversity and environment

Global marine environments are undergoing unprecedented transformations due to stressors such as climate change, overfishing, illegal wildlife trade, eutrophication, invasive species, habitat destruction and pollution. The loss of marine biodiversity is driven by a complex interplay of factors, with the global Marine Living Planet Index reflecting a notable decline in marine populations. Responses to marine environmental degradation have been slow and disjointed, primarily due to the perception of oceans as a global commons, highlighting the need for coordinated international action. The challenges posed by climate change complicate the effectiveness of current management strategies. Coastal and shelf ecosystems have suffered significant degradation, impairing their capacity to deliver critical ecosystem services. Understanding the interconnections between ecosystem services, habitat, biodiversity, and resilience is vital. Ecosystem-Based Management (EBM) and Ecosystem Approaches to Management (EAM) focus on achieving sustainable resource use and conserving biodiversity. The decline in marine biodiversity diminishes ecosystem resilience to stressors like climate change and pollution, disrupts essential ecosystem functions (such as primary productivity, nutrient cycling, and food webs), and negatively impacts coastal communities and economies through fisheries decline, tourism losses, and increased vulnerability to extreme weather events.

Key strategies for conserving marine biodiversity

A range of conservation strategies has been developed to address the threats facing marine biodiversity and ensure the sustainable management of marine ecosystems. Successful

conservation depends on the collective efforts of governments, researchers, industries, and local communities. The following approaches highlight key strategies for protecting marine ecosystems:

- **Habitat protection and restoration:** Establishing Marine Protected Areas (MPAs), restoring degraded ecosystems such as mangroves, coral reefs, and oyster beds, promoting sustainable coastal development, and reducing land-based pollution are critical actions. International agreements and legal frameworks support these efforts.
- **Sustainable fisheries management:** Science-based fishing quotas, no-fishing zones, selective fishing methods to minimize bycatch, regulations on fish size and the capture of endangered species, and ecosystem-based management practices are essential to ensure the long-term health of fish populations and ecosystems.
- **Pollution abatement and control:** Combating plastic and chemical pollution requires stronger regulations on waste disposal and discharges, enhanced wastewater treatment systems, sustainable agricultural practices, bans on single-use plastics, better waste management, and international cooperation (e.g., MARPOL Convention) to address pollution at a global scale.
- **Climate change mitigation and adaptation:** Reducing greenhouse gas emissions is essential. Restoring coastal ecosystems, such as mangroves and seagrasses, enhances resilience to climate impacts. Ongoing research and monitoring help refine and inform conservation strategies, enabling adaptive responses to changing conditions.
- **Community-based conservation:** Empowering local communities through initiatives like marine conservation cooperatives, ecotourism programs, and the integration of traditional knowledge with modern conservation techniques fosters sustainable practices, ensuring the long-term protection of marine environments.

IUCN's role in conservation and sustainable use of marine biodiversity

IUCN plays a crucial role in marine biodiversity conservation and the sustainable use of marine resources. Its Red List evaluates the extinction risk of marine species, including corals, fish, and sea turtles, providing valuable insights for guiding conservation priorities. The IUCN advocates for the establishment of Marine Protected Areas and conducts essential research through its Species Survival Commission. Its Global Marine and Polar Programme tackles pressing issues such as pollution, climate change, and overfishing, while working closely with stakeholders and governments to implement effective policies. As of 2022, more than 1,550 marine species face extinction risks, with climate change impacting 41% of them, underscoring the urgency for immediate action. The IUCN's efforts are critical to safeguarding marine life and ensuring the health of marine ecosystems.

Legal instruments for biodiversity conservation

Biodiversity conservation is a global priority, reinforced by international and regional legal frameworks. These instruments encourage sustainable practices, safeguard natural resources, and promote collaboration among governments, organizations, and individuals.

International legal instruments

- *Convention on Biological Diversity (CBD), 1992*
- *CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), 1973*
- *United Nations Convention on the Law of the Sea (UNCLOS), 1982*
- *International Whaling Commission (IWC)*
- *Convention on the Conservation of Migratory Species of Wild Animals (CMS), 1979*
- *FAO Code of Conduct for Responsible Fisheries*
- *Ramsar Convention on Wetlands, 1971*
- *United Nations Framework Convention on Climate Change (UNFCCC), 1992*
- *World Heritage Convention, 1972*

National legal instruments

- *The Environment (Protection) Act, 1986*
- *Wildlife (Protection) Act, 1972*
- *Biological Diversity Act, 2002*
- *Coastal Regulation Zone (CRZ) Notification, 1991*
- *National Green Tribunal (NGT) Act, 2010*

Regional legal instruments

- *European Union Habitats Directive (1992)*
- *African Convention on the Conservation of Nature and Natural Resources (2003)*
- *ASEAN Agreement on the Conservation of Nature and Natural Resources (1985)*

Corporate and community-level instruments

- *Environmental Impact Assessment (EIA)*

International legal instruments

Convention on Biological Diversity (CBD), 1992

The Convention on Biological Diversity (CBD) is a key treaty focused on conserving biodiversity, promoting sustainable use, and ensuring benefit-sharing. It encourages National Biodiversity Strategies and Action Plans, sets global goals, and includes protocols like the Nagoya and Cartagena Protocols.

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), 1973

CITES regulates international trade in endangered species to prevent overexploitation. Species are classified into Appendices based on trade vulnerability; with strict controls on Appendix I species.

United Nations Convention on the Law of the Sea (UNCLOS), 1982

UNCLOS establishes the legal framework for ocean use, including maritime boundaries and resource management, regulating activities like fishing and mining.

International Whaling Commission (IWC)

The IWC conserves whale populations by regulating whaling activities. The CMS focuses on migratory species conservation, promoting habitat protection and international collaboration.

Convention on the Conservation of Migratory Species of Wild Animals (CMS), 1979

CMS also known as the Bonn Convention, this treaty focuses on the conservation of migratory species that cross international borders. CMS Promotes habitat conservation and

restoration for species such as migratory birds, marine mammals, and sea turtles as well as Encourages international collaboration to protect migration corridors.

FAO Code of Conduct for Responsible Fisheries

The FAO Code of Conduct for Responsible Fisheries provides guidelines for sustainable fishing practices, emphasizing ecosystem-based management. The Ramsar Convention promotes wetland conservation, designating Ramsar sites and supporting restoration.

Ramsar Convention on Wetlands, 1971

This treaty emphasizes the conservation and wise use of wetlands, recognizing their critical ecological and economic value. The key objectives include, Designation of Wetlands of International Importance (Ramsar sites) to prioritize protection and Support for wetland restoration to sustain biodiversity and ecosystem services.

United Nations Framework Convention on Climate Change (UNFCCC), 1992

The UNFCCC, while focused on climate change, recognizes its impact on biodiversity and promotes ecosystem-based adaptation and mitigation, including protecting natural carbon sinks. The World Heritage Convention, administered by UNESCO, protects natural and cultural heritage, including biodiversity hotspots.

World Heritage Convention, 1972

Administered by UNESCO, this convention seeks to identify and protect natural and cultural heritage of exceptional universal value. The key objectives include conservation of biodiversity hotspots such as the Great Barrier Reef and the Sundarbans, designated as Natural World Heritage Sites and encouragement of international cooperation for safeguarding these sites.

Regional legal instruments

European Union Habitats Directive (1992)

This directive aims to safeguard habitats and species in Europe through the “Natura 2000” network of protected areas, ensuring the maintenance of biodiversity within member states.

African Convention on the Conservation of Nature and Natural Resources (2003)

Revised in 2003, this convention promotes biodiversity conservation and sustainable development across African nations, emphasizing the integration of conservation into national policies.

ASEAN Agreement on the Conservation of Nature and Natural Resources (1985)

The ASEAN Agreement addresses Southeast Asia's specific biodiversity issues, promoting sustainable resource use, habitat protection, and regional cooperation. International and regional legal instruments offer a comprehensive approach to global biodiversity preservation. A new UN instrument is being developed for marine biodiversity conservation in Areas Beyond National Jurisdiction (ABNJ), addressing gaps in current frameworks and focusing on marine genetic resources, EIAs, area-based management, and capacity building.

National legal instruments

India has a robust legal framework for biodiversity conservation, including laws, policies, and regulations protecting marine ecosystems, species, and habitats. These national

instruments form the foundation for biodiversity conservation and ecosystem management in India.

Key national legal frameworks

The Environment (Protection) Act, 1986

The law provides a framework for environmental protection and biodiversity conservation, enabling specific rules and guidelines.

Wildlife (Protection) Act, 1972

The law focuses on wildlife and habitat conservation, establishing protected areas and prohibiting hunting and illegal trade.

Biological Diversity Act, 2002

The law implements the CBD's objectives, emphasizing biodiversity preservation, local community involvement (BMCs), and regulating access to biological resources.

Coastal Regulation Zone (CRZ) Notification, 1991

The law protects coastal ecosystems, regulating development and promoting sustainable resource use.

National Green Tribunal (NGT) Act, 2010

The law establishes a specialized body for environmental dispute resolution and enforcement.

Corporate and community-level instruments

Environmental Impact Assessment (EIA)

Environmental Impact Assessment is mandatory for major projects, evaluating potential impacts on biodiversity and recommending mitigation measures. India integrates these legal instruments to protect biodiversity and promote sustainable resource use, balancing development with ecological preservation.

Conclusion

Marine biodiversity plays a pivotal role in ensuring planetary health, safeguarding human well-being, and maintaining climate regulation. Oceans, which cover over 70% of the Earth's surface, are not only home to a variety of life but also serve as a vital buffer against climate change, absorbing a significant amount of carbon dioxide and regulating temperature. Healthy marine ecosystems contribute to food security, livelihoods, and economic stability, supporting millions of people worldwide, particularly in coastal and island communities. However, marine ecosystems are under immense pressure from human activities, including overfishing, habitat destruction, pollution, and climate change. These threats are causing a decline in biodiversity, which undermines the resilience of marine environments and reduces their capacity to support human and ecological well-being. Immediate and robust action is essential to mitigate these risks. Establishing Marine Protected Areas (MPAs) is one of the most effective tools for conserving marine biodiversity. MPAs help preserve critical habitats, protect endangered species, and allow ecosystems to recover and thrive. Alongside this, implementing sustainable fisheries management is crucial to preventing overfishing, ensuring

that fish populations remain viable for future generations, and supporting the livelihoods of those dependent on them.

Suggested readings

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