Ocean Sustainable Development Goals and Marine and Coastal Ecosystem Management Postprint

Authors: Jingjing Yuan, Yonglong Lü, Guizhen He

Date: 2018-01-09T00:00:00+00:00

Abstract

Oceans and coastal zones can provide multiple ecosystem services for humanity. The protection and sustainable utilization of marine resources to promote the sustainable development of oceans and coastal zones has been formally incorporated into the United Nations Sustainable Development Goals. Implementing these marine sustainable development goals faces several major challenges, including reducing the impacts of land-based human activities, strengthening integrated management of coastal zones, improving marine resource efficiency, adapting to climate change, and enhancing the human well-being of coastal residents. To address these challenges, it is necessary to integrate oceans and coastal zones into a large ecosystem, utilize ecosystem-based management approaches, comprehensively consider the cumulative impacts of various sectors and multiple stressors, establish a comprehensive marine observation system, rationally delineate marine functional zones, limit land-based human activities according to marine environmental carrying capacity, rationally allocate and effectively utilize marine resources, and enhance the overall service functions of marine and coastal ecosystems, thereby further promoting the implementation of marine sustainable development goals.

Full Text

Preamble

Acta Ecologica Sinica (ChinaXiv Partner Journal)
Vol. 37, No. 24, December 2017
DOI: 10.5846/stxb201702040211

Sustainable Development Goals for Oceans and Marine and Coastal Ecosystem-Based Management

YUAN Jingjing[1],[2],*, LÜ Yonglong[1], HE Guizhen[1]

[1]State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China
[2]University of Chinese Academy of Sciences, Beijing 100049, China

Abstract

Ocean and coastal ecosystems provide a wide variety of ecosystem services. The conservation and sustainable use of oceans, seas, and marine resources has been formally incorporated into the United Nations Sustainable Development Goals (SDGs). Key challenges for implementing marine SDGs include reducing the impacts of land-based human activities, strengthening integrated coastal management, improving marine resource efficiency, enhancing climate change adaptation, and thereby improving human well-being for coastal residents. To address these challenges, oceans and coasts should be integrated as a single large ecosystem, and ecosystem-based management approaches should be applied to account for cumulative impacts from multiple sectors and various stressors. The ecosystem services provided by oceans and coasts can be enhanced by establishing integrated marine observation systems, implementing rational marine zoning, restricting land-based human activities according to marine environmental carrying capacity, and ensuring the rational allocation and effective utilization of marine resources. All these measures can advance the implementation of marine Sustainable Development Goals (SDGs).

Keywords: marine ecosystem; coastal ecosystem; Sustainable Development Goals (SDGs); ecosystem-based management (EBM); land-ocean integration

1. Marine Sustainable Development Goals (SDGs)

Healthy ocean and coastal ecosystems provide essential services including food security, resources for economic growth, coastline protection, and biodiversity maintenance. As one of the most productive ecosystems on Earth, oceans and coastal zones have historically been considered an inexhaustible resource with unlimited environmental capacity for human waste. However, current marine environmental degradation, biodiversity loss, and declining biological productivity now seriously threaten both coastal ecosystems and human well-being. Sea level rise and extreme weather events have pushed many coastal ecosystems beyond critical thresholds for healthy functioning, making marine sustainability increasingly vulnerable.

The role of oceans and coastal zones in human well-being will increasingly depend on national capacities to manage marine resource use and human impacts on marine and coastal environments. Marine resource management must fully consider land-based human activities to ensure that the health and self-restoration capacity of marine and coastal ecosystems are not compromised. Since the 1990s, major international initiatives have established principles, objectives, and timelines for ocean and coastal management. The United Nations Convention on the Law of the Sea (UNCLOS) called on nations to develop laws

and regulations to prevent, reduce, and control marine pollution from land-based activities. In 1995, governments adopted the Washington Declaration, committing to protect marine environments and reduce land-based impacts. The United Nations Environment Programme subsequently developed a Global Programme of Action (GPA) focusing on reducing marine pollution from terrestrial human activities.

The concept of the "blue economy" has emerged as an economic development model where international competition shifts from land to sea, with oceans and their hinterlands serving as crucial carriers. This strategy represents a lifestyle where humans coexist sustainably with oceans, integrating future economic development with environmental and social factors. Its core principles are land-sea coordination and sustainable development. In 2015, the UN Summit formally adopted the *2030 Agenda for Sustainable Development*, which includes 17 SDGs and explicitly addresses the conservation and sustainable use of oceans and marine resources as SDG 14. This agenda builds upon and upgrades the Millennium Development Goals.

SDG 14 encompasses several targets directly related to marine and coastal issues, including reducing marine pollution (especially from land-based activities), sustainably managing and protecting marine and coastal ecosystems, addressing ocean acidification, regulating fisheries to end overfishing, and promoting sustainable aquaculture and tourism. Other SDGs with indirect marine relevance include those addressing poverty elimination, food security, water resources, clean energy, sustainable cities, climate action, and biodiversity conservation. presents SDGs and targets with marine resource implications.

These SDGs exhibit strong interlinkages—some mutually reinforcing, others creating trade-offs. Past experience shows that isolated actions cannot achieve all targets, necessitating a systems approach. For instance, land use changes can create downstream effects on marine ecosystems, while promoting small-scale producer income growth may conflict with marine sustainability if not systematically considered. The interconnections can be framed through ecosystem services (food provision, climate regulation) or social dimensions (capacity building, transparency). Although SDG 14 explicitly targets ocean conservation, the role of marine and coastal management in achieving broader sustainability goals remains underappreciated, partly because methods for quantifying marine ecosystem services at national or global scales are still underdeveloped.

2. Main Challenges in Implementing Marine SDGs

Human activities such as coastal pond aquaculture have caused heavy metal and persistent organic pollutant contamination, seawater acidification, and coral reef degradation. The primary challenges stem from land-based impacts, marine-coastal environmental interactions, inefficient marine resource use, climate change pressures, and the need to improve coastal human well-being.

2.1 Pollutant Input from Land-Based Human Activities

Rapid coastal urbanization and industrialization, combined with pollutant emissions from fossil fuel combustion and mining, increasingly impact nearshore ecosystems and marine biogeochemical cycles. Nearly all marine ecosystems are affected by human activities, with many experiencing multiple simultaneous stressors. Sediment input represents a major land-based influence on coastal environments. Excessive sedimentation can smother coral reefs and seagrass beds by blocking light to primary producers, while dam construction or reduced water flow can cut off natural sediment supply, causing coastal erosion. Climate change-induced sea level rise alters estuarine ecosystem dynamics, submerging coastal ecosystems like coral reefs and seagrass beds.

Atmospheric deposition constitutes another significant land-based impact. Dust from the Sahara Desert, generated by vehicles and wind erosion, transports iron that triggers plankton blooms and fungal spores that sicken Caribbean corals, altering Black Sea and Caribbean ecosystems. Similar processes occur with dust from China' s Loess Plateau reaching North America, and evapotranspiration in tropical regions depositing toxic pollutants in the Arctic. Increasing plastic waste enters oceans, breaking down into microplastics that accumulate toxic chemicals and threaten wildlife and humans. Petrochemical pollution originates not only from coastal activities but also from inland oil and chemical extraction and processing. Enhanced monitoring of land-based pollutant inputs, source identification, and source reduction are urgently needed.

2.2 Interaction Between Marine and Coastal Environments

Growing coastal population demands place unprecedented pressure on coastal carrying capacity. Coastal sand and gold mining cause habitat degradation and alter river distributions, reducing biological productivity and negatively impacting tourism and recreation. Overdevelopment of shallow marine areas and beaches for aquaculture releases nutrients, undigested feed, veterinary drugs, and biocides, causing eutrophication, salinization of farmland, and harmful algal blooms. Surface runoff from agricultural fertilizers and livestock manure creates nutrient excess in coastal waters.

Coastal salt marshes provide storm protection and other ecosystem services, yet global salt marsh area is declining sharply, with nearly one-third lost to land reclamation. Pollutant discharge in estuaries and irrational coastal spatial planning exacerbate marine pollution, threatening public health and marine industries like mining, fishing, and tourism. Integrated marine and coastal planning and management are essential to prevent ecosystem damage and enhance service values.

2.3 Need to Improve Marine Resource Development Efficiency

As population and economic growth strain terrestrial resources, attention increasingly turns to oceans. Marine biological resources support fisheries and

aquaculture, while spatial resources like coastlines and islands enable maritime transport and tourism. Wave energy provides opportunities for clean renewable energy, and deep seas contain oil, gas, and polymetallic nodules. However, technological and cost constraints limit deep-sea mining expansion. Although China has enormous potential for marine resource development, low quality and efficiency in utilization persist. Improving efficiency requires not only better exploitation of productive resources like fisheries but also valuation of natural ecosystem services. Since ecosystem components have multiple uses and benefits, enhancing one use may harm others, requiring scientific assessment to balance trade-offs and facilitate effective public-private dialogue.

2.4 Climate Change Pressures

Climate change causes ocean acidification and biological impacts as species struggle to adapt to temperature changes. Coral bleaching demonstrates difficulties for ecosystems adapted to stable environments. While species may migrate coastally or inland following sea level rise, challenges remain regarding whether adaptation or extinction will occur. Coastal zones host approximately 40% of the global population and two-thirds of large and medium-sized cities, with residents heavily dependent on marine ecosystem services. Rapid coastal urbanization and industrialization increase vulnerability to natural disasters and impact nearshore ecosystems. Infrastructure upgrades, effective environmental policies, and resource management must incorporate natural defenses like mangroves and coral reefs to reduce risks.

2.5 Need to Improve Human Well-being in Coastal Zones

To ensure long-term ocean-dependent human well-being, marine and coastal ecosystems must be managed sustainably with clear SDGs to measure progress in coastal protection and welfare enhancement.

3. Ecosystem-Based Management (EBM) for Marine and Coastal Zones

Human management of oceans and coasts spans centuries, but recent approaches have typically focused on single ecosystem aspects. Ecosystem-Based Management (EBM) is a comprehensive approach that considers entire ecosystems, including humans, aiming to maintain ecosystem health, productivity, and self-restoration capacity to meet human service demands. Unlike traditional single-species or single-activity management, EBM integrates cumulative impacts across sectors. Although applied to marine systems much later than terrestrial ecosystems, EBM is increasingly used by academics and management institutions.

SDG 14 includes targets on land-based pollution, coastal ecosystem management, sustainable aquaculture, and tourism. Because jurisdictions and decision-maker priorities vary, marine and coastal emphases differ, but considering cross-

sectoral cumulative impacts supports long-term sustainability. [Figure 1: see original paper] illustrates the EBM framework for marine and coastal ecosystems.

3.1 Marine Zoning Based on Ecosystem Functions

Marine spatial planning identifies how different regions use marine resources and space, determining appropriate uses for each area to minimize impacts and conflicts. Planners can integrate information on ecosystem characteristics, human impacts, and inter-ecosystem interactions into maps to guide comprehensive zoning, ensuring long-term service provision. For example, Colombia' s San Andrés Archipelago, home to the Caribbean' s largest coral reefs, established a 65 km^2 marine protected area in 2005. The zoning allows handicraft production in some areas, tourism in others, and prohibits activities in sensitive zones, creating a harmonious system that protects both biodiversity and sustainable human use.

China has designated ten major marine functional zones including port shipping, fishery utilization and conservation, mineral resource exploitation, seawater utilization, marine energy development, engineering zones, marine protected areas, and special use zones. Since the 1980s, China has established various marine protected areas covering 5% of its jurisdictional sea area. While these areas adjust human uses within their boundaries, integrating other functional zones into ecosystem management remains a challenge. For instance, mineral exploitation zones must consider impacts on surrounding marine ecosystems and post-mining restoration, while fishery zones must balance human demand with species distribution, food web relationships, and ecosystem stability.

3.2 Establishing Integrated Marine Observation Systems

Achieving marine and coastal sustainability requires enhanced observation infrastructure and integrated data processing capabilities. Developing countries with weak observation capacity must cooperate with developed nations to build monitoring and analytical capacity. Developed countries like the U.S. (Integrated Ocean Observing System, IOOS) and Australia (Integrated Marine Observing System, IMOS) have established end-to-end systems linking data collection to management.

China' s marine observation network, covering coastal, offshore, and polar regions, is relatively recent. The *National Marine Observation Network Plan (2014-2020)* addresses layout and management across fisheries, transport, energy, environment, and research sectors. However, coordination remains challenging due to administrative rather than ecosystem-based boundaries. China' s network includes shore-based, offshore, and polar observation systems, but still lags behind developed countries in spatial layout and operational mechanisms—a key area for investment to achieve SDGs. Integrated observation must combine marine biogeochemical monitoring with land-based impact assessment, merging

fixed-point and mobile observations to capture both routine parameters and emergency events. Capability depends not only on deployed infrastructure but also on integrated air-space-ground coordination.

3.3 Limiting Land-Based Activities According to Marine Environmental Carrying Capacity

Marine and coastal ecosystems should be valued as natural capital. From an ecosystem services perspective, integrated valuation methods should assess food provision, raw materials, climate regulation, and other services to analyze overall carrying capacity. This holistic approach identifies constraints on resource capacity and proposes human use patterns and industrial adjustments adapted to ecosystem characteristics. Since impacts from different activities are cumulative, assessing these combined effects enables better planning under multiple pressures and trade-offs between ecosystem functions.

3.4 Strengthening Integrated Coastal Zone Management

Coastal issues involve numerous sectors, requiring inclusive, cross-sectoral management approaches that shift from administrative to ecological boundaries. Kenya's Tana River faces pressures from hydropower development, water supply for irrigation, and indirect impacts from poor land management. By connecting watershed management with coastal governance, authorities and NGOs reduced sedimentation-driven coastal erosion, groundwater salinization, and maintained delta fisheries and food security. Integrated coastal management requires comprehensive assessment and reform of existing systems, coordinating fisheries, tourism, and oil/gas development across sectors.

4. Advancing Marine SDGs Through EBM

EBM approaches can directly or indirectly advance marine and coastal SDG implementation through marine zoning, integrated observation systems, resource valuation methods, and integrated coastal management frameworks. [Figure 2: see original paper] illustrates this implementation pathway. To ensure SDG achievement, China should fully utilize EBM, establish inter-agency coordination mechanisms, control land-based impacts at their source, zone marine functions rationally, limit activities by carrying capacity, curb ecosystem degradation, enhance overall ecosystem services, and allocate marine resources effectively.

EBM is a comprehensive approach requiring integration of natural and social science knowledge with practical experience to better assess and manage human impacts on marine and coastal ecosystems. Continuous development of supporting science and technology is essential.

References

[1] Agardy T, Davis J, Sherwood K, Vestergaard O. Taking Steps Toward Marine and Coastal Ecosystem-Based Management: An Introductory Guide. Nairobi: UNEP, 2011.
[2] Widdows J, Donkin P. Washington declaration on the protection of the marine environment from land-based activities. Ocean Yearbook Online, 1998, 13(1): 722–724.
[3] Ki-Moon B. The Road to Dignity by 2030: Ending Poverty, Transforming All Lives and Protecting the Planet. Synthesis Report of the Secretary-General on the Post-2015 Agenda. New York: United Nations, 2014.
[4] ICSU ISSC. Review of the Sustainable Development Goals: The Science Perspective. Paris: International Council for Science (ICSU), 2015.
[5] Lu Y L. Sustainable development: rate oceans' capital to help achieve SDGs. Nature, 2016, 537(7618): 34–34.
[6] Halpern B S, Walbridge S, Selkoe K A, Kappel C V, Micheli F, D' Agrosa C, Bruno J F, Casey K S, Ebert C, Fox H E, Fujita R, Heinemann D, Lenihan H S, Madin E M P, Perry M T, Selig E R, Spalding M S, Steneck R, Watson R. A global map of human impact on marine ecosystems. Science, 2008, 319(5865): 948–952.
[7] Impacts of Land-Based Human Activities on Coastal Ecosystems, 2016, 36(5): 1183–1191.
[8] Pandolfi J M, Connolly S R, Marshall D J, Cohen A L. Projecting coral reef futures under global warming and ocean acidification. Science, 2011, 333(6041): 418–422.
[9] Schütz L. Long range transport of desert dust with special emphasis on the Sahara. Annals of the New York Academy of Sciences, 1980, 338: 515–532.
[10] Cotham W E Jr, Bidleman T F. Estimating the atmospheric deposition of organochlorine contaminants to the Arctic. Chemosphere, 1991, 22(12): 165–188.
[11] Rochman C M, Hoh E, Kurobe T, Teh S J. Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress. Scientific Reports, 2013, 3: 3263.
[12] Mateos J C R. The case of the Aznalcóllar mine and its impacts on coastal activities in Southern Spain. Ocean & Coastal Management, 2001, 44(1/2): 105–118.
[13] Naylor R L, Goldburg R J, Primavera J H, Kautsky N, Beveridge M C M, Clay J, Folke C, Lubchenco J, Mooney H, Troell M. Effect of aquaculture on world fish supplies. Nature, 2000, 405(6790): 1017–1024.
[14] Qiu J. Chinese survey reveals widespread coastal pollution. Nature, 2012, doi: 10.1038/nature.2012.11743.
[15] Cicin-Sain B, Knecht R W, Jang D, Fisk G W. Integrated coastal and ocean management: concepts and practices. Washington DC: Island Press, 1998.
[16] Study on the Classification System of Marine Resources, 2009, 26(5): 42–45.
[17] Low Utilization Rate of Marine Resources in China, 2014, (4): 40–40.

[18] Water Resources Research (2014).
[19] Hoegh-Guldberg O. Climate change, coral bleaching and the future of the world' s coral reefs. Marine and Freshwater Research, 1999, 50(8): 839-866.
[20] Rice J, Smith A D M. Ecosystem-based management: opportunities and challenges for application in the ocean forest // Rossi S, Bramanti L, Gori A, Orejas Sacodel Valle C, eds. Marine Animal Forests. Switzerland: Springer, 2015: 1-25.
[21] Grumbine R E. What is ecosystem management? Conservation Biology, 1994, 8(1): 27-38.
[22] Arkema K K, Abramson S C, Dewsbury B M. Marine ecosystem-based management: from characterization to implementation. Frontiers in Ecology and the Environment, 2006, 4(10): 525-532.
[23] Theory and Practice of Ecosystem-Based Marine Management, 2014, 29(2): 275-284.
[24] Ecosystem-Based Marine Management, 2008, 27(1): 74-78.
[25] The Concept and Elements of Ecosystem Management, 2000, 11(3): 455-458.
[26] Layzer J A. The purpose and politics of ecosystem-based management // Weinstein M P, Turner R E, eds. Sustainability Science. New York: Springer, 2012: 177-197.
[27] Slocombe D S. Lessons from experience with ecosystem-based management. Landscape and Urban Planning, 1998, 40(1/3): 31-39.
[28] Ecosystem-Based Management, 2014, (6): 58-65.
[29] McLeod K L, Lubchenco J, Palumbi S R, Rosenberg A A. Scientific consensus statement on marine ecosystem-based management. Compass, 2005, (2004): 1-21.
[30] A Brief Analysis of Trends in Marine Sustainable Development Goals, 2016, 41(1): 44-45.
[31] Lu Y L, Nakicenovic N, Visbeck M, Stevance A S. Five priorities for the UN sustainable development goals. Nature, 2015, 520(7548): 432-433.
[32] Ecological Carrying Capacity Based on Ecosystem Services: Connotation, Assessment Models, and Applications, 2015, 30(1): 1-11.

Note: Figure translations are in progress. See original paper for figures.