CHAPTER 10

INNOVATION IN COASTAL ENVIRONMENTAL GOVERNANCE: AN ANALYSIS

- **Dr. Jenifer Stella**[*] and **G. Uma Maheswari**[**]

ABSTRACT

Environmental governance is the adjudicative procedure which contains the effective regulation along with the management of the environment as well as natural resources. Coastal environmental governance includes the control and administration of coastal areas, which has the ecosystem that strengthens the biodiversity, cultural heritage of indigenous fishermen and economy. The coastal environment is dynamic in nature. The emergence of liberalisation, globalisation and privatisation impacted the coastal environment also. The advent of the blue economy has more significance on countries' economies, though it has impacted in other ways over the environment and in the lives of the indigenous coastal community people. The anthropological activities which include construction of beach resorts, buildings, coastal infrastructure, ship building, mining of beach sand also has a greater consequence in the coastal environment viz., biodiversity loss, pollution and climate change. Marginalised and vulnerable coastal community people suffer consistently because of this. The coastal environment is governed by United Nations Law of Sea 1982, MARPOL 1973, Ramsar Convention on Wetlands 1971, Paris agreement on climate change 2015, Convention on biological diversity 1992 and in national level the laws are Coastal Regulation Zone Notification 2019, Indian Fisheries Act 1897, Environmental protection Act 1986, Wildlife protection Act, 1972, Marine Fishing Regulation Act 1978, Water Act 1974, National Biodiversity Act 2002, Blue Economy Policy 2021. In spite of numerous legal frameworks, still the coastal environmental governance has its own insufficiencies. Inadequacy of involving the indigenous coastal community people in the decision-making process is the major drawback of coastal environment governance in many countries. The use of technologically advanced AI models to predict coastal hazards, fisheries management and enhancing the warning system for storms and floods, for debris tracking and coastal surveillance will enhance the governance system. The researcher in this paper will analyse the existing legal frameworks in detail and suggest plausible suggestions by which the same can be amended with the adaptation of innovative practices to have an effective coastal environmental governance.

[*] Assistant Professor *at Vels Institute of Science, Technology & Advanced Studies (VISTAS), Chennai, Tamil Nadu.*
[**] Assistant Professor *at Vels Institute of Science, Technology & Advanced Studies (VISTAS), Chennai, Tamil Nadu.*

Keywords: Coastal Environment Governance, Blue economy, Indigenous fishermen, Artificial intelligence in Coastal Zone Management

INTRODUCTION

The Coast all over the world has various ecological and social systems. It undergoes various dynamic changes in habitat, ecosystem by human developmental activities. The influence by humans is more stringent along the coastline viz., deforestation, urbanisation which ultimately results in sea level rise, climate change, global warming, ocean acidification etc. The increasing economic activities which largely impact in the environment become a threat to the global community. The coastal zone which is having enormous natural resources, human population when managed properly will facilitate potential opportunities for prosperity. Sustainable Development Goal 14 which showcases "Life Below Water" is having connections with probably all the other SDG's and so many coastal communities depended on the coastal resources. "Blue Growth" agendas showcased by the European Commission, World bank and the United Nations Food and Agricultural organisation compliment the ambitions of Blue Economy.[278] The existing traditional legal framework which is more fragmented and less effective has to be strengthened with innovation in coastal management. The technological innovations need to be appropriately used and it has to be insisted on through proper policy framework, legally, institutionally, technically and it should be participatory to achieve the sustainability mentioned by the United Nations.

CONTEXT OF COASTAL ENVIRONMENTAL GOVERNANCE AND CHALLENGES

Governance needs to play a predominant role in coastal environmental protection. Coastal governance is the combined interactions of policies, laws, institutions and other standards which assumes power and responsibility to make decisions and implement the policies and laws enacted for the betterment of coastal environmental production. Even the environmental governance becomes transboundary as the groundwaters that pass through or situated on borders among two or more states involves international actors in to it. Coastal governance hence is a multifaceted arrangement between states or through some legislations in municipal law which involves jurisdictions, different government agencies, non-state actors and non-governmental organisation. Though the process of implementation

[278] Stefan Partelow, and others, 'Environmental governance theories: a review ad application to coastal systems' (2020) *Ecology and Society* https://www.researchgate.net/publication/346024077_Environmental_governance_theories_a_review_and_application_to_coastal_systems assessed 12 April 2025.

is difficult as it can yield affirmative and also undesirable results. Resident coastal governance often referred by way of area based radical and established procedures for dealing the coast and executing the plans and decisions. It includes representatives from local community people and corporate sectors and it instigates to follow a proper rule. Indeed, it's a group effort. The coastal governance needs to consider the cohesive nature of the coastal systems across the earth. The geographical nature of the earth is such that the land and the ocean is aways in interaction with each other. The borderline created by the ocean's shoreline has to be rejected by the landscape to avoid the discrepancy between the gauges of modification and gauges of administration or otherwise amid the "governing system" and also the "system to be governed[279]." The United Nations defines "governance system as the framework of social and economic systems, legal and political structures within which humanity organizes itself[280]." For sustainable management and conservation of the earth's ocean and safeguarding the same for future generations governance playing an important role. The key principles of environmental governance consist of sustainability, transparency, accountability, inclusiveness, precautionary approach and particularly protecting the rights of indigenous communities.

Challenges which remain as a hurdle for effective coastal governance are climate change, pollution, coastal erosion, coral reef destruction, loss of wetland ecosystems over exploitation of resources, sea-level rise, habitat destruction and understandable ways for land sea interaction. The blue economy which is emerging has many components in it which contains fisheries, aquaculture, ship building, beach resort construction, tourism, sand mining, coastal infrastructure development etc., which inserts economic pressure over state actors and also on municipal level. The indigenous community people who were often displaced due to the ocean-based development, lost their livelihoods and they were often least considered while making policy decision making. Over population and over exploitation of oceans resources also become a major alarm for effective environmental governance.

INTERNATIONAL LEGAL FRAMEWORK GUARANTEEING INNOVATIVE COASTAL ENVIRONMENTAL GOVERNANCE

[279] Lena Rolfer, Louis Celliers, David J Abson, 'Resilience and Coastal governance: Knowledge and navigation between stability and transformation' (2022) *Ecology and Science* https://www.researchgate.net/publication/361602420_Resilience_and_coastal_governance_knowledge_and_navigation_be assessed 13 April 2025.

[280] Andrew Lou L., Mungcal, 'Community-Based Coastal Resource Management (CB-CRM): A case study of Mariveles, Bataan, Philippines' https://ejournal.unlam.ac.id/ assessed 13 April 2025.

Internationally, the overall organisations, policy makers, financing mechanisms, procedures, treaties, conventions and norms regulate the process of global environmental protection. In Stockholm, Sweden in 1972 the concept of sustainable development emerged. The discussions in the conference also directed to the establishment of the UNEP United Nations Environmental Program that plays a prominent role in environmental governance globally. It manages the environmental activities within the UN agencies and facilitates new initiatives regarding environmental governance. Amidst the UNEP's contribution for ocean governance is commendable. United Nations Environmental program's regional seas convention and action plans are influential in inviting regional cooperation with a robust focus on gender and youth engagement along with partnerships and science-policy dialogues. To guarantee the health and flexibility of marine ecosystems to ensure the food security, economic opportunities and the welfare of coastal communities' strong governance is needed. On this note, the regional seas programmes, provide an agenda for regional ocean governance which guides the state actors in handling their marine and coastal environments. Innovative Ocean Governance was also supported by UNEP. The regional program guarantees women and youth contribute to and benefit for sustainable ocean management.

UNCLOS 1982 which is also termed as United Nations Convention on Law of Sea is an umbrella convention which mandates the conservation of Ocean environment. Many of the Articles under UNCLOS speak about innovative governance indirectly. The convention mandates the obligation of the State to protect and preserve the environment[281]. It encourages states to collaborate, directly or by capable international organisations, to encourage studies, undertaking programmes of scientific research also encourages the interchanging of information and data attained regarding contamination of marine environment[282]. States shall unite in launching appropriate scientific measures for the construction and embellishment of guidelines, ethics and suggestive practices and measures aimed at the prevention, lessening and control of contamination of the ocean environment which insists the need for modern tools or technologies[283]. The convention promoting marine scientific research emphasizes the rights and duties of the state in conducting the same. States shall engage in multilateral treaties to generate a favourable environment to engage in marine research; states can initiate the availability for publication and broadcasting by means of appropriate networks, information on

[281] United Nations Convention on the Law of the Sea (adopted 10 December 1982, entered into force 16 November 1994) 1833 UNTS 3 art 192
[282] Ibid, art 200.
[283] Ibid art 201.

anticipated key programmes and their purposes and information resulting from nautical scientific research. States shall actively encourage the movement of data and information particularly to evolving states through programmes to afford suitable instruction and training. The deployment or any installations for the purpose of scientific research shall not establish any hindrance to recognized international shipping routes.[284]. The Nations shall encourage the procurement, assessment and propagation of nautical technological acquaintance and enable access to such material or data, expansion of necessary technological infrastructure, human resource training of citizens of evolving states, to foster international cooperation wholly at levels[285]. Though many articles mentioned about the scientific research under UNCLOS nothing had been explicitly mentioned or no mandatory provisions are there with respect to modern technologies such as Artificial Intelligence, or remote sensing etc., it's all grounded on the discretion of the nations and global cooperation is very much needed to effectively use the marine resources without destroying all or in other sense to save the coastal environment for future generation.

Marine environment which is a beautiful gift of mother nature must be protected by the pollution from the ships and marine pollution need to be controlled and the ecosystem has to be conserved, for the very purpose a multilateral convention and protocol was adopted.[286] The annexes enshrined in the convention addresses various sources of pollution mandating onboard technical equipment and procedures. Technical provisions given in the convention mandates oil-water separators for ships, oil filtering equipment for separating oil prior to discharge, oil discharge monitoring and resistor structures, sludge tanks and rubbish oil water management systems, it is mandatory to maintain an oil record book for recording machinery operations and discharges. Regulations made for the combatting of pollution through noxious liquid matters in Bulk, computerized cargo handling system for safe discharge. Importance given to proper packaging, labelling and documentation which implies the use of barcode tracking and logistics technology. Sewage pollution prevention is regulated by equipped sewage treatment plants, disinfected sewage systems. Use of incinerators, garbage compaction, sorting systems, are insisted on for preventing garbage pollution. Onboard technology for segregation and reduction is designed using garbage management plan. Air pollution from ships also prevented exhaust

[284] Ibid art 238-265.
[285] Ibid art 268.
[286] International Convention for the prevention of pollution from ships (MARPOL) (adopted 2 November 1973, as modified by the Protocol of 1978, entered into force 2 October 1983) 1340 UNTS 61, Annexes I-VI

gas cleaning systems. MARPOL focuses on technical equipment, but it does not contain any mandate for the use of artificial intelligence tools, satellite observation or real time emission tracking systems. Fundamental ecological functions of wetlands, which establish a source of excessive commercial, cultural, scientific and entertaining value need to be protect also it should be conserved along with their flora and fauna and a convention was adopted for the same.[287] The convention article 3(1) establishes that the "The contracting parties shall formulate and implement their planning so as to promote the conservation of the wetlands included in the list, and as far as possible the wise use of wetlands in their territory" article provisions not expressly speak about any modern methods or there is any technology mentioned. But the words 'wise use' opens the platform for the innovative methods like GIS mapping, remote sensing which are used to monitor climate change, mapping disaster zones, water resource management, mineral exploration can be utilised for proper governance of coastal resources. Article 4(3) runs as "The State Parties shall reassure research and the alteration of data and publications concerning marshlands and the corresponding flora and fauna, which encourages research and data sharing which indirectly implies technological monitoring. For the preservation and sustainable utilisation of components of biotic variety besides the reasonable and impartial dispersal of the profits rising out of the utilisation of heritable resources, counting suitable admission to genetic resources, through the necessary transmission of applicable technologies and by proper funding the international community has adopted a convention[288]. Article 16 "Each Contracting Party recognising that technology includes biotechnology, and both access to and transfer to technology among contracting parties are essential elements for the attainment of the objectives of this convention, and also the sustainable use of biological diversity." Article 17 "The Contracting Parties shall facilitate the exchange of information, from all publicly available resources, relevant to the conservation and sustainable use of biological diversity, taking into account the special needs of developing countries, such exchange of information shall include exchange of results of technical, scientific and socio-economic research and information on training and surveying programmes, specialised knowledge, indigenous and traditional knowledge as such and in combination with the technologies" Article 18 " The contracting parties shall promote international technical and scientific cooperation in the field of

[287] Convention on Wetlands of International importance especially as waterfowl habitat (Ramsar Convention) (adopted 2 February 1971, entered into force 21 December 1975) 996 UNTS 245 https://www.ramsar.org/sites/default/files/documen assessed 14 April, 2025

[288] Convention on biological diversity, (adopted 5 June 1992, entered into force 29 December 1993 1760 UNTS 79 https://www.cbd.int/convention/articles/default.shtml?a=cbd-01 assessed 14 April 2025

conservation and sustainable use of biological diversity, where necessary, through the appropriate international and national institutions" The convention on biological diversity recognizes the significance of scientific as well as technological advancement, even though no explicit provisions for the artificial intelligence is there in the convention it is exposed to the contracting parties to implement the technology through artificial intelligence. For species identification artificial intelligence biodiversity assessments and machine learning for species identification and habitat modelling, sharing of technology infrastructure consists of cloud platforms, data visualization tools and predictive modelling systems for conservation and exchange of information can be carried out by constructing a global biodiversity digital observatory with open access AI dashboards where the data can be assessed from acoustic sensors can be implemented through multilateral conventions.

The Paris Agreement is an international treaty on climate change which enforces obligation on state actors. The agreement was adopted at the United Nations Climate Change Conference in Paris, France in 2015 and it came into force in 2016, with a goal to limit the temperature increase. Article 10(1), "Parties share a long-term vision on the importance of fully realizing technology development and transfer in order to improve resilience to climate change and to reduce greenhouse gas emissions" this recognises technology as a strategic pillar of climate resilience and mitigation. Article 10 (2), "Parties noting the importance of technology for the implementation of mitigation and adaptation actions under this agreement and recognising existing technology deployment and dissemination efforts, shall strengthen cooperative action on technology development and transfer" which supports the cooperation of international actors for technology advancement. Article 10(4) "A technology framework is hereby established to provide overarching guidance to the work of the technology mechanism in promoting and facilitating enhanced action on technology development and transfer in order to support the implementation of this agreement" which guides the implementation at national level. Article 10(5) "Accelerating, encouraging and enabling innovation is critical for an effective, long-term global response to climate change and promoting economic growth and sustainable development, such effort shall be, as appropriate, supported, including by the technology for collaborative approaches to research and development and facilitating access to technology, in particular for early stages of the technology cycle, to developing country parties" acknowledges the necessity to promote innovation and this unlocks the door for implementation of artificial intelligence and renewable energy technologies. The convention can be improved by authorizing the road maps

for adaptation and mitigation, artificial intelligence-based climate modelling, satellite monitoring for emissions, and blockchain for carbon markets.

The international actors considering the health of the ocean and seas developed an approach and put forward the same, known as blue economy[289]. Blue economy means sustainable usage of ocean resources also conserving it for future use. Blue economy endorses commercial growth, societal insertion and better-quality livings mean time guaranteeing the ecological sustainability of oceans and seas. Sustainable development's three dimensions are economic, social and environmental. Striking the balance between social economic development and conservation of ocean resources is often difficult but the blue economy tends to do the same. If the resources are maintained in a healthy ecological condition, then there is a possibility to attain the balance which is a major task to comply with. Though the global sustainable development principles were agreed and adopted by state actors, still remain limited in practice. Better governance will be guaranteed through the concept of blue economy also it supports innovation; enforcement directives are still at deliberate level. Municipal law has to undergo transition in order to achieve the blue economy in a healthier way. Multilateralism played a major role globally in achieving the needed traits of the blue economy initiative. Funds need to be provided liberally for research and development and for education purposes particularly in coastal AI applications, spatial data infrastructure.

NATIONAL LEGAL FRAMEWORK

The technology implication under Environment Protection Act 1986, is not specific; rather the act mandates the central government to take appropriate steps for environmental protection and to improve the eminence of the environment by thwarting, monitoring and abating pollution, harmonization through the state governments, and other establishments of the State and their authorities. The act mandates to plan a nation-wide program for the prohibition, regulating and reduction of environmental pollution, the act lays down ideals for quality of environment in its innumerable facets and also for release or expulsion of environmental impurities from several sources. The act puts down measures and protections for the anticipation of accidents that may cause environmental contamination and counteractive actions for the accidents, precautions for the handling of perilous materials, examination of such manufacturing processes, materials and substances which

[289] United Nations, Blue economy: Oceans as the next great economic frontier, 2022, https://unric.org/en/blue-economy-oceans-as-the-next-great-economic-frontier/ assessed 14 April 2025

cause environmental pollution. The act insists on sponsoring and carrying out researches which are related to environmental pollution and for the establishment of ecological workshops and institutes under this act. The preparation of guidebooks, codes or directors relating to the stoppage, control and decline of environmental contamination is necessitated. Attempts are made to prevent coastal environmental pollution through the act, though it will be more feasible to govern if remote sensing technologies and real time monitoring systems are used to find out coastal pollution levels. Also, integration of data belonging of to various other coasts for the purpose easy analysis in order to minimize problems will be more helpful.

Ensuring the safety of the coastal societies and other living in the coastal zones, in observance towards the 1986 Environmental Protection Act, the central government set out Coastal zone regulation notification on 2011. In order to guarantee livelihood safety to the fisher societies and further local groups existing in coastal zones, to preserve and guard coastal stretches its atmosphere and the sea area and to encourage expansion by sustainable means constructed on scientific ideologies taking into account the hazards of natural threats in the coastal zones, oceanic rise because of global warming, affirm the coastal stretches of the state and the water zone up to its territorial water edge, without the islands of Lakshadweep and Andaman and Nicobar and marine extents adjoining the islands up to its territorial edge , as coastal Regulation Zone and confines the set up and growth of any industry, actions or procedures and production or management or storing or discarding of hazardous materials as detailed in the Hazardous substances Rules 2009. The coastal area has been divided into CRZ I, CRZ II, CRZ III, CRZ IV. The CRZ I zone includes biologically subtle and significant locations such as national gardens, aquatic parks, nature preserve and other major biologically sensitive places of historical or cultural importance, including the extent amongst low and high tide levels. Inside 500 metres of the high tide region, development is prohibited CRZ II are developed areas that have been developed near to the shoreline, construction of buildings is permitted here when they complied with the applicable laws. Area which is not coming under CRZ I and II is categorised as CRZ III. Farming, viticulture, gardens, playgrounds, forestry and manufacture of salt are allowed in this area. Lakshadweep islands. The islands of Andaman Nicobar and other tiny islands are categorised below CRZ IV excluding those under CRZ I, II, III. The 2011 notification was reviewed in 2019 guaranteeing developments in economic activities, ensuring the state government can have control over the decision-making process. To precisely map coastal zones, geographic information system tools can be

used also to detect encroachments easily on coastal areas and the damages to the environment can be easily tracked if artificial intelligence is used.

The Marine Fisheries Regulation Act, 1978 mandated the preservation and conservation measures taken to protect the coastal and marine environment and regulation of fishing vessels in the 12 nm territorial sea is carried out through this act. Those of which comprise regulation of net size to circumvent juvenile fish catch, control and restriction of certain gears and mesh size restrictions, the sizes of the fishes whether it can be minimum-maximum, directive of gear to evade overexploitation of particular species, arrangement of sectors to traditional fishermen and assertion of the period of closures, delineate fishing regions in territorial waters aimed at fishing through non-mechanised and mechanised fishing vessels, distance since the shore earmarked for separately category differs from state to state, five to ten kilometres is generally reserved for process through artisanal vessels, zone regulations based on vessel types, registration and licensing of fishing vessels[290]. In India each state has their own marine fishing act based on the central legislation to regulate marine fishing. The act must be amended such that smart nets and detectors to find and release juvenile fish have to be used to stop juvenile fish catching and over exploitation, AI powered gear monitoring to monitor the compliance of mesh regulations, QR code tagged gear which will be linked to the fishermen ID for easy detection can be used. To identify species smart mobile apps can be used which facilitates species preservation and stock regeneration. Utilisation of Geo fencing to restrict entry to closed zones, satellite surveillance and drones can be insisted to screen violations and to allow breeding and regeneration. GPS enabled vessel tracking and digital marine spatial planning tools can be suggested to alert the traditional fishermen entering into unauthorised zones, registration and licensing can be made digitally which is integrated with Aadhar to have accountability and regulation. The 1897, Indian Fisheries Act which extends to the Indian territory is also an age-old legislation which speaks about destruction of fish in inland waters and protection of fish by the state government and arrest made without warrant if any person committed any offence mentioned under the act. The legislation also needs to incorporate modern technological advancement for effective functioning.

The 1974, water prevention and control act, which affords for the preclusion and control of water pollution and boards has been established to carry out the stoppage and regulate of water pollution

[290] Ashish sahu, Abinaya Rajendran, Amritha Priya, Mohammed Nadim Ansari, *Trends in fisheries and aquatic sciences*, (December 2022), 'Marine Fisheries Regulation Act (MFRA) and its amendments in India: An overview' Assessed April 14 2025.

and they have been assigned such powers and functions. The water quality needs to be monitored by modern technological devices and AI analytics for pollution detection can be incorporated to detect industrial discharge and to initiate proper remedies immediately. With respect to the National Biodiversity Act 2002, it has been established to afford for conservation of biological diversity, sustainable usage of its components and reasonable and equitable distribution of the aids rising out of the usage of biological resources, knowledge and aimed at matters associated therewith[291]. As for as the act is concerned, though digital documentation is mentioned, it can be further widened by including technological methods of documenting species diversity, distribution, and conservation status by creating and maintaining digital biodiversity registers, for identification of habitats and to help conservation planning artificial intelligence can be used, apps can be developed for monitoring biodiversity, awareness and data collection by inducing public participation.

The Wildlife Conservation Act, 1972 is an important legislation designed at conserving diverse wildlife including marine wildlife, the act permits for the formation of national parks, wildlife sanctuaries and marine protected areas. The act prohibits certain human activities in and around the restricted areas. The act guarantees coastal ecosystem protection in coastal areas. The act can be amended by giving broader sense to the objective, as such implicating a separate chapter aimed at coastal and marine biodiversity, by including the protection and conservation of marine and coastal resources through technologically advanced mechanisms.

Global and national Institutions like United Nations Environmental Program, UNESCO's intergovernmental oceanic commission, Fisheries and Aquaculture, International Maritime Organisation, World Bank, National centre for oceanic research, National Biodiversity Authority plays a prominent role in ocean governance and these institutions use artificial intelligence for respective works.

CONCLUSION

The critical analysis of national and international legal frameworks shows the technological implications. Global conventions strongly mandate the conservation and protection of the marine ecosystem; there are no explicit provisions edifying the use of advanced technologies. Municipal legislation is also in a nature that it shows less concern over the technology implications. Coastal

[291] Biological Diversity Act, 2002 (India) https://www.indiacode.nic.in/bitstream/123456789/2046/4/a2003-18.pdf assessed 14 April 2025.

governance in the era of globalization, privatisation and liberalisation needs to be addressed in an innovative way to combat the effects of climate change, biodiversity loss and industrial pressures. Both international and national laws need to be amended in a way that the use of advanced technologies are mandated. Rather conveying a wider and broader meaning the provisions need to be stronger and technology integrated, making general obligations as a specific one. Indigenous community fishermen need to be empowered by giving chance for decision making while implicating the innovations in coastal environmental governance, as they have traditional knowledge, which will be useful for further development in a way United Nations objective of achieving SDG in 2030.