



This is an Open Access article distributed under the terms of the Creative Commons Attribution-Non-Commercial-Share Alike 4.0 International (CC-BY-NC-SA 4.0) License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium provided the original work is properly cited.

Blue Economy, Fisheries, and Aquaculture: Governance, Ecology, and the Road to Regeneration

Chhote Lal Yadav^a Prof. (Dr.) Anirban Chakraborty^b

^aResearch Scholar, International University of Legal Education and Research, Goa, India ^bProfessor of Law, International University of Legal Education and Research, Goa, India

Received 07 August 2026; Accepted 08 September 2026; Published 12 September 2026

The Blue Economy is now an emerging paradigm in global ocean governance that holds promise for integrating economic development, food security and environmental conservation. This paper challenges that promise by examining fisheries and aquaculture, based on the State of World Fisheries and Aquaculture 2024, produced by the Food and Agriculture Organisation of the United Nations (FAO). It looks at the historical shift of aquaculture surpassing capture fisheries in 2022, the diminishing sustainability of marine fish stocks and the ongoing issue of IUU fishing.¹ Aquatic food systems are evaluated to be at increased risk from environmental stressors such as climate change, ocean acidification, habitat loss, and biodiversity loss, which are evaluated as growing threats. The paper assesses international, regional and national levels of governance, including UNCLOS, Regional Fisheries Management Organisations, the High Seas Treaty, Marine Protected Areas, and national strategies. It identifies the missing link as not the lack of policy or technology, but the lack of implementation, enforcement, equity, and accountability. Small-scale fisheries, women in aquatic value chains and Small Island Developing States are given special attention. The paper concludes by arguing that a regenerative Blue Economy based on restoration, rights, inclusion and enforceable governance is essential for fisheries and aquaculture to contribute to the health of the oceans and human development.

¹ Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction 2023

Keywords: *blue economy, fisheries, aquaculture, ocean governance, sustainable development.*

INTRODUCTION

The sea has always been in a kind of limbo in development discourses. It has been used as a means of food, transportation, energy, trade, jobs and cultural identity and has been managed as if it were a resource that could sustain itself indefinitely without significant institutional control. This paradox is no longer hard to overlook. The ocean influences climate, sequesters heat and carbon dioxide, is home to biodiversity and provides livelihoods for millions of people in coastal and island communities. However, there is considerable ecological stress on many of the systems that humans rely on to benefit from the ocean. In response to this contradiction, the Blue Economy arose, particularly in the years surrounding the Rio+20 process, as a way to ensure that ocean-based economic activity is geared towards ecological protection and social welfare.

This notion has since found its way into national policies, multilateral development programmes and international declarations. By 2025, the value of the global ocean economy was estimated at approximately USD 2.3 trillion annually.² Yet, this popularity of policies has not necessarily been accompanied by better ocean health. Marine stocks continue to be subjected to unsustainable fishing pressure, coastal habitats are still degrading, IUU fishing is still economically and ecologically detrimental, and the warming of the oceans is speeding up. The main issue is thus not so much whether the 'Blue Economy' has been accepted institutionally. The question is whether the concept has influenced the behaviour of states, firms, financial institutions and resource users in ways that safeguard the ecological foundation of ocean economies.

Fisheries and aquaculture are critical for answering this question. They are one of the oldest types of ocean use, and at the same time, they are going through a major structural change. In 2022, the total output of aquatic animals produced in aquaculture for human consumption (94.4 million tonnes) surpassed the output obtained from capture fisheries (92.2 million

² Manuela Stefania Fulga and Alfredo Giron, 'How the ocean economy can catalyze sustainable growth' (World Economic Forum, 27 October 2025) <<https://www.weforum.org/stories/nature-and-biodiversity/how-the-ocean-economy-can-catalyze-sustainable-growth/>> accessed 05 August 2026

tonnes) for the first time in history. The movement is significant for food systems and food trade, as well as for rural employment, coastal planning and environmental regulation. This poses a challenging question: will the growth of aquaculture alleviate the pressure on wild stocks, or will it create new ecological and social pressures in the form of feed, pollution, disease, land use change and market concentration?

Fisheries and aquaculture are used as a case study in the paper to explore the Blue Economy. It claims that the sector can only contribute to food security and livelihoods with enforceable, inclusive and ecologically based governance. Technology and finance are important, but they are not a substitute for poor institutions. The article is structured around five themes: conceptual debates on the Blue Economy; current production and sustainability conditions; environmental pressures; governance architecture; and future pathways towards a regenerative Blue Economy.

CONCEPTUAL FOUNDATIONS OF THE BLUE ECONOMY

The Blue Economy is not monolithic or agreed upon. Its meaning is different in different institutions, regions and political contexts. It is defined by the World Bank as “the sustainable use of ocean resources for economic growth, improved livelihoods and jobs, and ocean ecosystem health. This definition has influenced various national strategies, especially in developing countries, that focus on enhancing ocean-based industries, including fisheries, tourism, shipping and ports, and renewable energy. It's appealing because it combines growth and sustainability in a single formulation. The problem is that the connection between these two objectives is sometimes taken for granted and not proven.

To demonstrate that the language of blue growth tends to be sustainability-hedged economic growth rather than a description of ecological constraints to growth. However, UNEP is more forceful in linking the Blue Economy to restoration, clean technologies, renewable energy, circular material flows and ecosystem resilience.³ This shifts the focus from the value generated from marine ecosystems to the condition of these ecosystems.⁴ The debate has gone further, with academic and civil society discussions. Power, access, justice and

³ Anne Maria Eikeset et al., ‘What is blue growth? The semantics of “Sustainable Development” of marine environments’ (2018) 87 *Marine Policy*

<<https://www.sciencedirect.com/science/article/pii/S0308597X17306905>> accessed 05 August 2026

⁴ ‘Sustainable blue economy’ (*United Nations Environment Programme*) <<https://www.unep.org/topics/ocean-seas-and-coasts/ecosystem-based-approaches/sustainable-blue-economy>> accessed 05 August 2026

distribution cannot be overlooked in a sustainable and equitable Blue Economy. This perspective is not only about the value created by the ocean economy but also about who benefits from that value and who suffers the social and environmental costs.⁵

The difference between the ocean economy and the Blue Economy is thus relevant. The ocean economy involves any activity, whether sustainable or not, that relies on the ocean. The Blue Economy should only be applied to activities that are ecologically and socially acceptable. This separation, however, is not always respected in international debates, in which the Blue Economy may simply be a new way to justify extraction.⁶ This criticism is particularly pertinent in the fisheries sector, where official sustainability rhetoric may exist alongside overfishing, labour abuse, and lax regulation.

SIDS introduce another element into the debate. The ocean is an economic resource for many SIDS, but not only. It has a relationship to sovereignty, food, identity, security and survival. Their stance is an opposition to growth-oriented models which tend to view the marine resources primarily as investment assets. Therefore, intergenerational responsibility, local rights and ecological restoration are essential components of any credible Blue Economy. This is why the 'regenerative Blue Economy' has been coined. It asks a more ambitious question than simply keeping the status quo: Can Ocean governance help to heal damaged ecosystems and enable communities whose futures rely on them?

FISHERIES AND AQUACULTURE: PRODUCTION, SUSTAINABILITY, AND FOOD SECURITY

The fisheries and aquaculture industry is now at a turning point. According to FAO (2024), the total aquatic production in 2022 was 223.2 million tonnes, of which 185.4 million tonnes were aquatic animals and 37.8 million tonnes were algae. The first sale value of aquatic animal production was estimated at USD 452 billion, of which USD 296 billion was from aquaculture and USD 157 billion from capture fisheries. While these figures are indicative of the economic importance of the sector, they also highlight that aquatic foods are no longer

⁵ Nathan James Bennett et al., 'Towards a sustainable and equitable blue economy' (2019) 2(11) *Nature Sustainability* <<https://doi.org/10.1038/s41893-019-0404-1>> accessed 05 August 2026

⁶ Jennifer J Silver et al., 'Blue Economy and Competing Discourses in International Oceans Governance' (2015) 24(2) *Journal of Environment & Development* <<https://doi.org/10.1177/1070496515580797>> accessed 05 August 2026

predominantly sourced from capture fisheries. The primary source of growth has been aquaculture.

This change has both good and bad consequences. The good news is that aquaculture can help to improve food availability, diminish reliance on wild-caught fish, provide jobs and help with nutrition. Marine aquaculture possesses great growth potential, which can be achieved if it is developed in appropriate ecological zones and managed appropriately.⁷ However, on the negative side, poorly managed aquaculture can result in habitat loss, transfer of disease, nutrient pollution, use of chemicals, social displacement, and reliance on wild fish for feed. It is also geographically concentrated. The production of aquaculture is dominated by Asia; China is the largest producer in the world, producing more than 50% of aquaculture output. This concentration can be a concern for market power, biosecurity, supply chain vulnerability and benefit inequities.

The situation is different in the case of capture fisheries. Marine capture has been largely stable for decades, but that does not mean that it is ecologically sustainable. According to the estimates of FAO (2024), only 62.3 percent of the assessed marine fish stocks were in a biologically sustainable state in 2021 compared to 64.6 percent in 2019. As a result, the percentage of stocks under unsustainable pressure has continued to rise. This trend implies that present management regimes have failed to keep up with the fishing pressure relative to what the ecosystem can support. A number of well-managed fisheries have recovered; however, the overall trend is concerning.

The significance of fisheries and aquaculture is not merely in terms of production. The consumption of aquatic animal foods was approximately 20.7 kg per capita in 2022. Fish is a significant source of animal protein and micronutrients in many coastal and island communities. Fisheries policy is thus food policy and nutrition policy, and it is livelihood policy. There is an added dimension of international trade. Fish and fishery products are one of the most traded food commodities, and the value of exports is estimated at approximately USD 189 billion in 2022. However, growth in exports does not ensure the welfare of the

⁷ Rebecca R Gentry et al., 'Mapping the global potential for marine aquaculture' (2017) 1 *Nature Ecology & Evolution* <<https://www.nature.com/articles/s41559-017-0257-9>> accessed 05 August 2026

fishers, processors and small traders. The middlemen, exporters, industrial estates and big processors reap the value, not the local communities.

This is highlighted by employment data. Fisheries and aquaculture provide support to approximately 600 million livelihoods, including value chains. Employment in direct primary production is approximately 38.3 million people, with the majority in small-scale fisheries and aquaculture in Asia and Africa. Women play a significant role in the value chain of aquatic products, especially in processing, drying, marketing and retail. But their efforts are frequently overlooked in official fisheries statistics, which are centred on harvesting. The FAO Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries acknowledge these realities and recommend secure tenure, participation, decent work and social protection.⁸ They are, however, voluntary and therefore limited. Implementation requires national political will, administrative capacity, and small-scale communities' capacity to engage in decisions that impact upon their access to marine resources.

ENVIRONMENTAL PRESSURES ON AQUATIC FOOD SYSTEMS

The fisheries and aquaculture sector is now being transformed by environmental change at various levels. Climate change is the greatest pressure as it impacts temperature, oxygen, currents, productivity, species distribution, and extreme weather. Most of the additional heat from anthropogenic greenhouse gas emissions has been taken up by the ocean. Many fish stocks migrate to cooler temperatures or deeper water as temperatures get warmer. The changes pose management issues since legal jurisdictions and fishing agreements are typically based on historic distributions, and the fish are not. The outcome is growing conflict potential among neighbouring countries, DWFS and regional fisheries organisations.

The burden of climate impacts is uneven. Under high-emission pathways, the biomass and catch potential of tropical and subtropical fisheries, which rely on many small-scale fishers, are projected to decrease. This consequently makes it a justice issue. Communities most vulnerable to the effects of fishery decline have made the least contribution to global emissions. If climate change is an external issue, the Blue Economy policy cannot be credible.

⁸ *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication* (Food and Agriculture Organization of the United Nations, 2015)

Fisheries management, climate adaptation, disaster planning, insurance and livelihood diversification must be addressed in the same context.

There is the additional risk of ocean acidification. When carbon dioxide is absorbed, it decreases the pH of seawater, which has implications for organisms that rely on calcium to build their shells or skeletons, including oysters, mussels, clams, scallops, lobsters and reef-building corals. It is relevant to aquaculture, capture fisheries and biodiversity. In coastal areas that are already vulnerable, shellfish farms are also experiencing the death of their seed and production variability. The loss of coral reefs also impacts fisheries, as reefs serve as habitat, breeding grounds and nursery areas for many commercially important species. How warming and acidification can combine with local stresses such as pollution and overfishing to affect marine ecosystems is demonstrated by the Great Barrier Reef and Pacific Island reef systems.

Habitat loss also contributes to reduced ecological resilience. Mangroves, seagrass beds, wetlands, coral reefs and estuaries are nursery grounds, shoreline protection, carbon storage and feeding grounds. IPBES (2019) establishes a connection between biodiversity loss and ecosystem services reduction in marine and coastal systems. Much of the critical fish habitat has been degraded by mangrove conversion for aquaculture ponds, coastal infrastructure, logging and urban expansion. Fish, turtles, dugongs and coastal productivity are impacted by seagrass decline.⁹ The biological foundation of the Blue Economy is at stake, with significant reductions in monitored marine wildlife populations since 1970.¹⁰

IUU fishing is one of the most obvious examples of governance failure. The annual estimates of IUU catch vary from 11 to 26 million tonnes, and direct economic losses are in the billions of dollars.¹¹ IUU fishing affects markets, legal fishers, stock assessment data, and ecosystems. It is also associated in various contexts with forced labour, debt bondage and unsafe working conditions. The FAO Port State Measures Agreement is an important legal instrument since it enables States to refuse port access to vessels suspected of illegal catches. However, it

⁹ *Global Assessment Report on Biodiversity and Ecosystem Services* (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019)

¹⁰ *Living Planet Report 2024: A System in Peril* (World Wide Fund for Nature, 2024)

¹¹ *The State of World Fisheries and Aquaculture 2024: Blue Transformation in* (FAO, 2024)

requires inspection resources, information sharing, vessel tracking and political will to take action against influential operators.

GOVERNANCE, LAW, AND INSTITUTIONAL PERFORMANCE

Governance of fisheries and the Blue Economy is broad but disjointed. UNCLOS continues to be the basic law of the sea with regard to maritime zones, rights, duties and high seas freedoms. It established the concept of the Exclusive Economic Zone and conferred upon coastal States sovereign rights to resources in the sea up to 200 nautical miles. But flag state responsibility and national enforcement are critical in UNCLOS. Laws and legal obligations can be weak in practice where states are unable to enforce them or where fishing interests are politically powerful.

The primary institutions for the management of shared and high seas fish stocks are Regional Fisheries Management Organisations. They have a mixed rating. Others have enhanced data collection, catch documentation, observer coverage and compliance processes. Others still establish catch limits in excess of scientific advice, accept poor reporting, and have poor enforcement. This really is a root issue of institutional problems. The RFMOs are member-driven, and member states can have significant economic reasons to defend their fleets when they begin negotiations. Political bargaining can water down scientific advice. Regional management will persist as long as compliance mechanisms are not made more transparent and enforceable.

The High Seas Treaty of 2023 represents a significant step toward advancing international ocean governance.¹² It establishes a framework for Marine Protected Areas in areas beyond national jurisdiction, establishes requirements for environmental impact assessment and provides for benefit sharing of marine genetic resources. Its value is in filling gaps in the current legal frameworks. Meanwhile, ratification, funding, design and implementation of institutions, and implementation of the treaty itself will be key. Legal adoption is a beginning, not an outcome.

MPAs are frequently offered as a panacea for the protection of biodiversity and recovery of fisheries. Evidence indicates that properly designed and managed no-take reserves can lead

¹² Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction 2023

to an increase in biomass and provide spillover effects. However, the issue is that many MPAs are more of a paper park than a water park. In the absence of surveillance, community support, ecological design, and curbing of harmful activities, protected areas can give the impression of progress. The value of the 30x30 target will be limited if the improvement in coverage of Protected Areas is not matched by improvements in management.

National Blue Economy strategies have grown significantly. In some countries, like Seychelles, Mauritius, Kenya, Bangladesh, Sri Lanka, Indonesia or Norway, the ocean sectors have been placed at the centre of development and sustainability. The European Union has developed a more integrated approach with the Common Fisheries Policy, Marine Strategy Framework Directive, maritime spatial planning and the annual Blue Economy reporting. Other countries have policy documents and less robust data systems and enforcement. However, to realise the opportunities of the ocean economy, developing countries need trade facilitation, capacity building, technology transfer, and finance, as stated by UNCTAD.¹³ This is correct, but support should be linked to outcomes for sustainability and equity that can be measured.

TECHNOLOGY, FINANCE, AND MARKET INSTRUMENTS

Fisheries and aquaculture are transforming due to technology, but not all these changes are beneficial. Precision aquaculture involves the use of sensors, underwater cameras, automated feeding systems, machine learning and water quality monitoring to optimise farm performance. The use of smart feeding systems can minimise waste, optimise feed conversion, and cut down production costs. Detection tools can be used to detect early signs of stress, parasites or infection, which helps to minimise the use of general chemicals. Recirculating Aquaculture Systems can reduce environmental discharge and dependence on coastal waters, but are expensive in capital and energy.

For capture fisheries, monitoring technologies are also crucial. Vessel surveillance and traceability can be improved through satellite tracking, Automatic Identification System data, Synthetic Aperture Radar, electronic logbooks and digital catch documentation. Global Fishing Watch has demonstrated the benefits of open vessel tracking to promote transparency and combat suspicious activity. However, many illegal vessels turn off

¹³ *Developing a Vibrant Blue Economy: Ocean Economy for Sustainable Development* (UNCTAD, 2024)

transponders, use flags of convenience or take advantage of gaps in monitoring. Technology therefore is complementary to governance, but not to inspection, prosecution, port controls and market restrictions.

Traceability in the supply chain is growing in relevance to market access. Use of blockchain has been tested in high-value fisheries such as tuna. If buyers, regulators and customs authorities demand verified data, they can help to limit laundering of illegal catches. This links ocean protection to more responsible market behaviour, which is often not enough on its own. To modify incentives across global seafood supply chains, stronger import controls, due diligence requirements, and labelling requirements will be necessary in major seafood markets in Europe, North America, and East Asia.

Another sustainability challenge is aquaculture feed. A large proportion of wild-caught fish is still converted to fishmeal and fish oil. This results in a paradox, where the development of aquaculture could still rely on capture fisheries. Alternative feeds such as algae-based oils, insect meal, single-cell protein and plant-based ingredients are becoming commercial interests. Although these alternatives can alleviate pressure on small pelagic fish, they need to be evaluated with regard to land use, energy, cost, nutrition, and scalability. Integrated multi-trophic aquaculture (IMT) is a circular system that holds potential as it integrates fish, shellfish and seaweed, with waste products of one species being inputs for another.

Finance is now at the heart of the implementation of the Blue Economy. Marine conservation and ocean-based sectors are being supported through blue bonds, blended finance, concessional lending, climate finance and debt-for-nature swaps. The Seychelles blue bond is frequently mentioned as an early example of a sovereign bond. Finance should be made available for the monitoring, data systems, coastal adaptation, sustainable aquaculture, port state controls and community livelihood needs of SIDS and developing coastal states. One of the greatest dangers is blue washing, which involves the conventional extraction of the resource and the promotion of it as sustainable investment. Independent standards, disclosure and accountability are therefore paramount.

EQUITY, SMALL-SCALE FISHERIES, GENDER, AND SIDS

Equity cannot be an afterthought in the Blue Economy. It is at the heart of the question of the legitimacy and durability of ocean governance. Small-scale fisheries provide a significant

proportion of jobs and catch, but are not always included in plans. Fishing communities can lose access to traditional fishing grounds when governments set aside coastal and marine areas for tourism, industrial aquaculture, offshore energy, conservation areas, or port development. This cannot be resolved through consultation alone, as it lacks decision-making authority. Maritime spatial planning should include rights, tenure, representation and grievance mechanisms.

Gender equality is also important. While women are actively engaged in processing, drying, and trading, seaweed farming and shellfish collection, as well as retail, are less visible than harvesting. According to UNCTAD (2024), the fisheries sector and tourism are sectors where gender-sensitive Blue Economy policy can yield development benefits. This involves improved data, credit, occupational safety, childcare support, training, leadership and recognition of post-harvest labour. If not, the growth of the Blue Economy can foster existing inequalities and still produce inclusive results.

SIDS are in a unique situation. The ocean provides the foundation for food security, income, mobility, identity and strategy for countries like Maldives, Kiribati, Tuvalu, Fiji, Marshall Islands, Mauritius and Seychelles. Collective fisheries under the Parties to the Nauru Agreement (PTNA) demonstrate how institutional innovation can enhance revenue capture for resource-owning states, in the case of Pacific tuna fisheries. Meanwhile, SIDS are vulnerable to sea-level rise, cyclones, coral bleaching, coastal erosion and changing fish stocks. For their Blue Economy pathways, they need climate justice, concessional financing, technical capacities, and increased ownership of the value that their marine resources create.

PATHWAYS TOWARD A REGENERATIVE BLUE ECONOMY

Based on the evidence presented in this paper, the conclusion is clear: Governance quality is the make-or-break factor for fisheries and aquaculture to contribute to the Blue Economy. The requisite tools are well recognised. These encompass science-based catch limits, ecosystem-based fisheries management, port state controls, secure rights for small-scale fishers, effective MPAs, transparent subsidies, traceability, labour protections and responsible aquaculture regulation. The challenge is the implementation.

Regenerative would go beyond just avoiding further damage. It would make it a policy goal to restore. This will involve rebuilding fish stocks, restoring mangroves and seagrass beds,

reducing bycatch, protecting nursery areas, changing harmful subsidies, and designing aquaculture systems that enhance rather than harm local ecosystems. It also involves putting communities, workers and women at the heart of governance instead of as beneficiaries of decisions made elsewhere.

Reforms for capture fisheries should include improvements in stock assessments, independent monitoring of stocks, transparency of catch allocation, improved RFMO compliance, and elimination of subsidies that promote overcapacity. Growth should be tied to carrying capacity, feed sustainability, disease control, water quality and spatial planning for aquaculture. Traceability and labour standards should be the basis for granting market access. Finance should be linked to indicators of ecological and social benefits by the use of blue instruments. International cooperation needs to be based on assisting SIDS and developing coastal nations with building capacity rather than on the transfer of responsibility without resources. The Blue Economy is thus not a slogan but is regenerative. It is a challenging governance agenda. It demands that governments challenge vested interests, investors embrace credible standards, consumers demand traceable products, and that multilateral institutions connect finance and tangible results. It also involves seeing that there is no separation between ocean sustainability and social justice.

CONCLUSION

The promise and weakness of the Blue Economy can be seen in fisheries and aquaculture. It provides food for billions, livelihoods for hundreds of millions, and is key to the future of food security. The increase in aquaculture reflects the fast transformation of aquatic food systems, and the reduced sustainability of stocks demonstrates that capture fisheries continue to be severely affected. Climate change, acidification, loss of habitat, IUU fishing and biodiversity decline are not separate issues. They are linked to governance gaps and social inequalities.

In this paper, it has been argued that the Blue Economy will not be complete if it is not enforceable, equitable and restorative. There is more institutional capacity than policy language. Political unwillingness can't be fixed with technologies. Finance is required, but it needs to be safeguarded against blue-washing. For MPA networks, traceability systems, blue bonds and aquaculture development to work, they must be part of a transparent, science-

based, and community-accountable governance framework. The Blue Economy is about using the oceans in sustainable ways. A regenerative Blue Economy poses the question of damaged systems and the possibility of reorganising development around ecological recovery and social rights. This choice is a pressing one for fisheries and aquaculture. The future of this industry is not about getting more out of the ocean; it is about disciplining, fairly and respectfully governing the ocean.