

# Harnessing Blue Economy for India's Economic Buoyancy: Challenges and Opportunities

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**Abstract**— The Blue Economy refers to the wide variety of economic activities dedicated to ensuring the sustainable use and conservation of ocean resources, from fisheries and aquaculture to marine biotechnology, renewable energy, maritime transport, coastal tourism, and seabed mining. It is a force for transformative change towards sustainable development through the growth of GDP and job creation, coupled with the fulfilment of protein needs for millions, social equity, and protection of ecosystems, particularly coastal ones. This converges well with SDG 14, Life Below Water. Another interesting aspect is that it also represents an enormous economic opportunity worth about \$1.5 trillion annually. In India, the Sagarmala Project and Deep Ocean Mission are taking the country forward on the path of the Blue Economy through an integrated approach designed in Maritime India Vision 2030. There are however several problems relating to the regulation, degradation of environmental concerns and lack of finances which have continually been an issue for this sector. Such issues require multi-dimensional approaches toward policy frameworks, education, community engagement, and indigenous knowledge with scientific practices. Community-based tourism and resource management can help galvanize local economies and minimize negative impacts on the environment, furthering a resilient and inclusive Blue Economy in India.

**Index Terms**— blue economy, sustainable development, community engagement, marine resources, coastal tourism.

## I. INTRODUCTION

The blue economy focuses on the effective use of ocean resources in a sustainable manner, hence meeting economic growth with improvements in livelihoods and jobs while conserving the health of ecosystems. It encompasses an enormous spectrum of financial activities related to oceans, seas, and coastal areas. The key components are maritime shipping, fisheries and aquaculture, coastal and marine tourism, renewable energy, marine biotechnology, seabed mining, marine genetic resources, water desalination, undersea cabling, and marine spatial planning. Maritime shipping refers to the transportation of both freight and passengers via sea routes, which is essential to international trade and, indeed, over 80 percent of international trade occurs in volume by sea. Catches for direct human consumption and aquaculture – the activities of catching, taking, and cultivating fish and other seafood – have become a source of proteins for more than 3 billion people and an important livelihood for millions of others. Coastal and marine tourism, including beach tourism, boating, and diving, is a significant activity in local economies around the world and, increasingly, along coastlines. It includes renewable energy sources such as offshore wind, tidal, and wave energy,

which may supply enough electricity to the existing grids which could power an enormous amount of energy minus fossil fuel dependence (Hazra and Bhukta, 2022)..

Marine biotechnology is described as the utilization of marine organisms in developing new products and technologies ranging from pharmaceuticals to cosmetics, industrial enzymes, and much more. Seabed mining is also another term for extracting minerals and other resources on or from the ocean floor. This includes deep-sea mining for metals as well as other rare earth elements. The discovery of genetic material or genetic resources from marine organisms represents marine genetic resources, an important role in bioprospecting as well as the development of new biotechnologies. The desalination of seawater to extract fresh water is referred to as water desalination. Undersea cabling refers to the laying and maintenance of submarine cables for telecommunication; it is the backbone of the global Internet and telecommunication networks. Marine spatial planning therefore refers to the strategic management of marine space to achieve a balance in ecological, economic, and social objectives for sustainable resource use while reducing conflicts (McBain, 2023).

## II. THE SIGNIFICANCE OF THE BLUE ECONOMY FOR INDIA

The term "blue economy" identifies the sustainable utilization of ocean resources toward economic growth, improved livelihoods, and jobs with preserved health of ocean ecosystems. Its activities start from fisheries to maritime transport, tourism, renewable energy, and marine technology. Estimates show that a blue economy can generate \$3 to 6 billion annually for the world's economy while creating more than 30 million jobs worldwide to sustain the livelihood of millions of people, particularly in coastal and island nations. Beyond this, oceans provide a critical source of protein for over three billion people (World Bank, 2022).

The Blue Economy accounts for about 4 percent of India's Gross Domestic Product, with fisheries, maritime transport, tourism, and offshore energy included. It gives a major source of the generation of employment opportunities to millions, wherein a significant chunk of its population lives in coastal areas, where fisheries alone support around 14 million livelihoods. With a coastline of over 7,500 kilometres and 12 major ports, maritime transport is the only feasible form of India's trade, as it amounts to 95% of the total trade volume of the country. Coast and marine tourism also becomes a lifeline source for the local economies, as millions of tourists pay a visit to them every year and provide hundreds of jobs. Again, the growth of offshore wind, tidal, and wave energy projects ensures a huge exploitation of marine renewable energy, thus amplifying energy security and reducing the dependency on fossil fuels. The Blue Economy promotes the sustainable

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management of marine resources; economic activities should not harm the health of the ocean ecosystem. Marine renewable energies help decrease the gases that cause global warming. They also supply carbon sinks by sound marine ecosystems that absorb carbon dioxide in the atmosphere. Responsible fishing and developing marine protected areas ensure the proper care of marine biodiversity. Marine biodiversity ensures that ecological balance and resilience across the world are well maintained. The Blue Economy consists of efforts to reduce and control marine pollution through waste management and plastic reduction efforts, protected marine life, and most importantly, quality water. Mangroves and coral reefs are natural and healthy ecosystems for coastal regions that provide resistance against storms and coastal erosion, which indirectly decreases the effect of natural disasters on coastal populations (SIRU, 2022).

The Government of India's initiatives, like the Sagarmala Project, Deep Ocean Mission, national fisheries policy, and Integrated Coastal Zone Management (ICZM), are going on and should spur the blue economy of India. The Sagarmala Project includes modernization of port infrastructure, improvement in connectivity, and induction of development through port activities. The deep ocean mission focuses on the resources' exploration at deep seas and the furtherance of technologies for the sustainable utilisation of oceanic assets. Again, the national fisheries policy focuses on the issues of promotion of sustainable fishing practices and improvement of the livelihoods of fishers. It is concurrently implemented for bringing environmental, economic, and social goals into harmony through the strategies of sustainable management within the coastal zones. The Blue Economy has great significance not only for India's growth in the economic sector but also towards an environmentally sound future. It holds great growth potential for the economy while promising not to jeopardize the health and resilience of marine ecosystems. Strong policies and sensible sustainable practices must be pursued to reap the fruits of the Blue Economy and overcome the impacts of climate change and environmental degradation (SIRU, 2022).

### III. EVOLUTION AND PROLIFERATION OF THE BLUE ECONOMY CONCEPT

Gunther Pauli coined the term "Blue Economy." The author penned his book in the year 2010 titled *The Blue Economy: 10 Years, 100 Innovations, 100 Million Jobs*. According to Pauli, an ecologically friendly model of the economy is also supported by a future model of an ocean-friendly economic model where that focuses on the protection of natural wealth and uses the resources of the ocean. In this respect, the concept, therefore, caught the world's eye at large when it was introduced during the Rio+20 United Nations Conference on Sustainable Development 2012 as an effort channelled towards trying to find a solution to issues related to sustainable development and poverty reduction—the focus for which was heightened by the new role that oceans play in such areas. In this regard, this year also witnessed the demarcation of the timeline when the Blue Economy is finally included in the international framework of Green Economy, as evidenced by a report by UNEP and other associated agencies. In this regard, Small Island Developing States have been advocates of realizing the strategy of the Blue Economy with enormous

capacity to overcome any solution that could apply to their challenge and avail themselves of opportunities which the concept provides. Indeed, countries in this group have had a tremendous impact on the international discussion of the Blue Economy. World Bank, United Nations, and Commonwealth are the major international organizations researched and policy planned toward Blue Economy, along with funding opportunities.

Beyond national policy and plans currently in the making, many countries are embracing concepts of the Blue Economy, such as marine protected areas, sustainable fisheries management, and investments in marine renewable energy. New 'blue' frontiers and opportunities hitherto unknown open up through advances in marine technology, deep sea exploration, marine biotechnology, and renewable energy. The Global Ocean Commission was formed in 2013 and has been extremely active towards sustainable governance of the oceans, advancing the Blue Economy. In 2015 – SDG Goal 14 (Life Below Water)—concentrated attention on the part that the Blue Economy would play in achieving sustainable development. In 2018, the initiative emerged to gather the leaders of the world to better ocean health and a more sustainable, ocean-based economy. Through the sustainable usage of marine and ocean spaces by various countries, all economic potential by such countries regarding marine resources should be optimally exploited in manners that ensure environmental sustainability. Good implementation of Blue Economy initiatives demands high coordination between the government, private enterprise, and civil society. Innovation remains quite crucial to effectively dealing with contentious challenges such as climate change, marine pollution, and overfishing, and to fully reap the fruits of the new opportunities arising for the Blue Economy. The Blue Economy has blossomed from a conceptual framework to a new global movement for sustainable development through responsible exploitation of resources from the oceans (Goulvello and Simard, 2024). It has gained momentum as more people become increasingly aware that the importance of oceans reaches beyond economic growth to include environmental health and social well-being.

### IV. INDIA'S MARITIME HERITAGE

Dockyards at Lothal in Gujarat add to the thought that the Harappan people had very sophisticated marine technology and trading practices because they traded with Mesopotamia. And during the days of the Maurya and Gupta regimes, it had seen the emergence of significant maritime trade routes between India and Southeast Asia not only for trade but for the spread of Buddhism. The Chola dynasty, in the 11th century, launched naval expeditions that extended Indian influence throughout Southeast Asia but demonstrated that India could dominate naval capabilities. Indian ports played a vital role in the Spice Route that served not only as a means of exchanging spices between India and Europe but also to secure maritime connections along the Silk Road connecting India to China and other places. The entry of European powers in the 15th century marked a new beginning in India's maritime history when major ports were founded and shipping activity gained further momentum. Bombay or Mumbai, Calcutta or Kolkata, and Madras or Chennai were

major centres during the British colonial rule in India (Jacob, 2014).

Maritime trade helped in transferring culture between India and other civilizations to enrich Indian culture. The spread of Buddhism along coastal routes is a fine example that depicts the cultural transfer done through the maritime activities of Indians. Maritime traditions are best represented through Jagannath Rath Yatra, Kerala boat festivals, and Varuna worship. Jagannath Rath Yatra festival is the most vivacious ceremony that symbolises the deep-rooted spiritual bonding with the maritime community in Puri, Odisha. Kerala boat festivals, as represented through their snake boat races, reflected the historical connection of the region with its rivers. Varuna, the Vedic god of the oceans and rivers, is worshipped along India's coast, showing a spiritual connection to the sea (Jacob, 2014).

This is something that over 7,500 kilometres of India's coastline and its twelve major ports as well as some 200 minor ports can swear by. In terms of volume, 95% of India's trade has to be done by sea. The GDP of India derives a major percentage from the maritime sector as it provides millions of jobs and makes international commerce possible. Besides providing livelihood support to nearly 14 million Indians, the fisheries industry is an important source of protein for large parts of the population. Coastal and marine tourism, highly contributing to the local economy boost, account by far for millions of visitors per year that go hand in hand with many jobs created. India has proposed to significantly invest in offshore wind, tidal, and wave energy projects to exploit marine renewable energy sources, thus strengthening energy security and reducing reliance on fossil fuels (Singh, 2021).

The Indian Navy had played its part in maintaining maritime security and protecting national interests besides promoting regional stability. The Blue Economy focuses on the sustainable use of resources provided by the oceans so that no harm is done to the health of the ocean ecosystem from activities conducted economically. Efforts to diminish marine pollution and manage waste are synchronized with the conservation of marine life and the improvement of water quality. Efforts from marine renewable energy programs help in reducing greenhouse gas emissions. Healthy marine ecosystems act well as carbon sinks that absorb CO<sub>2</sub> quite effectively from the atmosphere. In this context, India's special maritime heritage is not only associated with past importance but forms an essential component in its current economic and environmental strategies (Singh, 2021). This may be achieved when India harnesses its marine resources for sustainable economic growth, raises betterment in food security, and provides succour to global environmental sustainability.

#### V. CURRENT STATE OF BLUE ECONOMY IN INDIA

India's Blue Economy amounts to almost 4% of the country's GDP. This nation has more than 7,500 kilometres of coastline and an Exclusive Economic Zone extending up to more than 2.2 million square kilometres and, in turn, is making full use of its vast oceanic resources to create ample opportunity for economic growth. Central initiatives include Sagarmala - an initiative toward upgrading port infrastructure and developing coastal connectivity, Pradhan Mantri Matsya Sampada

Yojana to promote sustainable development in fisheries, and research into and utilization of deep ocean resources through the Deep Ocean Mission. So these too are developments, yet problems like climate change, marine pollution, and resource misuse yet again argue for an integrated approach toward attaining sustainable development (Singh, 2023).. Three sectors form the economy of India, broadly classified as including fisheries, tourism, shipping, and renewable energy, which along with other related activities contribute to the national economy but also provide livelihoods for a very large number of people.

The industry of fisheries sums up to around 1.24% of the Gross Value Added (GVA) for India and over 7.28% of the agricultural GVA. India is placed as the second-biggest producer of aquaculture and the third-largest fish-producing country in the world. Besides this, the sector also generates employment for about 14 million people. and sustains a huge portion of the coastal population thereby contributing to food security and income levels. The Marine exports between April 2021 and February 2022 stood at Rs. 56,200 crore (Rajeev and Bhandarkar, 2022). In other words, on average the tourism and travel sector contributes to about 9.1% of India's GDP. Tourism Value-Added accounts for 2.78 percent of the GDP in terms of direct contribution; when the indirect effects are also accounted for, then the share of tourism in the GDP is 5.83 percent. Significant portions of tourism also comprise aggregate employment and directly account for 4.59 percent of the aggregate number of jobs, thus being an important source of employment through jobs in the hospitality, travel services, and ancillary sectors of tourism. This sector also is a bankable source of foreign exchange earnings. In 2022, India attracted over six million foreign tourists whose revenues accounted for over \$16.93 billion (Singh, 2023).

The Indian shipping and logistics sector contributes to 13-14% of the country's GDP, handles 95% of India's trade by volume and 70% in value, and employs over 22 million people, thus making it the largest employer in India. This has also included visibly large investments in port infrastructures and maritime clusters in the states of Gujarat and Tamil Nadu over the past decade or so, supportive of rising economic efficiency and foreign investment. As renewable energy-generated almost entirely by solar and wind power at a breakneck pace-helps spur economic growth together with new energy security, clean energy investments constituted not more than a 5 percent contribution to GDP growth in 2023. Here, up to 2023, India added to its installed renewable energy capacity at 176 gigawatts, classifying it as the fourth leading nation with renewable power capacity globally. Innovation under the programmes of the Production Linked Incentive scheme for solar modules and batteries is creating jobs and value addition in this sector (Kamble et al., 2024). Hence, the important sectors for India's economic growth are those of the Blue Economy comprising fisheries, tourism, shipping, and renewable energy. They have a notable share of GDP, bring employment, add to trade, and also resonate with the sustainable development goals. With these industries, India can strike the optimal balance on the growth path of the economy and still have its environmental sustainability intact.

## VI. GOVERNMENT POLICIES AND INITIATIVES

India has been aggressively promoting the blue economy through initiatives adopted by the government with the overall aim of sustaining development and bringing economic growth. Some of the key policies/initiatives are the Sagarmala Project, Pradhan Mantri Matsya Sampada Yojna (PMMSY), Deep Ocean Mission, Maritime India Vision 2030, O-SMART, Integrated Coastal Zone Management (ICZM), national fisheries policy, and Draft Policy Framework for Blue Economy, etc. In 2016, the Sagarmala Project was launched, which mainly revolved around the process of modernizing India's port infrastructure, including improving connectivity to coastal areas, emphasizing port-led development, and enhancement of port connectivity to promote the development of coastal communities. It is going to reduce the cost of logistics for both domestic EXIM cargo, thus leading to overall economic growth. Launched in 2020, the Pradhan Mantri Matsya Sampada Yojana (PMMSY) aims at a 'Blue Revolution' achieved through sustainable and responsible development in the fisheries sector. This has at its core an increase in fish production, better infrastructure, and fisher welfare while laying down a positive paradigm for sustainability issues regarding marine ecosystems (Subhadarsani et al., 2024; EACPM, 2020).

The Deep Ocean Mission has been proposed to focus systematically on exploring and mapping the deep-sea environment. A combination of deep-sea mining, underwater robotics, and advisory services on ocean climate change, the mission supports sustainable harnessing of ocean resources and contributes towards the concept of blue economy. Maritime India Vision 2030 was launched in 2021 by the Ministry of Ports, Shipping, and Waterways, offering comprehensive vision proposals to develop world-class infrastructure in the maritime sector and increase India's global trade in the maritime sector. The plan has included modernization and digitization of ports besides focusing on green shipping. O-SMART is an umbrella scheme embracing ocean-related activities under Ocean Services, Technology, Observations, Resources Modelling and Science. Ocean information services, research on ocean science and technology, and developing technologies in the sustainable harnessing of ocean resources are all goals. The primary objective of ICZM is to integrate management of coastal areas sustainably. Its effectiveness involves the coordinated application of different policies affecting the coastal zone in implementing measures regarding coastal erosion and habitat conservation, pollution control, and similar concerns (EACPM, 2020).

National Fisheries Policy deals with the sustainable development of the fisheries sector. It aims at improving fish production, improving the livelihood of fishers, and conserving marine biodiversity. The other collaborative effort is between India and Norway referred to as India-Norway Task Force on Blue Economy for Sustainable Development. Focus areas are marine spatial planning, ocean governance, and sustainable fisheries. It also looks into ways of the draft policy framework for the blue economy in marine spatial planning, sustainable fisheries, coastal tourism, and ocean governance. The framework focuses on innovation, zero waste, and low-carbon technologies. NavIC or Navigation with Indian Constellation is India's independent regional

navigation satellite system. The positioning information services offered to users in India and the surrounding regions are of paramount importance for maritime safety and navigation. This reflects a commitment by India to exploit all its vast maritime potential and ensure that those exploits are sustainable both in the environment and in booming economies. (Subhadarsani et al., 2024; EACPM, 2020).

## VII. OPPORTUNITIES IN INDIA'S BLUE ECONOMY

Almost all sectors in the Indian economy look promising for its blue economy, contributing to several prominent growths hence keeping the country's economic growth and sustainable development at high levels. The presence of more than 7,500 kilometres of coastline in India presents many possibilities for fisheries, aquaculture, maritime transport, and coastal tourism. It can be said that millions of employees are engaged in the fisheries sector alone, and yet there is still much room for income generation through sustainable development. Besides these, ample opportunities exist for offshore renewable energy that includes wind power and tidal power. This would give the prospective regions promising areas in terms of energy security and lesser carbon emissions. Marine biotechnology is another segment of the blue economy, giving rise to new pharmaceuticals and bio-products. Last but not least, there are Sagarmala Projects; this is an upgrade in port infrastructure to boost trade and connectivity. On the whole, the blue economy kept the economies growing and has now ensured that there's always emphasis on sustainable and resilient environments.

### i. Sustainable Fisheries and Aquaculture

Sustainable fisheries and aquaculture are perhaps the biggest drivers for India while pursuing the blue economy. They have huge potential in shaping food security, economic growth, and environmental sustainability. Fisheries and aquaculture significantly contribute to the Indian economy, as hundreds of millions of people directly earn their livelihood through the former. These mainly take place in coastal and rural areas. India ranks second in aquaculture production and third as a fish producer globally. This is a very significant contributor to the GDP of the country. The sector can produce greater growth in the economy if proper sustainable practices are followed. Sustainable fisheries and aquaculture are key elements for food security and nutrition. Fish remains the main source of protein and much-needed nutrients for millions of people in India. However, productivity gained through sustainable practice will enable the industry to maintain healthy marine ecosystems from which a stable supply of good nutrition will be produced. In this respect, marine biodiversity and ecosystems appear to be manageable through sustainable practices, with overfishing, habitat destruction, and pollution as some of the major threats to marine life. These will be counterbalanced by the negative effect of eco-friendly technology-restrained fishing, habitat renewal and control of pollution; therefore, a thriving productivity – and rich environment for the aquatic ecosystems of the marine. The newer technologies in aquaculture such as recirculating aquaculture systems, biofloc technology or integrated multi-trophic aquaculture have increased productivity but at the same time addressed

sustainability concerns. Resource optimization makes it socially environment-friendly and reduces the negative impacts on the environment while the process of fish farming becomes more efficient and effective (FICCI, 2020).

Sustainable fisheries and aquaculture development with various initiatives taken by the Indian government is concerned. In that respect, one such plan would be the Pradhan Mantri Matsya Sampada Yojana or PMMSY through which 'blue revolution' would be aptly understood. It focuses on the areas of increasing fish production, infrastructural improvements, and welfare of the fishermen aside from its focus on the National Fisheries Policy on sustainable practices that enhance fish production and marine biodiversity. The other area where the capture fisheries and aquaculture can contribute in the fight against global climate change lies in ensuring healthy ecosystems, which absorb huge amounts of CO<sub>2</sub>. Protecting such systems by ensuring sustainable practices adds the sector to the efforts of mitigating climate change. Sustainable fisheries and aquaculture support the socio-economic development of coastal communities. Such practice works towards reducing poverty through the establishment of stable livelihoods, improving the living standards of people along the coast. This includes efforts towards policy alignment with international organizations and countries, such as the India-Norway Task Force on Blue Economy, which works towards sustainable development of the blue economy. Themes include marine spatial planning, ocean governance, and sustainable fisheries. In other words, sustainable fisheries and aquaculture are the goals behind the blue economy in India. It will support economic growth, food security, environmental sustainability, and community development; hence, the core of the Indian blue economy (PIB, 2023; FICCI, 2020).

#### ii. Marine Biotechnology

Marine biotechnology is to be applied for novel applications in various sectors. Marine resources are to be brought to the forefront to search and use marine organisms and their derivatives for producing products and technologies that would eventually lead toward economic facilitation and environmental sustainability. Marine biotechnology promises a lot in transforming the pharmaceutical industry through the production of new and innovative compounds that may be feasible in the discovery of new drugs. It is for this reason that naturally occurring potent substances found in marine bioresources form a basis for new medicines and health supplements. Most of the products from marine biotechnology go to the cosmetic industries. The most typical applications in which the marine ingredients, due to their origin derived from the marine environment are utilized in anti-ageing creams as well as other skincare productions that utilize their unique qualities. Marine biotechnology also helps in producing renewable fuels. For instance, using algae in biofuels would imply renewable sources of energy and less reliance on fossil fuels with carbon emissions. Marine biotechnology has made a lot of contributions towards environmental conservation, particularly due to the development brought about in some techniques, such as biosensors and bioremediation. Biosensors and bioremediation have given way to better observation and remediation of marine pollution, thereby leading to more balanced marine ecosystems (Pramanik et al., 2022).

The largest factor in changing aquaculture practices has been biotechnology. Developments include disease-resistant strains of fish, formulation of feeds that increase productivity but reduce environmental impact, and prudent agricultural practices applied with high success. Another very important contribution of marine biotechnology is in the exploration of marine biodiversity for its commercially valuable genetic and biochemical resources. Such bioprospection may open up avenues for finding new materials and compounds useful in industries. Marine biotechnology has been fostered by various government efforts and research initiatives. India has already initiated the process by establishing institutions like the NIOT (National Institute of Ocean Technology) and CMFRI (Central Marine Fish Research Institute) for leading positions in marine biotechnology, with an emphasis on the sustainable exploitation of marine resources. Marine biotechnology is expected to significantly add value to India's GDP by producing high-value products, thus offering a source of employment. It would bring India to the top ranks of innovative and sustainable development in a high-tech field (Pramanik et al., 2022; Juneja, 2021).

#### iii. Coastal and Marine Tourism

The blue economy provides a very important coastal and marine tourism scope for India, full of economic development, employment opportunities, and sustainability. This industry has contributed considerably to the GDP of this country. Some such segments within this industry that attract internal and foreign tourists and provide income and stimuli to local economies are beach tourism, marine sports, cruises, and ecotourism. The coastal tourism infrastructure development will raise the economic activities to include hotels and resorts besides other recreational facilities. Tourism is the largest sector that employs people. It directly employs millions of people, more so in the coastal areas. It supports different kinds of employment in hospitality, guides, transportation, and local artisans. This will stimulate employment to reduce poverty and improve the standards of living of the coastal populace. Sustainable tourism practice is very important in the conservation of the coastal and marine natural beauty and biodiversity. Practices like the Blue Flag certification for beaches help obtain improved standards in the effort toward environmental responsiveness for sustainable tourism practices. These will halt several ills associated with the development of tourism from ravaging the very ecosystems that drew them in the first place. Coastal and marine tourism protects and enhances local cultures and customs. Authentic experiences include local cuisine, festivals, and handicrafts and, therefore, tourists look for such experiences. Such cultural exchange enriches visitor experiences and contributes to the protection of the coasts' cultures (IBEF, 2022).

Such investment in coastal and marine tourism often involves the construction of roads, airports, as well as ports. These activities do improve access and connectivity and make the sea-coast location a much more attractive tourist destination. The level of access to services and markets also improves for the residents. It helps raise public awareness about marine conservation. Enhanced awareness through educational programs in coastal tourism and eco-tourism increases the tourist's urgency to preserve marine ecosystems. In such a scenario, increased consciousness helps the tourists to

endorse conservation and other sustainable activities. The Indian government takes several initiatives to popularize coastal as well as marine tourism. Among those, the Swadesh Darshan Scheme of the Ministry of Tourism has particularly focused on developing coastal circuits that could bring improvement in the facilitation offered to tourists across the coastal areas. The Sagarmala Project will further look to add port connectivity and infrastructure and thus support the development of tourism. India would enter into agreements with intergovernmental organizations orientated toward the promotion of sustainable coastal and marine tourism with international bodies like the World Bank and the United Nations Development Programme. With such collaborations, it would be relatively easier to implement best practices and models of sustainable tourism. This way, coastal and marine tourism forms a highlight of the blue economy in India because it promotes economic growth, and supports job creation, and development in an economically sustainable manner. Coastal and marine resources will be fully put to use if India will be promoting responsible tourism practices and will be investing in an infrastructure about which public-private partnerships are keen (IBEF, 2022).

#### iv. Offshore Renewable Energy

Offshore renewable energy includes wind, tidal, and wave energy, and therefore, offshore renewable energy is considered a natural component of India's blue economy through sustainable energy solutions, economic growth, and environmental sustainability. Offshore wind energy could be one of the emerging sectors in India's renewable energy landscape. The coastline of India is over a thousand kilometres, and enormous prospects exist for the establishment of offshore wind farms. Offshore wind turbines contribute considerably to cleaner forms of energy with minimal use of fossil fuels, which reduces the quantities of greenhouse gases. Offshore wind farms call for jobs in construction and maintenance jobs for the construction, operation and maintenance. Electricity is produced to generate electricity from tidal currents to harness tidal energy. The country has tremendous potential and much of estuaries along a long coastline and can tap tidal energy. Tidal energy is also very predictable and reliable. It can therefore be the saviour for renewable energy, to ensure uninterrupted availability. Examples include project proposals for a tidal power plant in the Gulf of Kutch, demonstrating the contribution that tidal energy will make to India's portfolio. Electricity generated from wave energy is that which uses power from waves in oceans. India has a long coastline with hundreds of places, suitable for wave energy projects. Though at the developing stage, these wave energies promise much for a reliable renewable source of energy. Experiments are being conducted, besides pilot projects, underway in India to understand the feasibility and scalability of wave energy (Arora and Agrawal, 2023).

The reasons that offshore renewable energy projects stimulate economies include job creation, and availability of more productive local economic activities, and it also provides an attractive investment area. Innovative ability with industrial growth is supported by skilled labour and the higher technologies that are required to execute facilities for offshore wind, tidal, and wave energy. Offshore renewable energy facilitates diversity in the energy mix which indirectly

enhances energy security through reduction in dependence on imported fossil fuels. In India, there is adequate potential for renewable energy on coasts, and renewable can support deeper stability in the supply of energy. Although not as harmful to the environment as the forms of energy that were traditionally in use while back, an offshore renewable energy project compensates the carbon emissions, minimizes the impact caused by the greenhouse effect, and saves the marine ecosystems of the seashores. As these projects are sustainable, interference with marine life and habitats is brought down. India has always been transparent on the government issues of offshore renewable energy. Offshore renewable energy projects are being accelerated through policies and initiatives at the national level, including the National Offshore Wind Energy Policy, as well as bilateral collaborations with international agencies, such as the International Renewable Energy Agency (IRENA). Growth in offshore renewable energy is a result of technological innovations. Off-shore renewable energy will soon gain a cumulative efficiency and will become cheap and competitive not only due to advancements in the design of turbines and energy storage but also because of integration with the grid. Further research and development are required to bridge technical challenges and scale up these technologies. Off-shore renewable energy represents a core part of the Indian blue economy by providing sustainable energy solutions, economic benefits, and sustainability. Offshore wind, tidal, and wave energy investments should be made to tap into this enormous marine resource of India by engaging in balanced sustainable development and energy security (Arora and Agrawal, 2023; IRENA, 2020).

#### v. Marine Spatial Planning

Marine spatial planning (MSP) is one of the most important tools for enhancing the blue economy in India, which in return contributes towards sustainable and integrated use of marine resources. It provides an organized framework to manage the marine and coastal regions effectively. Therefore, MSP brings a harmonious balance between various uses of the ocean, including fishing, shipping, tourism, conservation, and others by providing certain zones that specifically dominate those activities. By integrating these two approaches, the result would be the reduction of potential conflicts and sustainable use of marine resources. MSP is set up to protect marine ecosystems and biodiversity. Therefore, an important aim of MSP is the identification and designation of MPAs to conserve critical habitats and species, thus forming a healthy marine environment for the long-term sustainability of the blue economy. It is a supportive factor in the optimum use of marine resources for economic development. It identifies areas for developing aquatic activity, renewable energy projects like offshore wind farms, or tourism. MSP reduces uncertainties and puts clear guidelines that attract investment and promote regional economic growth in coastal regions. MSP helps act as a tool to solve conflicts among various stakeholders. Placing involvement of MSP with other sectors and communities participating in the planning course ensures that the interests of all are considered. This way, via participation, conflicts are mitigated while ensuring the harmonious coexistence of different marine activities (World Bank, 2022).

MSP is a critical intervention in climate adaptation and also in terms of resilience. This avoids destroying areas that are known to be vulnerable to the effects of sea-level rise and coastal erosion; more measures are provided, with more guarantees for the protection of these sensitive areas. MSP also encourages the boosting of blue carbon initiatives that help build up lessened effects of climate change through higher carbon capture from the ocean. The foundation of MSP claims is based on data reliability and scientific research. It involves the gathering and analysis of data in terms of marine ecosystems, human activities, and environmental conditions. Data-driven decisions for planning allow better effectiveness and sustainability in results. The same is enhanced through marine governance because of the clear policy framework offered for the management of marine resources. This is inline with national and international policies, more specifically the United Nations SDGs, SDG 14 (Life Below Water). MSP is supportive of cross-border cooperation over marine issues as well as greater regional and global governance. MSP's success incorporates that local communities must be engaged. MSP in including indigenous knowledge and local perspectives, again supports this requirement that there should be an equitable sharing of the benefits of the blue economy. Community participation introduces stewardship and compliance with marine conservation activities. Marine Spatial Planning is going to feature at the forefront of India's blue economy blueprint. With MSP, there will be sustainable and integrated usage of resources in the sea; it would promote accelerated economic development, conservation of marine ecosystems, and climate-resilient outcomes. With MSP, India will achieve harmonious and climate-resilient management of its vast marine and coastal resources (Taylor et al., 2021).

#### VIII. CHALLENGES FACING INDIA'S BLUE ECONOMY

Several provocative issues confront India's blue economy, challenging at every turn the test of sustainable development. Sea levels rising, cyclonic storms intensifying, and ocean acidification are but a few of the changes attributed to climate change that are escalating the vulnerabilities threatening coastal communities and their marine biodiversity. Marine pollution has an extremely negative impact on the environment and its human resources; India generates around 9.46 million tonnes of plastic waste yearly. Overfishing and resource depletion further stretch marine resources to perilous points of food security and livelihoods. Such issues shall hinder the proper management of the marine resources through regulatory and governance issues, as bifurcated policies exist on many fronts such as inefficient and poor coordination and issues of enforcement. The vacuums of the technologies and infrastructure in those sectors or fields, such as renewable ocean energy and effective systems for waste management, only limit further sustainability improvement. In this respect, the set of those challenges would call for and thus dictate a holistic approach that encompasses the dimensions of environmental sustainability, economic growth, and social equity.

##### i. Climate Change and Its Impact

The rising sea level related to climate change is conducive to coastal erosion and inundation of low-lying areas, thus threatening coastal infrastructure, habitats, and communities; meanwhile, increased salinity in the coastal aquifer impairs

freshwater availability as well as agriculture. The Indian Ocean is also warming at an alarming rate: accounting for over 30% of the global ocean heat content increase over the past two decades. Warm waters displace marine life, affecting the distribution, abundance, and diversity of fish. High sea temperatures impact coral reefs as coral bleaching events strip the foundation of their home - coral reefs are important for the biodiversity of marine environments and in protecting coasts. Overabsorption of CO<sub>2</sub> by oceans enhances acidification, which impacts the health and productivity of marine species, especially shellfish and coral reefs, potentially impacting fisheries and aquaculture. More regular and severe cyclones and storms cause damage to coastal infrastructure, fisheries, and tourism facilities. Their risk of flooding and storm surges makes them face displacement and economic losses (Anagha, 2022).

Climate change interlinks with other stressors, such as over-fishing and habitat destruction, in amplifying the decline of fish stocks. Changes in ocean conditions may disrupt the breeding pattern and migration of fish and impact on the lifestyle of coastal people and communities that count on fisheries. Threatened marine species and habitats due to changed ocean conditions will result in biodiversity loss. The loss of biodiversity hinders the ecosystem from functioning correctly in various services, such as nutrient cycles and carbon sequestration that impact the health and sustainability of marine ecosystems. Some of the imbalances caused by the degradation of marine resources lead to economic loss in coastal communities that directly depend on fisheries and the tourism industries. Loss of livelihoods and increased vulnerability to the impacts of climate change further increase vulnerability to poverty and social inequalities. Therefore, adaptation strategies are very critical but challenging because they are profoundly resource-constrained and characterized by technological gaps. Synergies in the sense of blue economy policies call for beyond various sectors and levels of governance (Willige, 2024). The impacts, therefore, call for a holistic approach, which includes sustainable management of marine resources, investment in resilient infrastructure, and community adaptation strategies.

##### ii. Impact of Marine Pollution and Waste Management

Marine pollution involves plastic wastes, oil spills, industrial effluents, etc. India generates around 9.46 million tonnes of plastic waste annually, and 90 percent of this accumulation ends up in the ocean. Food chains disturb marine life and ecosystems. Sharp impacts on marine habitats, fisheries, and tourism are caused by oil spills from ships or the off-shore drilling business. Generally, the main cause of the accumulation of negative long-term effects in the marine environment is the disposal of untreated industrial wastes in coastal waters. The problems that are facing waste management include inadequate infrastructures and gaps in regulation and extended producer responsibility, or EPR. Most of the coastal areas lack infrastructure. This contributes to the accumulation of waste within the marine environment. In this respect, undilute regulation framing and enforcement of waste management and pollution control measures will not prosper. All of the enforced EPR policies introduced share the same failure: their applicability is never consistent; what's left

is the need to prevent plastic pollution that has weakened it (Singh, 2019).

Reduction in fisheries, affected tourism, and increase in cost towards healthcare services are some examples that can give a glimpse of the potential economic impacts of marine pollution and waste. The fish stock suffers from exploitation; it is greatly harmed through contamination of breeding grounds and scarcity of clean water supply, which is fundamental for aquaculture. This consequently impacts the livelihood of coastal dwellers involved in fishing activities. Coastal and marine pollution reduces the aesthetic and recreational benefits of beaches and coastlines and thus impacts tourism-derived revenue negatively. Health effects of pollution- respiratory and gastrointestinal diseases- increase costs for healthcare and reduce the productivity of affected populations. Other than economic impacts, marine pollution and waste also have environmental and ecological implications in biodiversity loss and degradation of services of marine ecosystems. Furthermore, its pollution degrades critical habitats such as coral reefs and mangroves, which are important in maintaining marine diversity. Marine ecosystem degradation leads to loss in services such as carbon sequestration, nutrient cycling, and coastal protection whose loss is crucial for a healthy blue economy (Chaturvedi and Bajaj, 2023).

One of the key issues on the agenda for effective Integrated Coastal Zone Management (ICZM) policies is the balancing of economic development with environmental conservation, where coordination among various stakeholders has indeed proven to be a baneful factor affecting their successful implementation. Border crossings with neighbouring countries and international organizations are needed to handle transboundary marine pollution issues. Technological and innovative solutions relate to investment in waste-to-energy technologies and management of marine litter. Investing in waste-to-energy technologies is a crucial step that reduces the volume of waste in the oceans. Other initiatives aimed at reducing pollution in the oceans are cleaning the beaches, observing marine litter, and enhancing public awareness. All these require a multi-faceted approach, which begins with robust regulatory frameworks aimed at enhancing the waste management infrastructure; hence, international cooperation is crucial in this direction (Chaturvedi and Bajaj, 2023; Singh, 2019).

### iii. Impact of Overfishing and Resource Depletion

Such depletion is rapid for fish stocks, and a general decline in key species also impacts marine food webs that directly affect the sustainability of fisheries on which millions depend for their livelihood and supporting coastal communities worldwide. More directly, reduced catches also entail financial implications in terms of income to fishers and other related industries. Lower fish stocks may translate to higher seafood prices, having a rather indirect impact on home market realization as well as export earnings. Food security is impacted as well since fish forms a critical source of protein in several sections of the population in India; lower availability at reasonable prices threatens food security. The stock decline may be so severe that communities have to turn towards less healthy or considerably more expensive sources of food. Besides, overfishing targets specific species, but in the wake

of its impacts, rolls out to affect the vast marine ecosystem through biodiversity loss. The removal of key species leads to ecosystem cascades that are produced as a result of changes in habitat structures and functions. Small-scale fishers turn out to be the greatest casualty, simply because they do not have the resource capacity that compete with industrial fishing operations. IUU is substantially contributing to the problem of overfishing, not necessarily for any grand reason but merely because some fishermen want to circumvent the measures that were intended to regulate catch levels in sustainable fisheries and max out on resources whenever possible. Such activities undermine the legal rights and jeopardize the livelihood of genuine fishers. IUU fishing activities increase competition for limited resources, hence worsening economic distress and social instability in communities which are hugely affected by their hands (Krishnan and Gopalakrishnan, 2023; Jadhav, 2023).

The problems involved in the issue of overfishing and resource depletion include several on the lines of regulatory and governance, technological and infrastructural backlogs, and degradation of the environment. It faces strong hindrances in effective fisheries management related to sparse regulation and poor enforcement. Its effective framework of governance requires the integration of scientific data, community input, and coordination with international cooperation. An equally important problem associated with the latter is that many fishers cannot adopt more sustainable practices, as they lack access to modern technologies and infrastructure. Better monitoring, control, and surveillance mechanisms that could help prevent overfishing and ensure proper use of the resources in a sustainable manner are needed. Overfishing further contributes to habitat decline including coral reefs and mangroves-whose loss frequently renders the marine ecosystem less resilient to other stresses, including climate change and pollution. Such an improvement in response to these challenges would encompass the holistic means of building regulatory capacities, developing and practising sustainable fishing practices, and strengthening the capacities of coastal communities (Krishnan and Gopalakrishnan, 2023; Jadhav, 2023).

## IX. CONCLUSION

The Blue economy encompasses a tremendous range of activities across the oceans, seas, and coastal areas. Some of the groups under this category include fisheries and aquaculture, biotechnology from marine, renewable energy from the ocean, transport by sea, coastal, and marine recreation mining of seabed, and conservation of sea. The Blue economy is indeed a prime factor of sustainable development as it offers a wide range of benefits to economic growth in terms of increased GDP and generating employment. It serves as a source of protein for millions of people, promotes the sustained exploitation of marine resources as well as the preservation of marine ecosystems; it promotes the promotion of livelihoods and social equity of the population, especially in coastal areas; it plays a very important role in carbon sequestration and world climate regulation; and it produces income for local communities that helps to enhance local development and growth. It is more interested in the sustainable uses of ocean resources toward increasing economic growth and improvements in livelihood



and jobs while maintaining the healthy state of ocean ecosystems. The blue economy goes well with other global sustainability goals, such as SDG 14 – Life Below Water. The world ocean economy is estimated to be of the order of \$1.5 trillion a year, and oceans have indeed become extremely important in the regulation of climate and carbon sequestration. The aforementioned trend of docking new technological innovation in the field of marine technology and biotechnology has led to this concurrently.

The blue economy of India is becoming stronger and more remarkable with each passing day. Some of the important steps in this direction are under Sagarmal initiative, which sees port-led development. It aims to bring a 'Blue Revolution' in fisheries. A Deep Ocean Mission concentrates on deep-sea exploration and mapping, and Maritime India Vision 2030 formulates a holistic plan towards further development of the maritime sector. Opportunities abound for India from marine biotechnology to renewable ocean energy, sustainable fisheries and aquaculture to coastal tourism and maritime transport and infrastructure. The growth of the Indian blue economy is, however, shrouded by many challenges that include a regulatory framework, environmental degradation, climate change, limited financial resources, and community involvement.

Such underpinnings would consist of policy and regulatory measures including education and capacity building, job creation and livelihood, sustainable resource management, social equity and inclusion, building resilience, fostering innovation, governance strengthening, conservation enhancement, and tourism promotion. Because the knowledge and needs of such communities need to be taken into account, the implementation at local levels will necessarily involve them. Empowerment will lead to more sustainable and culturally appropriate practices for communities who can, after all also support and maintain what they have an interest in. Human capacity building through education and training programs will equip community members with the skills required to participate in and benefit from the blue economy, including sustainable fishing practices, marine conservation, and emergent technologies such as aquaculture and renewable ocean energy. Perhaps, community participation will be able to mobilize economic benefits through the provision of employment that enhances livelihoods. In the case of the blue economy, community members will be in a position to obtain reliable sources of income and security through engagement in tourism, fisheries, and marine biotechnology sectors. Local communities hold paramount traditional knowledge regarding marine and coastal ecosystems. With such knowledge harmonized with scientific research, it results in sustainable improved resource management practices with a high probability of effectiveness.

At the same time, it would involve members of the communities – themarginalized and other people – totake part in the blue economy project. Such engagement, therefore, looks to social equity and inclusive developmental outcomes. The ability of the communities to be resilient to environmental change and economic shocks will be strengthened with such capacity-building initiatives. Training skills towards disaster preparedness and climate change adaptation as well as sustained livelihoods can strengthen

these communities in the face of adverse events. It will help in innovating by engaging communities in the development and implementation of blue economy projects. For this reason, the input from members of the community can be developed into unique ideas that create solutions aligned with local conditions and challenges. In addition, governance can be enhanced through increased transparency and inclusivity in decision-making processes for more efficient management of marine resources and more accountable ones. Engaged communities are likely to conserve and retain their marine ecosystems. This could; therefore, ensure positive effects on biodiversity and ecosystem conditions. Initiatives of community-based tourism can promote sustainable tourism with the economic benefit of driving local economies while having a minimum negative environmental impact. It may include ecotourism, cultural tourism, and marine tourism. Focusing on these areas ensures that the contribution derived from community involvement and capacity-building into the blue economy in India will be helpful for sustainable development, inclusivity, and resilience.

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