Blue Economy:

India's Pathway to Sustainable, Secure, and Resilient Economy

KONRAD ADENAUER STIFTUNG

National Maritime Foundation

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The Energy and Resources Institute
Creating Innovative Solutions for a Sustainable Future

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Acknowledgment

The book has been a culmination of joint efforts and initiative by Konrad Adeanuer Stiftung India office, The Energy and Resources Institute (TERI), National Maritime Foundation (NMF) and Federation of Indian Chambers of Commerce and Industry (FICCI) to nurture and encourage a holistic discourse on Blue economy in India. FICCI, NMF and TERI with the partnership of KAS India collaborated to bring together eminent voices and thinkers on blue economy with six webinars and a hybrid national conference focusing on establishing synergies, multidisciplinary approach and augmenting discussions for a cohesive perspective on blue economy. The focus of the book has been to build a collective dialogue on the three pillars of blue economy – maritime security, economic growth and sustainable development. We are immensely thankful to our partner KAS India for helping us shape this collaboration.

We are indeed grateful to all the distinguished speakers whose insights, suggestions, reviews and comments helped us to understand blue economy from several perspectives. It provided us new learnings on how different sectors view blue economy and how each pillar of the framework needs to compliment the other for a successful long term vision and mission.

We would like to thank Mr. Peter Rimmele, Resident Representative KAS India, Vice Admiral Pradeep Chauhan, Director General, National Maritime Foundation (NMF), Amb. Rajiv Bhatia, Member FICCI Blue Economy Task Force, Souvik Bhattacharjya, Associate Director, TERI, Capt. Sarabjeet Parmar, Executive Director, NMF, Sushma Nair, Joint Director FICCI and Mr. Pankaj Madan, KAS India for their unwavering support, inputs and guidance for the overall initiative and the publication.

We would also like to thank esteemed colleagues Sukanya Natarajan at FICCI, Simran Dhingra and Ashish Gupta at KAS, Mani Juneja, M K Bineesan and John Andruse and TERI press at TERI for their continued their support throughout the initiative. A big thank you to Dr. Vibha Dhawan, DG TERI for providing the organisational support for the project. We would also like to thank all the authors for contributing interesting and informative papers that will surely add value to the discourse.

As the coordinator of the initiative and editor of this publication, I am extremely privileged and honoured to have been able to learn from distinguished experts from all the institutions and be part of the ideation process of the initiative and contribute to its outcomes.

Swati Ganeshan
Coordinator and Editor

Foreword

The European Union first adopted the concept of "Blue Growth" way back in 2012 as a way to strengthen the economies of member countries at a point of time when the provision of viable sources of sustainable energy as well as environmentally sustainable marine tourism and aquaculture and the importance of the 'Blue' paradigm as a complement to the Green Economy approach was still largely underestimated within the global development discourse.

Fast forward some 9 years later and the Blue Economy derived therefrom has been genuinely embraced around the world as indispensable for addressing and bringing economic, social and environmental challenges as well as opportunities all under one paradigm roof. This achievement is largely due to the numerous fora, multilateral partnerships and interactions that have been organised and established around this concept with ever-increasing frequency over the past few years.

Regarding the Indo-German perspective, it appears pertinent to hereby point out past dialogue series such as the "Quadrilateral Virtual Series on Blue Economy" as well as publications such as the 2019 "Blue Economy Report" by the Konrad-Adenauer-Stiftung (KAS) in cooperation with the Federation of Indian Chambers of Commerce & Industry (FICCI). These have been instrumental in creating enhanced awareness and understanding as well as illustrating the positive implications of Blue Economy for scholars, policy makers, members of the industry and the civil society alike, within the Indo-Pacific region and well-beyond.

Recently, the European Commission's fourth edition of the "EU Blue Economy Report" once again strikingly illustrated how the seas and oceans act as driving forces behind the European economy and that unlocking their vast potential for both sustainable innovation and growth was an imperative. The relevance of the Blue Economy paradigm in tandem with the European Green Deal is bound to expand sharply in the years to come.

The Blue Economy framework has already achieved great strides in developing innovative long-term solutions to some of the greatest conundrums we face across our pale blue dot today. In this field, the EU took a pioneering stance, with around 66% of the world's wave energy capacity having been harnessed within EU member states. Emphasis must be placed here on the burgeoning marine renewable energy sector, which is encompassing inter alia floating offshore wave, tidal and wind energy as well as floating solar photovoltaic

energy. Together, these cutting-edge energy sources are already now pivotal to the EU's efforts to transition towards a carbon-neutral, circular and biodiverse economy by 2050. Moreover, these nascent maritime businesses were only mildly impacted by the COVID-19 crisis and can be expected to bounce back quickly and continue their expansion.

Yet, we must all recognise that to be truly impactful, the Blue Economy necessitates further transnational alignment. The establishment of multilateral institutions in the Indo-Pacific, such as the Indian Ocean Rim Association (IORA), to lobby for the Blue Economy and India's growing partnership with neighbouring South Asian countries, Australia, Japan and some other sea-washed African states in this context, indicate that the first important steps in this direction have been taken. However, multilateral cooperation with EU countries such as Germany, being one of the largest exporting countries and having around 400,000 jobs linked to the maritime sector, still leaves ample scope for future improvement. Enhancing this multilateral, trans-continental cooperation under the Blue Economy archetype will add further weight to the framework and move the world significantly closer to the objective of sustainable, secure and peaceful water bodies.

I am immensely pleased what The Energy and Resource Institute (TERI), the National Maritime Foundation (NMF), the Federation of Indian Chambers of Commerce and Industry (FICCI) and the India Office of the Konrad-Adenauer-Stiftung (KAS) have achieved together and come out with the present publication. It is a tribute to the cooperative spirit of the institutions and their cohesion, which have achieved deep economic and analytical insights that will serve as a valuable tool to support evidence-based policy-making aimed at an increasingly global, democratic and multilateral Blue Economic framework.

Peter Rimmele
Resident Representative to India
Konrad-Adenauer-Stiftung e. V., Foundation Office India,
B-4, Ground Floor West End I Rao Tula Ram Marg, 110 021, New Delhi, India

Preface

When Blue economy emerged as a 'buzzword', the major question that the epistemic community, practitioners and policymakers began to answer was the definition of blue economy, its essential components, its linkages, overall impact, its utility and its potential impact among other aspects. This task to answer the question is still incomplete and will keep evolving with the emergence of new science, discoveries, and innovations, changing geopolitics, transforming economic relations, human induced impacts, environmental degradation and climate change. Each nation is contextualising, deciphering and redesigning the blue economy framework in accordance to its ocean economy, security and its health. India has been one of the few countries to take a step forward to examine and contextualise blue economy for its own shores and beyond. Though a tough and a complex exercise, the working group reports by the task forces created under the Economic Advisory Council to the Prime Minister of India undertook a mammoth initiative to bring together issues on economy, security, environment and sustainability under one umbrella.

These working group report have emerged as a basis for several Indian institutions to further intensify research and policy focused thinking on Blue economy. This publication is one among many steps to further comprehend, analyse and provide strategies and solutions for sectoral, environmental, social, institutional and governance related issues within the blue economy spectrum. Several institutions working on blue economy provide focused intervention on either ocean or maritime security, economic development or environmental issues- with limited opportunity to establish synergies and create a platform for multi layered and multi-sectoral approach.

We (TERI, FICCI and NMF) are eternally grateful to Konrad Adenauer Stiftung India office for providing us an unique and timely opportunity to engage and collaborate with each other. This collaboration has been a learning experience and provided us all an opportunity to think- not just ahead of the curve but beyond it. The work on the publication was a parallel process along with a series of diginars and a hybrid national conference that was organised by all the partner institutes to examine and provide inputs into each other discourse on blue economy. While beginning this online journey during the ongoing pandemic, we were unsure about the momentum we may be able to create for Blue economy through the diginars that we had planned. Yet the response was overwhelming and the quality of inputs was prolific. A constellation of eminent experts from across the globe and within India adding value and providing deeper understanding of blue economy from different perspectives including- industry, information and communication, science and technology and environment was unexpected. This exchange of notes has provided the opportunity to all of us to sensitise each other about various aspects within blue economy, rethinking older narratives on ocean issues and seeking holistic solutions- as wide and deep as the oceans are. The papers in the publication discuss several issues that have been touched upon in the working group reports and in the consequent draft blue economy policy. The papers focus on further deepening of knowledge on specific issues within the framework and creating a pathway for further deliberation, research and to aid policy making.

In February 2021, The Ministry of Earth Sciences, Government of India shared the Draft National Blue economy Policy for public comments. The policy is the culmination of the working group reports that were developed under the Economic Advisory Council to Prime Minister of India. The Report of Blue Economy Working Group on National Accounting Framework and Ocean Governance by the Economic Advisory Council to the Prime Minister of India provides a working definition of Blue Economy as - "Blue economy refers to exploring and optimizing the potential of the oceans and seas which are under India's legal jurisdiction for socio-economic development while preserving the health of the oceans. The Blue Economy links production and consumption to capacity and envisages an integrated approach to economic development and

environmental sustainability. It covers both the marine, that is offshore resources, as well as the coastal, that is onshore resources." The publication takes into cognizance the basic working definitions and understanding as laid out in the working group reports as a basis for continuing the discourse. According to the working group report the definition of "Blue Economy by India is comprehensive in the sense that it covers many dimensions of the ocean activities – a) occurrence of activities – activities in the coastal and off-shore region, b) within country's economic jurisdiction, c) integrated approach of blending development with sustainability, and d) all these activities keeping in view health of the oceans." The comprehensive working group reports have etched out a framework for establishing a policy that would be critical for India' economic growth, security and to achieve sustainable development. Blue Economy has become the buzzword in the present times, vis-à-vis the growing concern over sustainably harnessing the ocean and water body resources. It is a holistic paradigm in the development discourse which gives equal weightage to economic growth and environmental sustainability. The publication focuses on bringing forward the intricate linkages among the three pillars mentioned in the working definition. The publication focuses on several issues such as blue accounting, blue finance, climate change and oceans, ocean health and livelihoods, science and technology, holistic maritime security, industry 4.0 technologies and traditional blue economy sector issues.

The first set of thematic papers in this publication focus on comprehensively discussing India's blue economy policy, the need to focus on the blue aspects in blue economy and also examining the different knowledge based approaches to the framework and the different dimensions to definitions across the globe have also been explored. One aspect that emerges in each of the papers in the thematic is to approach blue economy from a multi-sectoral approach, the need to create linkages among institutions and policies across sectors to approach oceans as a unified entity and the need to focus on environment and climate change as a bedrock for a brighter blue future.

The second theme of papers focusing on blue finance and blue economy accounting provid perspective and recommendations to enhance India's financial investments in the BE sector and global opportunities that are emerging for blue economy. The methodologies and estimation framework for activities in the blue economy is still a work in progress. There are several attempts to quantify the contribution of blue economy, however the vastness of the framework and the massive contribution of oceans in all sectors has been a challenge to account for. There is a need to take sum of all economic value added by activities related to oceans, water bodies and other marine resources. Three basic points of capture (i) Employment, i.e. people engaged in identified/related economic activities, (ii) Goods and Services produced and (iii) environmental accounting. There is a need to Map activities on the basis of what each sector produces, the activity and the industry. There is significant requirement of data for quantifying the contribution of blue economy and there is a need to initiate a robust Data collection exercise to enhance the estimation methodology. Best practices and methodologies adopted by other countries to quantify ocean based economic activities should be considered to enhance blue accounting.

The papers focusing Blue finance highlight the types of financing instruments available, the methods and current processes for blue financing, major players in the blue financing landscape, major challenges and the type of financing opportunities visible in the coming years. The papers elucidate the need for intensive research and academic rigour to enhance the current methodologies and financing instruments. The papers also highlight the need to strengthen the regulatory framework for financing to enable instruments that can aid blue economic opportunities It is certain that the investments in oceans will take precedence in the coming decades and almost all of this investment would require a sustainable and environment friendly approach to be an essential foundation.

With increasing need to meet sustainability standards, the investments in oceans would focus on prioritising projects align themselves to climate change adaptation, mitigation and resilience standards. While global

ocean economy generates about $1.5 trillion per annum and about 350 million jobs globally, around one billion people depend on oceans for their food. The oceans (Blue Economy) offer a definitive scope for additional resources by way of food, energy, transport, recreation and a decentralised source of economic activity and employment creation. For ages, people have been deriving benefits from the marine resources and have been exploiting the oceans for food, energy, biodiversity, recreation, etc. In every nation, the coastal states are largely dependent upon the oceans and other water bodies in terms of employment generation and livelihood fortification. But what one fails to realise is that constant exploitation and overuse can lead to depletion of resources and harm the ocean health, which can have irrevocable consequences. Ensuring ocean health would become a precursor to sustain a blue business and to accrue benefits from the deep sea.

The next theme of papers focus on the transformations and challenges in the traditional blue economy sectors such fishing, tourism and shipping. The paper on shipping provides a comprehensive overview of the need to strengthen the sector and elevate its position in the global shipping domain. The paper emphasizes the need to build a robust shipping sector to achieve India's geopolitical and trade expansions in the future. Another paper takes a futuristic approach to look at 4.0 technologies in the maritime domain and the role of science and technology for blue progress. Industry 4.0 technologies are penetrating every sector and the ocean sector is not far behind. The paper discusses several innovations and technologies that are either being utilized or in the innovation stages with a potential to bring significant changes to how business on the ocean is conducted.

The key traditional sectors of Blue Economy are fisheries, ports and shipping, marine tourism, offshore oil and gas, marine biotechnology, deep-sea mining, renewable energy and transport and logistics. The role of Blue Economy, which aims at optimum and sustainable use of oceanic resources for growth and development, is critical for the coastal states with the potential to develop strong hinterland linkages and value chains. Traditional ocean industries such as fisheries, tourism, and maritime transport in India present huge scope for development. Industry and service sector development associated with emerging sectors like offshore renewable energy, aquaculture, seabed extractive activities, and marine biotechnology and bioprospecting while having immense potential, have been rather slow in development. The emerging industries such as blue biotechnology, deep sea mining also are opening new avenues of research and development contributing to innovation. Yet the critical need to ensure the preservation of marine ecosystem is central to all discussions.

The next theme of papers focus on the changing marine ecosystem, ocean health, environmental degradation, climate change impacts, sustainability and enhancing resilience strategies focuses on discourse that connects with the other themes and has critical relevance for the success of blue economy. An effective harnessing of Blue Economy by mankind presets a condition to care for ecological balance, ocean health and regeneration of these precious resources. Rising sea levels could submerge valuable land, extreme weather and rising temperature could disrupt water cycle and hurt agriculture, fisheries, rich marine biodiversity and further to aggravate tropical diseases. This could cause unimaginable suffering and economic loss. The good news, though, is that the world community has realised this impending danger and has been working hard to find mitigating solutions. One of the papers focuses on the impacts of climate change on maritime security and another focuses on the need to preserve ocean health for ensuring livelihoods. Both papers look at two key issues maritime security and livelihoods from the blue lens- emphasising on the need to examine and analyse the linkages further for enabling effective planning and implementation strategies. The paper on coastal disasters and climate change highlights the how climate induced natural disasters would impact coastal countries and their economies. The paper highlights the need for climate resilient infrastructure, higher investments, technologies and capacity building in the Indian Ocean region. The fast-growing public opinion is clearly demanding the future economic growth and development to be more sustainable. Caring for the oceans' health would always be central to any meaningful solutions. Some estimates suggest that in many sectors, the ocean-based productivity will exceed the corresponding land-based production both in

value and employment generation by 2030. However, these benefits would accrue only if the oceans remain healthy. This realisation over time has culminated in the emergence of a whole new paradigm called the "Blue Economy".

The other papers under the theme address three critical themes- marine biodiversity, marine litter and the integration of SDG 14 in blue economy. Each of these papers also discuss the need to strengthen governance frameworks and to enhance regional cooperation for higher impact and better outcomes. Each paper highlights how the IOR region could collaborate and engage to address the central question of preserving ocean health.

The Blue Economy of India is inextricably linked to the global Blue Economy. The development of India's Blue Economy requires strong domestic synergy and integration with the wider international ocean community. The essential objective is to develop Blue Economy through a robust regulatory framework which contributes to sustainable use of existing natural resources. Blue Economy is now considered as the fountainhead of a number of national priorities which can potentially trigger national growth, economic prosperity and job creation. The Blue Economy is also a significant facet of India's larger economic and strategic architecture, including its commitment to the Paris Agreement and UN's Sustainable Development Goals (SDGs).

Despite these commitments, we are still a long way from realising our targets of protecting biodiversity, securing livelihoods of indigenous people and devising sustainable methods of economic growth, especially in sectors such as fishing, tourism and waste management. Any articulation of Blue Economy, therefore, must view it as a part of a broader project of strengthening economic security and building a sustainable, resilient future for all. The geostrategic significance of oceans, its role as an economic lifeline and its impact on global climate change and biodiversity requires a cohesive policy that goes beyond "business as usual".

Blue economy as a sector and as a concept provides us a unique opportunity to approach themes, issues and sectors from multiple windows but with one definitive single outcome- to ensure a healthy and an economically viable ocean for our future generations from whom we are borrowing resources beyond our needs.

The Blue economy policy needs to be implemented at the earliest to ensure a multidisciplinary approach to its design and implementation on the ground. A holistic approach to oceans is need of the hour. The proposed National Blue economy Council needs to be established as a priority to strengthen and engage all ministries, agencies and stakeholders for a common approach.

A shared and mutually beneficial understanding of the concept of Blue Economy, informed by inclusive and bottom-up approaches to its governance, will be a critical component of a just and 'Blue' transition in the IOR. India should lead in implementing the approach and strengthening governance for a secure and resilient region. An ecosystems approach must be adopted to interlink economy, security and sustainability while ensuring livelihoods and creating pathways for innovations and emerging sectors.

Blue economy is all encompassing concept requiring multidisciplinary approach to each problem and the involvement of all stakeholders for successful implementation of solutions. The stakeholders need to focus on science-based, community- based and participative-based understanding for developing Blue Economy. There is great need to learn from past mistakes and develop sustainable policy pathways that minimise negative impacts and require limited to no offset measures. The need of the hour is to focus on the "blue" in India's economy and ensure that it is resilient, sustainable and secure.

About Authors

Swati Ganeshan – Coordinator & Editor

Swati Ganeshan has over 15 years of research experience and media experience. She is an experienced policy researcher, networking and outreach expert working in the energy, climate and sustainability sector. Her research is largely focused on policy analysis and geopolitical issues in the field of energy, climate, oceans and SDGs. She is Hon. Adjunct Fellow, National Maritime Foundation. She was Fellow and Area Convener, Centre for Resource Efficiency & Governance, The Energy and Resources Institute (TERI), New Delhi. She has led and contributed to research on Blue economy in Asia-Pacific, Blue economy and sustainable development issues, regional energy cooperation, carbon neutral strategy roadmap for Indian States, role of energy in European Union (EU) and emerging power relations (emerging 5), assessing energy risks across fuels, coal and nuclear energy, hydro politics in GBM basin, critical non-fuel minerals for India's strategic interests, and global and regional energy security cooperation, among others. She has led and been part of projects supported by Asian Development Bank, AETS France, UNESCAP, GIZ, Norwegian Ministry of Foreign Affairs, Konrad Adenauer Stiftung, EU, DFID and Volkswagen Foundation, among others. She was network manager of Sustainable Development Solutions Network (SDSN) South Asia Secretariat hosted by TERI. She coordinated TERI-ITEC capacity building programmes for international participants supported by the Ministry of External Affairs, Government of India and has several publications to her credit. Swati is also a member of South Asia Women in Energy network (SAWIE).She has a Masters in International Studies (Security Studies) from the University of Birmingham, UK, and Masters in Mass Communication from Jamia Milia Islamia University, Delhi and Bachelors in Journalism from Kamala Nehru College, New Delhi.

M RAJEEVAN

Dr M Rajeevan has recently retired from the Government Service on superannuation after serving about 38 years. He was the Secretary to the Government of India, Ministry of Earth Sciences from December 2015 to July 2021.

Dr Rajeevan holds a Ph.D in Physics and specialized in Atmospheric/Climate Sciences. He did pioneering research work related to monsoon variability and prediction, climate change and prediction of extreme weather events. Many of the application tools developed by him are being used by India Meteorological Department (IMD) for their operational use. He is an expert member of the Research Board of the World Meteorological Organization (WMO).

Dr Rajeevan is a fellow of all three Science Academies of India and a Member of the prestigious International Academy of Astronautics. Under his leadership as the Secretary, Ministry of Earth Sciences made significant achievements which include substantial improvement in weather, climate and ocean forecasts and warnings.

Under his stewardship, Ministry of Earth Sciences has recently launched the ambitious Deep Ocean Mission with an estimated budget of ₹4077 crores. He also closely worked with the office of Economic Advisory Council to PM to develop a new Blue Economy Policy, which Ministry of Earth Sciences will be implementing.

VICE ADMIRAL PRADEEP CHAUHAN

Vice Admiral Pradeep Chauhan is the Director General of the National Maritime Foundation, New Delhi. With an experience base incorporating four decades of distinguished Indian Naval service, he enjoys international renown as a strategic analyst and is a prolific writer on maritime and strategic issues, including India's transition to a Blue Economy.

SAURABH THAKUR

Saurabh Thakur is an Associate Fellow at the National Maritime Foundation, New Delhi, India. His work focuses on the issues of global environmental politics, equity, climate security, and sustainability politics. His research sits at the intersection of governance, international politics and sustainability, looking specifically at the climate security and Blue Economy discourses in the context of South Asia.

He was the Kodikara Fellow (2020-21) at the Regional Centre for Strategic Studies, Colombo, Sri Lanka, where he worked on the issue of climate security and the Anthropocene in South Asia. Currently he holds the CDRI Fellowship (2021-22) at the Coalition for Disaster Resilient Infrastructure, for which he is working on the topic 'Incorporating Infrastructural Resilience in India's Port-led Development Model'. He also holds the VAdm K.K. Nayyar Fellowship at the National Maritime Foundation where he is working on climate resilience of coastal urban agglomerations.

Saurabh holds a Master's degree in Geography, from The Centre for the Study of Regional Development, School of Social Sciences, JNU and M.Phil. in International Relations from CIPOD, School of International Studies, Jawaharlal Nehru University, New Delhi, India, where he has submitted his PhD thesis on the principles of equity in the international climate change negotiations.

ADLURI SUBRAMANYAM RAJU

Adluri Subramanyam Raju is Professor in the Centre for South Asian Studies & Coordinator of the UGC Centre for Maritime Studies at Pondicherry University, Pondicherry. He was recipient of the Mahbub Ul Haq Award (Regional Centre for Strategic Studies (RCSS), Colombo, 2003); Scholar of Peace Award (WISCOMP, New Delhi, 2002) and Kodikara Award (RCSS, Colombo, 1998). He was Salzburg Seminar Fellow (2006). He received the National Best Teacher Award (C.V.S.Krishnamurthy Theja Charities, Tirupati, 2017) and Best Teacher Award twice (Pondicherry University, 2013 & 2018). He was a Visiting Fellow at the Bandaranaike Centre for International Studies, Colombo, May 2012. He is a member for Third Task Force on Blue Economy, FICCI, New Delhi. He is on editorial board for five journals. He has published 22 books and fifty papers; delivered fifty lectures and presented ninety papers at national and international seminars. His forthcoming publications include: Authored: Governance and Poverty in South Asia: A Study with reference to India, Bangladesh and Nepal; Emerging India from Maritime Perspective; (Co-editor) Routledge Handbook on South Asia; & (Co-editor) BIMSTEC: Mapping Sub Regionalism in Asia. He is currently working on French Presence in the Western Indian Ocean Region, funded by the Indian Council of World Affairs, New Delhi.

DEEPAK SHETTY

Mr. Deepak Shetty is a former senior I.R.S. officer, who retired as Secretary to the Govt. of India. He had served as Director General of Shipping and Joint Director General of Shipping, Govt. of India between 2011 to 2016. He is empaneled on the Global Roster of Experts of the United Nations in the areas of maritime transportation and maritime crime.

He is the recipient of 24 international, regional and national awards in his service career, including the Presidential Award of Appreciation Certificate for a Specially Distinguished Record of Service, bestowed on the Republic Day, 2002, Commendation Certificate for Meritorious and Sincere Services Rendered, conferred on the International Customs Day, 2002 and Commendations issued by the Foreign Minister, Govt. of India, Foreign & Maritime Affairs Minister, Govt. of Seychelles and Director (Maritime Security), INTERPOL..

VIJAY SAKHUJA

Dr Vijay Sakhuja is former Director, National Maritime Foundation, New Delhi, India. He is currently Visiting Senior Fellow, Cambodian Institute for Cooperation and Peace (CICP), Phnom Penh; Distinguished Fellow, Centre for Public Policy Research (CPPR) Kochi; Co-founder and Trustee of The Peninsula Foundation (TPF) Chennai; and is associated with Kalinga International Foundation and Vivekananda International Foundation, New Delhi. He has been on the faculty of a number of think tanks and universities in India and abroad. A former Indian Navy officer, Dr. Sakhuja specialises in Indo-Pacific affairs, maritime security, climate change, Arctic affairs, Blue Economy and 4th Industrial Revolution technologies. He has published over 40 books, edited volumes and monographs.

CHRISTINA DE SOUZA

Ms. Christina De Souza is an Associate Fellow at TERI. She has completed her M.Sc. in Microbiology (Goa University) and an Erasmus Mundus Joint European Masters in Water and Coastal Management. She has worked as a Junior Research Fellow at Goa University and also conducted environmental analyses for wastewater management. Since joining TERI at its Goa office, she has been actively involved in several biodiversity-related and other projects for research and documentation and has also conducted extensive literature surveys.

MANI JUNEJA

Mani Juneja is currently working as a Research Associate under the Centre for Resource Efficiency and Governance division of TERI. She did her Masters in Economics from Jamia Millia Islamia, New Delhi and graduation in economics from University of Delhi. In TERI she has been working on topics around resource efficiency, blue economy, SDGs and just transitions. Additionally, her work is also around environmental economics, energy economics and health economics. In the past she was engaged as a researcher in research organisations like Research and Information Systems for Developing Countries (RIS) and Institute for Economic Growth, New Delhi. She has also served a short tenure at the Election Commission of India, Government of India as a statistical intern and also worked briefly as a research assistant in an ICSSR funded project at Jamia Millia Islamia, New Delhi.

ASHA L GIRIYAN

Asha Giriyan is a biologist and has experience of working in environmental and natural resource management issues. She has an ability to work across the boundaries between the two disciplines (social sciences and natural sciences). She has experience of working at National Institute of Oceanography (NIO) on marine microbiology and enzymology. She has long standing experience, at the Coastal Ecology and Marine Resources Centre, TERI Goa regional office, working on projects which cut boundaries between the two disciplines, addressing issues at the interface of environment and development and pollution impacts, with a focus on the coastal and marine sector.

She is Currently Pursuing her PhD in Goa University in studying the bioremediation of Arsenic pollutant using Biofilm forming bacteria isolated from Mangrove ecosystem.

ANUP K MUDGAL

Ambassador Anup K. Mudgal, a member of the Indian Foreign Service (IFS), retired in May 2016 as India's High Commissioner to Mauritius. As part of his diplomatic career, spanning thirty two years, he served thrice at the Headquarters of the Ministry of External Affairs handling relations with India's neighborhood, ASEAN region, Russian Federation and some countries of Central and Eastern Europe, as well as issues relating to Human Resource Development.

As part of his eight assignments abroad, Amb. Mudgal served in different capacities at the Indian Missions in Mexico (including NAFTA matters), Peru, former Yugoslavia, Belgium (including EU matters), Germany, Austria (work relating to: IAEA, UNIDO, UNODC, UNOOSA, UNCITRAL), and Mauritius (including IORA).

Post retirement, Amb Mudgal has been engaged in several voluntary assignments, the important ones being: Member, FICCI Task Force on Blue Economy; Member, Steering Committee on Blue Economy under PMEAC, and chaired a working group on security, strategic dimensions, and international engagement; Member, Core Team of Kalinga International Foundation; Chair, Diaspora Committee, ARSP; Joint Secretary, Association of Indian Diplomats; Guest lectures at various higher education and professional institutes.

AMEY SAPRE

Dr. Amey Sapre works as an Assistant Professor at NIPFP. Previously, he worked as a Consultant in the Macro Finance group at NIPFP, teaching assistant in Economics at Indian Institute of Management (IIM) Ahmedabad, IIM Indore. He has a Ph.D in Economics from the Indian Institute of Technology (IIT) Kanpur and works in areas of national accounts statistics, GDP computation and public finance.

RIA SINHA

Ria has the expertise in the areas of Climate Finance, Voluntary Sustainability Standards (VSS) and Business Sustainability with nearly eight years of experience in industry and academia.

Ria holds a PhD in Business Sustainability from TERI School of Advanced Studies (TERI SAS), New Delhi and is a Masters in Economics from University of Calcutta. She was an HSBC Scholar in TERI SAS. As a DAAD-German Indian Climate Change Dialogue Fellow, she spent quite some time in Germany and presented her research at conferences held in Vienna, Berlin and Boston MA. She was also invited as an ICRIER Young Scholar by the National Bureau of Economic Research (NBER) Summer Institute, Massachusetts. She has previously worked with the Indian Institute of Foreign Trade, Centre for Budget and Governance Accountability, Development Alternatives Group on various issues pertaining to taxation, budgets, climate finance, financing of clean energy and resource efficiency.

At present Ria is a Fellow at TERI working on various sustainability issues, policies and resource efficiency. She is also a Visiting Faculty at TERI SAS, New Delhi in the Department of Business and Sustainability.

PUSHP BAJAJ

Dr Pushp Bajaj is a Research Fellow and the Head of the Blue Economy and Climate Change Cluster at the National Maritime Foundation in New Delhi, India. His research areas of interest include climate change impacts on India's maritime and naval security, climate resilience of India's critical maritime infrastructure, sustainability in the maritime domain, and the Blue Economy. Prior to joining the Foundation, Dr Bajaj worked as an independent science writer and researcher focusing on climate change and the environment where he published several articles on sustainable development, climate science, climate policy, and related areas. He received his PhD in Chemistry from the University of California, San Diego, USA, where he was a graduate student researcher for the NSF-funded Center for Chemical Innovation - Center for Aerosol Impacts on Chemistry of the Environment based in San Diego, CA, USA.

PRASOON SINGH

Mr. Prasoon Singh is an environmental research professional and hydrologist by practice. He is currently associated with TERI School of Advanced Studies and doing his PhD in the area of disaster Hydro-Meteorological disaster management. He has been working with TERI as an Associate Fellow and looked after the research and development work in the area of Climate Change Adaptation & technologies in impact assessments. His research and policy interests lie primarily in the area of water resources management, HRVA, Urban and Coastal Disaster management, and use of remote sensing and GIS technologies in natural resource management. He has written and published widely on the topic, both in academic journals and mainstream outlets. He has working experience with government, private and non-government research institution and has working collaborations with research institutions that are centres of excellence at national and international level. He had also led the T20 Task Force to prepare the policy document for G20 Summit convened in Saudi Arabia last year in the area of climate change and coastal disaster management.

FRADDRY D'SOUZA

Dr. Fraddry D'Souza is a Fellow and Area Convenor, The Coastal Ecology and Marine Resources Centre, TERI Goa. Prior to joining TERI, Fraddry has worked as a Scientific Researcher in TNO Science and Industry, The Netherlands, where he worked for FIVE years in Applied Marine Industrial research. He has worked at National Institute of Oceanography (NIO) as JRF/CSIR-SRF and completed his doctorate. He was awarded an Erasmus Mundus Scholarship for the "Joint European Master in Water and Coastal Management programme" at Portugal and Spain Universities. His most frequent subjects of interest are ranging from Coastal resources management, Water management & technology, Aquaculture, Biodiversity assessment, marine biofilm and biofouling, & microbiologically influenced corrosion.

He had also served as a member of Technical Advisory Committee (TAC) of Goa State Pollution Control Board for a period of three years and currently a TAC member of Goa State Waste Management Cooperation (GSWM). He is also a member of three committees of Government of Goa for Preparation of draft plan, i) 'Comprehensive Plan of Fishing community living in CRZ areas', (ii) 'Khazan land management plan' and '(iii) 'Mangrove management plan. He has published more than 25 research papers in national and international peer reviewed journals on range of topics.

VISHVA NATH ATTRI

Professor Vishva Nath Attri is Former Chair in Indian Ocean Studies and Member FICICI Task Force on Blue Economy. He is one of the leading experts on Blue Economy and an Architect of the Blue Economy of the Indian Ocean Region (2018). He is the Managing Editor Journal of Indian Ocean Rim Studies. He has been a visiting scholar at University of California, Los Angeles and at George Washington University, Washington DC, USA. He has contributed intensively to the six Priority Areas and two Focus Areas of IORA.

YUGRAJ SINGH YADAVA

Dr. Yugraj Singh Yadava, heads the Bay of Bengal Programme, which is an Inter-Governmental Organisation working on fisheries in the Bay of Bengal region. Formerly, Dr Yadava was the Fisheries Development Commissioner to the Government of India and Member Secretary of the Coastal Aquaculture Authority. With a career spanning forty-five years, Dr Yadava has worked in many South, South-east and Far-east Asian countries. He is well-known in the national and international fisheries and has contributed to a large number of global fisheries and environment-related agenda.

Rajdeep Mukherjee

Mr. Rajdeep Mukherjee is a Policy Analyst at Bay of Bengal Programme Inter-Governmental Organisation Chennai.

1.

RESHAPING BLUE ECONOMY IN INDIA: Initiating a Discourse

Chapter 1

Blue Economy: India's pathway to sustainable, secure, and resilient economy

M RAJEEVAN* (secretary@moes.gov.in)

Introduction

Oceans cover 72% of the surface of our blue planet and provide a substantial portion of the global population with food and livelihood. Oceans are a storehouse of living and non-living resources, and have features at the seabed that have not been explored. The oceans play a key role in the air we breathe, the water we drink while also modulating the daily weather and climate patterns. Our present knowledge of the oceans is mostly confined to shallow waters. The global security issues involved with oceans dictate exploration of deep sea that needs specialized modern technology, which is not commercially available at present.

India has a unique maritime position. Its 7517 km long coastline is home to nine coastal states and 1382 islands. The country has 12 major ports and 187 non-major ports, handling about 1400 million tonnes of cargo every year, as 95% of India's trade by volume transits by sea. India's Exclusive Economic Zone (EEZ) of over two million sq. km is rich in natural resources and holds significant recoverable resources of crude oil and recoverable natural gas. The coastal economy also sustains over 4 million fishermen and other coastal communities. India should strive for efficient and sustainable utilization of ocean resources and to integrate and boost ocean-related capabilities, capacities, and skills. However, the economic activities should be carried out by safeguarding the environment and in harmony with the UN Sustainable Development Goals.

Blue Economy Concepts

The economic philosophy of the blue economy was first introduced in 1994 by Professor Gunter Pauli at the United Nations University (UNU) to reflect the needs of future growth and prosperity, along with the threats posed by global warming [1]. The concept was based on developing more sustainable models of development including concepts of engineering based on "no waste and no emissions". After the Third Earth Summit Conference—Rio+20 in 2012, the blue economy assumed greater importance. The concept of blue economy received more thrust when the United Nations' Sustainable Development Goal 14 sought to "conserve and sustainably use the oceans, seas and marine resources for sustainable development" as a guiding principle for global governance and use of ocean resources. Countries such as Australia, Brazil, the United Kingdom, the United States, Russia, and Norway have developed dedicated national ocean policies with measurable outcomes and budgetary provisions. Countries such as Canada and Australia have even enacted legislation

* Dr M Rajeevan is Secretary, Ministry of Earth Sciences, Government of India.

to ensure progress and monitoring of blue economy targets. While there are traditional ocean activities, such as fisheries, tourism, and maritime transport, blue economy entails emerging industries including renewable energy, aquaculture, seabed extractive activities, and marine biotechnology and bioprospecting. Blue economy also attempts to embrace ocean ecosystem services, such as carbon sequestration, coastal protection, and waste disposal. Blue economy is indispensable for addressing many of the global challenges, such as food security, climate change, provision of energy, water, new medicines, oil, gas, minerals, and other natural resources.

The definition of blue economy is multi-faceted and not a single definition suffices the coverage of blue economy in its entirety [2]. Considering pros and cons of different definitions, India has developed a working definition of Blue Economy [3] as: "Blue economy refers to exploring and optimizing the potential of the oceans and seas which are under India's legal jurisdiction for socio-economic development while preserving the health of the oceans." Definition of blue economy by India is comprehensive in the sense that it covers many dimensions of the ocean activities.

Recent Initiatives of the Government of India on Blue Economy

India has a rich history of engaging in ocean-related activities [4], [5]. India was among the first in the world to create a Department of Ocean Development in 1981, now the Ministry of Earth Sciences (MoES). India has already completed the survey of 92% of area of India's EEZ. As per the Article 76 of the United Nations Convention on the Law of the Sea (UNCLOS), India has delineated the continental shelf (beyond EEZ) and claimed an area of over 0.6 million sq. km over Arabian Sea and Bay of Bengal, which is equal to the combined area of the states of Maharashtra and Madhya Pradesh. This claim was based on acquired marine geophysical data. India also has exploration contracts with the International Seabed Authority (ISBA), for exploration of polymetallic nodules (PMN) over an area of 75,000 sq. km and for hydrothermal sulphides over an area of 10,000 sq. km over the central Indian Ocean. It is estimated that total content of PMN over the area is around 380 million metric tonnes with an economic benefit of more than $110 billion. Based on the experience of more than three decades, India has come a long way with the launch of new ambitious mission such as "Deep Ocean Mission," with a budget outlay of 4168 crore during the period 2021–26 to explore and harness marine resources in a sustainable way [6]. This mission can lead to a revolution in the understanding of the oceans around us, and make India a pioneer in several technological fronts and also lead to security and self-sufficiency of the nation as a whole. Through this mission, we should aspire to bring similar revolution in the use of ocean science and technology to shape the life and developmental activities of the country. The MoES has recently joined the United Nations on the "Clean Seas Programme" to develop strategies for estimating and reducing marine litter/plastic in the oceans, which is also a part of SDG14. The Government of India's Vision of New India by 2030 enunciated in the budget speech in February 2019 identified blue economy as the sixth dimension stressing the need for a coherent policy integrating different sectors so as to improve the lives of the coastal communities.

By recognizing a holistic and inter-sectoral approach, the Office of Economic Advisory Council to Prime Minister (EAC-PM) recently initiated an inter-ministerial and stakeholder consultation to evolve a draft policy framework for India's Blue Economy. With the objective of striving for efficient and sustainable utilization of ocean resources and to integrate and boost ocean-related capabilities, the Government of India has come out with a Blue Economy Policy document, which is available in the Public domain— (https://moes.

gov.in/writereaddata/files/BlueEconomyPolicy.pdf). The policy document has been formulated after several rounds of multiple deliberations with relevant ministries, think tanks, and experts. The draft expresses both the strategy as well as the vision that can be adopted by the Government of India. This document can be the foundation to harness blue resources to secure a better economic future for the people in a sustainable manner.

The essential components of the Blue Economy Policy will cover eight different areas in its ambit. They are: 1) A National Accounting Framework for the Blue Economy; 2) An Environmentally Sustainable National Coastal Marine Spatial Planning Framework; 3) A vision to Develop Marine Fisheries, Aquaculture, and Fish Processing; 4) A vision to enhance domestic manufacturing, emerging industries, trade, tourism, technology, services and skill development; 5) An Integrated Plan for Developing Logistics, Infrastructure, and Shipping; 6) A Framework for Coastal and Deep-sea mining, New and Renewable Off-shore Energy and Research and Development; 7) An Integrated Framework for Ocean Security, Strategic Dimensions, and International Engagements; and 8) Ocean Governance.

A crucial issue concerning blue economy is the measurement of its size and the contribution to GDP. The size of the blue economy in India has conservatively been estimated to be about 4% of GDP [3]. It is likely to be even higher if the methodology is improved. For some of Asian countries such as Malaysia and Indonesia, the contribution of blue economy is more than 20%. A new robust mechanism needs to be devised to collect data for estimating the blue economy in India. It is desired to identify all the sectors and sub-sectors/activities, which fall under the purview of the blue economy.

In the next few sections, major components of the Blue Economy Policy of India are discussed.

Marine Spatial Planning

Marine Spatial Planning (MSP) is a science-based tool of analysis that regions or coastal states in a country can use to address ocean management issues and challenges and advance their goals for inclusive growth, sustainable development, employment generation, and conservation of marine resources. MSP is a process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that have been specified through a political process [7], [8].

MSP can offer us a way to address the human–human and human–environment conflicts and select appropriate management strategies to maintain and safeguard necessary ecosystem service. MSP can have significant economic, social, and environmental benefits [8]. Some of the environmental benefits are identification of biological and ecologically-important areas, and allocation of space for biodiversity and future conservation. Some of the economic benefits are greater access to desirable areas for new private sector investments, identification of compatible uses within the same area of development, improved capacity to plan for new and changing human activities including emerging technologies, and promotion of the efficient use of resources and space [8]. The USA is one of the leading countries in the application of MSP, which introduced the Oregon Territorial Sea Plan, approved in 1994.

MSP must form the basis for the future development of blue economy in India's EEZ including India's island territories [7]. Mapping of ocean resources is needed to develop a functional MSP. The introduction of Coastal MSP is likely to enhance the sustainability and productivity of oceans, seas, lakes, and rivers which further enhance the optimum utilization of marine resources. India has made considerable progress in

terms of mapping its coastal regions and EEZ. There is a need that all existing data and mapping policies are streamlined and dovetailed with the MSP requirements covering the relevant areas. zTherefore, formulation of a new National Map and Data Policy is desirable balancing emerging requirements of data security and transparency. UNESCO-IOC developed the MSP Step-by-Step Approach for MSP towards Ecosystem-based Management 2009 [8]. This step-by-step approach can serve as a guide to introduce MSP in India.

Recognition and development of marine clusters (MCs) under MSP is another factor which is crucial for India today. MCs are viewed as means of providing enhanced efficiency and productivity so that businesses can be competitive on a national, regional, and global level [7]. Further, socio-economic aspects/factors, such as employment and sustainability are also seen as positively influenced by cluster dynamics.

India and Norway recently signed a Memorandum of Understanding (MoU) establishing the India–Norway Ocean Dialogue in January 2019. The MoU emphasized "the need to move towards integrated and ecosystem-based approaches in the management of renewable and non-renewable natural resources" and identified Integrated Ocean Management as an area of mutual interest for future cooperation. Under this collaboration—Puducherry and Lakshadweep—two distinct sites have been identified for developing a framework for MSP. This framework once developed for these two sites can be replicated for other coastal areas of the country.

Fisheries

Fisheries sector is one of the main resources of the Indian Ocean which provides food to hundreds of millions of people and contributes to the livelihoods of coastal communities. It plays an important role in ensuring food security, poverty alleviation, and also has a huge potential for business opportunities. Global fish production is estimated to have reached about 179 million tonnes in 2018 with a total value estimated at $401 billion, of which 82 million tonnes values at $250 billion came from aquaculture production [9]. Aquaculture accounts for 46% of the total production and 52% of fish for human consumption.

India's total fish production during 2016–17 was estimated at about 11.41 million metric tonnes. This constituted around 6% of the global production. The fisheries sector contributed to approximately 1% of the National GDP and more than 4% of the agricultural GDP [10]. The marine fisheries sector of India contributed 3.6 million tonnes in 2016 making the country the sixth largest contributor to global marine capture fisheries production [10]. In the inland waters capture production, India stands at second position with 1.70 million tonnes and 14% of global production. Marine fish production in India so far has been heavily dependent on capture fishing constituted by about 1200 fish and shellfish species. However, production from capture alone is insufficient to meet the growing demand for seafood in the country.

Estimates indicate that by the year 2030, India's annual demand for fish will be about 18 million metric tonnes. Currently, we produce about 11 million metric tonnes annually. Therefore, 7 million metric tonnes is required [10]. This calls for careful strategizing and a strong action plan involving all stakeholders. The marine capture fisheries sector will not be able to contribute very significantly given the limitations and the plateauing off seen in the sector. Modest enhancements are likely from the deep sea resources and the land-based fisheries and aquaculture systems. We need to aim at an increase in production in the range of 4 to 5 million metric tonnes annually from mariculture by 2030 if we are to meet the requirements.

Maricuture is a subset of aquaculture and is the farming of marine organisms in salt water for food and other products such as pharmaceuticals and jewellery items like pearls. This is an important emerging subsector of

the blue economy. Marine aquaculture is almost non-existing in India and the National Fisheries Development Board is currently exploring opportunities for marine cage culture in India. With the development of captive breeding and mass production technologies for high-value marine fish species, mariculture through cage farming is being established all along the coastal waters of maritime states and Union Territories (UTs).

One of the approaches to intensify capture fish production is exploitation of deep-sea resources, which is yet to be tapped fully. India has an estimated harvestable potential of 3.3 million metric tonnes in deep-sea areas at depths between 200 and 2000 metres in both EEZs and in Areas beyond National Jurisdiction (ABNJ). There are increasing cases of fishing in the high/deep seas in the most productive fishing areas of the world including the Indian Ocean. Genetic and biotechnological interventions offer huge potential for tapping the rich resources of ocean and meeting the Sustainable Development Goals towards realization of a blue economy in India.

Marine Tourism

Tourism has emerged as an important sector of the Indian economy. In 2017, India made its way into the top 10 travel and tourism markets in the world [10]. The total GDP contribution of Travel & Tourism was $247 billion or 9.2% of GDP in 2018 growing at the rate of 6.7%, which is more than the global average of 3.9%. Coastal and marine tourism sector is poised to grow, expand and diversify faster and can contribute substantially to the development of the country in the years to come. The European Union is the best example of such development where coastal and maritime tourism sector has been identified as a part of their blue growth strategy.

Marine tourism, with its related marine activities (including cruise tourism), is a growing industry that represents an important contributor to the economy of countries and for generating employment. However, these activities should be managed sustainably to protect the marine environment and biodiversity. Otherwise, it could develop an adverse relationship with the environment, leading to destruction and degradation of marine habitats and environment. Protecting local marine resources is one of the most urgent needs in promoting sustainable tourism. While it is important to leverage the potential that coastal and marine resources hold for tourism, at the same time various challenges that would eventuate in course of development should be negotiated with. Specific to islands, these concerns are even more concerning.

In India, it is necessary to promote beach benchmarking standards using eco-labelling, sustainability procedures, and waste management systems. In accordance with the Blue Flag Standards, the Ministry of Environment, Forest and Climate change (MoEFCC) has already rolled out 'Blue Flag Certification' in 13 nominated pilot beaches across coastal States/UTs in India. The certification scheme aims to improve beach clean-up and sustainable development to attract more tourists and make beaches pollution-free. All coastal States and Union Territories are now strategizing to develop and promote water sports, beach sports, and other marine tourism opportunities. The potential of cruise tourism, marine tourism and lighthouses has been acknowledged and plans are being developed in India.

Marine Manufacturing and Emerging Industries, Marine Services

Marine manufacturing is a relatively untapped field of blue economy. It covers a range of activities, such as ship building, development of marine compounds and drugs, manufacturing of equipment and instrumentation,

exploration materials for deep-sea mining, net making, boat making, and fish processing and aquaculture tools. Among services sectors, ship repair, marine finance and insurance, marine ICT, coastal tourism and port services can unleash a huge potential for investments and job-creation under an integrated policy to develop and harness the potential of blue economy [11].

The regulations to enhance ease of doing business (EODB) and the flow of private investment while applying time-tested paradigms of public-private-partnerships should be also geared to blue economy investments [11]. With a fast pick-up in awareness about business and investment opportunities in the country, there would be demand for loans and other financial services for marine and other related sectors. A strong and a deep market for supporting and satiating demand for finance and financial services is the need of the hour.

Investment is the crucial determinant of the future of blue economy in India. The major sectors with strong investment prospects are shipping, including capacity expansion of vessels, ship-building, repairing and breaking, coastal shipping, ship chartering and ship brokerage services, warehousing, freight forwarding, bunkering and storage facilities, developing dedicated coastal shipping, and dedicated coastal berths management. But, investments in blue economy sectors involve many unknown risks as more than 80% of the oceans stay unmapped, unobserved, and unexplored.

Ports Infrastructure, Shipping Services, Ship Building

The seaport and maritime transport sector is one of the important priority sectors under the blue economy, in which many countries are showing a greater interest. India sits astride busy International Shipping Lanes (ISLs), through which, more than 120,000 ships and craft transit annually. Globally, there has been an increase in the cargo movement around the world. Seaborne trade volumes grew by 4.4% in 2018 showing an upward trend. Considering the fact that 95% of the country's trade by volume (70% in terms of value) transits by sea puts the Indian maritime sector at an advantageous position [12]. India is a potential destination for shipping and trans-shipment in the future. Ship building industry in India is however currently on a decline. It needs investment in financial capital, physical capital, natural capital and human capital to harness the potential of the blue economy [12]. Currently, there are 28 shipyards in the country—six under Central Public Sector, two under State Governments, and 19 under Private Sector [12]. The industry is further facing a lot of competition from international shipbuilding yards located in Japan, South Korea, and China. The size of the Indian fleet is very small. As a result, the current availability of ships is poor. In order to increase the availability of the ships, the Indian Government has recently relaxed rules to enabling them to carry certain types of cargo without obtaining license.

The Sagarmala programme is a strategic, long-term customer-oriented initiative of the Government of India to accelerate the model of port-led development, whereby India's long coastline will become the gateway of India's prosperity. Sagarmala will be a key to comprehensive port-led coastal development. To promote port-led industrialization, the Government has identified 12 major ports and 14 Coastal Employment Zones (CEZs) as part of the National Perspective Plan under the Sagarmala programme. To promote shipping industry, government may formulate a 30-year holistic shipbuilding plan to be implemented across existing and future greenfield indigenous shipyards under the Atmanirbhar initiative to give a boost to shipping and shipbuilding sector.

With India's strategic location in the Indian Ocean, an efficient well-geared ship repair facility closer to the international shipping routes can attract foreign ships and vessel calling on the Indian ports as well as those

passing through the vicinity of the Indian waters. For global competitiveness, there is a need for creating competition among ports and building in port specialization. The performance of Indian ports on most parameters has been low. However, with renewed focus on port infrastructure development and EODB measures, ships calling at Indian ports are turning around faster and benefiting from higher berth productivity.

Exploration of Ocean Energy and Deep Sea Minerals

The world population is expected to increase resulting in an increase in countries' demands on fossil fuels. Renewable sources of energy, such as solar and wind, are already being implemented worldwide. India has taken a great initiative on both these sectors. However, there is a potential of renewable energy that can be derived from the ocean. The ocean offers vast potential for renewable 'blue energy' from wind, wave, tidal, thermal, and biomass sources. There is a huge potential for off-shore winds off the coasts of Gujarat and South Tamil Nadu. The Government of India through the Ministry of New and Renewable Energy (MNRE) has taken an initiative to tap clean energy from off-shore winds.

In addition, there are mineral deposits, such as PMN and hydrothermal sulphides, over the sea beds. By virtue of sustained exploratory activities and investments in the Indian Ocean, India was accorded the pioneer status on deep sea mining of polymetallic nodules/polymetallic sulphide (PMS) in an area of 75,000 sq. km in the central Indian Ocean by the International Seabed Authority (ISA) for exploration. In September 2016, the ISA approved an application submitted by the MoES for allotment of 10,000 sq. km area along with 15 years' plan of work for exploration of PMS along the central Indian ridge and the Southwest Indian Ridge region of the Indian Ocean. These regions are enriched with iron, copper, zinc, silver, gold, and platinum. These contracts will open up new opportunities for resources of commercial and strategic value in an area beyond national jurisdiction.

For scientific exploration of the oceans, substantial investments in engineering and technology need to be prioritized along with deployment of human resources. The development of manned submersibles is a major requirement before mining is commenced and undertaking a manned submersible mission by 2023 is recommended [13]. To harness these resources, development of submersibles and mining systems are necessary as these technologies are not available commercially. The new Deep Ocean Mission launched by the MoES [6] is likely to address these technological challenges for the deep ocean mining.

India has about 2 million sq. km of EEZ, which is nearly two-thirds of its total land area. The mineral potential of the EEZ includes well-known monazite-ilmenite-rutile placers on the east and west coasts, calcareous aggregates and sands in the shallow waters (especially in the Lakshadweep island group off the southwest coast), and phosphate mud and sediments (along the west coast, and possibly in the Andaman Sea) [14].

Environmental Sustainability

While there is a focus on economic activities related to blue economy, it is important to recognize that blue economy emphasizes the need for sustainability and protecting the health of oceans. Therefore, we need to address the issue of environmental sustainability more seriously. For example, marine pollution has grown to be a major concern today globally, dominated by plastic waste. Plastic and microplastics being non-biodegradable remain in the environment for centuries. The United Nations has also called for the prevention and significant reduction in marine pollution of all kinds by 2025, particularly from land-based activities which are the main source of plastics and microplastics.

India is also committed to phase out single-use plastics by 2022. India needs a far more robust waste management strategy, behavioural changes in place to counter the rising ocean pollution and degrading health of oceans. The MoES through the National Centre for Coastal Research (NCCR), Chennai has taken up awareness programme and assessment of marine litter along the Indian coasts. Through 6900 volunteers, they have collected almost 30 tonnes of marine litter. An analysis of this waste suggests that most of marine litter is in plastic form (food wrappers and cups). The United Nations General Assembly (UNGA) has decided to develop an international legally-binding instrument on conservation and sustainable use of marine biological resources in areas beyond national jurisdiction (in short called 'BBNJ'), under the UNCLOS.

International Cooperation and Maritime Security

There is a huge potential for India to engage in international cooperation in blue economy. India should carefully identify international partners with common interests, proven capabilities and know-how in the blue economy for technology sharing, adaption, and transfer with long-lasting benefits. India, in turn, should share its own capabilities with other maritime partners and neighbours for enhanced goodwill and inter-dependence [15]. A comprehensive plan to understand the requirements of our maritime neighbours and offer focused assistance for their capacity development through supply of hardware, training, joint operations, data gathering/sharing for better marine domain awareness, and disaster relief should be evolved.

Maritime security should be seen as a complement to terrestrial security [15]. The prerequisite for a strong naval capability is a sound and well-developed industrial base. Maritime security must be seen in a holistic manner by including civilian maritime domain, state police and ports trusts—which if not adequately addressed can lead to adverse effects on maritime security.

Capacity Development and Training in Blue Economy

There is a need for capacity development for integrated ocean governance to achieve sustainable development of oceans and coasts including responses to address new challenges, biodiversity, climate change, and provide sustainable ocean and coastal livelihoods. A global strategy for mobilizing expertise and partnerships needs to be developed to ensure that governments and institutions have the skills, knowledge, and capacity to develop blue economy frameworks and to address challenges on oceans and coastal communities in a long-term, integrated manner. Since its establishment in 1960, the International Oceanographic Commission (IOC)/UNESCO has built up a rich tradition of providing technical training, scholarships and fellowships, initially through the IOC's TEMA (Training, Education, and Mutual Assistance), and more recently through its Capacity Development Section.

India should explore more technical collaborations with countries which have large expertise pool for training Indian scientists, industries, policymakers and academic community in blue economy-related activities. For example, the recent collaboration between India and Norway on MSP is the best example. While India has very little experience in MSP, the expertise from Norway will bring productive results in MSP. In India, there are a very few universities responsible for inculcating education in marine sciences and oceanography. There is hardly any educational institute in India with a teaching programme in ocean technology. To reap more dividends in blue economy, there is an immediate need to strengthen university education in Marine Sciences and Oceanography, including ocean technology development.

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Chapter 2

Transitioning from a 'brown economy' to A 'Blue Economy': challenges and opportunities for India

Vice Admiral Pradeep Chauhan, Director-General, National Maritime Foundation

Concept of 'Blue Economy'[1]

The term 'Brown Economy' is used to describe the 'old way' of running the global economy, with its high carbon footprint and unsustainable exploitation of the earth's resources. However, the risks of climate change as a consequence of human degradation of the global environment are now recognized as being too high for continuing the Brown Economy. Thus, to offer a more sustainable model of global economic development, a whole slew of measures, suggested by the United Nations Conference on Sustainable Development (UNCSD), have found increasing acceptance in the capitals of the developed and developing world alike, albeit not without some significant differences in the committed pace of remedial change. This new model of sustainable development is known as the 'Green Economy', which is focussed not merely upon the sustainability of the economic model, but even more upon meeting the central global challenge of eradicating poverty.

The expression 'Blue Economy' is rapidly gaining currency within a host of academic and analytical circles around the world.[2] In India too, increasing attention is being paid to Blue Economy by both government and non-governmental agencies. As an expression, the Blue Economy has its origins in the deliberations, in mid-2012, of the UNCSD. The forum provided by this conference, often referred to as the 'Rio + 20 Conference', was very effectively used by many coastal countries, and especially by Small Island Developing States (SIDS). They pressed for the Green Economy model to be significantly modified to take far greater cognisance of the world's oceans as these maritime expanses represent the 'final frontier' for sustainable human development. They emphasized that the oceans cover 72% of the surface of the planet and constitute more than 95% of the biosphere. They reminded that life itself originated in the oceans and continued to be supported by the oceans through the generation of oxygen, absorption of carbon dioxide, recycling of nutrients, and the regulation of global climate and temperature. The oceans provide a substantial portion of the global population with food and livelihood and are the means of transport for over 80% of the global trade. They underscored that the oceans constituted a key resource for global tourism – ranging from the familiar 'sun, sand, and sea' formula to the diverse and expanding domain of nature-based tourism. It was also pointed out that the seabed provides about 32% of the global supply of hydrocarbons and advancing technologies are fast facilitating the mining of seabed mineral resources. Finally, the sea also offers vast potential for renewable 'blue energy' production from wind, wave, tidal, thermal, and biomass sources.

[1] United Nations. n.d. Blue economy concept paper: Sustainable development. Details available at https://sustainabledevelopment.un.org/content/documents/2978BEconcept.pdf, last accessed on August 11, 2021

[2] Voyer, Michelle, Genevieve Quirk, Alistair McIlgorm, and Kamal Azmi. "Shades of blue: what do competing interpretations of the Blue Economy mean for oceans governance?." Journal of Environmental Policy & Planning 20, no. 5 (2018): 595-616.

Thus, while in the traditional Brown Economy, oceans were used as a medium for inequitable economic exploitation of global resources and the dumping of all kinds of waste, the new model conceptualized the oceans as 'development spaces'. The new model seeks to integrate conservation, sustainable use, oil and mineral wealth extraction, bio-prospecting, sustainable energy production, and marine transport. Indeed, it was this very emphasis upon the oceans as the principal focal area of the new model of global development that was the leitmotif of the Blue Economy. It needs to be reiterated that both the 'Blue' and 'Green' economic models have the same desired outcome, namely, 'improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. Also, the desired outcome endorses the same principles of low carbon, resource efficiency, and social inclusion'.[3] The difference is that the Blue Economy is grounded in a developing world context and is founded upon the principle of equity to reflect the circumstances and needs of countries whose future resource base is significantly, if not predominantly, maritime.

The idea of the Blue Economy stimulated, and the world soon witnessed a whole slew of initiatives including, *inter alia*, the United Nations Department of Economic and Social Affairs (UNDESA) expert group meeting on 'Oceans, Seas and Sustainable Development', the work of the Global Ocean Commission, the Global Partnership for Oceans, and the prominence given to oceans and seas in the UN's five-year Action Agenda.[4] The Blue Economy model recognizes six major challenges:[5] (1) the urgent need for restoration and sustainable use of biodiversity and renewable resources, as also the proper management of resource extraction; (2) the criticality to assure food security through an integrated approach to both aquaculture and wild capture fisheries that respects ecological parameters throughout the cycle of production and consequently creates sustainable, decent employment, and offering high-value commodities for export, even while removing subsidies that encourage overfishing; (3) the mitigation of the impact of climate change in general and of 'sea-level rise', 'ocean acidification', and 'blue carbon' in particular, to transit to a low-carbon economy utilizing the ocean's enormous potential for renewable energy in terms of wind, wave, tidal, thermal, and biomass, as also the long-term sequestration of carbon by maintaining and rehabilitating key coastal habitats such as mangroves, salt marshes, and seagrass meadows; (4) managing the adverse impacts of marine and coastal tourism – increased greenhouse gas emissions, water consumption, sewage, waste generation, and loss or degradation of coastal habitats, biodiversity, and ecosystem services – especially in island and coastal economies that are solely or heavily dependent on this industry; (5) the comprehensive addressal of marine pollution and marine debris caused by increased human habitation along the coast, increased maritime shipping, and hydrocarbon and mineral offshore exploration and extraction; and (6) the need for structured international cooperation and research, technical assistance, technology transfer, and capacity building – all aimed at the sustainable development, effective management, and utilization of national Exclusive Economic Zones (EEZs), as also in terms of ocean governance, maritime security (including the maintenance of oceanic Maritime Protection Areas [MPAs]), sustainable fisheries, and oil and mineral extraction – through adherence to the principle of 'common but differentiated responsibilities'.

3 ibid, p. 3

4 The United Nations Secretary General's Five-Year Action Agenda, 25 January 2012. Details available at https://www.un.org/sg/sites/www.un.org.sg/files/atoms/files/sg_agenda_2012.pdf, last accessed on September 15, 2021.

5 United Nations. Blue Economy Concept Paper: Sustainable Development. Details available at https://sustainabledevelopment.un.org/content/documents/2978BEconcept.pdf, last accessed on August 11, 2021

India's 'Blue' Imperative

Economic development in India, too, seeks for a sustainable model and the Blue Economy approach has begun to be seen by a much wider community than just the marine-scientific one as one that offers the greatest hope. This fortuitously coincides with the contemporary increase of awareness of the criticality of our maritime spaces among the political class – after far too many protracted years of sea blindness. Governing structures in India are increasingly aware of the job opportunities and national development options offered by at least five elements of the Blue Economy, which are:[6] (1) shipping and port facilities that are compliant with the International Maritime Organization's regulatory framework; (2) sustainable and scientifically driven aquaculture and wild fisheries; (3) coastal, maritime, and cruise tourism (as also ecotourism and nature-based tourism); (4) petroleum-based energy, algae-based biofuels, and renewable energy, derived from coastal and offshore sources and locations; and (5) undersea mining within and beyond national EEZs.

Today, not just the EEZ, but the Indian Ocean as a whole is recognized as a foundational maritime interest of India, feeding into the country's core national interest, namely, 'to assure the material, economic, and societal well-being of the people of India'. The Blue Economy model, recognized by all the SIDS and island states and most of the coastal states of the Indo-Pacific, offers a significant opportunity for India to demonstrate inclusive regional leadership. Countries that look at India to leverage its considerable scientific, technological, economic, and diplomatic prowess to provide precisely this type of inclusive regional leadership include (*inter alia*) Bangladesh, Myanmar, Maldives, Seychelles, Mauritius, and Indonesia.[7]

Indian Ocean Regional Association (IORA), which has undergone a major revival as the multilateral political grouping of the Indian Ocean Region, is increasingly supportive of the Blue Economy and has acknowledged the large potential of the oceans for sustainable development of the countries in the region. It is a feature that India should leverage. IORA, with its key objectives of regional cooperation, employment, food security, poverty alleviation and ensuring sustainability, has successfully charted out its Blue Economy roadmap. The three joint declarations issued in Mauritius (2015), Jakarta (2017) and Dhaka (2019) are important steps towards a more regional approach to Blue Economy.

With several facets of national well-being, such as food security, economic security (most particularly energy security), and health security having marked salience in India's 'blue' endeavours, it would be useful to take a broad overview of the more important facets of India's efforts at creating and sustaining a Blue Economy. In this context, the working groups set up by the Economic Advisory Council to the Prime Minister (EAC-PM) recently published seven reports on the major aspects of the Blue Economy of India.[8] The reports provided a much-needed and comprehensive perspective on the scope and true potential of India's Blue Economy. This was a followed by a draft policy framework on Blue Economy released by the EAC-PM highlighting the primary thrust areas of the central government.[9]

History has been a persistent teacher of the harsh lessons of food scarcity and India recognizes the huge potential inherent in aquaculture for the provision of food and livelihood. And yet, it would be unnecessarily self-limiting to assume that the available fish stocks within the EEZ are useful solely as food. Ocean-based

6 Ibid

7 Vijay, A. 2017. Blue Economy: A Catalyst for India's 'Neighbourhood First Policy'. National Maritime Foundation, New Delhi. Details available at https://maritimeindia.org/blue-economy-a-catalyst-for-indias-neighbourhood-first-policy/, last accessed on September 15, 2021.

8 The seven reports of the Blue Economy Working Groups may be accessed from the website of the Economic Advisory Council to the Prime Minister here: https://eacpm.gov.in/index.php/whats-new/, last accessed on September 15, 2021.

9 Economic Advisory Council to the Prime Minister (EAC-PM). "India's Blue Economy: A Draft Policy Framework", September 2020. Details available at https://www.ncmrwf.gov.in/ncmrwf/Inviting-public-consultation-to-the-draft-Blue-Economy-policy.pdf, last accessed September 15, 2021.

biotechnology is another area where the potential is enormous. Marine bacteria are a rich source of potential drugs, including new antibiotics. 'Recent data strongly suggest that the marine environment represents an untapped source for new biologically active molecules, in particular antibiotics. In this respect, marine bacteria and fungi seem to be the most prominent sources for antibiotic discovery due to their diversity and ability to grow rapidly and sustainably in bioreactors. Other sources, like sponges, corals, and other marine animals, can also supply very interesting scaffolds for antibiotic discovery, which can be reproduced through chemical synthesis. Finally, metagenome libraries prepared from diverse marine samples and giving access to the genetic material from unculturable species may also supply new antibiotics.[10][11] The available fish species within the Indian EEZ critically support the country's healthcare sector and there are enormous dividends to be obtained from marine biological and microbiological research and production.[12]

Likewise, energy (conventional and unconventional) is the key to India's future economic and societal progress. It is to the oceans that India must increasingly turn for the transportation of crude oil imports and burgeoning exports of refined petroleum products. Notwithstanding the contemporary and future criticality of India's Sea Lines of Communication to the country's energy flows, the oceans offer India far more than just the transportation arteries. And, where the conventional sources of petroleum-based energy are concerned, the potential offered by India's extensive reserves of gas hydrates is staggering. Far more encouragingly, the past few years have seen a discernible acceleration in India's quest for sea-based unconventional sources of energy. Fields such as Ocean Thermal Energy Conversion (OTEC) and Offshore Wind-Energy are turning India's economic endeavours distinctly 'blue'. India's collaboration with the EU on the Facilitating Offshore Wind in India (FOWIND) project, which aimed to provide feasibility research, knowledge sharing, and guidance for the development of India's commercial offshore wind market, and the follow-up studies on the feasibility of Offshore Wind power generation in Gujarat and Tamil Nadu are clear signs of India's growing interest in harnessing ocean-based renewable energy resources. This diversification to other forms of renewable energy, besides land-based solar and wind, will increase India's chances of meeting its ambitious target of installing 175 GW of renewable energy capacity by 2022. Insofar as contemporary concerns and some scepticism regarding the cost and cost-effectiveness of renewable energy from the oceans exist, the following extract from the draft National Renewable Energy Act 2015 of India's Ministry of New and Renewable Energy is relevant:[13]

> 'In a business-as-usual scenario 'cost-effective energy system' would mean cost becoming the singular overriding consideration. The attractiveness of a specific energy supply option depends also on broader economic as well as environmental and social aspects. The environmental and social externalities of conventional power generation if computed and internalized in the pricing of fossil fuel based power, then the RE based power becomes competitive or even cheaper than fossil fuel based power generation. Moreover, Renewables are the only free hedging mechanism against the price volatility of fossil fuels. Risk adjusted cost of generation portfolio including renewable energy is lower than that of a fossil fuels only portfolio.'

[10] MDPI. n.d. Marine antibiotics, marine drugs (ISSN 1660-3397). Zotchev, S. B. (Ed.). MDPI AG, Basel, Switzerland. Details available at http://www.mdpi.com/journal/marinedrugs/special_issues/marine_antibiotics, last accessed on September 15, 2021

[11] 2015. Marine Biomedicine: From Beach to Bedside. Baker, B. J. (Ed.). CRC Press: FL, USA. Details available at https://books.google.co.in/books?id=xSbSCgAAQBAJ, last accessed August 11, 2021

[12] Thakur, N. L., A. N. Thakur; E. G. Werner & Müller. Marine natural products in drug discovery. NPR 4(6): 471–477. NISCAIR Online Periodicals Repository (NOPR). Details available at http://nopr.niscair.res.in/handle/123456789/8143, last accessed on August 11, 2021

[13] Ministry of New and Renewable Energy. Draft 'National Renewable Energy Act 2015'. Details available at https://mnre.gov.in/img/documents/uploads/68b053c5a944493e813c24a93cb39263.pdf, last accessed on September 15, 2021

At a different but no less critical level, undersea mineral resources within India's EEZ and, increasingly, within the central and south-central Indian Ocean's expanse, offer exciting opportunities for sustainable exploitation under an equitable international order set out by the International Seabed Authority of the United Nations. India has recently begun to take important policy steps in this direction such as the recently approved five-year-plan called the 'Deep Ocean Mission', under the aegis of the Ministry of Earth Sciences (MoES), which aims to explore the deep ocean for resources and develop deep sea technologies for the sustainable use of ocean resources.[14] Indeed, it would be crucial that such exploratory missions also assess the impacts of extraction of deep-sea minerals on the marine ecology, in order to meet the blue economy objectives.

The embracing of the principles of a Blue Economy is not merely important for India's economic and societal development, but equally for the Indian Ocean as a whole. India's geostrategic and geo-economic influence in the Indian Ocean makes it a net maritime security provider – facilitating freedom from threats emanating 'in', 'from', or 'through' the medium of the sea. Although India is typically modest and self-effacing in assessing its comprehensive national power, several SIDS of the Indo-Pacific are actively seeking India's quintessentially benign leadership in the development of a regionally inclusive and equitable blue economic model that could assure their future prosperity. The Prime Ministerial vision of Security And Growth for All in the Region (SAGAR) and the Indo-Pacific Oceans Initiative (IPOI) are important instruments of foreign policy which are paving the path for greater cooperation in the region. However, there is no gainsaying that a large part of that future will be adversely impacted by the current manifestations and upcoming risks of climate change. In fact, the decoupling of socioeconomic development from environmental degradation lies at the core of the Blue Economy concept. The concept recognizes and places renewed emphasis on the critical need for the international community to address effectively the sound management of resources in and beneath international waters by the further development and refinement of international laws and ocean governance mechanisms. India, for one, is clear that it must join in the international efforts to ensure that each country takes its share of the responsibility to protect the high seas, which cover 64% of the surface of the oceans and constitute more than 90% of their volume.

Ocean acidification and 'Blue Carbon' are the issues that are rapidly becoming central to future economic models.[15] Since the commencement of the Industrial Revolution, the world's oceans are estimated to have absorbed approximately 25% of the carbon dioxide generated by human activity. This resulted in an identical percentage increase in the acidity of the oceans. The 25% increase in oceanic acidity has had a significant and very adverse impact. For instance, there is clear evidence of the reduced ability of many organisms to form and maintain shells and skeletons, as well as reduced rates of their survival, growth, abundance, and larval development. Acidification is also causing net decreases in the global coverage of coral reefs, which are the breeding ground and nurseries for a very large number of fish species. Future projections are uniformly grim and pH levels for the more vulnerable oceanic regions could reach the 'aragonite tipping point' within decades, not centuries. As if these were not bad enough, increasing oceanic acidity causes a significant reduction in the ocean's capacity to absorb carbon dioxide and diminishes their traditional ability to moderate many harsh manifestations of climate change.

Blue Carbon is a generic term covering several marine long-term mechanisms that have far been very effective in preventing carbon dioxide from being released into the atmosphere. For instance, coastal

[14] PIB Delhi, "Deep Ocean Mission", Press Information Bureau of the Government of India, 15 March 2021. Details available at https://pib.gov.in/PressReleseDetailm.aspx?PRID=1704840, last accessed on September 15, 2021.

[15] Lovelock, Catherine E., and Carlos M. Duarte. "Dimensions of blue carbon and emerging perspectives." Biology Letters 15, no. 3 (2019): 20180781.

habitats such as mangroves, salt marshes, and seagrass meadows are known to 'fix' carbon at a much higher rate per unit area than any less effective but better known land-based systems. In fact, mangroves are so efficient at keeping carbon dioxide out of the atmosphere that when they are destroyed, they release as much as 10% of all the emissions worldwide attributable to deforestation – even though mangroves account for just 0.7% of the world's tropical forest area.[16] A part of the reason for this efficiency lies in their location in the complex root systems that mangroves develop to keep breathing even when the tides come in. It is this very complexity that traps sediment coming from rivers and then it builds up. In most forests, this sediment and litter would decay rather quickly, but because much of it gets submerged in a coastal mangrove forest, there is not enough oxygen to break it down. Thus, the breakdown of materials is much slower and a slower rate of decay means more carbon dioxide gets stored. The carbon dioxide is trapped mostly in the thick 'organic muck' layer in the soil. Yet, a Blue Economy approach must face the uncomfortable fact that mangroves live where many people want to live, i.e., along ocean coastlines. Brown Economy approaches have already led the areal extent of mangroves (the amount of land they grow on) to decline by 30–50% over the last 50 years. And, if this habitat continues to be sacrificed to developmental greed, then the coastal mangrove forests and the ecological services they provide could be gone in as little as 100 years. India's coastal cities bear as eloquent a testimony to the greed of realtors and land developers as they do to governmental ignorance and apathy.

As soon as one goes beyond the simplistic attractiveness of the expression – the Blue Economy – one encounters many complex challenges of a 'balance'. On the one hand, there is the maximization of maritime shipping as it is a preferred form of transportation of merchandise goods. And, on the other hand, there are significant associated environmental risks. For example, ballast water, which often contains aggressive micro-organisms native to one maritime area and are transferred by increasing numbers of merchantmen visiting other distant oceanic areas. This causes the local organisms along with the complex food chains they support to be overwhelmed by these 'foreign' organic species, causing not just environmental but economic havoc as well. Mitigation of this by the way of stringent ballast water treatment norms is technologically difficult to be implemented and monitored. Moreover, such measures carry additional attendant costs which could upset the economic considerations that led to shipping being the option of choice in the first place. Likewise, the production of biofuels from mangrove habitats offers alternatives to carbon-intensive fossil fuels. However, the large-scale harvesting of the mangroves leads to the release of staggering quantities of carbon dioxide that was thus far sequestered by those mangroves. Similarly, the melting of the Arctic ice sheet may well open up the Northern Sea Route to international shipping, bringing about enhanced trade between northern Europe and north-eastern China. But the release of the humungous quantities of methane presently trapped within the permafrost will far exceed anything that human beings with all their years of rapacious greed have managed to emit since the Industrial Revolution. Staying with the inter-relationships between the ecological impacts of seemingly disparate blue economic activities, the environmental impact of seabed mining, whether within the EEZ or in terms of deep-sea mining, is yet another challenge whose contours are not particularly well defined. Contraindicative of the increasingly obvious economic benefits accruing from deep-sea mining is the fact that such activities disturb or destroy the benthic layer, which is the natural habitat of several marine organisms such as mussels, worms, bivalves, and crustaceans, all of which support, in turn, the fisheries. There are issues related to sediment plumes when fine particles from the mining process are dumped back into the oceans, creating clouds of turbidity and clogging the filter mechanisms of benthic

[16] Donato, D. C., J. B. Kauffman, D. Murdiyarso, S. Kurnianto, M. Stidham, and M. Kanninen. 2011. Mangroves among the most carbon-rich forests in the tropics. Nature Geoscience 4: 293–297.

organisms. There are concerns regarding surface plumes which could impact plankton and even physical light penetration, thus, adversely affecting the entire marine food chain.

In other words, the Blue Economy is not without its formidable challenges. Hence, the choices that India make and regionally demonstrate will require scholarship and wisdom of an unprecedented order. The Indian Ocean Region is holding its collective breath... for when it exhales, there will be even more carbon dioxide to be contended with!

Given the foregoing discussions, it is practically self-evident that science and scientific research is a key element of the architecture of any ocean economy aspiring to be increasingly 'blue'. As such, the provision and constancy of governmental support to the development of cutting-edge scientific research is a critically important maritime interest of India. Scientific knowledge is needed to help people make informed decisions for their own benefit, now and the future, and to address social, environmental, and economic challenges of the 21st Century insofar as they are related to ocean management. Without this knowledge and input from scientific research, sustainable development, which is the foundation of the Blue Economy, cannot be achieved.[17] In common with the global scientific community, Indian science and scientists have an 'essential role to play in producing and sharing reliable information on our changing ocean, and to support the formulation of sustainable policies, planning of economic activities, and development of new technologies, leading to the integrated ocean and coastal management'[18] by the government of the day acting both nationally and internationally. Moreover, marine and maritime scientific research needs to be nurtured and proactively encouraged through fiscal and societal support, not just by the government alone, but by a host of private and public–private structures and entities within the country.[19] This is because the range of the various fields of research is vast and incorporates several disciplines. Even the most superficial set of examples would include marine and maritime fisheries, marine biology (including coral reef biology), marine phycology (the study of seaweeds), marine ecology, marine conservation, oceanography, marine engineering, maritime law, maritime transportation, maritime trade, port and harbour development and management, earth sciences, seabed mining, etc.

However, while multiple sources of knowledge can and should inform the management of environmental resources, the primacy of 'primary science', i.e., the knowledge that is generated through formalized processes such as through research and/or the application of scientific methodology into decision-making processes is incontestable. This has been succinctly brought out by a group of Australian scientists in an excellent and very contemporary article.[20] Primary science can determine environmental baselines, improve our understanding of the likelihood and potential impacts of natural and human disturbance to the system and

[17] Dr Wendy Watson-Wright, "Marine Scientific Research and Ocean Observations", Presentation to the 'Expert Group Meeting on Oceans, Seas and Sustainable Development', 18-19 April, 2013. https://sustainabledevelopment.un.org/content/documents/178501-%20Watson-Wright%20DESA%20April%202013%20FINAL.pdf, last accessed on September 15, 2021.

[18] Ibid

[19] Although the adjectives 'marine' and 'maritime' tend to be used interchangeably, for the most part, the adjective 'marine' is meant to connote the branch of 'earth science' that studies the oceans and seas including their flora and fauna, as also their interaction with coastal territories and the atmosphere. It covers a wide spectrum of scientific knowledge and phenomena such as marine organisms, ecosystems dynamics, ocean currents, plate tectonics, and geology. These diverse topics involve multiple disciplines to understand the underlying processes and the complexity of their interaction. Nowadays, one of the major concerns of marine research is the preservation of marine ecosystems. 'Maritime' research, on the other hand, aims at technologies and innovative solutions for a better exploitation of sea and ocean resources such as the design, building and operation of vessels, harbours, offshore oil or wind platforms, and more widely, any kind of human activity centred upon sea and ocean resources (e.g., tourism). Details available at https://www.researchgate.net/, last accessed on January 24, 2016

[20] Cvitanovic, C., A. J. Hobday, L. van Kerkhoff, S. K. Wilson, K. Dobbs, and N. A. Marshall. 2015. Improving knowledge exchange among scientists and decision-makers to facilitate the adaptive governance of marine resources: A review of knowledge and research needs. Ocean and Coastal Management Journal 112: 25–35. Details available at http://www.sciencedirect.com/science/article/pii/S0964569115001167, last accessed on August 11, 2021

predict the implications of these changes to society, thus promoting proactive rather than reactive actions. And yet, it is equally true that social and economic sciences, too, are critical for the sustainable management of ecological goods and services. For instance, the social sciences (including, of course, economics, but not limited to that discipline alone) are important for elucidating the cultural beliefs, values, norms, and rules of local communities. These provide the foundation of the many formal laws and regulations that are intended to govern marine and maritime activities, thus increasing their likely success.[21] There is, therefore, a clear need for the Indian education system to remove the current stove-piping of the physical and the social sciences. This stove-piped approach has led to an implementation gap between science and natural resource management. As a consequence, specifically related to marine systems, decision-makers remain largely isolated from and unaware of the full breadth of existing scientific information. The information could have been used to inform their decision-making processes, relying instead upon individual experiences or other secondary sources of information when developing and implementing sustainable blue economic models. The resultant ineffectiveness has adverse flow-on effects on the people and communities who depend on the goods and services provided by marine systems. Improving knowledge exchange among marine scientists and decision-makers is, thus, fundamental to the adaptive governance of marine resources and to ensure their sustainable management for future generations.

Any viable and effective maritime strategy that India adopts will accordingly have to have a large and significant intellectual component. It is a feature that is conspicuously missing in contemporary strategy documentation in India, which consciously sets out to minimize the differences of approach between marine scientists and decision-makers (often referred to as the differences in their respective culture). For example, in general, scientists construct theories, test hypotheses, and refine conceptual models over time, based on rigorous methodological approaches, to withstand the highest degrees of public scrutiny and criticism. In the world of decision-making, however, science is just one point of view and frequently not the most influential one. Decision-makers, on the other hand, are driven by a range of political, economic, and social drivers that reflect other societal issues. They are forced to manage a process of negotiation and compromise among the competing interests of diverse stakeholders.[22] Within the highly stratified societal context of India, scientists and researchers frequently lack the autonomy or power to independently translate scientific knowledge into practice. While scientists generate data to advance knowledge, decision-makers may mobilize specific information to support a particular agenda without always considering the full range of available evidence or detailed public debate. If not consciously addressed by a coherent and formalized strategy, these cultural differences lead to friction and frustration among scientists and decision-makers alike and often undermine efforts to improve knowledge exchange and collaboration. As American marine conservation scientists Rose and Parsons put it, 'policy is politics and politics is people. This means that when governments determine [conservation] policy, values, ideologies, economics, biases, and emotions are all factors to consider in the decision-making, with varying degrees of relevance depending on the issue. Politics and policymakers often (usually) have a different agenda from that of science, which seeks unbiased, objective descriptions of reality'.[23]

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[21] Ibid

22 Ibid

23 Rose, N. and E. C. M. Parsons. 2015. Back off, man, I'm a scientist! When marine conservation science meets policy. *Ocean and Coastal Management Journal* 115: 71–76. Details available at http://www.sciencedirect.com/science/article/pii/S0964569115001222, last accessed on August 11, 2021

Chapter 3

Meeting in the middle: a knowledge-based approach to Blue Economy

Saurabh Thakur, Associate Fellow, National Maritime Foundation, New Delhi*

Introduction

The concept of the blue economy holds critical prospects for the economic growth of nations, as well as the health and sustainability of oceans, which are the lifeline of the modern interdependent economies. The concept draws upon several existing discourses on environmental conservation, sustainable development, ecological modernization, and green growth. While its popularity has surged in recent years, it is critical for the policymakers to keep in mind that the window of opportunity for any concept to facilitate radical policy shift remains brief. In an extensive survey conducted by J R Beniger in 1986, he created an inventory of 75 buzzwords that came into existence, and failed to leave a mark, in the period between 1950 and 1984. Much like in the case of the earlier attempts, which merged the questions of economic growth and sustainability, the pertinent question remains—will blue economy prove to be a catalyst for paradigmatic change or just yet another oxymoron? (Brand 2015; Brown 2012; Godin 2006).

This article argues that, in order to avoid the pitfalls of the previous concepts, blue economy must not simply be sub-categorized as another section of national and international economies, as is the case with terms like 'blue growth', and 'ocean economy', which limit their scope to the planned expansion of marine and coastal activities (Voyer, Quirk, McIlgorm, *et al*. 2018). Instead, the article makes a case for a knowledge-based systemic approach to the concept which challenges the artificial divisions between land, sea, and terraqueous spaces in between. The article focuses on the interface between the concept of blue economy and knowledge-based economy to make the case that the emergence of blue economy must be understood as a case of 'soft discontinuity', which means that it is not a "new" sector of the economy which operates outside of the existing economic laws; rather it is intrinsically traceable in all sectors of interconnected and interdependent economies and global supply chains (Brinkley 2006). A knowledge-intensive blue economy is also most likely to succeed in the new and emerging context of geopolitical shifts and anthropogenic climate change, which are reshaping the world. In the past three decades, increased references to concepts and terms such as 'knowledge society', 'knowledge management' and 'knowledge-based economy' have indicated a shift in thinking about the nature of development, from resource-based ideas to knowledge-based economies and the new geopolitics of intangibles such as, "trust, happiness, knowledge, capabilities, norms, or confident institutions" (Mulgan 2009:2). Alongside the traditional factors of production, the World

* Saurabh Thakur is Associate Fellow, National Maritime Foundation, New Delhi, India. He currently holds the CDRI Fellowship (2021) at the Coalition for Disaster Resilient Infrastructure

Bank acknowledges 'knowledge' as a separate factor of production in modern economies which, it argues, is "like light. Weightless and tangible it can easily travel the world, enlightening the lives of people everywhere" (Mehta 2007:154).

The article argues that the countries in the Indo-Pacific region are home to a large section of the world's poor, but at the same time, they have also demonstrated a unique ability to harness knowledge in order to make transformative socio-economic changes. The blue economy offers similar opportunities and set of strategies to transform the region, but it must incorporate a greater role for the knowledge development in order to avoid the pitfalls of earlier efforts that attempted to balance economic growth, just transition, and sustainability. In the wake of anthropogenic climate change, which is accelerating the global race towards a low-carbon economic model of growth, and the return of geopolitics, wherein one can witness a global pushback against globalization, and increased economic uncertainty, the development of blue economy will form a critical link between regional development, maritime multilateralism, and goals of sustainability and climate mitigation.

Knowledge Economy: History and Prospects

The term knowledge-based economy is fairly ubiquitous in the mainstream literature on economic theory and regional development, and it represents the transformative changes that have taken place in the global economies due to the accelerating speed of innovation, the growth of information and communication technologies such as the internet, and the rising importance of intangible capital, which shifted the focus away from the quantity or abundance of resources towards the quality of human and natural capital (David and Foray 2002; Acs, de Groot and Nijkamp 2013).

The term 'knowledge economy' itself grew out of a 'soft discontinuity', which was observed in developed economies in the twentieth century, where the share of the knowledge sector grew sizeably and led to creation of new sets of occupations and practices, encapsulated in the term, coined by Fritiz Machlup, 'knowledge industry'. He wrote, "As an economy develops and as society becomes more complex, efficient organization of production, trade and government seems to require an increasing division of labour between knowledge production and physical production. A quite remarkable increase in the division of labour between pure 'brain work' and largely physical performance has occurred in all sectors of our economic and social organization" (Machlup 1962).

A key outcome of this shift within the economic thinking was that if knowledge has become the critical resource in modern economies, in that case, the process of learning and its distribution will require the greatest of investments (Lundvall 2007). The Organisation for Economic Co-operation and Development (OECD) countries in the 1990s embraced this idea but soon realized that it will require new set of indicators and novel methods of measurement to truly capture the state of distribution of knowledge (OECD 1995:6). In the absence of conceptual clarity and objective indicators, the term was reduced to a rhetorical device, which Foray and Lundvall (1996) argued served its own unique function of attracting attention of the statisticians, create policy influence, increase the visibility of science and technology in policymaking, and finally in spawning productive debates around the concept.

Leveraging the opportunities provided by a knowledge-based economy became a key theme of early twenty-first century and it has gained many takers both at the level of corporations, as well as nation-states. A 2005

World Bank report titled '*India and the Knowledge Economy Leveraging Strengths and Opportunities*' outlined the relevance of "twin forces of globalization and technological advances" and prescribed that, "India's development policy challenges will require it to use knowledge more effectively to raise the productivity of agriculture, industry, and services and reduce poverty. This is because the application of knowledge, as manifested in areas such as entrepreneurship and innovation, research and development (R&D), and people's education and skill levels, is now recognized as one of the key sources of growth and competitiveness in the global economy" (Dahlman & Utz 2005). Cities in the Indo-Pacific region such as Singapore, Hyderabad, and Seoul have emerged as knowledge hubs for innovation in the last three decades and this knowledge architecture has been, "a crucial determinant for the innovative capacity of firms, knowledge hubs and, indeed, entire knowledge clusters at national level...the competitive advantage of nations in Asia will increasingly be determined by the ability to nurture robust innovation clusters and hubs" (Menkhoff 2015: 16).

Forms of Knowledge: Explicit Versus Tacit

The term 'knowledge', which itself is a complex entity, has gained significant attention of theorists and policymakers. Michael Polanyi's (1958) classification of knowledge into explicit and tacit categories continues to remain a popular and relevant distinction. The explicit or codified knowledge encapsulates all forms of knowledge or information that can be codified, patented and communicated in written or digital forms (See Tale 2) (Hallin and Marnburg 2008). Economists have long wrestled with the problem of codification because, "to be treated as an economic good, knowledge must be put in a form that allows it to circulate and be exchanged. The process of codification allows them to treat knowledge-reduced-to-information according to the standard tools of economics" (Ancori, *et al*. 2000: 255–256).

While data and information gathering have become synonymous with the knowledge-based economy, its failure to contextualize this information has proven to be a trenchant problem, often leading to implementation failures and crises of legitimacy, both political as well as cultural. One of the oversights, in this case, is the tacit forms of knowledge which are difficult to codify, transfer and are mainly acquired through shared experiences. They refer to the knowledge that is, "tied to physical experiences, senses, intuition, movement skills, or implicit rules of thumb. Tacit knowledge is experiential and subjective, which includes ideals, ideas, mental models, perspective, and beliefs" (Zhang, Xiao, Gursoy, *et al*. 2015: 1; Nonaka and Von Krogh 2009; Nonaka, Toyama, and Nagata 2000). The geographical context is another key indicator of these forms of knowledge, wherein history, local governance, socio-economic structures, and spatial proximity tend to play an important role in the processes of knowledge creation and transfer. Singapore's economy is a successful example of an emerging market, where policymakers have built a knowledge architecture in an effective manner by marshalling its tacit forms of knowledge and utilized the spatial proximity to create competitive advantage (Menkhoff 2015). Explicit forms of knowledge are near universal in their character; therefore, they are employed within different contexts across varied geographies. However, contextual understanding, particularly in the case of transformative changes such as the blue economy, will require an equal amount of attention on tacit forms of knowledge (See Table 2).

Sustainability as knowledge practice: weak versus strong sustainability

In the case of environmental management, which includes the current discourses on decarbonization, carbon neutrality, green and blue economy, the explicit forms of knowledge are prioritized. This includes an increased

emphasis on cleaner technologies, future climate projections, international regulatory frameworks, and high levels of specialization for sampling new methods of audits and evaluations. The dominance of explicit forms of knowledge tends to obfuscate the relevance of tacit and subjective knowledge. From the standpoint of sustainable development and a just transition, tacit forms of knowledge are critical both for the organizations and individuals as they incorporate and internalize environmental concerns in their organizational set-ups, as well as routine daily lives. Inkepen and Dinur (1998) explain that the process of internalizing such behavioural and organizational change is trenchant because, "tacit knowledge is highly context specific and has a personal quality, which makes it difficult to formalize and communicate".

This knowledge binary has important lessons for the longstanding debate on climate action and its relationship with the economic development of states as well as individuals. The sustainable development discourse is sharply divided between those who argue that man-made capital and natural capital are substitutable and those who argue against such an interchangeability between two forms of capital as it tends to generate, in their view, vastly different kinds of well-being (Davies 2013; Neumayer 2003; Hediger 2006). The proponents of weak sustainability uphold a techno-managerial view of sustainability, wherein the current use of non-renewable resources does not impact the future prospects, as technology and innovation compensate in the long run. The advocates of strong sustainability have contested this framing, pointing to the irreversible nature of damage to the natural capital as well as multidimensionality of ecosystem services, which unlike manufactured capital, cannot be captured by markets alone and requires a more transdisciplinary approach. The technological optimism of weak sustainability proponents, as evident in the debates surrounding geoengineering and ecological modernization, is often met with a deep scepticism of those who argue that industrialization and technological advances do not equate to sustainability and intergenerational equity, which requires a greater emphasis on tacit forms of knowledge.

Meeting in the Middle: A Knowledge-led Blue Economy

A successful blue economy will require an integration of stakeholders far beyond the national and state governments, especially as it aims to achieve the twin objectives of economic development and sustainability. The role of non-governmental organizations, community, corporate organizations, and maritime multilateralism will play a significant role in the realization of these objectives. A knowledge-based view of blue economy, therefore, entails a broader vision of blue economy, which can provide a meeting ground for different types of knowledge architectures to interact and facilitate a blue transition. The emphasis on different forms of knowledge, ranging from the technical and explicit aspects such as low-carbon innovation, exploration of renewable marine sources, coordination of multiscale, multilevel risk assessments and drafting of legal regulations, to the tacit forms of knowledge which includes traditional and indigenous forms of knowledge, cultural values, social skills, and new skills acquired through interpersonal interactions and social networks. The advent of information and communications technologies may have led to 'death of distance' in certain domains, but the questions of space and localized forms of knowledge continue to shape policies across the world (Lin and Sim 2012; Capling and Nossal 2001). In a study of epistemic communities, who facilitate knowledge creation and policy change, Miller and Fox (2001) noted that, "knowledge is responsive to the culture in which it is embedded, they take a perspectival approach, gathering localized intentionality, context, social practices, and linguistic meaning (called ground) into the project of inquiry (called figure). Knowledge building, in other words, depends on the background and interests of the epistemic community that is generating knowledge." This is particularly relevant in the case of blue economy, which concerns a vast

maritime domain and its multiple stakeholders. Furthermore, a regional conception of blue economy, whether it is the Indian Ocean Region or the Indo-Pacific can facilitate the exchange of best practices and human capital, which will lead to knowledge sharing between states, citizens, and communities (Majewska and Szulczyńska 2014).

Both these concepts have been difficult to define both nationally and internationally, which has hindered their successful implementation in the past. While the national level conception of blue economy is emerging as a key driver of policy, it has managed to grow at a multilateral level as well. There are intergovernmental level organizations such as the European Union, African Union, Indian Ocean Region Association (IORA) and Food and Agriculture Organisation (FAO) that have significantly contributed in establishing the core tenets of this concept (See Table 1).

Table 1 Key approaches to blue economy: A comparison

Regions/States/ Individuals	Sources	Key Takeaways
European Union	1. The Ocean Economy in 2030 2. Blue growth strategy (EU 2012)/ Limassol Declaration	1. Promotes a capacity-based understanding of blue economy 2. Uses the term 'blue growth' to denote the ocean economy as a separate sector of the economy 3. Blue economy as part of the grand design of interdependence within the European Union
African Union	1. 2050 African Integrated Maritime Strategy (2014) 2. African Charter on Maritime Security and Safety and Development in Africa (Lome Charter) (2016) 3. Agenda 2063	1. Blue economy envisioned as a shared vision of future and an African Renaissance 2. Blue economy is directly linked with maritime security in the region 3. Environmental concerns are highlighted
IORA	1. Mauritius Declaration on Blue Economy (2015) 2. Jakarta Declaration (2017) 3. Dhaka Declaration (2019)	1. A distinction between blue economy and traditional ocean economy and coastal economy (Voyer, Quirk, McIlgorm, et al. 2018) 2. Key objectives include generating employment, food security, poverty alleviation, and ensuring sustainability 3. Blue economy is a subset of coastal economy (Mohanty, Dash, Gupta, *et al*. 2015)
Asia-Pacific Economic Cooperation (APEC)	1. Xiamen Declaration: "Towards New Partnership through Ocean Cooperation in the Asia-Pacific Region" (2014)	1. Blue economy as an approach to advance sustainable management and conservation of ocean and coastal resources and ecosystems and sustainable development, in order to foster economic growth
East Asia	1. Changwon Declaration by ten countries of East Asia Seas (EAS)	1. Focuses upon ocean-based BE 2. The Declaration is the region's support for the implementation of theRio+20 Outcomes embodied in "The Future We Want," and other relevant international and regional commitments related to coasts and oceans

In order to decipher the importance of knowledge in the development of blue economy, a key indicator is the definition of the concept itself. The distinction that appears in the definitions, especially between the Global North and Global South, is that the former tends to favour a capacity-led understanding of the concept, while the latter, given their socio-economic conditions, focus on capabilities (See Table 1). This distinction is a continuation of the divide that has existed in the global environmental negotiations as well as world trade negotiations. The articulation of the concept from these distinct points of references often lead to differences in priorities and preferences, resulting in a difference in emphasis and prioritization of multiple forms of knowledge. The 'blue growth' and 'ocean economy' articulations of blue economy favour a techno-managerial overhauling of the maritime sector. The fact that such arguments primarily emerge in the developed nations, reflect the socio-economic realities of those nations. In the developing world, blue economy must accommodate the questions of poverty, livelihoods, local networks, access to innovation and technology and the tacit forms of knowledge within their blue economy framework, in order to facilitate a bottom-up consensus for a blue transition. The bottom-up approach to blue economy, both at the national and regional level, can create the right business environment for transfer of innovation and new economic investments. Any form of knowledge transfer is best achieved through interaction, whether it is between states, groups or individuals. It has been classified in four different ways (See table 2) (Nonaka 1991).

Table 2 Classification of knowledge transfers: Examples within blue economy

Type	Details
From tacit to tacit	• Knowledge transfer through socialization • It is a limited form of knowledge creation, often limited to smaller units like family and community such as artisanal fishing
From tacit to explicit	• The tacit forms of knowledge are externalized as well as internalized through use of brainstorming and exchange • This includes innovation which is drawn and shared from experience of individuals or organization. Self-help groups and NGOs are a critical part of this knowledge dissemination process • This is critical exchange for the development of local blue economy especially in sectors such as fishing and tourism, where traditional forms of knowledge, local experiences of populations can be harnessed in meeting the broader objectives
From explicit to explicit	• This is a codified form of knowledge that can be transferred through networks and technologies • Risk assessment and business feasibility studies are examples where collected data is analysed, synthesized, and shared • From a blue economy perspective, it is a crucial factor is assessing the impacts of climate change, sharing global and regional best practices to develop new hubs of tourism and new clusters of maritime research and innovation
From explicit to tacit	• When new forms of knowledge, especially in the case non-traditional sectors of blue economy as well as emerging climate risks, are used in broadening, and reframing the tacit knowledge • The think tank reports on blue economy, IPCC reports and research articles are some key forms of explicit knowledge that can be used in shaping policy, reshaping behaviour, and generate new forms of livelihoods and social networks

Compiled by author from:

1. Nonaka, I. (1991). The knowledge-creating company. *Harvard Business Review* **69** (6): 96-104.

2. Zhang, Chaozhi; Xiao, Honggen; Gursoy, Dogan; Rao, Yong (2015). Tacit knowledge spillover and sustainability in destination development. *Journal of Sustainable Tourism* **23** (7): 1–20.

New Contexts and New Knowledge: The Climate Change Question

In the past three decades, the climate change crisis has emerged as a big threat to existing modes of thinking and production. On the one hand it has added to our previous knowledge of the planet, and on the other, it is forcing the world to unlearn preconceptions, old theories and rhetoric about man-nature relations. "The growing technical uncertainties and complexities of problems of global concern have made international policy coordination not only increasingly necessary but also increasingly difficult" (Haas 1992: 1). In the 1980s, the idea of sustainable development grew out of conditions that were brought about by a growing body of scientific evidence and it led to birth of intergovernmental institutions such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC). This scientific framing of climate change was soon overtaken by a more political framing, which saw the developing countries upholding the banner of justice, historical responsibilities, equity, and differentiation. The developed world favoured a more dynamic reading of ethical principles, which were enshrined in the international treaties and frameworks such as the UNFCCC, the United Nations Convention on the Law of the Sea (UNCLOS), and Kyoto Protocol. This mismatch between the technical and political readings of climate change continues to shape the behaviour of states on questions of sustainability and climate action, and it will be critical for the development of blue economies as well. The Sustainable Development Goals (SDGs) as well as the Paris Agreement, both acknowledge this binary, and lay emphasis on principles of differentiation, technology transfer, climate finance, and equity. Although, capabilities remain a major concern, the urgent focus on the two-degree temperature target, and carbon neutrality by 2050, which are backed by publication of *The Fifth Assessment Report (AR5)* of the IPCC in 2014 and subsequent special reports, have favoured a more capacity-based reading of the problem in recent years. Capacity building, in fact, finds mention within the SDGs and other major international initiatives, as a key tool of dealing with the crisis. It is important to note here that this binary is no more evenly distributed among the Global South and Global North. The fragmentation within the Global South states on the questions of climate mitigation and adaptation targets, most apparent in the formation of the 'High Ambition Coalition', prior to the COP21 summit in 2015. This coalition consisted of all 28 EU countries, the USA and another 79 countries, mainly poor and vulnerable countries in Africa and the Pacific. There is now an emerging consensus that climate change is a planetary-scale crisis, which requires global collective action. More and more countries are now committing to a carbon neutral target by 2050 and transition to green and blue forms of economy, which are built on cleaner fuels and sustainable livelihoods. The problem of environmental harm has posed both legal and ethical challenges, especially in light of anthropogenic climate change, which is both transboundary and cross-generational in nature. This problem magnifies once we enter the maritime domain, where traditional sectors of economic growth are also the key sources of marine pollution and carbon emissions. The IPCC Special Report: *Special Report on The Ocean and Cryosphere in A Changing Climate* notes, "It is virtually certain that the global ocean has warmed unabated since 1970 and has taken up more than 90% of the excess heat in the climate system (high confidence). Since 1993, the rate of ocean warming has more than doubled (likely). Marine heatwaves have very likely doubled in frequency since 1982 and are increasing in intensity (very high confidence). By absorbing more CO_2, the ocean has undergone increasing surface acidification (virtually certain). A loss of oxygen has occurred from the surface to 1000 m (medium confidence)" (IPCC 2019:42) (See Figure 1).

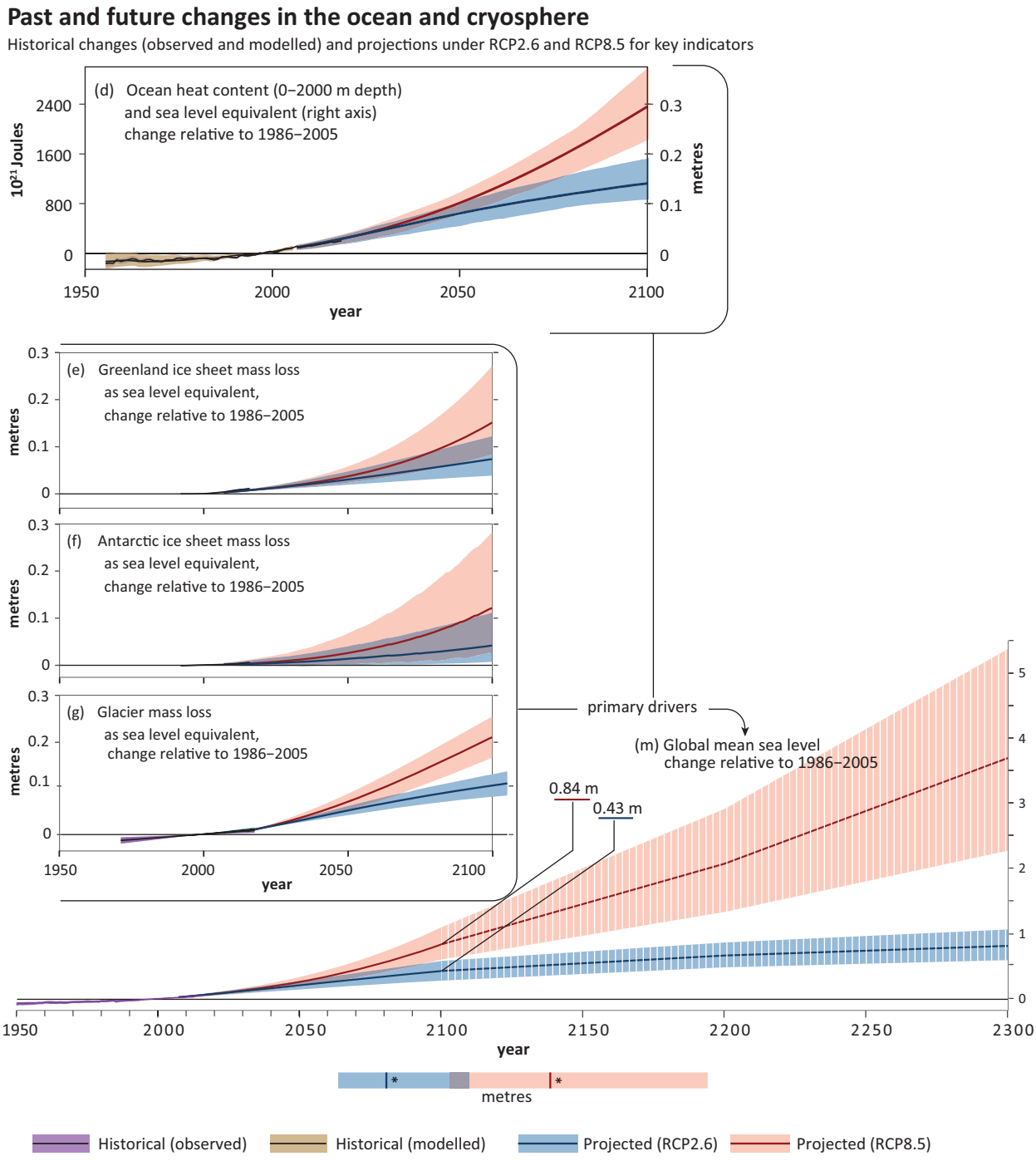

FIGURE 1 Comparing warming projections in ocean and cryosphere: high emissions vs. low emissions

Source: IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.- O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]. In press.

States are increasingly taking cognizance of the impacts of climatic factors such as rising sea levels, sea surface temperatures, shifting ocean currents, changes in migratory patterns of fishes, and disasters at sea. The blue economy frameworks, while they acknowledge these concerns, do not, as of yet, reflect this in their accounting methodologies. The current practice falls into the trap of regurgitating old ideas for the sake of neatness in the national accounts, while the broader goals of sustainability, as propounded in the working definition, remain neglected. This is a critical shortcoming of the existing accounting approach to blue economy.

India's Blue Economy: Gaps between Knowledge and Practice

India is well endowed with coastal and marine resources, which are likely to perform the role of catalyst in India's transition from a fossil fuel-based model to a blue economy model. This paradigmatic shift will carry long-term implications which are articulated at great length in the recent publication of *Draft Policy Framework of India's Blue Economy* by the Ministry of Earth Sciences, Government of India. Apart from its focus on the development, the draft policy blends sustainability and health of oceans into its broader agenda of development. Blue economy is listed as a *"sub-set of economy"*, which is most comprehensive in its scope and inclusive of all other similar concepts. Although this definition is an inclusive one, it fails to overcome a fundamental contradiction which arises out of subsuming blue economy under the broader definition of economy, which is predominantly grey in its structure.

One of the critical problems that emerge with a concept such as blue economy is the less than impressive ability of the current measures to capture the scope of blue economy. The draft policy too highlights the inability of current accounting frameworks to capture the entire scope of the blue economy. Most notably, the sustainability of oceans hardly seems to drive any component of a traditional accounting approach and, therefore, falls short in meeting the scope of the objectives of sustainability of oceans. Blue economy as a strategy is a much broader task than merely accounting for its components. It is deeply linked with the SDGs which are essential for well-being and therefore, any efforts at defining as well as measuring blue economy must transcend the current framework of economic thinking.

Environmental accounting can be an important tool for understanding the role played by the natural environment in the blue economy. Environmental accounts provide knowledge and information that highlight both the contribution of natural resources to the economic well-being and the costs imposed to the economy by pollution or resource degradation. The dominance of market-based evaluation methodologies tends to obscure the intangible benefits that ecosystems offer to nations, communities, and individuals. Evaluation of such services and their inclusion in the policymaking processes will require a more detailed and analytical understanding of nature's role in blue economy.

Another significant omission in the accounting frameworks of blue economy is the cost of loss and damages that are likely to arise out of climate change induced extreme weather events. As the impacts of climate change become more visible, particularly the impacts of changes in weather extremes, they will need to be reflected in the costing, reporting and disclosure of impacts, vulnerabilities and adaptive capacity, with resulting implications for corporate governance (Guba, Holland, Lemos-Stein, *et al*. 2020).

The knowledge-based view of blue economy can prove useful in implementing the blue economy policies in India as it focuses on some key lacunas. Among them, two are most relevant: financing of blue economy and

ocean awareness. The former remains a difficult proposition given the high risks and low returns in the sectors of blue economy. As pointed out previously, the knowledge about oceans' socio-economic and environmental value remains a neglected category, which creates a hindrance for the financial flows in blue economy. This lack of knowledge also carries detrimental implications for the environment as most of the capital and subsidies flowing into blue economy sectors do not take into account the negative externalities. This is most evident from the experiences in the shipping, fisheries and aquaculture sectors, which receive high flow of subsidies but end up paying very little in return for the access or management of resources. Therefore, India's vision of blue economy must emphasize on building knowledge resources about the oceans, as it not only benefits the oceans' health, but also facilitates the flow of capital into the blue economy sectors.

Governments must pay greater attention to the linkages between the ocean health and de-risking investments, both in large-scale sectors as well as small-scale blue initiatives. Creation of knowledge clusters in different parts of the country can prove helpful in setting up the playground for the investors to swim. Such knowledge clusters can focus on streamlining government policies, sorting out legal frameworks, building ocean awareness, local skills and innovation hubs. Governments can invest in building stronger legislations both for taxation and marine conservation, strengthen the data infrastructure at regional scale to facilitate capital flow, and invest the human capital to enhance productivity. This requires a bottom-up view of the blue economy, where the local populations and local governments are made stakeholders in the process of transition and knowledge generation. Ocean awareness can prove to be the clinching factor in the success or failure of the blue economy concept. Applying incremental changes to today's accounting practices and unlocking the creative potential of local populations would contribute not only to increased transparency around climate-related risks, but would also enhance visibility of any capital expenditure needed to adapt to, or mitigate, future climate risks.

Way Forward: Challenges and Opportunities

Facilitating a knowledge-based blue transition will require India to design the policy and regulations which prioritizes the building of a knowledge society. While the infrastructure capacity building, which a dominant component in current blue growth discourses, is a critical pillar of blue economy, it is equally important to emphasize the questions of resilience, local entrepreneurship, smart innovation, climate adaptation, socio-cultural identities, and the role of the state and just transition. Some critical lessons that can be drawn from this frame of understanding blue economy include:

a. *Policy diffusion*: The distinction between tacit and codified forms of knowledge and the complex interplay between them will be a critical factor in generating public acceptance and invite corporate, institutional funding, which has so far lacked in the developing countries. An example of this emerges from studies on linkages between access to knowledge economy and livelihood generation. In a study of the tourism sector in China, Zhang, Xiao, Gursoy, *et al.* (2015:4) found that, "despite the fact that the tourism industry is rich in tacit knowledge, these knowledge-based practices have not received much attention... Lack of appropriate knowledge of sustainability-related measures has been noted as one of the major barriers to adopting sustainability practice across the tourism industry." Hall and Williams (2008) outline four different mechanisms through which a sustainable and economically-viable tourism model can be built: observation, imitation, and demonstration; knowledge brokers; mobility of labour and inter-firm exchange (Zhang, Xiao, Gursoy, *et al.* 2015; Hall and Williams 2008; Shaw and Williams 2009). In this regard, the role of the state

and local policymakers will become critical in developing maritime innovation clusters and implementing policies that facilitate blue transformation of local economies and foster a business-friendly environment for local innovation and practices to emerge and spill over. Another critical stakeholder will be the local entrepreneurs, who tend to observe and learn from the best practices around the world and imitate similar models at home. In sectors such as fisheries, aquaculture, tourism, where a majority of livelihoods are generated, an introduction of blue and green policies, through imitation, will require such new forms of tacit knowledge to spill over in the entire region, both through government policies, mobility of labour, and collaboration between businesses.

b. *Just transition*: The three critical pillars of blue economy are: equitable societal transformation, economic growth and wealth generation, and protection of knowledge, both codified and tacit in nature. Without a clear understanding of the socio-economic and cultural impacts of the transformative policies, it is likely that blue economy policies will face a crisis of legitimacy and persistence of business-as-usual thinking and false solutions. Both climate adaptation and community resilience are vital aspects of blue economy, which need to be emphasized more in order to avoid the familiar trap of ocean grabbing.[1] If new forms of knowledge and vocations have to be promoted under the new policy, it must reconsider the potential dangers such as inadequate utilization of tacit knowledge, loss of traditional livelihoods, dispossession of the poor who will lose control and access to the resources of the sea and coastal lands.

c. *Geopolitics of knowledge*: While it is difficult to arrive at a precise understanding of the blue economy, it is also important to note that, "the negotiations of meanings, understandings, and beliefs are interwined with the negotiations of actions at every step along the way" (Adler and Hass 1992:389). The new theatre of global power politics is emerging in the Indo-Pacific, a vast maritime space replete with strategic chokepoints and new windows of economic opportunities. The ongoing tussle to gain a strategic advantage in the region has consequences, not merely for the Asian countries but global geopolitical order. The recent events mark a return of traditional Hobbesian geopolitics, which dominated the twentieth century and concerns mostly with the generation of wealth and power through the contestation of space. However, we can see the emergence of "a de-centering and de-territorializing world characterized by overlapping sovereignties and networks of power" (Moisio 2018:35). During the past two decades, states have recognized the polycentric nature of the current world order, and efforts have been made to create non-territorial spaces of interaction to enhance economic success at the national level. In this polycentric world, economic, geopolitical and cultural power is enmeshed in a network of states, regional groupings, city regions, and multinational organizations, all of which compete for gaining competitive advantage. The blue economy of Indo-Pacific region will, therefore, acquire a geopolitical and geoeconomic character leading to the creation of new clusters of innovation and new hubs of commerce. Spatial proximity, for example, among the states in the Indian Ocean region, can play catalyst to such innovation as the most effective way of transmitting knowledge and boost innovation is through cooperation, creation of communities of practice (Wenger 1998), and social and interpersonal interactions. The Indian government must coordinate its efforts, through consent and meeting mutual expectations, in order to build a robust regional understanding of blue economy and take lead in building the blue economy narrative on a broader scale.

d. *Overcoming silos*: The integration of economic and environmental policies has proven to be ineffective in the past, given the lack of any roadmap to policy integration. The siloization of ministries and departments,

1 Ocean grabbing is defined as, "dispossession or appropriation of use, control or access to ocean space or resources from prior resource users, rights holders or inhabitants. Ocean grabbing occurs through inappropriate governance processes and might employ acts that undermine human security or livelihoods or produce impacts that impair socio-ecological well-being. Ocean grabbing can be perpetrated by public institutions or private interests."

each catering to a certain facet of the blue economy leads to a disaggregated vision of blue economy at the top. The siloization impacts policymaking at both the level of formulation, where the temptation to put out policies without adequate consultation leads to inadequate design, and at the level of implementation, where impact evaluation of policies is often too slow, and feedback loops and self-corrective behaviour is non-existent. Apart from the flawed design and implementation, a key outcome of this absence of dialogue is the path dependency within institutions which resists any transformative change and fails to account for new challenges such as climate change. In order to remain relevant, a successful blue economy will have to invest in modern data collection techniques, organizational overhauling, and community participation.

e. *Embracing new forms of knowledge in policymaking*: Human well-being is heavily dependent on the context, which constitutes both the built world and natural environments. The idea that economic growth and environmental action will coalesce together to form a win-win scenario fails to stand the test of empirical observation. The failure of the Kyoto Protocol, with its multiple market-led mechanisms such as Joint implementation (JI), Clean development mechanism (CDM) and Emissions trading (ET), to contain the global greenhouse gas emissions is a prime example of the hurdles that the concept of blue economy is likely to face in the coming decades. The argument in this article is not to deride the importance of markets or green growth mechanisms; rather, it is to ask the question—can states rethink the relationship between economic growth and ecosystem sustainability? The failure to do so will lead us down a path that has historically failed to yield the purported results. In order to reconcile the two imperatives and prevent blue economy from turning into yet another catchphrase or worse, an oxymoron, states have to account for all forms of knowledge creation and understand the new context, both geophysical as well as geopolitical, in which the blue economy policies will unfold.

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2.

BLUE ECONOMY PAST AND PRESENT: Planning for future

Chapter 4

Blue Economy: opportunities in traditional sectors

Adluri Subramanyam Raju, Ph. D. Dean, International Relations, Professor, Centre for South Asian Studies & Coordinator, UGC Centre for Maritime Studies, Pondicherry University, Puducherry

Introduction

Ocean is a part of the world economy. It is seen as a last frontier for development. Global ocean economy contributes about US$1.5 trillion per annum, contributing approximately 2 to 3% to the world's gross domestic product. Tourism and shipping provide the largest proportion (US$880 billion), marine resources (US$377 billion) and marine manufacturing (US$107 billion).(*The Blue Economy and Small States*) About 350 million jobs globally are linked to the oceans through fishing, aquaculture, coastal and marine tourism and research activities. Further, 1 billion people depend on fish for their food (https://unctad.org/en/pages/MeetingDetails.aspx?meetingid=1240). Coastal states are exploring new opportunities for economic growth in their marine waters. The blue economy concept seeks to promote economic growth, while ensuring environmental sustainability of the oceans and coastal areas.

Blue economy offers an alternative economic approach that is guided by environmental principles. It focuses on improvement of human well-being and social equity and minimizes environmental risks and ecological scarcities. Its importance is "realised prominently after the unprecedented contraction of global output and employment affecting the livelihoods of millions of people in different regions of the world." (Mohanty, p.12)

The main components of blue economy are fisheries, sea-minerals including oil and gas, ports and shipping, marine tourism, marine biotechnology, deep-sea mining, renewable energy and, transport and logistics. The role of blue economy, which aims at optimum and sustainable use of oceanic resources for growth and development, is critical for the coastal states. The benefits of marine resources are too many to be counted for. Catching fish and farming of fish (aquaculture) has become not only a source of food but also a source of income. Coastal shipping has recently become an important means of moving goods across the country. Offshore gas and oil and mining are a very important element of national income and wealth. Coastal tourism contributes to income and provides employment in coastal areas. Sustainable marine energy and marine biotechnology play a vital role in economic development and also in mitigating the ill-effects of climate change.

Sustainable development implies that economic development is inclusive and avoids depletion of the natural resources. Balancing the economic, social, and environmental dimensions of sustainable development in oceans is a key component of the blue economy. Each country needs to plan for oceans of sustainable economy, focusing on balanced growth and optimal use of ocean resources with maximum benefit to the environment. A sustainable blue economy provides social and economic benefits for present and future

generations by contributing to food security, poverty eradication, livelihood, income, employment, health, safety and political stability. Goal 14 articulates the link between oceans and sustainable development, which was previously not specified. It places the oceans on the development agenda. It focuses on conservation and sustainable use of the oceans, seas and marine resources.

India has 7,516.5 km of coastline, 2.37 million km^2 of exclusive economic zone and 530,000 km^2 of continental shelf. Since 2011, India has been claiming for extending its exclusive economic zone, from 200 nautical miles (nm) to 350 nm, which would provide to 1.2 million km^2 additionally. India has an opportunity to enhance its economic growth through developing blue economy.

The article focuses on fisheries, shipping, ports, trade, coastal tourism, marine energy, marine biotechnology, maritime security, private sectors and blue clusters, which contribute to develop India's blue economy.

Fisheries

Fisheries sector has a long history compared with other blue economy sectors. Traditionally, fisheries management has operated in isolation and the relationship of fisheries with other sectors has not been fully considered. Fish is a key source of nutrition, employment and export revenues and is essential for economic survival of many states. Total global exports of fish and fishing products in 2015 were estimated at US$143 billion, an 8% increase from the previous year. (Commonwealth) Marine fisheries contribute more than US$270 billion annually to global GDP. (World Bank) A key source of economic and food security, marine fisheries provide livelihood for the 300 million people and meet the nutritional needs of the 3 billion people who rely on fish. (Food and Agriculture Organization) The world's population is expected to rise to 9.6 billion by 2050, creating a considerable demand for food and sources of protein. The *Sunken Billions Revisited* study shows that fisheries could provide an additional US$83 billion to the global economy each year if they are properly managed with a significant reduction in overfishing (http://www.worldbank.org/en/news/press-release/2017/02/14/giving-oceans-a-break-could-generate-83-billion-in-additional-benefits-for-fisheries)Food and agriculture organization estimates that about 57% of fish stocks are exploited and 30% are overexploited/depleted/recovering.(http://www.worldbank.org/en/news/press-release/2017/02/14/giving-oceans-a-break-could-generate-83-billion-in-additional-benefits-for-fisheries)

Fish is exploited further by illegal, unreported and unregulated fishing, which is roughly 11to 26 million tonne of fish catch annually or US$10–22 billion in unlawful or undocumented revenue. (United Nations)Demand for fish products has been increased due to: population growth, higher incomes, especially in middle-income countries and increased globalization of seafood markets. (World Bank Group)

India is a peninsula, where a large number of people (4,056,213) engage in fishing. There are about 3432 villages and 1537 fish landing centres and about 874,749 families that depend on fishing in India. India has about 73.59 lakh ha of inland water bodies; 195,210 km of rivers and canals; 29.07 lakh ha; tanks and pond around 24.14 lakh ha; 7.98 lakh ha of lakes and 12.40 lakh ha of brackish water, which can be the base for fisheries. (*dahd.nic.in/sites/default/files/India%20Profile%20updated_0.pdf.*)

Fishing sector employs 15 million people in India and ranks second (6.3%) in the world's fish produce (₹1 lakh crore in 2015–16). Employment opportunities in fisheries have enabled young people and women to get employment (fish processing and marketing) and enhance their status in developing countries. Despite remarkable statistics of the Indian fishing industry, India lags by many miles behind China.

Fish stocks are affected by illegal, unreported, and unregulated fishing, which, as noted earlier, accounts for roughly 11–26 million tonne of fish catch, or US$10–22 billion in unlawful or undocumented revenue. Poor fisheries management results in foregone revenues of more than US$80 billion annually, which could be recovered if global fisheries were reformed significantly, through a 44% reduction in the level of fishing. (*The Potential of the Blue Economy*)Successive governments have focused on subsidies than enhancing infrastructure. Apart from subsidies, public investment is required in fisheries, including availability of seeding, refrigeration, roads, transportation, markets.

The government needs to take initiatives to increase fish and prevent overexploitation. Further, there is a need to focus on protecting mangroves and coral reefs, which act as breeding and feeding grounds for fish. Coral reefs are particularly sensitive to increased turbidity and pollution from fertilizers, chemicals and sewage and damage the habitat. Such pollution can make seafood harvested from these areas unfit to eat or sell.

In view of the constraints, the government needs to promote aquaculture to meet the requirements. Aquaculture supplies 58% of fish to global markets. Promotion of aquaculture development for food security could play a crucial role. Indian government, in 2016, developed around 26.869 ha area for aquaculture which has benefited 63,372 fishermen. (*Portugal-India Friendship Association News Letter*)

Table 1 Fisheries Sector Data (2000–01 to 2017–18)

Year	Fish Production (in lakh tonnes)		Total	Annual Average Growth Rate (%)		All India
	Marine	Inland		Marine	Inland	
2000-01	28.11	28.45	56.56	-1.44	0.78	-0.33
2001-02	28.30	31.26	59.56	0.68	9.88	5.30
2002-03	29.90	32.10	62.00	5.65	2.69	4.10
2003-04	29.41	34.58	63.99	-1.64	7.73	3.21
2004-05	27.79	35.26	63.05	-5.51	1.97	-1.47
2005-06	28.16	37.56	65.72	1.33	6.52	4.23
2006-07	30.24	38.45	68.69	7.39	2.37	4.52
2007-08	29.20	42.07	71.27	-3.44	9.41	3.76
2008-09	29.78	46.38	76.16	1.99	10.24	6.86
2009-10	31.04	48.94	79.98	4.23	5.52	5.02
2010-11	32.50	49.81	82.31	4.70	1.78	2.91
2011-12	33.72	52.94	86.66	3.75	6.28	5.28
2012-13	33.21	57.19	90.40	-1.51	8.03	4.32
2013-14	34.43	61.36	95.79	3.67	7.29	5.96
2014-15	35.69	66.91	102.60	3.66	9.04	7.11
2015-16	36.00	71.62	107.62	0.87	7.04	4.89
2016-17	36.25	78.06	114.31	0.70	8.99	6.21
2017-18	36.88	89.02	125.90	1.73	14.05	10.14

Source: Government of India. Handbook on Fisheries Statistics, 2018. 2019. Ministry of Fisheries, Animal Husbandry and Dairying, Department of Fisheries, New Delhi. September ,http://dof.gov.in/sites/default/files/2020-08/HandbookonFS2018.pdf.

Table 1 indicates that annual average growth in the marine fisheries sector was positive except during 2000–01, 2003–04, 2004–05, 2007–08 and 2012–13. The annual average growth in the inland fisheries sector registered positive growth rates from 2000–01 to 2017–18. The annual average growth rate in the all-India fisheries sector registered a positive growth except during 2000–01 and 2004–05. The annual average growth rate in the all-India fisheries sector registered double-digit growth rate of 10.14% during 2017-18 and the major share was from inland sector. Table 1 suggests that there is a need to focus on increasing marine fisheries production, which will enhance the fisheries production.

Shipping

Shipping helps in carrying huge volume of goods. It is the cheapest, fastest and safest mode of transportation. The cost involved in transportation of goods from coast to coast is about 21% of road transport and 42% of rail transport. Further, consumption of fuel will be less for cargo. Fuel consumption by coastal shipping is 15% of consumption by road and 54% of that by rail. An emission of carbon dioxide from rail transport is twice and 6 times that from road transport from that of coastal shipping. Regarding safety, road and rail movement result in a significant loss of lives in India as compared to shipping. (Chopra) It facilitates for global trade and contributes to economic growth. Shipbuilding acts as a catalyst for industrial growth. It would enhance the development in other industries: steel, engineering equipment, port infrastructure, trade, shipping services, employment generation and contribution to gross domestic product.

Indians have built ships with the capacity of 800 to 1000 tonne, by using teak at Daman. They were regarded as superior to their British counterparts both in design and durability. The British shipbuilders were agitated and against the ships built by foreigners including Indians. As a result, the British passed an Act of navigation of 1651, that stated "no goods whatever of the growth, produce or manufacture of Asia, Africa or America should be imported into England or Ireland or any of the plantations, except directly in ships belonging to English subjects, of which the Master and the greater number of the crew were Englishmen." (Bansal, p.3) British did not want to promote the Indian industry. However, many Indian ships were inducted into the Royal Navy such as HMS Hindostan in 1795, HMS Cornwallis (a frigate) in 1800, HMS Camel in 1806, HMS Ceylon in 1808 and HMS Cornwallis in 1842. (Bansal, p.3)

India had advantage in terms of cheap labour cost, established steel industry skilled manpower and know-how technology. However, it did not have adequate domestic capacity in promoting strong demand for shipbuilding and ships repairs. A "strong ship-repair industry, world class R&D facilities, design capabilities and ancillary base for commercial shipbuilding are areas of focus" that make Indian shipbuilding yards competitive in both the domestic and the export markets. (*Union Minister of Shipping*)

India, currently, has around 32 shipyards, owned by: central government (6), state governments (2), public listed private shipyards (3) and privately held shipyards (22). The major share of the ship-building capacity in India is controlled by 8 public sector yards, with Cochin Shipyard Limited and Hindustan Shipyard Limited having capacity and infrastructure to build vessels of 1.1 lakh dwt, and 80,000 dwt, respectively. Barring these 2 shipyards, the majority of private sector shipyards have limited ability to build vessels. India's capability of building technologically advanced ships, including LNG carriers are relatively less (https://www.eximbankindia.in/Assets/Dynamic/PDF/Publication-Resources/ResearchPapers/Hindi/25file.pdf) and Indian shipyards are primarily defence oriented.

About 90% of shipbuilding was undertaken in only 3 Asian countries. South Korea, which accounted for 37.3% of gross tonnage, China accounted for 28.6% of gross tonnage and Japan accounted for 24.6% of gross tonnage. South Korea is specialized in container ships, oil tankers and, to a lesser extent, LNG carriers, while China dominates the dry bulk carrier market and Japan has an excellent hold on oil tankers and a small number of container vessels.'' (Herbert-Burns) These 3 Asian countries contribute to shipbuilding industry, whereas India, which was considered to be one of the best shipbuilding nations is nowhere in competition at the global level.

Despite the growth in tonnage, the percentage of cargo carried by Indian flagships has reduced from 40.7% in 1987-88 to 7.45% of total EXIM (Export-import) trade in 2014-15 (Ministry of Shipping). Of the total Indian cargo, 65% goes by foreign ships. It is essential for India to invest on shipbuilding so that its cargo can go on its own ships. Shipping not only plays an important role in the transport sector of a country's economy, but also generates employment and produces ancillary industries which a country of India's size cannot neglect.

In 2015, the Ministry of Shipping had approved certain incentives to promote domestic shipbuilding industry. There are about 19 private sector shipyards in India and 8 public sector shipyards. These would have to be provided autonomy to compete in the international and national market. Private companies will have to be encouraged to form joint ventures with foreign shipbuilding enterprises, such as the Japanese, Singaporean and Korean yards, which help transfer technology, engineering skills and production know-how. Trade can be enhanced through using own ships and, hence, needs strong shipbuilding.

Table 2 Shipping and Port Facilities

Year	Major Ports		Non-Major Ports	
	Cargo(MT)	% Growth	Cargo (MT)	% Growth
2013-14	555.5	2	417.20	7.5
2014-15	581.3	5	470.6	12.8
2015-16	606.5	4	465.9	-1
2016-17	648.4	7	485.2	4.14
2017-18	679.4	5	528.5	8.9
2018-19	699.1	2.9	582.5	10.22
2019-20	704.8	0.8	-	-

Source: Ministry of Shipping. EXIM Bank Research, https://eximmitra.in/en/information-data-on-exports/research-and-publications/others-information/ports-and-shipping..

As per Table 2, cargo traffic at major ports in India stood at 704.8 MT in 2019–20 and growth of 0.8% in 2019–20. The traffic at non-major ports has been increasing from 2013–14 to 2018–19, except during 2015–16. The cargo traffic handled at non-major ports in India was more than the traffic handled at major ports with a growth of 10.22% in 2018–19 (https://eximmitra.in/en/information-data-on-exports/research-and-publications/others-information/ports-and-shipping). The Government has to look for mechanisms to enhance the growth from the major ports.

Ports

Ports act as an interface between ocean transport and land transport. India has 12 major ports and 187 minor ports. (Ports and Shipping) India, in its maritime agenda, focuses on an increase in port capacity from 1 billion tonnes to 3.2 billion tonnes, which will enhance its global shipbuilding from 1% to 5%, and an increase in Indian seafarers from 6% to 9%. (Fonseca) Nine of the top 10 cities are in coastal states and 4 of these are port cities (Mumbai, Chennai, Cochin and Mormugao), contributed to GDP. Net profit at major ports has increased from ₹1150 crore (US$178.4 million) in FY13 to ₹3413 crore (US$529.6 million) in FY18. So it increased from 23% to 44%.

The Indian government realized the importance of port development and initiated the Sagarmala project. Under the Sagarmala project, the government has envisioned a total of 189 projects for modernization of ports involving an investment of ₹1.42 trillion (US$22 billion) by the year 2035. The project, at the cost of US$11.3 billion with 400 projects, is planning to construct ports, coastal infrastructure, inland waterways, fishing, and creating special economic zones and tourism projects along the coastline in two decades.

Project Sagarmala envisions port-led development under four broad categories: port modernization, port connectivity, industrialization and coastal community development. Under this project, it was planned to upgrade more than 40 ports and build new 6–8 ports. As many as 14 coastal economic zones and 12 energy and material industries are envisaged. Inland waterways transport and coastal shipping can lower cargo costs by 60–80% than rail or road. A saving of over ₹10,000 crore can be made if coal is transported through the Rail–Sea–Rail route. Despite India having 12 major and 187 minor ports, currently the total share of coastal shipping in the transportation sector is merely 6.5% as compared to 30% and 57% by rail and road, respectively.

India does not have natural and deeper port facility despite having the longest coastline. The Indian government has proposed to construct port in the South Bay (Great Nicobar islands).However, there were objections raised by the Ministry of Environment, Forest and Climate Change. The Ministry is against the large-scale development in the area. (Chaudhury, et al, p.36)There are a few locations in the Islands that can be considered ports for transshipment. These include Port Meadow, Campbell Bay, Mac Pherson Strait and Great Nicobar. (Chaudhury, et al, p.36).

There are two busy transshipment hubs to the east (Singapore) and west (Colombo) of the ANI and the east–west shipping route passes just below the Indira point. The Islands can tap at least 5"% the traffic traverse through this route.(Chaudhury, et al, p.37)

A big oil bunkering facility could be built in the Islands to cater to the refuelling requirements of the plethora of passing vessels. (Chaudhury, et al, p.112). The international trading route originates from Singapore and connects with the east-west corridor, which is hardly 15 nautical miles from Indira point, and hence these Islands provide huge potential to India. (Arora)

Through the proposed Kra Canal, it will reduce the distance of travel for vessels to the east by almost 1200 km, making the Andaman and Nicobar Islands the most logical location for trans-shipment. A deep-water harbour at either Port Blair or Car Nicobar will be able to serve vessels not only originating within the Bay region but also those travelling along the east–west shipping route. The government has planned a container trans-shipment terminal in the area which could be closer to the international trading route to cut down on freight costs. The Andaman and Nicobar administration is also planning to declare Port Blair a free trade area to boost employment opportunities. (Arora)

The proposed project is for transshipment terminal at Campbell Bay at Great Nicobar, the largest of the Nicobar Islands. Campbell Bay is 90 km away from Malacca Strait, the main sea route between the South China Sea and the Indian Ocean. (https://www.livemint.com/Politics/JCT4ZtOLXTVgRwpyXIasbI/India-to-invite-global-investors-to-develop-Andaman-and-Nico.html) Biswajit Dhar said. "A large port facility at Campbell Bay could offer a better opportunity for India to trade with the Association of Southeast Asian Nations (ASEAN) region, which is in the vicinity ... The project may also have a strategic dimension considering the way China is influencing the dynamics around the region (https://www.livemint.com/Politics/JCT4ZtOLXTVgRwpyXIasbI/India-to-invite-global-investors-to-develop-Andaman-and-Nico.html)." Admiral Prakash, who is critical of India's negligence towards ocean,said that "... developing Campbell Bay is a good idea. It can also be used for refuelling by ships (https://www.livemint.com/Politics/JCT4ZtOLXTVgRwpyXIasbI/India-to-invite-global-investors-to-develop-Andaman-and-Nico.html)." He further said Campbell Bay can be developed for transshipment facility "given that it lies on an international trade route." He said large international container ships avoid Indian ports because of the long time taken to load and unload cargo. (https://www.livemint.com/Politics/JCT4ZtOLXTVgRwpyXIasbI/India-to-invite-global-investors-to-develop-Andaman-and-Nico.html)

Trade

Trade can be enhanced through strong ports and using own ships. Maritime transport is considered as the backbone of international trade and globalization.

About 50% of the global population, cities and industrial hubs are concentrated in coastal areas. Close proximity to coasts enables to have easy access to international markets. Maritime transport plays an important role in the economies of coastal states given their reliance on imports and openness to international trade.

India was an ancient sea-faring nation, as the 4000 years old port at Lothal and Indus Valley port are evidence. Sea is the major means for India to link to the west and the east. Major trade is being conducted by the sea and hence ports play a significant role in economic development. Though, 70% of connectivity is through road and rail, maritime transport plays a dominant role in shipping the trade commodities to other countries. (National Transport Development Policy Committee)

Ports and shipping industry in India play a vital role in sustaining growth in the country's trade and commerce. India is the 16th largest maritime country in the world, with a coastline of about 7516.5 km. The government has taken several measures to enhance operational efficiency through mechanization, deepening the draft and speedy evacuations (https://www.ibef.org/industry/ports-india-shipping.aspx).

Indian government plans to develop 10 coastal economic regions as part of Sagarmala project. The zones would be converted into manufacturing hubs, supported by port modernization projects and could span 300km to 500 km of the coastline. The government is planning to develop the inland waterway sector as an alternative to road and rail routes to transport goods to the ports and attract the private investment in the sector.

Coastal Tourism

Coastal tourism is vital sector of the economy in many countries that includes dive tourism, maritime archaeology, surfing, cruises, ecotourism and recreational fishing operations. It not only generates revenue but

also protects and respects local cultures, traditions and heritage. It becomes an important source of foreign exchange and is linked to the social, economic and environmental well-being of many countries. Tourism is instrumental for the economic survival of many coastal states and is a key sector in developing blue economy. Eighty per cent of tourism takes place in coastal areas. Tourism, fast becoming the largest global business, employs 1 out of every 11 persons globally. However, tourism is highly dependent on environmental quality to attract visitors. Tourism development can introduce a host of environmental concerns, including loss of valuable habitats such as coral reefs, wetlands and mangrove forests for tourism infrastructure, significant consumption of resources including locally available sources of food and clean water.

India has a long coast and needs to promote coastal tourism, which could enhance in developing the blue economy. The Indian government has identified 8 beaches, viz. Shivrajpur (Gujarat), Ghoghla (Diu), Kasargod and Padubidri, (Karnataka), Kappad (Kerala), Rushikonda (Andhra Pradesh), Golden beach (Odisha) and Radhanagar (Andaman and Nicobar Islands). It has approached the Foundation for Environment Education (FEE) for blue flag certification. These beaches will promote high-value tourism and will attract many tourists to the country.

Marine Energy

Energy security has become an important concern to most of the countries including India. Energy availability is one of the foremost requirements for India's economic growth. Economic reforms, population growth, urbanization, demographic transition and growing transport sector in India are resulting in a rapid demand for more and more energy. Many people in India still lack access to electricity for their basic needs (200 million Indians lack access to electricity). (India says all Villages have Electricity) There are hundreds of isolated (coastal) communities, which lack access to power. The demand for energy consumption is likely to increase in the future. India is largely dependent on coal to meet its energy needs, which produce more CO_2.More than half of India's energy needs are met by coal, as well as about 70% of its electricity generation. Sixty eight per cent of India's CO_2 emissions are from coal.

Projections indicate that fossil fuels will remain the dominant source of energy in the future. The International Energy Agency forecasts that between 2004 and 2030, fossil fuels would account for 83% of the overall increase in global energy demand.

The demand for energy consumption is likely to increase many folds. Economic growth is the major cause of rising emissions. There would be a major reorientation of its energy strategy, if India has to reduce its carbon emissions, i.e. a shift from its current coal-based to (renewables, etc.). India needs to explore alternatives to secure its energy needs viz. renewable energy.

Sustainable marine energy can play a vital role in social and economic development, as well as in climate mitigation. Many coastal states have the potential to produce significant amount of ocean-based energy, but are limited due to physical constraints or lack of investment. Ocean based energy refers to all sources of energy: wave, tidal, thermal conversion, salinity gradient and offshore wind energy. The Indian government has taken initiatives to depend more on renewable/blue energy resources.

India has conducted 4.91 lakh geological surveys of 540 wells for oil and gas up to 31 March 2017. Out of the total crude oil reserves of 604.10 MT, 279.86 MT (46%) are offshore. With regard to gas, out of the total reserves of 1289.81 BCM, 810.10 BCM (62%) is offshore. The volume of methane gas in the deep ocean located gas

hydrates reservoirs of India is expected to be 1900 TCM. Krishna, Godavari and Mahanadi basins and other places have gas. It is assumed that only 10% recovery can meet India's energy requirement for 100 years.

While offshore wind energy is becoming more common, other forms of marine energy extraction are still experimental, and in most cases have not yet been developed on a commercial scale. India needs to reorient its energy strategy.

Marine Biotechnology

The marine environment offers a new frontier of biological resources for developing various products. India was allocated an area of 150,000 km^2 in the Central Indian Ocean Basin (CIOB) for development activities by the International Seabed Authority of the UN in 1987. It has obtained the rights to explore an area of over 75,000 km^2, rich with about 380 million tonnes of metals such as manganese, iron, cobalt, copper, etc. (India says all Villages have Electricity). The total worth of these reserves initially estimated to be about US$45 billion, however, the International Seabed Authority (ISA) estimates their worth to be around US$187 billion. (Nayak, p.192)India has entered into an exploration contract in 2016 with the ISA covering an area of 10,000 km^2 for 15 years in the South Western Indian Ocean.

Marine species provide key ingredients for biofuel, cosmetic products, dietary supplements, painkillers and even treatments for cancer, asthma and arthritis. Scientists have discovered krill, sponges, soft corals, worms and deep sea bacteria that could provide a variety of new innovations. Algae can provide biomass for biofuel production; chemicals for food processing, cosmetics, and pharmaceuticals; soil additives and fertilizers; animal fodder etc. Coastal placer minerals, such as ilmenite, rutile, magnetite, garnet, zircon are extensively available in Kerala, Tamil Nadu, Andhra Pradesh, Odisha and Maharashtra coasts and near shore waters. The reserves of ilmenite, rutile, garnet, zircon, kainite and sillimanite are estimated to be about 600, 30, 60, 35, 2 and 4 million tonne, respectively, which is worth approximately US$120 billion (Nayak, p.192). A plant was set up with the capacity of 500 kg at the Hindustan Zinc Ltd, Udaipur, to extract copper, nickel and cobalt (Nayak, p.193). The Hindustan Zinc Ltd is India's largest and the world's second largest zinc-lead producer and one of the lowest cost zinc-lead producers in the world. Its revenue in 2018 was ₹22,084 crore. Similar efforts are to be initiated to extract other metals.

In 2011, marine species offered pharmaceuticals which was valued at US$4.8 billion worldwide and is expected to grow to US$8.6 billion by 2016 (Botei). For instance, a painkiller called Prialt Ziconotide derived from marine cone shell venom, generated sales revenues of US$12.1 million (Vierros and S. Arico).

Mining is an intrusive activity requiring heavy machinery and some amount of damage to the seabed. The mining process can introduce toxic substances, sediment plumes, vibrations, light and invasive species that can harm local sea life. As a young industry, the extent of environmental damage from seabed mining activities is yet to be understood.

An analysis of Tables 3 and 4 provides information on the volumes of the heavy taxation rates of the mining industry in India. Table 3 shows that the Indian corporate tax in the mining sector hovers around 30%, which is significantly high. The corporate tax for domestic companies is 30% and for foreign companies, it stands at 40%. This makes the sector highly uncompetitive for foreign investment and despite having a 100% FDI in the mining sector very few companies are actually interested to invest. Given that the mining is an industry

Table 3 Mineral Exploration

Country	Corporate Method Tax	Method	Coal	Gold	Copper	iron Iron ore
Australia	30%	R	2.75%–15%	2.5%–5%	2.5%–5%	5.35%–7.5%
Brazil	25%	R	2%	1%	2%	2%
Canada	25%–31%	P	2%–16%	2%–16%	2%–16%	2%–16%
Chile	20%	P	0–14%	0–14%	0–20%	0–14%
China	25%	R	0.5%–4%	0.5%–4%	0.5%–4%	0.5%–4%
Ghana	25%	R	5.00%	5.00%	5.00%	5.00%
India	30%	R	14%	3-4%	4.62%	15%
Indonesia	25%	R	3–7%	3.75%	4.00%	3.00%
Mexico	30%	P	7.50%	8.00%	7.50%	7.50%
Mongolia	10–25%	R	2.5%–7.5%	5%–7.5%	5%–30%	5%–7.5%
Peru	30%	P	1%–12%	6%–21.5%	6%–21.5%	6%–21.5%
SouthAfrica	28%	R	0.5%–7.0%	0.5%–7.0%	0.5%–7.0%	0.5%–7.0%
US	40%	P/R	8%–12.5%	4%–10%	4%–10%	4%–10%

Global Avg. 2014: 23.57%

Source: Kumar, Manoj and A.K.Verma.2018. *Creating the Right Policy Environment for India's Mineral Sector*. New Delhi: Observer Research Foundation, p.21.

Table 4 Royalty Rates in India and Other Mining Countries

Country	Royalty Rates
Australia	5.35%–7.5%
Brazil	2%
Canada	2%–16%
Chile	0–14%
China	0.5%–4%
Ghana	5.00%
India	15%
Indonesia	3.00%
Mexico	7.50%
Mongolia	5%–7.5%
Peru	6%–21.5%
South Africa	0.5%–7.0%
US	4%–10%

Source: Kumar, Manoj and A.K.Verma.2018. *Creating the Right Policy Environment for India's Mineral Sector*. New Delhi: Observer Research Foundation, pp.22-23.

with highly uncertain rates of return, starting from prospecting to actual exploration, such high rates of taxes de-motivates investment and consequently mineral exploration sector growth.

Table 4 shows the royalty rates in mining in India, which again shows one of the highest payment rates compared to other countries. Most importantly, the absence of a uniform and standard taxation regime– such as the GST regime– leads to pay varying rates of taxes for different states. A uniform tax system should be put in place for the minerals sector, applicable to all the states in India.

Overall, mining in India is one of the most highly taxed sectors globally with an estimated effective tax rate of around 43% (for iron ore) as compared to 35–40% for most of the major mining countries such as Brazil, South Africa, Australia and Canada. (Kumar and A. K. Verma)

Maritime Security

Governance at sea is to safeguard the sea frontiers, ports, offshore installations and EEZs, to protect marine ecosystem, lives and property, sea lanes of communication, and to prevent smuggling, poaching, piracy, gun running, and trafficking. Two-thirds of the world's population lives within 100 km of the coast and it is bound to get worse, when the population doubles in the future. Maritime security is an enabler of the blue economy and maritime security as a sector (Voyer, et al) within the blue economy. Port development and shipping in the region will require investment in security and defence. The role of maritime security as a sector within the blue economy is difficult to quantify, given the wide array of industries.

The 2015 Coastal Governance Index from *The Economist Intelligence Unit* evaluates the state of coastal governance at the national level across 20 countries with ocean-based economies, assessing the business environment for coastal activities along measures, including ease of doing business, corruption perception, effectiveness of dispute resolution mechanisms, and quality of coastal infrastructure. Table 5 provides India's position on coastal governance policies including capacity, coastal activities, water quality, mineral and energy, land and living resources. India needs to improve particularly on living resources and business environment for coastal activities.

Table 5 Coastal Governance Index

S.No.	Variables	Rank/20	Score/20
1	Coastal Governance Policies	17	56
2	Capacity	16	54
3	Business Environment for Coastal Activities	17	40
4	Water Quality	11	75
5	Minerals & Energy	12	74
6	Land	13	63
7	Living Resources	17	31

Source: "The Coastal Governance Index, 2015". *The Economist Intelligence Unit*. https://eiuperspectives.economist.com/sites/default/files/images/EIU_CGIndex_WEB%20final_0.pdf.

Private Sectors

There is a significant need for private sector capital and expertise to scale up blue economy investments. There are numerous opportunities through involvement of private sectors: reduced costs through efficiency, a differentiated employment proposition and more engaged workforce, stronger relationships with communities and government, and the social license to operate that comes with it, greater levels of innovation, enhanced

reputation; access to new markets, and access to new sources and lower cost of capital. (Nidumolu, et al) However, there are constraints regarding private investments such as: lack of financial resources to devote to sustainable development, lack of public awareness about practices by consumers, pressure from competitors following unsustainable practices, and challenges in establishing effective partnerships with government and NGOs.

The Government must provide effective policies and regulatory regimes to enable sustainable private sector operations and investments, including policies ensuring that environmental and social costs are internalized. The private sectors could participate actively through collaboration in "Corporate Ocean Responsibility" in various sectors of blue economy.

Blue Clusters

Clusters have been originally defined as "geographically proximate group of interconnected companies, associated institutions and research bodies, in turn linked by commonalities and complementarities" (Porter) Maritime clusters play a significant role in bringing industry and government stakeholders together to promote development of the different sectors.

The cluster is a focal point for all: companies, institutions, research centres acting at various levels in the transformation of products, including the programming of maritime activities. The role of cluster is to promote, coordinate and represent the needs of the sectors. The cluster supports companies from different sectors such as fishing, aquaculture, shipbuilding, maritime transport, maritime tourism, maritime research and training, ports and port activities and industries. To develop blue economy, we need to bring together science, technology, industry and financiers, and other stakeholders from different value chains, sharing common interests to develop synergies.

Conclusion

Traditional ocean industries such as fisheries, shipping/shipbuilding, ports, maritime transport and tourism in India present huge scope for development. Industry and service sector development associated with emerging sectors like offshore renewable energy, aquaculture, seabed extractive activities, and marine biotechnology and bioprospecting while having immense potential, have been rather slow in development. Considering that the coastal regions of India are home to over 560 million populations, government needs to focus investing in blue economy. Besides, there is a need to bring synergy among/between multitudinous agencies and ministries to enhance growth in a sustainable manner.

There should be an exclusive ministry to look after the development of blue economy, as there is poor coordination among the multiple ministries/institutions. Ministries associated with blue economy in India include: Ministry of Statistics and Programme Implementation; Ministry of Agriculture; Ministry of Coal; Ministry of Defence; Ministry of Food Processing Industries; Ministry of Mines; Ministry of New and Renewable Energy; Ministry of Petroleum and Natural Gas; Ministry of Science and Technology; Ministry of Shipping; Ministry of Tourism; Ministry of Urban Development; Ministry of Labour and Employment; Ministry of Heavy Industries and Public Enterprises; Ministry of Commerce and Industry; Ministry of Finance (Insurance); Ministry of Human Resource Development. We need to identify blue clusters (investment, sharing technology, industry-private and public, etc.) which will focus on coordination among different sectors, to enhance the economic development.

The slogan Sabka Saath Sabka Vikas, which translates as 'Collective Effort and Inclusive Growth' has been the Prime Minister's call for India's national development agenda. India cannot become an economic power unless it becomes a maritime power. Unless we develop blue economy, India cannot become a maritime power. India can be a global leader in several coastal and marine industries through transitioning from an ocean economy to a blue economy

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Chapter 5

Profile of India's shipping industry and its role in a Blue Economy, going forward

Deepak Shetty, Former Secretary to the Government of India and Director General of Shipping.

Preface

In his foreword to the Indian Navy's doctrine publication (2015) titled 'Ensuring secure seas: India's maritime security strategy', Admiral R K Dhowan, the then Chief of Naval Staff, Indian Navy had opined that "There seems little doubt today that the 21st century will be the 'Century of the Seas' for India and that the seas will remain a key enabler in her global resurgence."

This perspective has gained an exponential traction with the philosophy underlying the approach to the blue economy paradigm in the Indian Ocean Region (IOR) as spelt out by the Indian Prime Minister, Shri Narendra Modi, under his 'SAGAR' (Security and Growth for All in the Region) ethos and framework.

Profile

India ranks 19th in the 'Total Ranking of the 30 Benchmarked Maritime Nations' published in the report of DNV-GL titled 'The Leading Maritime Nations of the World 2018'.[1] The Indian registered/flag merchant shipping fleet comprises a diverse main fleet of foreign/ocean going and coastal trade ships, off-shore service/supply vessels, merchant sailing vessels and an assortment of smaller crafts, such as barges, dredgers, tugs, harbour crafts, pleasure crafts, yachts, and so on.

This mercantile marine fleet is used for the movement of merchandise goods along the coast of India, as well as for the international transportation of trade-oriented export–import commodities along the worldwide sea lines of communication (SLOCs). It also services passenger/cruise movement, port/harbour operations, offshore service/supply activities, pleasure/leisure trips, etc. Besides, there are other vessels that are engaged in Indian riverine trade and passenger movement along inland waterways, through its network of rivers, canals, backwaters, and creeks. However, this fleet discounts the separate grouping of Indian fishing vessels. That said, several of these types of vessels could be leveraged for productive deployment for blue economy purposes, directly or indirectly.

1 The Leading Maritime Nations of the World 2018, Menon Publication, DNV GL, 2018

Overview

With a vast coastline of 7512 kilometres and an exclusive economic zone (EEZ) that straddles around 2.3 million square kilometres of area, effectively tapping into the vast blue economy resources of the country, including in its EEZ, for bolstering national economic growth and development and also for effectively securing its geo-strategic interests, is a sine-qua-non.

This is even more so given India's nationally declared aspiration of becoming a $5 trillion economy by 2024. It is estimated that merely about 1.5 million square kilometres of its EEZ have been explored, as yet, leaving the remnant EEZ patch of 0.8 million square kilometres unexplored, so far. The Indian blue economy, comprising economic activities linked to its sovereign marine resources, such as deep-sea mining, fisheries, oil & gas and allied sectors, represents approximately 4.1% of its current national GDP.

Case for 'Priority Sector' and 'Infrastructure Sector' Status for Shipping

In this scheme of things, it is imperative that the Government of India must expeditiously consider acknowledging the Indian shipping industry as a 'priority sector' and further reckon according it 'infrastructure' status. This industry is proven, empirically, to be the most cost-effective, eco-friendly and energy-efficient mode of transportation vis-à-vis its generally competing road, rail and civil aviation counterparts on the transportation front.

The sovereign intent doctrine of the Government of India must accord primacy of place to the mercantile marine of the country in the overall national transportation policy documentation, with inter-se and complementary priorities and plans of action mapped out very clearly and sharply as between the said different modes of transportation. This document should aim for the short, medium and long terms, bearing projections spanning the next 30 years going until 2050, towards attaining the holistic, resilient and sustainable development and growth of all these sectors, including shipping, harmoniously. On the basis of this document, policy programmes and projects to the above end must be shaped.

Mooted Coverage of Maritime Sector Dovetailed to Blue Economy

The various constituent sectors of a blue economy should also cover maritime transport, marine and coastal tourism, ship-building and ship repair, fishing, aquaculture, marine biotechnology, mineral resources, offshore oil and gas, and offshore wind power, among others. The related term 'blue growth' means 'support to the growth of the maritime sector in a sustainable way'. The forward and backward linkages of India's blue economy inter-alia vis-à-vis the role of its maritime transportation sector, with the robust ability of the latter to service the emerging needs of the former, must be clearly delineated in consultation and conjunction with all germane stakeholders, in the interest of public good. In the overall maritime prowess of India, contextual to the growth of its blue economy, merchant shipping will play a pivotal role. The robustness, sufficiency, scalability and typological diversity of its mercantile marine fleet, dovetailed to the roadmap of its holistic blue economy development, going forward, will be key thereto.

We must aim to more than double the share of Indian registered/flag shipping currently from 6.4% to about 15% in the carriage of its overall EXIM merchandise trade by 2025, to also minimize the annual outflow of around $56 billion towards freight charges being presently paid to foreign flag vessels for carrying 93.6% of

the Indian EXIM cargo. The emerging profile of Indian ships/vessels has to metamorphose in sync with the requirements of the growth sectors of the economy, inclusive of its blue economy segments. For instance, this would, apart from the normal typologies of vessels, involve the acquisition of more specialized vessels such as deep sea diving vessels for oil & gas exploration and production, and separately for prospecting and mining deep sea marine resources, dynamic positioning vessels, offshore vessels, including very large crude carriers (VLCCs), for carriage of oil & gas, over dimensional cargo carriers, etc.

Rationale for a 'National Mission for Shipping'

Contextually, it is pertinent to note the constitutional and executive framework in respect of merchant shipping in India. This is delineated under the 'Union List/List-I' of the Seventh Schedule of the Indian Constitution, on which Parliament has exclusive power to legislate (item nos. 24 to 28 thereof). The Central Government, with reference to merchant shipping as a subject, is defined as the Ministry of Shipping, under the Government of India (Transaction of Business) Rules, 1961, as amended.

In this context, there is also a critical need for the entire policy, programme and project approach to the shipping sector to be pivoted on a 'mission' mode. Given the national, cross-cutting and multi-stakeholder importance of this industry, as well as the international character thereof and global developments that impact it, the Government of India may consider launching a concerted and high-powered 'National Mission for Shipping', with a tenure of at least 10 years, ab-initio. This lead-time is essential to address and redress the deep-rooted, multi-disciplinary and structural issues and concerns that beset it. This mission must be invested with the clear authority to bring to bear the whole-of-government (WoG) outlook to this sector. The flagship 'Sagarmala' project of the Government of India, among other things, may be subsumed within the same. The ambitious port-led development oriented 'Sagarmala' programme of the Government of India, that is presently underway, envisages and provisions for the creation of coastal/maritime economic regions (CERs/MERs), along the Indian coastline, both on its eastern and western seaboards, through a hub and spoke approach with ports being the fulcrum thereof. These regions, straddling an approximate area of 200 km radius linked to each hub port, underpin the premise that economic activities, including manufacturing, will be promoted in the coastal areas to facilitate the swift evacuation and movement of inputs, intermediates and finished products along the manufacturing and supply chain through the coastal and inland waterways. It is essential that shipping is integrated, all-round, into the manufacturing/industrial policy of the country, for establishing robust and resilient backward and forward linkages for facilitating the seamless movement of merchandise inputs, intermediates and finished products, along the manufacturing and supply value chains, at locations that abut waterways—also serving the blue economy requirements. Contextually, it is pertinent to note the constitutional and executive framework in respect of merchant shipping in India.

Linkage Between Maritime Transportation and Blue Economy

Moreover, this 'National Mission for Shipping' can and should also be tasked with a mandate to drive the merchant shipping dimensions of the Indian blue economy paradigm, including robust forecasting, mapping, planning and facilitating the same holistically. To that end, this Mission ought to build resilient and sustained coordination and engagement mechanisms, institutionally, at the national level, with allied Ministries/ Departments of the Government of India such as Shipping, External Affairs, Defense, Earth Sciences, Science and Technology, New and Renewable Energy, Petroleum and Natural Gas and other associated agencies of

the Government of India and further with the Governments and allied organizations of the maritime States and Union Territories concerned. Such regular collaboration, interaction and information sharing will facilitate the said process saliently, which is largely non-cohesive and disjointed now.

Case in point is that this Mission should address the pronounced absence/inadequacy of high-end and technologically-advanced typology of vessels such as liquefied natural gas (LNG) carriers, liquefied petroleum gas (LPG) carriers, fully cellular container ships, roll-on and roll-off (RORO) cargo carriers, refrigerated (reefer) vessels, specialized cargo ships, multi-purpose and project vessels, specialized tankers, passenger vessels, ferries, etc.,—the number of gas carriers also is too few. Bulk of these categories of vessels would also serve the growing needs of the Indian blue economy in the years to come.

Proposed Connect of Merchant Shipping and Blue Economy to the UN-SDGs and NDCs

There is also an imperative need for the mercantile marine industry as well as for the maritime administration to jointly push, under the aegis of the 'National Mission for Shipping', the envelope of the sector's growth on a sustainable development plank, reckoning the perceptible adverse impact of climate change on the global environment. Although it is an empirical fact that the shipping industry has the lowest amount of carbon emissions footprint, worldwide, including in India (reportedly cumulating to less than 2% overall), yet all concerned must be acutely mindful of the need to strive to further minimize greenhouse gas (GHG) emissions in the sector. To this end, there is a crying need to sensitize all entities, in perspective, on an urgent and sustained basis. Such an information dissemination drive must be a collective endeavour on a public-private partnership (PPP) mode.

This should include a solemn commitment on the part of all of them to subscribe to and implement on a structured and time-bound format the relevant objectives of the Sustainable Development Goals—2015–30 of the United Nations. Of these goals, the ones numbered 7 (Affordable and Clean Energy), 12 (Responsible Consumption and Production), 13 (Climate Action), 14 (Life Below Water) and 17 (Partnerships for the Goals), inter-alia, are pertinent for the survival and growth of the maritime industry too and hence must be actionalized collectively and on priority. These goals and the targets thereunder must be clearly broken down for identifying responsibility for action by all concerned. To the latter end, it is imperative for the Government of India to engage the shipping industry stakeholders, associate them and map out specific and targeted deliverables and timelines for the purpose and encourage collaboration on a PPP mode, monitor the same pro-actively and more importantly send out a strong message that all entities need to be on board regarding this issue, ineluctably, in larger public interest. India's climate action oriented Nationally Determined Contributions (NDCs) under the Paris Agreement must, in relation to the Indian maritime industry, be also anchored by the proposed 'National Mission on Shipping'. This should be dovetailed to blue economy optimization, via perspective short-, medium- and long-term plans, programmes and projects.

The shipping industry must, in this direction, be encouraged to also voluntarily sign-in, participate and jointly lead as co-stakeholders in the process of promoting sustainability in the sector via the United Nations Global Compact template for corporate entities. The larger of these companies, to begin with, should further be motivated to consider and adopt the 'Integrated Reporting' framework of informational disclosures and reporting under the standards developed by the International Integrated Reporting Council (IIRC).

Harmonization of Port-led Community/Region Development Model and Blue Economy

The ambitious mega project of 'Sagarmala' will also have a bearing on shaping the blue economy in India. The concept of 'Coastal Economic Regions' (CERs)/'Maritime Economic Regions' (MERs) that underpins this programme must entail a perspective approach to town/city planning and integrated development in such identified areas with requisite backward and forward linkages built in suitably. Economic activities including fisheries, aquaculture (rearing of aquatic animals or cultivation of aquatic plants for food), etc., ought to be better planned for generating employment and viable and sustainable livelihoods in and around such regions. However, holistic marine community living must be encouraged therein so as to provide for a better sense of outreach and engagement of such stakeholders with the model of port-led development planned under this scheme of CER/MER. Other entities that have a role to play therein would be the small ship repair units, small shipyards, small ship breaking units, etc., that are expected to come up therein as service providers. The impact of all their activities would potentially spill out beyond the given beachheads/fronts on the surrounding marine ecology and hence will bear out on the way blue economy resources are leveraged and used. An enabling ecosystem that makes for a sense of empowered partnership should be fostered so that these marginalized segments along the marine value chain are also brought on board for an integrated blue economy development. A calibrated endeavour must be made to encourage responsive and responsible marine life behaviour among all the stakeholders. Education, sensitization and imparting of appropriate skills among them are key to the sustainable success of such regions.

All of this calls for robust and integrated planning and execution of programmes and projects therein, involving very close coordination and cooperation amid the central, state and local level inter-ministerial entities such as port authorities, civic/municipal authorities, Central Pollution Control Board, other associated government bodies, city/town planners, architects, conservationists, environmentalists, associations /organizations of local communities and other allied stakeholders. This necessitates an appropriate, composite, compact, standing and active institutional mechanism for the purpose, duly mandated with the requisite remit from the central government and the governments of the jurisdictional 13 maritime states and union territories. The above mooted 'National Mission for Shipping' may be considered to be tasked with this mandate as well. It may draw up a roadmap for suitably dovetailing the 'Sagarmala' framework with the blue economy paradigm, with graded and telescopic perspective plans. To this end, it may perhaps be also useful to consider leveraging the specialized expertise and experiential learning in some of these areas of global bodies such as the Indian Ocean Rim Association (IORA), UN (United Nations)-Habitat and Urban Economy Forum (UEF-a Toronto, Canada, headquartered coalition of worldwide multi-disciplinary experts on urban/ town planning), in relation to dynamic and evolving best practices of sustainable blue economics, financing, resource mobilization, planning of human settlements, infrastructure growth, industry and trade, municipal governance, environmental resilience, maritime transportation and logistics supply chain linkages, education, outreach, disaster management, etc.

Case for Ratification of the High Seas Intervention Convention

India must immediately consider ratifying the International Convention Relating to Intervention on the High Seas in cases of Oil Pollution Casualties, 1969. This is vital to secure India's sovereign and inalienable rights to intervene in a timely manner to effectively combat oil pollution disasters from merchant ships in the high

seas, which may potentially impair salient blue economy marine resources on a large, irreparable, and possibly recurring scale. This Convention, although signed by India in the year 2000, was sought to be ratified by it and incorporated into its national legislation only under the new Merchant Shipping Bill drafted in 2016 and presented to the Parliament in the same year via cabinet approval. However, unfortunately this Bill is still languishing further consideration, five years down the line, and has not yet been enacted and hence is in urgent need of ratification through due parliamentary approvals.

There is the ongoing regular maritime traffic of innumerable VLCCs, chemical tankers and such other product carrying ships, apart from all other general typologies of vessels, through the Indian Ocean and Arabian Sea in proximity to the Indian waters and its EEZ. These activities, including the 'right of innocent passage' of merchant ships, bear the potential for the possible occurrence of accidents/incidents, grounding, sinking, etc., in respect of such vessels that may lead to the spillage of large volumes of bunker oil of ships as well as oils, chemicals and similar hazardous products carried as cargo on board vessels into the seas and oceans within the Indian jurisdiction. The potential for consequential damages to the marine ecology and blue economy ecosystem of the nation may be way too staggering. Thus, the imperative and exigent case for India is to be proactively armed with the requisite statutory powers under this international legal instrument for timely intervention for the efficacious prevention, containment and mitigation of such mega marine disasters in the high seas that can severely impair the nation's blue economy resources too.

Time to have OSROs

Equally necessary is the need to consider putting in place Oil Spill Response Organizations (OSROs). In the USA, in response to the catastrophic and humungous 'Exxon Valdez' oil spill incident in 1989, in the Gulf of New Mexico, the Oil Pollution Act (OPA) was enacted in 1990 in that country. This legal framework is a crucial plank in the USA's oil spill governance programme whereby OSROs, as highly specialized and experienced companies providing expert services for marine oil spill containment and salvage, are contracted to respond to major oil spillages. The OSROs need to be evaluated, certified and accredited by the National Maritime Administration, in concert with the Coast Guard, in the Indian context for also conserving, preserving and protecting invaluable, yet fragile, deep sea bio-species and marine resources in the blue economy ecosystem. The services of OSROs, with their ultra-sophisticated vessels, high-tech equipment and gadgets and super-skilled technical manpower, customized for the purpose, can be readily availed off as first responders to mitigate, contain and remediate major oil spill incidents in the maritime space—effectively and timely.

Through a process of global tendering/'Swiss Challenge' modalities and compatible with the prescriptive norms of the Indian Central Vigilance Commission, the selection and empanelment of suitable OSRO/OSROs may be considered to be done expeditiously. A Draft Cabinet Note (DCN) may be considered to be initiated to this end by the Ministry of Shipping, Government of India/said proposed 'National Mission for Shipping' for seeking due authorization for this proposal which has been hanging fire for quite a while now. We can ill-afford to have the current status-quo of seeking knee-jerk, on a case-to-case basis and occasioned by a felt-need demand only on the occurrence of a major maritime disaster, the services of professional and world-class maritime disaster remediation and salvage service providers. Instead, what is mooted is that such an OSRO/OSROs should be empanelled (for about 2–3 years at one go) for ready availability to be leveraged for meeting such a contingency at very short notice by having their fully equipped outfit (s) positioned in India (preferably one each on its western and eastern seaboards at Mumbai and Chennai, respectively) and

not being scrambled from overseas bases entailing valuable time lost in the process as of now. This template would also go a long way in providing such much-needed customized services for meeting the requirements of an emerging blue economy framework for India.

Continued Reduction of Carbon Emissions by the Shipping Industry

The International Maritime Organization (IMO), in terms of its commitment to further scale down the carbon footprint of the maritime sector has introduced, with effect from 1 January, 2020, a regulation mandating that for all sizes of operational vessels the sulphur oxide content in bunker/marine oils shall not be in excess of 0.5% (vis-à-vis 3.5% hitherto until end 2019). To this end, refineries have reoriented their product profile to supply compliant fuel oil by blending fuel oil with a high sulphur content with fuel oil bearing sulphur content lower than the required sulphur content. Many ships have installed scrubbers, which are exhaust gas cleaning systems, to minimize air pollution. Some ships have begun using different fuels comprising low or zero sulphur, such as biofuels or LNG.

Yet, these compliance measures, including getting refineries to rejig their internal systems and offer such compliant fuel supplies in adequate quantities, on a regular basis, at cost-effective price points and across jurisdictions have posed major challenges. The merchant shipping industry is generally risk-averse and slow in adapting to changes. But, over time, the situation has eased significantly. The softening of fuel prices since then has also been a catalyst in the process, in the face of the downturn in the global economic order that has otherwise impaired freight rates and profitability of shipping companies. Nonetheless, the National Maritime Administration must monitor this development very closely and ensure that all stakeholders concerned with this progressive measure are in complete and regular compliance therewith, to also preserve the blue economy resources.

India, which is one of the earliest signatories to the IMO Convention and is a Category-B member of the Council of the IMO, must be proactively clued to some more environment-friendly measures for the shipping industry that the IMO is currently working on viz.: reduction in the emission of harmful gases, such as nitrogen oxides and ozone-depleting gases, as well as the project of the IMO aimed at decarbonizing shipping by incrementally paring down GHG emissions. The timely and efficacious execution of all these steps, on an ongoing basis, will also have a beneficial bearing on India's blue economy paradigm.

The effective implementation by India, from the sustainability perspective, through efficient port state control and flag state inspections, conducted by the National Flag Administration, of merchant ships, regularly, of the following global maritime legal instruments of the IMO also hold a key to further leveraging the benefits of the blue economy: International Convention for the Safety of Life at Sea (SOLAS), International Convention for the Prevention of Pollution from Ships (MARPOL), International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM), and International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) and their respective Protocols. Incrementally, the following conventions (now under consideration) too must be fast-tracked for ratification and incorporation into the Indian national merchant shipping legislation (Merchant Shipping Act) for better securing India's blue economy interests: International Convention on Maritime Search and Rescue (SAR), 1979 and International Convention on Oil Pollution Preparedness Response and Cooperation (OPRC), 1990.

Propagation of Self-reliance

Merchant shipping fulfills the energy sources transportation need of the country, coupled with servicing its blue economy requirements. The mercantile marine will incrementally have to play an even more significant part going forward given the 'Atmanirbhar Abhiyan' of the Government of India, the paradigm shifts in the global geo-political-strategic matrices, move towards rejigging of supply chain networks, availability of shale gas for large-scale exports from the USA, continued dependence of India for bulk of its oil and natural gas requirements from abroad, etc.

India's merchant shipping sector will have to upscale and diversify its vessels fleet to meet these critical needs. Larger and more modern oil tankers, VLCCs, CNG/LNG carriers, LPG carriers, etc., will have to be looked at for acquisition via investments under Indian tonnage/India controlled tonnage, including the extant 100% FDI route, or by way of chartering. Ports, their infrastructure and operations too would have to be constantly modernized and upgraded technologically towards this end, including through deeper drafts, better dredging, improved economies of scale, enhanced efficiencies, augmented cost-cutting and the like, in both brownfield and greenfield infrastructure and facilities. The Major Port Authorities Bill, 2020 and Indian Ports Bill, 2020, will hopefully incentivize these moves for ports across the country, be they in the public or private sector. Corporatization of public sector ports will further provide a major fillip towards these ends.

Futuristic Scenario of Fuel Use and Eco-Friendliness of the Merchant Shipping Industry

Climate change is for real and it is imperative that this industry too is cognizant of its paramount responsibilities to mitigate the adverse impacts of climate change by further reducing its carbon/GHG emissions footprints. This calls for, inter-alia, a calibrated and studied relook at the propulsion systems of ships to render them even more sustainable. This is also necessary for the conservation of the blue economy.

Apart from conventional propulsion methods and fuels, it is also essential to holistically examine and consider emerging alternate options such as biofuels, LNG, hydrogen, nuclear propulsion, batteries, fuel cells, renewable energy, superconducting electric motors, and hybrid propulsion. Additional propulsion influences such as magneto-hydrodynamic propulsion, energy-saving devices, hull design and coatings need to be also reckoned in the calculus. ***Manoeuvring*** away from poor weather en-route by using weather-routing technologies make for reduced fuel consumption. Ship speed optimization during voyages, crew training to understand implications of the decisions and actions that they take and to pump prime their motivation levels and ensuring that vessels and their machinery are well-maintained also have a salient bearing on fuel consumption and emissions performance. Larger ships are generally deemed to be comparatively more carbon-efficient. Lowering of ship speed also facilitates carbon emissions reduction.[2] The IMO, which is a specialized agency under the United Nations system, as the global shipping standards-setter as well as regulator-cum-facilitator has, over the past few years, already put in place a slew of measures to promote sustainable shipping and through it the blue economy paradigm, going forward. Among other things, these are very historic and substantive steps aimed to usher in significant GHG emission reductions /de-carbonization as well as bring about salient cost-savings in the operations of merchant ships, worldwide, since 1 January, 2013, on a mandatory basis. These are in the form of the introduction of the following initiatives, by way of

2 Future Ship Powering Options. Exploring alternative methods of ship propulsion, Royal Academy of Engineering, July 2013.

appropriate amendments to the MARPOL (Marine Environmental Pollution Regulations) Annex VI Regulations for prevention of air pollution from ships:

- Energy Efficiency Design Index (EEDI) for new ships
- Ship Energy Efficiency Management Plan (SEEMP) for all ships in operation
- The above-institutionalized framework is anticipated to lead to the following projected climate change beneficial results, vis-à-vis the then extant status quo:
  - » Paring of annual CO_2 emissions of about 200 million tonnes, constituting around 10–17%, by 2020
  - » The aforesaid CO_2 emission trimming figures are likely to rise to approximately 420 million tonnes by 2030, representing about 19–26%
  - » Annual fuel cost savings of around $20–80 billion by 2020
  - » The above fuel cost savings are likely to go up to $90–310 billion by 2030.

In response, Mr Ban Ki Moon, the then Secretary General of the United Nations had commented that "This underscores the fact that IMO is best positioned to play a leadership role in addressing GHG emission from international shipping." Mrs Christina Figueres, the then Executive Director of the United Nations Framework Convention on Climate Change (UNFCCC) had observed "I would like to congratulate IMO for this outstanding result, which for the first time in history establishes a global mandatory GHG emission reduction regime for an entire economic sector."

The entire foregoing template will also have to be dovetailed into the widely projected scenario of the successful development and deployment of semi-autonomous and fully autonomous merchant ships gradually anytime in the next 15–30/40 years' time horizon. This is not an amateurishly wild and fantasy scenario, but is a realistic best-case estimation duly informed by mature thinking, conceptualization and research and development of advanced technologies that are already underway globally in this direction. Illustratively, the Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) project of the European Union is a case in point. Therefore, it is just as well that this is duly factored into the paradigm of India's futuristic blue economy projections, plans and programmes and all germane stakeholders, led by policy planners, are fully sensitized for preparations for these emerging developments.

Ship Breaking and Its Implications

This is another facet of the maritime industry that can potentially, nay more often than not, actually impact the blue economy template of the country. This major activity of ship breaking is an inevitable part of the value chain of the maritime industry. The only way to dispose of the end-of-life vessels is to break them up into scrap material-recycle and use the same as much as is feasible, on a sustainable basis. The activity/industry of recycling of typically decrepit ships that have outlived their operational life cycle is largely concentrated in the coastal states of the Indian Subcontinent, viz., India (Alang), Bangladesh (Chattogram), and Pakistan (Gadani). Of these, Alang, in Gujarat, is by far the largest ship breaking location in the world, which draws numerous such ships from across the world for the said purpose all the year round. However, over the years, this activity of dismantling of fully run-down and obsolete ships on the beaches of Alang has drawn an adverse international attention, consistently, in relation to the deleterious impacts that it has had through lack of robust enforcement and poor coastal zone management on the blue economy in general by way of:

- Damaging consequences on the surrounding fragile marine ecosystem in the form of environmental pollution, via release of toxic and hazardous wastes arising out of ship demolition processes into the proximate waters. This negatively impinges on the nearby human habitation as well as fishery resources.
- Exploitation of the cheap, unorganized and often replaceable labour employed and deployed under occupationally hazardous, untrained and unsafe conditions and subject to long working hours, which entail serious costs to their health—sometimes leading to workers' fatalities.
- Operation of mafia groups who are long suspected to be involved in racketeering, money laundering, potential nexus to terrorism and other serious crimes that feed further into and aggravate the above deplorable ecosystem around.

To overcome the aforesaid ills plaguing the ship recycling industry in the country, India has now ratified the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships. Among other things, India has recently also notified the concurrent designation of the Directorate General of Shipping of the Government of India as the National Authority for Recycling of Ships, under the Recycling of Ships Act, 2019. This move is aimed at ensuring the sustainable development of the ship recycling industry, overseeing compliance of the associated environmental norms and protecting and promoting the safety and health of its stakeholders. This is expected, in turn, to also safeguard and foster the blue economy paradigm in India.

Need to Provide Reception Facilities in Ports for Efficient Discharge and Treatment of Wastes from Ships and Land-based Sources

Another maritime dimension that has a close connect with and bearing on the blue economy paradigm in India is the template of reception facilities available or otherwise in various ports across the country. These amenities are for the environmentally safe and sustainable delivery, treatment and disposal (including recycling and recovery, through the circular economy routes) of different forms of wastes arising from the operations of ships when they come calling at ports for EXIM and coastal trade loading and unloading purposes at regular intervals. It is noteworthy that there are over 200 ports across India, of which about 65 are EXIM trade load/discharge ports. It is estimated that around 20,000–25,000 vessel calls take place annually among all the ports in the country. Under the applicable provisions of the United Nations Convention on the Law of the Sea (UNCLOS), coastal and littoral states are obligated to protect and preserve their marine environment. Further, the Flag States are mandated to put in place laws and regulations to minimize pollution that may arise from intentional or unintentional discharge of wastes from vessels at ports. To this end, the IMO has, under the MARPOL (International Convention for the Prevention of Pollution from Ships) advised its Member-States to put in place and enhance the effectiveness of their port reception amenities ashore and treatment of marine plastic litter. Besides, port reception facilities also encompass land generated waste disposal, appropriately, in their respective jurisdictions. In toto, such wastes cover hazardous waste, medical waste, quarantine waste, cargo residues, cooking oil and food waste, operational waste, grey water, e-waste, garbage, etc. The unchecked release of such multiple wastes into the water streams in and around ports can potentially have catastrophic consequences on the surrounding marine ecosystem and even beyond through domino effects over a period of time. Therefore, effective and timely monitoring and enforcement of counter measures under law, to safeguard blue economy resources, sustainably, cannot be over-emphasized.

However, unfortunately, not many ports in the country are sensitized to these concerns, much less have in place suitable reception amenities in and around them to receive, process and dispose of such waste streams

in a safe and ecologically-efficient manner. Cost considerations (initial capital and subsequent recurring costs entailed) seem to weigh in their decision-making against having robust infrastructure and auxiliary services. This is somewhat ironical considering that several ports are being run quite profitably, over time. This does not augur well for India's commitment to its obligations under the MARPOL. This also does not do justice to its invaluable blue economy marine resources in proximity to its ports and even beyond within its EEZ area. It is expected that the major ports, which incidentally are owned by the Government of India, and are now due to be corporatized, should take the lead in this critically imperative and exigent matter. A consortium approach among them may perhaps be one way forward in this direction.

To address these challenges, the Directorate General of Shipping, Government of India, as the Indian National Maritime/Flag Administration and National Maritime Assistance Service, has recently issued a circular mandating that both ship generated wastes as well as land generated wastes in and around the ports must be handled on an environmentally robust mode and in an integrated manner and hence should be in compliance with jurisdictional municipal and other applicable regulations thereto. This is a sequel to the directive issued by the Central Pollution Control Board, Ministry of Environment, Forest and Climate Change, Government of India, in pursuance of its 'Final Report of Monitoring Committee on Management of Hazardous Waste' of July, 2019, calling upon the authorities concerned to set up such facilities within one year.

This has been followed up by an associated initiative of the Directorate General of Shipping, Government of India, leading to the creation of an online portal known as 'Swachh Sagar' dedicated for port reception facilities in India. This centralized web platform captures information about the inventory of ship generated wastes onboard in respect of all Indian flag ships, as also foreign flag vessels, every time that they come calling at any Indian port, anchorage, roadstead, etc. Such data, including complaint (s) about the non-availability of shore reception facility (ies) in a given port or an inadequate service delivery thereof, is needed to be filled in by ship masters (and required to be ensured by ship owners) in the said portal, regardless of whether such a vessel needs port reception facility (ies) or not.

The aforesaid measures are anticipated to enable Indian ports to generate an effective, efficient and transparent port reception and service delivery institutional mechanism. However, if this paradigm is to succeed, it is imperative that there ought to be in place robust infrastructure, close coordination and sensitization among stakeholders and suitable monitoring thereof on an ongoing basis.

Chapter 6

Blue Economy, Industry 4.0 Technologies, and Market Trends

Vijay Sakhuja, Member, FICCI Taskforce on Blue Economy and Former Director, National Maritime Foundation

There is a symbiotic relationship between the sea and technology. Wooden boats propelled by oars and later by sails, lengthened into ships for undertaking long-distance voyages and provided with a rudder for greater manoeuvrability, were emblematic of some of the maritime technological transformation in earlier times. Mariners had also used a variety of instruments made of wood and metal including a magnetic compass to navigate along the coast and across the seas making voyages safe and predictable against the forces of nature.

In modern times, scientific and technological advancements have been the feature of maritime-industrial revolutions. The First Industrial Revolution featured water–coal–steam as the primary driver for industrialization, manufacturing, and transportation leading to steam propulsion for ships. The Second Industrial Revolution harnessed electric power to facilitate mass production and internal combustion engine that found place onboard ships. The Third Industrial Revolution or the Digital Revolution led to ships equipped with electronic devices and sensors. The maritime industry is now transitioning to the Fourth Industrial Revolution (4IR) which is referred to as Industry 4.0.[1] It is tethered to the Third Industrial Revolution technologies but is exponential and marked by rapid disruptions.

While the above are some of the markers of maritime technological transformations, the seas too have experienced resource revolution. From being only a source of food (fish and salt) and means of transport, seas have turned into providers of a variety of goods (living and non-living resources) and services (tourism, environmental-ecological services, carbon sink, etc.). The estimated value of the global ocean economy is between US $ 3 and 6 trillion annually and over 3 billion people are connected to the oceans for livelihoods.[2]

At the theoretical level, the concepts associated with the use of the seas and oceans are under transformation. For instance, the concept of sea power lasted nearly a century.[3] It went through a major metamorphosis in the last century and came to be labelled as maritime power due to the widespread use of seas for politico-diplomatic engagements, strategic contestations, economic purposes, and technological developments.[4] In the 21st century, it is fair to argue that the concept of maritime power is under mutation and can be labelled as blue power epitomized by the blue economy. The World Bank defines blue economy as 'sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem.'[5]

1 Acatech. n.d. Towards the fourth industrial age. Details available at https://en.acatech.de/project/industrie-4-0/, last accessed on August 26, 2020. The term 4IR is referred in the high-tech strategy of the German government presented at the 2012 Hannover Fair by Siegfried Dais (Robert Bosch GmbH) and Henning Kagermann (Acatech)

2 United Nations Conference on Trade and Development (UNCTAD). n.d. Oceans economy and fisheries. Details available at https://unctad.org/en/Pages/DITC/Trade-and-Environment/Oceans-Economy.aspx#:~:text=The%20value%20of%20the%20global,the%20oceans%20for%20their%20livelihoods, last accessed on August 28, 2020

3 Rear Admiral Alfred Thayer Mahan, United States Navy, through his most famous work, The Influence of Sea Power Upon History 1660-1783 (Boston: Little Brown and Co., 1918) propounded the concept of Sea Power.

4 Sakhuja, V. 2011. Asian Maritime Power in the 21st Century: Strategic Transactions China India and Southeast Asia. Singapore: ISEAS, pp.17–24

5 The World Bank. 2017. What is the blue economy. Details available at http://www.worldbank.org/en/news/infographic/2017/06/06/blue-economy, last accessed on August 26, 2020

However, human knowledge about oceans is still very limited and requires deeper study so that this last 'reservoir of resource wealth' can be used sustainably. Significantly, the underwater domain is the least explored and 4IR technologies can help to scientifically collect knowledge of the material and mineral capital of the seas and oceans and the ecosystem services provided by this large body of water.

Maritime-related industries and businesses are marshalling 4IR technologies such as artificial intelligence (AI), machine learning (ML), Big Data, blockchain technology, Internet of Things (IoT), robots, drones, digital twinning, and additive manufacturing (AM) or 3D printing to harness the wealth and services of seas and oceans. In this context, this paper illustrates the role of 4IR technologies in the development of the blue economy. It argues that these technologies will be at the core of the future of the blue economy. The paper also provides the details of the current market size of some of the 4IR technologies.

Autonomous Vessels

At the heart of the 4IR is artificial intelligence and it is driving innovation in all facets of maritime activity. AI-enabled autonomous vessels are under development and these are expected to enhance efficiency, reduce downtime through preventive–predictive maintenance, and harmonize ship operations with the supply chains ashore. Furthermore, these vessels will reduce onboard personnel and their living spaces can be repurposed for cargo. It is also hoped that smart vessels would reduce ship accidents at sea which in most cases are attributed to human error.

However, experts are divided over the introduction of smart vessels and believe that the human factor cannot be left out of the ship operations. The International Maritime Organization, the specialist arm of the United Nations, has labelled AI-enabled autonomous vessels as Maritime Autonomous Surface Ships (MASS) and identified four degrees of autonomy in ships.[6]

Several projects connected with MASS are currently under development. For instance, Kongsberg Maritime, a Norwegian company is building an autonomous electric-powered vessel, Yara Birkeland.[7] It is capable of carrying 100–150 shipping containers and the first voyage is expected by the end of 2021. Similarly, another Norwegian company Massterly has announced plans to launch a complete value chain for autonomous ships, from design and development, to control systems, logistics services, and vessel operations.[8] The European Commission is funding a collaborative project titled MUNIN (Maritime Unmanned Navigation through Intelligence in Networks) 'to develop and verify a concept for an autonomous ship, which is defined as a vessel primarily guided by automated on-board decision systems but controlled by a remote operator in a shore side control station.'[9]

The market trends for autonomous ships are quite promising and this segment is "projected to reach USD 13.8 billion by 2030, at a Compound Annual Growth Rate (CAGR) of 7.00% from 2018 to 2030.'[10] In terms of

[6] International Maritime Organization. 2018. IMO takes first steps to address autonomous ships. Details available at http://www.imo.org/en/MediaCentre/PressBriefings/Pages/08-MSC-99-MASS-scoping.aspx, last accessed on August 28, 2020

[7] Kongsberg. n.d. Autonomous ships equipment/products/systems. Details available at https://www.kongsberg.com/maritime/solutions/ship-types/autonomous-ships/?OpenDocument, last accessed on August 21, 2020

[8] Schuler, M. 2018. World's first autonomous shipping company established in Norway. Details available at https://gcaptain.com/worlds-first-autonomous-shipping-company-coming-to-norway/, last accessed on August 21, 2020

[9] Maritime Unmanned Navigation through Intelligence in Networks (MUNIN). n.d. **MUNIN project.** Details available at http://www.unmanned-ship.org/munin/, last accessed on August 21, 2020

[10] MarketsandMarkets. 2021. Autonomous ships market. Details available at https://www.marketsandmarkets.com/Market-Reports/autonomous-ships-market-267183224.html, last accessed on August 21, 2020

numbers, there could be nearly 1000 autonomously operated vessels by 2025, and as many as 2000 semi-autonomous vessels.[11]

Smart Ports and Supply Chains

Several major ports have begun integrating 4IR technologies. These ports are designated as 'smart ports' and use data-driven decision-making tools to improve operational efficiency. Industry experts believe that only smart ports will survive.[12] The future global market for the smart port segment is projected to touch USD 5.3 billion by 2024 from an estimated USD 1.7 billion in 2019, at a CAGR of 25%.[13]

Smart ports also use blockchain technology which helps in bringing numerous nodes into the supply chain. Multiple stakeholders including customs and port authorities can access and share data which makes the shipping industry more transparent, efficient, and secure. The blockchain segment (control over the information, privacy of the user, and prevention of manipulation of data) in the smart port ecosystem is expected to be the fastest-growing market from 2019 to 2024.[14]

Bigdata and Cloud Computing

Oceans and seas are perhaps the largest producers of data. Ships, offshore platforms (oil and gas, and wind, wave, and tidal energy), ocean observations, scientific studies concerning environment–ecology–marine biodiversity, weather, etc., generate colossal amounts of structured and unstructured data which are collected by humans as well as recorded by machines. These data are characterized by 5Vs, i.e., volume scale (data generated and collected); velocity (rapidity and time); variety (heterogeneity in data types, formats, structure, and data generation); veracity (quality of the data), and value (value obtained from processing and mining big data).[15] It is estimated that the maritime industry 'generates roughly 100–120 million data points every day, from different sources such as ports and vessel movements.'[16] The global Bigdata market is expected to grow from USD 138.9 billion in 2020 to USD 229.4 billion by 2025, at a CAGR of 10.6% during the forecast period.'[17]

The traditional data management infrastructure is insufficient to deal with the 5Vs and the solution lies in the Bigdata information system. It comprises a cloud platform, data processing and analysis, and Bigdata standardization. For instance, the Global Fishing Watch (GFW) and Ocean Data Foundation (ODF) have announced a common mission to harness and openly share new data and technology to advance the understanding and stewardship of oceans and their resources and develop new methods for combining

[11] International Chamber of Shipping. n.d. Seafarers and digital disruption. Details available at https://www.ics-shipping.org/docs/default-source/resources/ics-study-on-seafarers-and-digital-disruption.pdf?sfvrsn=3, last accessed on August 21, 2020

[12] Bold Business. 2018. How the fourth industrial revolution is impacting ports of the future. Details available at https://www.boldbusiness.com/digital/fourth-industrial-revolution-impacting-ports-future/, last accessed on August 21, 2020

[13] MarketandMarkets. 2021. Smart ports market by technology (IoT, blockchain, process automation, artificial intelligence (AI)), elements (terminal automation, PCS, smart port infrastructure, and others), throughput capacity, port type, and region – global forecast to 2024. Details available at https://www.marketsandmarkets.com/Market-Reports/smart-ports-market-165784113.html#:~:text=%5B141%20Pages%20Report%5D%20The%20global,25.0%25%20during%20the%20forecast%20period, last accessed on August 29, 2020

[14] Intrado Globe Newswire. 2019. Worldwide smart ports market insights (2019–2024): Big data analytics, IoT, and AI to transform port operations. Details available at https://www.globenewswire.com/news-release/2019/08/08/1899479/0/en/Worldwide-Smart-Ports-Market-Insights-2019-2024-Big-Data-Analytics-IoT-and-AI-to-Transform-Port-Operations.html, last accessed on August 26, 2020

[15] Sheriff, S. 2019. Understanding the 5Vs of big data. Details available at https://acuvate.com/blog/understanding-the-5vs-of-big-data/, last accessed on August 29, 2020

[16] Trelleborg. n.d. Use of big data in the maritime industry. Details available at https://www.patersonsimons.com/wp-content/uploads/2018/06/TMS_SmartPort_InsightBee_Report-to-GUIDE_01.02.18.pdf, last accessed on April 10, 2020

[17] Marketsandmarkets. 2020. Big data market worth $229.4 billion by 2025. Details available at https://www.marketsandmarkets.com/PressReleases/big-data.asp, last accessed on August 31, 2020

and visualizing big ocean data, and complementary technology solutions that make open data sources easy to use and share, in support of better science and management of the ocean.[18] GFW's vessel detection capability and ODF's ability to collect ocean environmental data generate actionable information that helps in ocean governance.

As far as cloud computing is concerned, the cloud-based management tool facilitates monitoring of various operations such as shipping, vessel management, shipbuilding progress, port operations, supply chain management, etc. Cloud computing services help in storing data securely, which allows industry executives to understand and address market and operational risks effectively.[19] For instance, the United Arab Shipping Co. has a fleet of 70 vessels, and cloud-based management systems and tools helped the company save on bunker fuel costs by 3–5%.[20] Cloud computing is also an integral part of MASS given that these vessels use enormous amounts of data from numerous sources including onboard navigation systems to detect, identify, and track objects as well as monitor various machinery and other systems.

The Cloud System Management Market **by component** is expected to grow from USD 10.6 billion in 2020 to USD 31.4 billion by 2025, at a CAGR of 24.1%.[21]

Digital Twinning and Predictive Maintenance

Maritime platforms are inherently complex and comprise machinery, systems, sensors, and devices. These require constant monitoring to ascertain the health and performance of the equipment or a machinery part through embedded sensors. Digital twinning is a process in which a physical object is digitally mapped, mirrored, and continuously monitored using data from sensors fitted in the equipment. It is now possible to create a 'digital twin' of a ship or an offshore platform. Also, when connected to the shore it helps in obtaining real-time performance or parameters of various onboard machinery or systems. It also helps in predicting breakdowns before the equipment fails, and enables remedial measures through replacements and repair, thereby enhancing operational efficiency.[22]

Liv A. Hovem, CEO, DNV GL - Oil & Gas has observed that 'a single, unscheduled downtime event can cost from $2 to $5 million per day – thus, better and up-to-date risk information may significantly reduce unplanned or unnecessary downtime.'[23]

As per the findings of a report on digital twinning market trends, up to 89% of all IoT platforms will contain some form of digital twinning capability by 2025; digital twinning will become standard feature/functionality for IoT Application Enablement by 2027; over 92% of vendors recognize the need for IoT APIs (application program interface), and platform integration with digital twinning functionality for industrial verticals, and; nearly 36% of executives across a broad spectrum of industry verticals understand the benefits of digital twinning and 53% of them plan to incorporate within their operations by 2028.[24]

[18] Woods, P. and M. L. Mathiesen. 2020. New partnership aims to build a better understanding of the ocean. Details available at https://globalfishingwatch.org/news-views/new-partnership/, last accessed on April 25, 2020

[19] Sakhuja, V. 2018. Maritime digital trends in 2018. Details available at http://www.ipcs.org/comm_select.php?articleNo=5417, last accessed on August 23, 2020

[20] Mishra, B. 2020. Shipping and maritime industry powered by cloud computing. Details available at https://seanews.co.uk/features/shipping-and-maritime-industry-powered-by-cloud-computing/, last accessed on August 31, 2020

[21] MarketsandMarkets. 2020. Cloud system management market worth $31.4 billion by 2025. Details available at https://www.marketsandmarkets.com/PressReleases/cloud-system-management-software.asp, last accessed on August 31, 2020

[22] Sakhuja, V. 2018. Maritime digital trends in 2018. Details available at http://www.ipcs.org/comm_select.php?articleNo=5417, last accessed on August 30, 2020

[23] Slater, N. J. 2019. DNV GL unveils concept for live asset risk assessment using digital twins. Details available at https://www.dnvgl.com/news/dnv-gl-unveils-concept-for-live-asset-risk-assessment-using-digital-twins-157142, last accessed on July 15, 2020

[24] Research and Markets. n.d. Digital twins market by technology, solution, application, and industry vertical 2020–2025. Details available at https://www.researchandmarkets.com/reports/5006128/digital-twins-market-by-technology-solution?utm_code=r84k6x&utm_medium=GN, last accessed on March 15, 2020

Additive Manufacturing

Several shipyards have set up AM facilities to support the construction of ships, offshore platforms, and other associated equipment. In particular, machinery spare parts for ships are being 3D printed. Some of the leaders in this technology are (a) Innovation Quarters, Havenbedrijf Rotterdam, RDM Makerspace and AEGIR-Marine, a consortium of 27 marine-related companies have established a project called '3D Printing of Maritime Spare Parts'; (b) China Shipbuilding Industry Corporation which plans to set up a 3D printing technology material manufacturing base in Kunming; (c) South Korea's Ministry of Trade, Industry and Energy which has decided to invest USD 20 million over 5 years (2017–2022) to research in 3D printing ships and offshore equipment; (d) 3D Scanning AS, a subsidiary of The Maritime Group of Norway, which has a partnership with 3Discovered of Chicago to supply 3D-printed parts to its cruise/maritime ship repair and retrofit service business; and (e) 3D Matters in Singapore, which is a well-established additive manufacturer.[25]

Marine Robotic Platforms and Vehicles

A variety of platforms and vehicles are used by scientists to help gain access deep into the ocean and seas to gather data and information about the complexity of the marine environment, seabed resources, and the behaviour of marine habitat. These platforms can be manned, autonomous, or tethered, and are characterized as manned and unmanned submersibles, autonomous underwater vehicles, and remotely operated underwater vehicles. Likewise, autonomous surface vehicles, as the name suggests, are used for operations on the surface of the water for inspection, monitoring, and search and rescue missions. In essence, both underwater and surface platforms help in a variety of operations at sea under the most hostile and treacherous conditions.[26] Robots and autonomous vehicles, through the use of artificial intelligence programs and machine learning, can automatically identify microscopic marine species. The global underwater robotics market size was estimated at USD 2.52 billion in 2017 and is expected to grow at a CAGR of 13.5% from 2018 to 2025.[27]

Communication and Data Centers

As noted earlier, the 4IR-enabled maritime ecosystem data exchange involves 5Vs and is critical for the optimal performance of 4IR technologies. It must necessarily have real-time access to cloud data, low latency, and be high on information security protection. In current times, 5G offers an optimal solution to the above requirements and a variety of devices, equipment, and machinery are connected through the internet facilitating access from multiple locations across the ecosystem. In 2017, the Port of Qingdao in China upgraded itself into a fully automated harbour featuring milli-second level end-to-end latency at a gigabit per second level speed.[28] An automated ship-to-shore crane in Port of Qingdao operated from the control centre successfully lifted a container by using a 5G connection.[29]

[25] Moltke, I. 2016. Maritime guide to 3D print. Details available at https://greenship.org/wp-content/uploads/2017/01/App-3DP.pdf, last accessed on August 31, 2020

[26] Schroer, A. 2019. AI Robots: How 19 companies use artificial intelligence in robotics. Details available at https://builtin.com/artificial-intelligence/robotics-ai-companies, last accessed on August 31, 2020

[27] Grand View Research. 2018. Underwater robotics market size, share & trends analysis report by type (ROV, AUV), by application (commercial exploration, defense & security, scientific research), by region, and segment forecasts, 2018–2025. Details available at https://www.grandviewresearch.com/industry-analysis/underwater-robotics-market#:~:text=The%20global%20underwater%20robotics%20market,13.5%25%20from%202018%20to%202025, last accessed on August 31, 2020

[28] 5G smart port system trialed at Qingdao. Details available at https://maritime-executive.com/article/5g-smart-port-system-trialed-at-qingdao, last accessed on August 5, 2020

[29] Ibid.

While speed is crucial, the volume of data is equally important. In future, billions of devices and networks could be transmitting zettabytes (ZB) of data and this would have to be warehoused in special storage called data centre. These centres must have a huge capacity with very high-performance capability and their location close to a cheap power source can make it more affordable.[30] Besides, these must be safe, secure, and reliable against seismic activity, flooding, and other types of natural disasters. Given that data centres generate huge amounts of heat these require cooling. For instance, Facebook has set up a data centre in the Arctic Circle; Microsoft is developing a pilot project for an underwater data centre (size of a shipping container) off the coast of Scotland, and; Keppel Data Centre and Toll Group in Singapore plan to install a floating data centre.[31, 32, 33]

Hyperloop-enabled Maritime Supply Chain

The maritime transport sector has been in a near-continuous revolution and in the coming days, ships capable of transporting 50,000 TEU (twenty-foot equivalent unit) in a fully autonomous mode will be a reality. These boxes will be loaded/unloaded at smart ports, transferred to trains and trucks, and last-mile deliveries could be done by drones. The containers would be pre-cleared by customs and it may be rare to see containers piled in ports for a long time. Plans are underway to connect smart ports' destinations on land through 'hyperloop' (first introduced in 2013 by Elon Musk). This would enable cargo/containers to move at very high speeds (600–800 miles per hour) and shrink travel time across destinations and supply chains. This is comparable with commercial aircraft but the hyperloop technology is expensive ($20 and $40 million per kilometre).

In Germany, the Hyperloop Transportation Technologies (HyperloopTT/HTT), a joint venture of Hyperloop Transportation Technologies and Hamburger Hafen und Logistik Aktiengesellschaft (HHLA), a container terminal operator in the Port of Hamburg, is developing a hyperloop transport system for seaport and inland shipping container operations. It will enable the movement of containers at high speeds using magnetic levitation in a partial vacuum tube to avoid traffic congestion and reduce the environmental impact of transportation.[34]

The top functionary of the HHLA, Angela Titzrath said, 'as a gateway to the future, we want to employ innovative approaches to make a contribution towards relieving the strain on the transport infrastructure in and around the Port of Hamburg and to use the capacities of our terminal facilities in an even more efficient way.'[35]

Likewise, India too has shown interest in hyperloop technology. Virgin Hyperloop One – DP World Consortium is the Original Project Proponent (OPP) for the Pune-Mumbai Hyperloop Project.[36] Under this project, Jawaharlal Nehru Port in Mumbai will be connected to Pune, a major economic and industrial zone, through a hyperloop.

[30] The future of data centers. Details available at https://www.cbinsights.com/research/future-of-data-centers/, last accessed on April 21, 2020

[31] That's really cool: Facebook puts your photos into the deep freeze as it unveils massive new five acre data center near Arctic circle. Details available at https://www.dailymail.co.uk/sciencetech/article-2054168/Facebook-unveils-massive-data-center-Lulea-Sweden.html, last accessed on April 21, 2020

[32] Mines, underwater, outer space – the weirdest data centers on Earth and beyond. Details available at https://datacenternews.us/story/mines-underwater-outer-space-the-weirdest-data-centers-on-earth-and-beyond, last accessed on April 21, 2020

[33] Keppel Data Centres partners with Toll Group and Royal Vopak to explore Floating Data Centre Park and LNG-to-power solutions in Singapore. Details available at https://www.kepcorp.com/en/media/media-releases-sgx-filings/keppel-data-centres-partners-with-toll-group-and-royal-vopak-to-explore-floating-data-centre-park-and-lng-to-power-solutions-in-singapore/, last accessed on August 21, 2020

[34] Wollenhaupt, G. n.d. Hyperloop cargo train pilot set for Hamburg port. Details available at https://www.supplychaindive.com/news/hyperloop-cargo-train-hamburg-port/543920/, last accessed on August 21, 2020

[35] Hyperloop Transportation Technologies and Hamburg port to explore hyperloop possibilities in new joint venture. Details available at https://www.eft.com/technology/hyperloop-transportation-technologies-and-hamburg-port-explore-hyperloop-possibilities, last accessed on August 30, 2020

[36] Natalucci, M. 2019India chooses DPW-Virgin Hyperloop One. Details available at https://www.porttechnology.org/news/india-chooses-dpw-virgin-hyperloop-one/, last accessed on August 30, 2020

The first phase could be operational by 2025. It will reduce the transport time to 35 minutes and will help reduce pollution in Mumbai city as well as bring over USD 36 billion with wider socio-economic benefits and manufacturing opportunities for the region.[37]

Biomimetic

Humankind has mimicked nature and learnt to jump, crawl, roll, and swim. It observed bats, birds, and insects, and through replication produced an aircraft. Scientists are now observing octopuses and developing robots with arms (electrical motors) and clutch (pneumatic valves) like their tentacles. Similarly, jellyfish is being mimicked to make devices (bionic jellyfish by embedding microelectronics) to explore underwater life. Scientists also plan to embed miniaturized sensors and cameras on marine life and undertake long-term measurements of ocean conditions such as temperature, salinity, acidity, oxygen levels, nutrients, and microbial communities and monitor signs of climate change or observe natural phenomena.[38]

A French start-up has developed a device that can measure (24/7) the water quality and provide parameters such as temperature, dissolved oxygen, pH, salinity, turbidity, and chlorophyll, and these help in forecasting the condition of the water.[39] NASA scientists successfully copied 'microscopic patterns of dentricles' of shark's skin, which reduces drag and deters microorganisms (such as algae) attached to the surface.[40] Its uses in the development and utilization as coatings for ships' hulls, submarines, and even swimwear for humans are being explored.

Human Resources

The 4IR-led technological advancements require a workforce with new skills which currently is quite insufficient. The International Labour Organization has acknowledged that the demand for specialized and highly skilled crews will increase as the sector moves towards more digital operating systems on vessels.[41] China-based Tencent Research Institute has estimated that there are roughly 300,000 AI researchers and practitioners worldwide, with the market demand for millions of roles.[42] The international 4IR technology community is looking towards India and China who are the largest non-US suppliers of technology professionals and international students in AI-related fields.

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37 Ibid.

38 This is why bionic jellyfish are the latest environmental tool for scientists. Details available at https://www.weforum.org/agenda/2020/02/bionic-jellyfish-ocean-measurements/, last accessed on August 28, 2020

39 Underwater weather station nets €1.5m funding. Details available at https://thefishsite.com/articles/underwater-weather-station-nets-1-5m-funding, last accessed on June 10, 2020

40 Skin reduces biofouling. Details available at https://asknature.org/strategy/skin-reduces-biofouling/#.Xk5Jl5UzZ0w, last accessed on February 15, 2020

41 Bhardwaj, S. 2013. Technology, and the up-skilling or deskilling conundrum. WMU Journal of Maritime Affairs 12(2): 245–253. Cited in "Recruitment and retention of seafarers and the promotion of opportunities for women seafarers. Details available at https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/meetingdocument/wcms_664163.pdf, last accessed on August 24, 2020

42 A magnet for overseas talent, US might lose AI race if restrictive immigration policies remain, says report. Details available at https://www.scmp.com/tech/policy/article/3027672/magnet-overseas-talent-us-might-lose-ai-race-if-restrictive-immigration, last accessed on August 24, 2020

Conclusion

There are numerous practical uses of 4IR technologies in multiple sectors of the blue economy such as shipping, ports, shipbuilding, onboard operational and technical management and automation, maritime supply chains, and human resource management. The 4IR technologies for maritime operations are at different levels of maturity, i.e., some are just at the conceptual stage, many are at the experimental level or demonstration stage, and some have been developed and are in operational use. These will potentially change the way operations at sea–underwater–littoral–land are conducted and would also have a dramatic impact on the future growth of the blue economy.

Chapter 7

Role of science, technology and innovation in Blue economy

The Energy and Resources Institute

As populations around the world expand, our coastal and marine environments are becoming a very significant means for global economic development to the extent that the oceans have been labelled the 'economic frontier', which is still largely unexplored. However, as over 3 billion people depend on coastal and marine ecosystems for their livelihoods, either directly or indirectly, unregulated economic activities occur that cause notable damage to the oceanic environment. Science and technology will lead in determining new sources for growth, while innovations will aid in gaining access to new resources and spaces for development. The vast resources of the world's oceans can only be harnessed if countries develop the technological means of doing so. Within the Indian Ocean, this still is a challenge for the countries of the region to achieve (Mostaque 2020, OECD STI policy note 2019).

Capacities for developing and guiding the processes of science, technology, and innovation (STI) are seen by the World Bank as a tool for countries to achieve their foremost objectives for social and economic development (Schwachula et al. 2014). The policies of governments in terms of science and research greatly impact business development and marine preservation, and, additionally, are critical in ocean stewardship, regulation, and management. For effective performance across these areas, it becomes necessary for the policies to be evidence-based and coherent, the supporting evidence for which could be obtained by advancing economic measurement and monitoring of the oceans (OECD 2019).

India is undertaking efforts to develop a blue economy framework and this step requires consistent developments and investments in the science and technology domain of the blue economy sectors including fisheries, shipping, deep sea mining and blue biotechnology among others. The increasing thrust to enhance emerging sectors in blue economy would require consistent and rapid improvements in India's S & T framework, and align strategies and policies for a conducive environment for innovation to thrive. This paper discusses the role of S & T in the blue economy sectors, technological advancements, challenges, and opportunities for innovation in the sectors.

Overall current role

An estimated 3 billion people over the world depend on the marine and coastal systems directly or indirectly for livelihood generation (Senaratne 2017). The ocean economy has to harnessed sustainably by using clean technologies that will ensure the economic and social needs of the people without damaging the planet. This would include traditional as well as new and emerging ocean industries, and also incorporate services provided by water ecosystems for which markets do not exist, such as carbon sequestration, coastal protection, waste disposal, and the existence of biodiversity. In Blue economy, science, technology and innovation play the role

of shifting the society, from scarcity to abundance based on existing resources. Science and technology will have to search for new sources of growth, while innovative advances will make new resources and spaces accessible for development. The first requirement for successfully exploring the oceans and for a sustainable ocean economy is to know about it more thoroughly, for which there is a need for data about the oceans (Attri 2016; BE-IORA; IORA, 2020).

Another major role of STI is its use in stimulating improvements in efficiency, productivity, and cost structures in the ongoing oceanic activities. Within the ocean economy, STI is most popularly utilized in blue biotechnology, where it plays an important role in the extraction of marine species, which are then applied to a number of other sectors to yield high economic returns (Ninawe and Indulkar 2019). The ocean environment is still a largely unexplored area where new compounds can be found with the potential to be used in novel drugs, health, nutraceuticals, and personal care products. STI also has wide applicability in bioremediation of ocean pollutants, developing cost-effective and non-toxic antifouling technologies in the shipping sector, and in the renewable energy sector (PSA to GOI 2006).

Evolution of S & T in India - From Past to Present

Over the past few decades, India has sought to prioritize reducing dependence on foreign technology through indigenous innovation. Security concerns about neighbouring countries and protecting the coastline make development of dual-use technologies a high priority. Ever since India become independent in 1947, the Planning Commission has issued five-year plans, each of which contains an important section on S&T. The five-year plans identify detailed research foci and envisioned outcomes for 16 sectors with the greatest proposed national laboratory funding (PSA to GOI 2006).

India's ocean economy initiatives mostly consist of port facilities and building partnership with many of its neighbours. The country has also generated significant revenue from marine biology and biotechnology (Rao and Griffths 1998). The Indian Department of Biotechnology is also under the process of setting up institutes for research and development of oceanic resources. The Ministry of Shipping has started using IT-enabled services extensively for its port-led development programmes (Ninawe and Indulkar 2019). Additionally, under the 'sagar-mala' initiative, it is assisting Africa in increasing its maritime capabilities (PSA to GOI 2006).

"Technology Vision 2020," a strategy document prepared by the Technology Information, Forecasting and Assessment Councils of Department of Science & Technology has identified key programmes under the 11th five-year plan: Space (development of satellite launch capabilities and critical technologies required for manned missions), Biotechnology (stem-cell, animal, and plant biotechnology), Ocean (coastal protection, ecosystem modelling and marine ecotoxicology), Atomic Energy (improve nuclear capacity, enhance competitiveness of nuclear energy), Pharma (drug discovery) and improvement of basic and rural infrastructure (DST, 2007).

Modern India has had a strong focus on science and technology, realising that it is a key element for economic growth (DST, 2007). India has moved forward in the S & T sector, however R&D in several sectors, including oceans, is still largely conducted by government and autonomous agencies with limited private sector investments. Additionally, India still has a long way to achieve in the areas of patents and data gathering in the ocean perspective in comparison to developed countries such as the USA and EU among others.

Major policies and initiatives in Blue economy

The Indian Ocean is projected to become a dominant global geopolitical and economic force in the 21st century. Indeed, the region's contribution to the global GDP has significantly increased over the last century from an average 6% to 7% in 1980 to 10% or USD 78 trillion in 2014. Owing to limited land resource base, many of the coastal and island Indian Ocean Rim Association countries (IORC) are dependent on marine resources for economic opportunities. Therefore, pursuing the goals of blue economy would be critical to the region's prosperity and development (Attri, 2016; IORA, 2020, BE-IORA).

With a coastline of above 7500 km, encompassing 12 major and 187 non-major ports, it becomes necessary for India to tap the enormous potential of ocean-based blue economy, which will propel the nation into a higher growth trajectory. The development of blue economy can serve as a growth catalyst in realizing the goal to become a $10 trillion economy by 2032 (DST, 2007).

Great potential for employment generation is envisaged in fishery and aquaculture, novel marine products, mineral resources, renewable energy resources, and port-based activities. The Sagarmala project, launched by the Ministry of Shipping, is the strategic initiative to maximize economic and trade potential for port-led development through the extensive use of IT-enabled services for modernization of ports. This industry has a high multiplier effect on investment and along with its large number of associated industries can accelerate industrial growth (DST, 2007). The draft blue economy policy by Ministry of Earth Sciences (MOES), shared in early 2021, when finalized would be an integrated policy to deal with ocean issues. Several other policies related to ports, ship recycling have been adopted in the past two years to strengthen India's' blue economy initiative.

Emphasis is also placed on international relations and security. Majority of maritime trade between the West and the East is done through the Indian Ocean region (IOR). The increasing naval activity in the IOR region through joint naval exercises with many of the IOR regional countries as well as with other maritime powers highlights India's increasing emphasis on ensuring readiness in international relations and security. The increasing emphasis on naval readiness also highlights the increasing importance of the Indian Ocean and the rising focus on joint cooperation as the critical focal point for regional cohesiveness. India's increasing strategic presence in the Indo-Pacific region is coupled with increasing international collaborations in Science and Technology domain. The Indo-Pacific has emerged as a major interface for scientific collaboration and fostering innovation. For instance India and the USA are making efforts to engage with Indo-Pacific countries in the areas of renewable energy. In the past decade, joint or bilateral scientific research collaborations have increased exponentially in India that focus on specific mutual research interests such as the Indo-German Science and Technology Centre.

At the regional level, framework and mutual cooperation to deter illegal activities that directly impact and degrade ocean health is imperative. India requires a coordinated approach among stakeholders in the region in combating issues such as the rise in Illegal, Unregulated, and Unreported (IUU) fishing, narco-terrorism, human trafficking. These needs to be tackled by strengthening transoceanic partnerships and developing a synchronized strategy for a way forward (Indian Navy, 2016; DST, 2007; NMSP).

Science and Technology across different impact sectors

Science and technology play an important role in all the sectors of blue economy. With rising instances of climate change in the marine environment, technology and innovation provide a chance to deeply understand the changing ecosystem and find solutions. Assessing oceanic resources and understanding the various complexities of its ecosystem are the initial steps in helping to reduce the risk of critically damaging or exhausting marine resources. In such a case, technology and innovation will play a key role. Ocean mapping is one such example and already many technology and innovation projects are in various stages of development and execution worldwide. Technology supporting real time data analysis, GIS mapping, data visualizations are integral part of such projects that ultimately support sustainable development of various sectors related to oceans, especially shipping, energy, logistics, fishing industries, and even offshore energy.

India's investment in science and technology has also been increasing in the past few years and in the sectors related to ocean economy, yet the gaps in financing and investment are evident and vast in comparison to other sectors and countries. India has the third largest Science and technology (S & T) manpower in the world but the gross domestic expenditure on R & D stood at 0.65%, according to Economic Survey 2021. In 2020, India ranked 48 in the Global Innovation Index, highlighting the miles that it needs to achieve in the sector.

Fisheries and Aquaculture

The fisheries sector is a major sector of blue economy and India is the third largest fish-producing country and the second largest aquaculture fish producer in the world. India contributes about 7% to the global fish production. The country is also home to more than 10% of global fish biodiversity and is one of the 17-mega biodiversity-rich countries (NFDB 2020). Further with advancement in fishing technology, the demand for fishery is increasing due to it being a source of food and livelihood. The marine fisheries potential is estimated at 5.31 million tonne as against the production of 4.17 million tonne during 2018–19 and its activities are spreading along the country's vast coastline. Besides, India is also bestowed with varied inland fisheries potential resources in the form of rivers and canals (1.95 lakh km), floodplain lakes (8.12 lakh ha), ponds and tanks (24.1 lakh ha), reservoirs (31.5 lakh ha), brackish water (12.4 lakh ha), saline/alkaline-affected areas (12 lakh ha), etc. with the current estimated fish production potential of about 17 million tonne as against production of 9.58 million tonne during 2018–19 (NFDB 2020).

Different kinds of techniques are used for fishing. For example in artisanal fishing, fishing gears are used that include boats, motors, nets, and lines (Bhilave 2018). Among the traditional techniques of fishing, gears, gillnets, drift nets and bag nets of different mesh sizes are widely used across the coastal states of India. Bottom trawlers up to 13 m Over All Length (OAL) are operated along the entire coast, while the second-generation large trawlers 13-17 m are operated from selected harbours (Pillai and Katiha 2004). There are 1332 fish landing centres in India, 6 major fishing harbours, 27 minor fishing harbours, 58911 mechanized vessels, 75591 motorized vessels and 104270 non-motorized vessels (CMFRI 2012). The Indian fishing sector has shown a shift towards mechanization in the recent past.

In the last two decades, the use of non-mechanized boats has dropped sharply while there has been a significant increase in motorized and mechanized boats. Development of harbours and landing jetties, motorization of artisanal crafts and the rapid expansion of mechanized fishing have contributed towards a significant increase in fish production, employment generation and revenue earnings (NCAP 2003).

Table 1 Number and growth of non-mechanized, motorized and mechanized fishing fleet in India

Year	Non-mechanized		Motorized		Mechanized	
	Number	Growth Rate (%)	Number	Growth Rate (%)	Number	Growth Rate (%)
1961–62	90424	-	-	-	-	-
1973–77	1064800	18	-	-	8086	-
1980	137000	29	0	0	19013	135
1998	160000	17	32000	0	47000	147
2003	76596	-52	50922	59	49070	4
2005	104270	36	75591	136	58911	25
2010	50618	-51	71313	-6	72559	23

Source: Sathiadas and Salim (2012)

Aquaculture is also a fast-growing sector in the blue economy and has shown more than six-fold increase in the past two decades. Freshwater aquaculture with a share of 34% in inland fisheries in the mid-1980s has increased to about 80% in recent years (Jayasankar 2018). The technologies of induced carp breeding and polyculture in static ponds and tanks have brought about remarkable upwards trend in aquaculture productivity and made the sector into a fast-growing industry. There have been technological developments both for fish seed development and for production of aquaculture. The different technologies for seed production include eco or circular hatchery or collection of spawn from natural abode, raising the spawn to fry in nursery ponds, and rearing of fry to fingerlings in ponds. The major freshwater culture technologies may be classified as polyculture of Indian carps, mono-and polyculture of air-breathing fishes, mono- and polyculture of freshwater prawns, integrated fish farming, cage culture, pen culture, and pearl culture (NCAP 2003). The recent inclusion of aquaculture in India's' financial budget resonates the growing importance of this sector; however, future investments should be based on sustainability principles and to conserve the ocean's aquatic life with responsible harvesting of fish and fish products.

Marine Biotechnology

Marine biotechnology has an important role in the extraction of marine species which then find application in a number of sectors including biotechnologies, nanotechnology, biomaterials, and the introduction of genetically modified fish in the Aquaculture sector having high economic returns (Ninawe and Indulkar 2019). It has been projected that India will generate USD 100 million by 2025 from biological and bio-technology industrial growth. Though the 'Sagar Mala' programme focuses on development of maritime infrastructure, it will have significant spin off benefits for marine biotechnology sector as well. India is looking towards deep sea mining and deep sea exploration for biological materials that could prove significant for several sectors including pharmaceuticals and beauty industries.

Offshore energy sources

Science and technology has an important role in exploring offshore energy sources. Technologies related to harnessing wind, wave and even hybrid energy from oceans like Ocean Thermal Energy Conservation (OTEC) help reap benefits of oceanic energy. In the National Offshore Wind Energy Policy released in 2015 by

Government of India, some of its key objectives were to explore and promote offshore wind energy in EEZs of the country, promote investment in energy infrastructure, promote R&D in offshore wind energy sector, and facilitate deployment of Project EPC (Engineering, Procurement, and Construction) and Operation and Maintenance concerning the offshore wind industry (Gulia and Jain 2019). Still to take strides in the offshore wind sector, India intends to establish wind farms in the coast of Gujarat and Tamil Nadu, and the plans are yet to be set in motion.

Shipping and Ports

The shipping and port industry is incorporating more and more science-based technologies and IT-enabled services (Mostaque 2020). The government has signed several MoUs with countries such as Korea and Egypt for cooperation in the development of ports, sharing of technology, manpower training, and stimulating the steady growth of maritime traffic (Dasgupta 2018). The digitization of various processes in both the major and the non-major ports has enabled seamless coordination in the logistics while ushering in the regulation of activities at various container freight stations (CFSs), inland container depots (ICDs), and port terminals. The technology has indeed induced transparency in the various processes while lowering their costs. India has to adhere to IMO 2020 obligations. It has also signed on the Hong Kong convention that requires it to enhance technological adoptions and sustainable innovation in the shipping sector. Under the new Maritime India Vision 2030, the focus would be to enhance ports in conjunction to India's blue economy initiative. The Vision looks towards intelligent port systems with significant focus on data-based analytics and tools for operations.

Harnessing Technological Solutions for Blue Economy Sectors

Other technological instruments such as acoustics, optics, and radars are also extensively used in extracting data and potential of various resources from oceans. Remotely Operated Underwater Vehicles, Satellite Oceanography, GIS, SONAR and Animal Telemetry, among others, also help in mapping varied ocean resource base. India has the status of pioneer investor and has been allotted a site in the Central Indian Ocean Basin (CIOB) by the International Sea Bed Authority (ISA) for exploration and technology development for polymetallic nodule mining. Development of reliable deep-sea mining system for harnessing resources from ocean will help to meet the country's growing mineral requirements and increase the country's self-sufficiency in the near future (MoES 2015). India launched the Deep Ocean Mission in 2021 and in early 2021, the National Institute of Technology sent their deep ocean crawler for 6 -km dive to test the vehicle for future readiness. With a 4000 crore budget for five years, spanning 2021-2026, India is set to make significant strides in the deep ocean domain.

S&T Budget and Investments in Blue Economy

Investment in marine technology and research is imperative to build a foundation for a sustainable blue economy. Sustained and cost-effective investment in blue economy is required urgently. However, both the availability and the allocation of budgets for ocean sciences and technology vary across countries wherein developed countries have allocated higher share of their budget to science and technology. Investments in marine science and technology are overall less compared to other major fields of research in developing countries. Globally it has been estimated that only 1.7% of the national budget is allocated to ocean sciences and technology. The survey of various countries estimating the ocean science budget by UNESCO indicated that out of a total of 24 countries, 14 countries had increased their budget allocations for marine science

and technology between 2013 and 2017. The Russian Federation had the highest annual growth with more than 10%, followed by the UK and Bulgaria. However, 10 countries including Japan, the USA, Brazil and Italy have decreased their ocean science and technology budgets drastically. Overall, the USA reports the highest institutional funding for ocean activities. In 2016, more than USD 12 billion was allocated to ocean activities. Followed by the USA, Japan allocated USD 600 million to ocean activities and Australia allocated USD 511 million in 2017 (UNESCO 2020). However, such assessments for India have not been done yet. The various indicators under the SDG14 (Life Under Water) that represent any budget allocation to marine sciences and technology are currently under compilation by the authorized ministry.

UNCTAD recorded in 2019 that overall, ocean sustainability projects have received just USD 8.3 billion in grants from philanthropic donors and USD 5 billion in financing from development banks which is insufficient to manage the USD 3 trillion per year valued ocean-based economy. Public sector financing contributes 70% of the total financing for ecosystems and biodiversity (UNCTAD 2019). Though private capital commitments showed an increasing trend between 2004 and 2015, but many opportunities still remain untapped. Therefore, the major sources of funding for blue economy have been ODAs and philanthropy grants till now. In the past 10 years, philanthropy has the maximum share in the funds, followed by ODA globally (WEF and FOA 2020). A total funding of USD 8 billion has been received through philanthropy and USD 5 billion from ODAs in the past one decade. However, this funding is not enough to fund even the conservation and sustainability activities of the sector (WEF and FOA 2020). Therefore, investment is not just required to sustain oceans but also for certain regulatory, market, and physical risks associated with current levels of unsustainable activities in blue economy. This is applicable for investments in marine technology and innovations as well. However, in the past few years the role of the private sector has increased in the overall funding for ocean activities.

It has been estimated that from the USD 500 million allocated to ocean-related activities and projects, around USD 150 million were spent on more than 1000 marine science projects globally. In the past few years, the private sector has contributed around USD 668 million to marine science and technology through granting support to more than 6000 projects. In 2019, only around USD 200 million was invested in marine energy globally while this was around USD 700 million in 2007 and USD 400 million in 2014 (IRENA 2020).

Investments to science and technology have been significant in India and numerous efforts have been taken to deepen the knowledge base on ocean sciences. Around ₹5500 crore were budgeted for science and technology in the Union Budget 2019–20, which increased to ₹6,300 crore in 2020-21 (MoST 2020). As the scope of blue economy is spread across many sectors, the budget allocation varies across different ministries. Table 2 summarizes the overall budget allocated to various blue economy sectors. This list is representative of public sectors funds at the centre only and does not include any intergovernmental, bilateral or multilateral agency funds or any private sector funding or any state-level budgets.

*This includes Oceanographic survey, Marine Living Resources, Central Sector schemes such as Ocean Services, Technology, Observations, Resources Modelling and Science (O-STORMS), Ocean services, Modelling, Application, Resources and Technology (O-SMART), and Oceanographic research and Other scientific research

Out of the budget allocated to the Department of Fisheries, particularly the Fisheries Institutes, that handle post-harvest technology and training, were allocated ₹140 crore in 2019–20 that increased to ₹150 crore in 2020–21 (MoFAD 2020). The total budget allocation to blue economy was ₹570 crore in 2020–21 which was an increase from ₹455 crore in 2019–20 and ₹410 crore in 2015–16.

Table 2 Budget allocated to various blue economy sectors through the different ministries

Ministry	Budget 2015–16 (in ₹Crore)	Budget 2019–20 (in ₹Crore)	Budget 2020–21 (in ₹Crore)
Agriculture and Allied Activities (Department of Fisheries)	410	805	825
Environment, Forests and Climate Change (National Coastal Management Programme)	100	95	103
Earth Sciences*	508	1700	2070
Shipping and Ports	1440	1900	1800
Tourism	1570	2190	2500
Total	4028	7590	7300

Source: Compiled by Authors

The National Coastal Management Programme under the Ministry of Environment, Forests and Climate Change is responsible for ensuring livelihood security of coastal communities, conserve, protect coastal stretches and promote sustainable development based on scientific principles. The Shipping ministry is responsible for developing ports, shipping and ship building, inland water transport and investments in public enterprises as well.

Other than these funds that are part of the budget allocated for ocean-based activities and research, budgets are also allocated at the state level. There are investments from the private sector and from CSR funds and other innovative financing tools. Though the role of the private sector has been limited but their share in funding science-based programmes has increased. Many private players, that are a part of this space, have developed strong expertise, by partnering with researchers to improve their science-based decision-making, respect regulations, and avoid negative environmental impacts on the ocean. The role of private foundations in funding ocean science projects is also increasing. In 2017, a total sum of USD 150 million was allocated to ocean science projects globally . Further, it has been estimated that private foundations and donors alone contributed around USD 668 million to various marine science and technology projects between 2013 and 2017 globally (UNESCO 2020).

Conclusion and Way Forward

There is a need to converge existing scientific developments in the blue economy sectors to map their impacts, trade-offs, and advantages to design the future course of action. Innovation and scientific development in one sector has domino effects on another sector. A critical assessment of the positive or negative impacts on the related sectors requires considerable research. A strong example is the role of ISRO in the development of deep ocean vessel. The vessel will be employing similar technologies utilized for space vehicles.

For instance, in recent years there has been an increase in studies to understand the interlinkages and trade-offs that occur in the food–water–energy nexus. Many energy innovations have been considered to have posed significant challenges for water sector that are emerging in the post-deployment phase of energy solutions (for instance, the use of solar water pumps in water scarce regions). It would be beneficial for blue

economy sectors to integrate ideas and innovations to understand the overlapping and underlying impacts on other sectors to reduce and eliminate negative consequences.

- Budgetary enhancements and promotion of investments for technological innovations and resources are necessary and critical to achieve a harmonized blue economy framework. Private participation and creating an attractive investment market is essential for taking forward the blue economy initiatives.
- India should focus on building scientific interface, especially for biodiversity and for addressing natural disasters. A regional consortium would add value and encourage countries to work together.
- Investing in innovation has been the key for countries to achieve high rate of economic and social development while preserving the environment. Innovation and technological excellence centres in coastal states and in universities would encourage younger population to view blue economy sectors as a potential career path. This needs to be prioritized in India for higher gains and to strengthen global presence. India also needs to invest in creating more research institutions both in the public and in the private space to accelerate innovation and ideation process in blue economy.
- Mapping current technologies in ocean-related sectors and leveraging on existing technological solutions and information is essential to pave the road map for the future of ocean-based research.
- Data and policy interface platforms that provide stakeholders collated information and reduce knowledge gaps is imperative for pursuing blue economy.
- Each ocean-based sector needs to prioritize human resources for a better future. Skill development, capacity building, and training need to be accelerated and enhanced to ensure a strong and skilled workforce. Increased awareness generation on potential opportunities for employment in blue economy sectors would generate interest and aid in building a workforce.
- The proposed National Blue Economy council should prioritize science and technological innovations in the blue economy sector to guarantee India's long-term future in global oceans.

India has the opportunity to focus on innovation and technology that is the bedrock of blue economy. It is imperative for India to stay one step ahead in the oceans sector to counter increasing strategic presence, rising economic activity, and address environment and climate change challenges simultaneously. Science and technology can provide the right solutions to steer ahead blue economy in India.

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3.

DEVELOPING FINANCING FRAMEWORK FOR BLUE ECONOMY

Chapter 8

Financing Blue Economy

Anup Mudgal, Member, FICCI Taskforce on Blue Economy and Former Ambassador to Mauritius

A rapidly increasing population coupled with diminishing land resources leads to higher pressure on the oceans to bridge the widening resource gaps. The need for decoupling economic growth from environmental degradation is equally compelling. Hence, the blue economy (BE) discourse is seeking to make all economic activity with or within the oceans and other waterbodies more sustainable. A better understanding of the ecosystem functioning and new technologies can help mitigate the adverse environmental consequences. Otherwise, the deteriorating environment has the risk of disrupting the basic planetary functions, which would also entail heavy economic costs.

The global economy is projected to grow from the current estimate of about USD 93 trillion to about USD 173 trillion by 2031 (Nextbigfuture.com). The G-20 infrastructure platform estimates the global infrastructure investments for the 2016-2040 period at USD 94 trillion. The BE sectors will constitute a substantial part of this expansion. Nearly half of this investment will be accounted for by four countries namely China, the USA, India, and Japan. This expansion would need resources including investments for capacity expansion, adaptations of existing operations, new sectors, technology development and induction, and innovative management tools. The success of today's generation in combining growth with sustainability would depend on the preparedness for addressing inadequacies of policy, regulation, technology, finance, and management tools. The BE precisely seeks this paradigm shift.

The Worldwide Fund for Nature (WWF) estimates the value of the ocean assets at USD 24 trillion with annual value addition of about USD 2.4 trillion. According to the Organisation for Economic Co-operation and Development (OECD), the ocean economy sectors could surpass their land counterparts both in value addition and employment generation by 2030.

As the transition to BE would essentially be achieved through the public-private partnerships, essential pre-requisites for its success would include easy availability of financing and reasonable returns on investments. While no one doubts the long-term profitability of adopting sustainable means of growth, businesses need to be assured of the availability of financing. The obvious question is where will this money come from?

As regards financing growth, the BE needs to be seen as an integral part of the larger global and national visions for sustainable development, including climate finance for mitigation and adaptation. In this context, one needs to remember that the oceans are the single biggest sinks of greenhouse gases and this capacity is directly dependent on ocean health. Therefore, while there are some initiatives for raising finances specifically for BE, a better perspective could emerge only in the larger context of the emerging state of financing for sustainable development and green growth.

The evolving global policy frameworks are favouring sustainable practices through various enabling tools, both voluntary and binding. The multilateral and global financial systems are promoting greener investments. As time passes, only environment-friendly projects would succeed in raising money. The economic viability of new projects would be essentially dependent on their environmental sustainability. No investor would risk money on polluting or unsustainable ventures.

Improved regulations, growing consumer preference, demand for improved standards and quality assurance, and advocacy are already leading to a strong investor bias in favour of sustainability and this will surely grow in the years to come.

The majority of financing for quality green and BE projects would continue to be sourced through the conventional channels of budgetary allocations, private, public, public-private investments, foreign direct investment, and equity routes. Funding for such projects would also be available through multilateral, regional, and bilateral development assistance programmes. Another important and fast-evolving source of market-driven finance is the bond route. Given that most major world economies have put in place sustainability compliance as a pre-condition for project approvals through the environment and social impact assessments and audits, irrespective of the source, a substantial part of investments on infrastructure and other development projects will gradually transition towards green and sustainable growth, including BE.

Sustainable financial markets and systems are evolving in sync with the global and domestic regulatory and advocacy trends. The multilateral system, led by the United Nations, is at the centre of this campaign, as the majority of the member states have committed to the Sustainable Development Goals (SDGs) under Agenda 2030 followed by the Paris Accord on climate change and the Addis Ababa Action Agenda that translates the SDGs and Paris commitments into concrete and measurable follow-up on the ground especially on the allocation of financing. In the BE sectors, there are several binding requirements for the protection of the marine environment under the UN Convention on the Law of the Sea (UNCLOS), International Maritime Organization (IMO-MARPOL), and the Regional Fisheries Management Organizations (RFMOs). Two more binding treaties are under negotiations at the UN for protecting marine biodiversity (Biological Diversity of Areas Beyond National Jurisdiction) and pollution due to seabed harnessing (Areas Beyond National Jurisdiction) in the high seas. The resulting policy and regulatory framework would progressively make it more difficult and expansive to raise money for unsustainable business activities.

According to the UN, the perception of sustainability being more expensive appears surely misplaced once we take into account the value of the ecosystem services for which we do not pay at all or at least a fair price. Unsustainable practices also cause direct losses on account of healthcare, soil degradation, loss of biodiversity, loss of quality ecosystem services including habitat, tourism, and recreation, disaster relief, and finally climate change. If all these costs are counted, sustainability becomes the most competitive option in the medium-to-long run.

As per the UN Secretary-General's Roadmap for Financing the 2030 Agenda, the SDGs could open additional market opportunities of USD 12 trillion and create 380 million new jobs. Actions on climate change would also result in a saving of about USD 26 trillion by 2030. These estimates should more than redress any doubts about the business or economic sense of following sustainability in development.

The UN estimates that the financing gap for achieving SDGs and Paris Accord targets in the developing countries alone would require additional USD 2.5–3 trillion annually. The global need for meeting these goals is estimated between USD 5 and 7 trillion annually and India would need a total of around USD 2.65 trillion by 2030. These are huge requirements. As per the UN, with an appropriate mix of policies, finding this money should not be difficult, considering the size of the global economy of over USD 90 trillion and gross global financial assets value of over USD 200 trillion.

The World Bank Group (WBG), supported by other multilateral/regional development banks, has a treaty-based partnership with the UN for supporting the global developmental agenda and has embedded its development finance in three basic goals of a green, clean, and resilient world. The WBG would mainstream these goals in the development financing ecosystem at all stages of degradation – avoidance, mitigation, and redressal.

World Bank was the founding member of the famous multi-donor International Coral Reef Initiative for the protection and revival of the coral ecosystems in many countries. Since the early 90s, there has been an investment of over USD 235 million on coral protection and related projects under this initiative, resulting in diverse benefits of biodiversity restoration. This has also helped local communities by the way of better reef fishing and ecotourism.

In a major BE initiative, the World Bank has launched a global programme called PROFISH for promoting sustainable fishing to primarily assist fishing communities in developing countries. The assistance is provided through improved governance, technical, finance, and market support. PROFISH investments of USD 4.5 million in research, analysis, and technical support have generated USD 1 billion in World Bank lending to the sector, including private sector investments into sustainable supply chains.

Another innovative landmark for financing BE was the setting up of PROBLUE in September 2018, which is a multi-donor trust fund, addressing marine pollution for healthy and productive oceans and managing fisheries for fostering sustainable growth of coastal economies. This initiative is part of the overall BE programme, which follows a multi-pronged approach for ensuring the protection and sustainable use of all marine resources. The key themes of the PROBLUE programme are: i) management of fisheries and aquaculture; ii) marine pollution, including plastic; iii) sustainable development of coastal tourism and; iv) other sectors namely maritime transport, offshore renewable energy, and governance issues.

In addition to a very large portfolio of already committed development assistance through grants and concessional loans to the developing countries, at the UN Climate Action Summit in September, 2019, the World Bank-led multilateral development banking system announced their climate action targets for 2025. The targets included annual climate finance at USD 65 billion, adaptation finance of USD 18 billion, and a co-financing target of USD 110 billion. This would further build on the cumulative commitments of USD 192 billion for the period 2015-2019.

Besides the traditional sources of finance, an important source of finance for sustainable development would come from the fast-growing market of green, blue, and climate bonds, started by the World Bank group in 2007. By 2019, the World Bank had issued green bonds exceeding a total of over USD 13 billion in over 150 issuances in about 20 currencies. At the end of 2018, they had more than 90 eligible projects with a total commitment of over USD 15 billion. International Financial Corporation of the World Group also entered the green bond market in 2010 to raise funding for clean energy projects and till mid-2020, it issued over 170 sets of green bonds worth USD 10.4 billion in some 20 currencies.

Following the World Bank Group initiative, the green bond market has expanded exponentially with a wide range of public and private entities entering this growing space. A Bloomberg NEF report of October 5, 2020 measures the cumulative green bond issuance to have already crossed the USD 1 trillion mark. As per the latest Climate Bond Market analysis, green bond issuances for 2019 were quite encouraging. The total issuance was recorded at USD 257 billion, registering over 50% growth in 2018.

Regionally, the European Union has been at the forefront of promoting sustainable development for many years now. The European Union estimates an additional annual investment of about Euro 180 billion for achieving the targets of their 2030 plan. The EU strategy for promoting financing and investments for sustainability includes a) unified taxonomy; b) strict disclosure norms and; c) factoring of environmental risks into the insurance coverage and premium determination. The ultimate goal of the EU strategy is to direct greater investments into sustainable products, activities, and services using a mix of incentives and regulatory tools.

This would also affect their international economic relations, including differential treatment of trade where possible, investments, and development assistance.

The Association of Southeast Asian Nations (ASEAN) issuance almost doubled in 2019, reaching USD 8.1 billion compared to the previous year. This growth has been encouraged by the new regional regulations. The cumulative amount since 2016 reached USD 13.4 billion as of the end of 2019. ASEAN represents only 3% of the global market and it is dominated by Singapore with nearly 55% of the total.

The African Development Bank, in collaboration with the Climate Investment Fund, has been at the forefront of mobilizing finances for sustainable development. As per their 2019 report, they have arranged USD 2.7

billion for 27 projects in the region. Climate financing represents nearly 35% of the total project approval of USD 10.2 billion. The primary target sectors have been renewable energy and resilient agriculture. The Bank has a target of mobilizing USD 20 billion in green finance till 2025.

Latin American green bond market is led by Chile, Brazil, and Mexico accounting for cumulative issuances of USD 7 billion, 5.7 billion, and 2.1 billion, respectively, till June 2019. The regional total stands at around USD 17.9 billion.

In 2019, the USA issued the green bonds of a total value of USD 51.7 billion, followed by China at USD 30.1 billion and France at USD 29.5 billion. As a region, the EU led the pack with the issuance of USD 106.7 billion. The EU has also decided to raise part of their Covid recovery package of Euro 750 billion through green bonds.

There have been important initiatives for raising money through green bonds by some Indian banks and private companies. According to a YES bank report for 2017-18, the green bond market in India has witnessed surprising growth since its inception in early 2015. By the end of the above report period, the size of the Indian green bond market was assessed at over INR 50,000 crores with a total of 25 issuances, including foreign currency-denominated bonds. According to the report 'Bonds and Climate Change: The State of the Market 2018', the cumulative green issuance from India between 2015 and 2018 stood at USD 6.5 billion. In 2017, Indian public and private sector companies issued USD 3.9 billion worth of green bonds, which is 2.5 times higher than in 2016. The majority of them (51%) were sold by the public sector entities. With transactions worth USD 10.3 billion till mid-2019, India emerged as the second-biggest emerging market for green bonds (ET World 2020).

In India, major foreign currency denominated green bonds have been issued by: i) SBI for USD 650 million (2018); ii) Hyderabad-based Greenko Group for USD 950 million (Live mint 2019); iii) Hero Future Energies Group issued a series of climate bonds for financing their clean energy projects; iv) YES Bank for USD 600 million (2019) and; v) Adani group for USD 500 million (2019) to finance clean energy.

According to the Emerging Market Green Bond Report 2019, USD 52 billion worth of green bonds were issued in 2019 in the emerging markets alone. This represents a robust 21% growth over 2018. The outstanding green bonds till 2019 reached an impressive value of USD 168 billion. Financial institutions issued close to 60% of this amount. As many as 35 emerging markets are participating in the green bond issuance, a demonstration of the green bond's wide acceptance as an attractive investment option. Emerging markets account for over one-third of the global green investments but only one-fifth of the green bond issuance. This means that there is greater potential for the markets' expansion in the years to come. IFC estimates USD 29.4 trillion investment potential in transitioning emerging markets to low-carbon and sustainable economies. So far, China has been driving the green bonds in the emerging markets, but the coverage is spreading fast. In 2019, emerging markets, other than China, contributed USD 18 billion, registering threefold growth over 2018. This issuance was led by India, accounting for USD 3.19 billion. From 2012 to 2019, the cumulative green bond issuance market was dominated by China at USD 143 billion, followed by India at USD 10.9 billion.

To what degree the global investors are turning towards greener and cleaner investment portfolios could be judged from the fact that till 2018 an estimated USD 30.7 trillion worth of funds were held in green or sustainable investments, which represents a growth of 34% compared to 2016. Sustainable bonds cover all investment into cleaner projects even if they are not certified as green. According to the global sustainable investment alliance, in Europe in 2018, over 48% of the total managed investments of USD 14 trillion were deployed in green or sustainable assets. In the USA, of the total USD 12 trillion, the share of green and sustainable investments was 25.7%. This share exceeded 50% in the case of Canada and Australia.

Along with the growth of the green and sustainable bond market, global norms are also taking shape. Encouraged by the World Bank group's success at issuing green bonds, the International Capital Market

Association has also developed a set of voluntary but comprehensive green bond principles, covering nearly every aspect of the market operations and regulations. These principles broadly cover the definitions, eligibility criteria, managing proceeds, reporting obligations, auditing, certification, ratings, and tracking. Though this is still a work in progress, many regions and countries are adopting these principles in their domestic regulations.

In conclusion, to fully appreciate the value of the BE, we need to take a wider view of both the tangible and intangible benefits. Even though the BE is generally listed under SDG 14, which is limited to 'life under water', given its wider contributions, it would only be logical to count its contribution to other relevant goals as well. For instance, the BE outcomes would have a significant impact on achieving SDG 1 for poverty elimination – the BE is forecast to generate about 40 million full-time jobs and many times more in the informal sector by 2030; SDG 2 for achieving zero hunger – the fish consumption provides 15-20% of animal protein to the world population; SDG 5 for gender equality – as the BE sectors of fishing and tourism are better aligned to female employment; SDG 7 for affordable and clean energy – the offshore oil and gas already contributes over 25% of the total energy whereas offshore power generation would reach 4% of the total by 2040, and; finally SDG 13 for climate stabilization – this is directly dependent on the ocean health.

A significant part of the projected infrastructure investments of USD 94 trillion would be directed to the various BE sectors, major ones being ports, shipping, offshore energy, tourism, and fisheries. While a large share of the needed investments would come from the traditional sources, all BE projects would also qualify for sourcing financing through green and climate-aligned bonds.

The above account demonstrates that the growth of the BE (all of which by nature are green projects) should not be handicapped by the lack of financial resources. The only segment of BE which may need greater public sector investment in India and other developing counties would be in the R&D sector. The private sector may not be willing to invest in pure blue research beyond their own project-related obligations. However, given the complexity of the environment impact dynamics of the overall economic growth, India and other developing countries need to strengthen their R&D capabilities, capacity building, and regulatory systems. This would, however, be a minuscule share of the overall project investments forecast for developing sustainable projects in the years to come.

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Chapter 9

Methodologies and Estimation Framework for Activities in the Blue Economy

Amey Sapre,* Assistant Professor at the National Institute of Public Finance and Policy
(amey.sapre@nipfp.org.in)

Abstract

This paper uses a general framework followed in the national accounts that is based on identifying and including economic activities that operate and relate in periphery to the blue economy. A methodological framework is developed that outlines possible avenues to compile blue economy aggregates, such as value addition. The estimation framework uses the National Industrial Classification (NIC) economic activity classification as opposed to products and employment survey to identify activities that can be directly attributed as part of the blue economy. Given the existing framework and data sources, the recourse to compiling regular estimates of the blue economy requires: (i) Mapping of crop and produce in agriculture and allied sectors, such as fishing, livestock, and forestry; (ii) Mapping of various products within several manufacturing activities ranging from processed foods, off-shore or deep sea mining, equipment, instruments used in marine activities; (iii) Identifying direct and supporting services, such as tourism, sports and recreation, administrative services; and (iv) Schematic classification of activities as per organized and unorganized sectors of the economy. The framework is aimed at: (i) Compiling estimates for a benchmark or base year, (ii) Using indicators to move the estimate for later years, and (iii) Re-estimating the benchmark or base year periodically. Blue economy estimates can also aid in providing economic valuation of goods and services and can feed into a larger framework, such as natural resource valuation, environmental economic accounting, and disaster management.

Keywords: Blue Economy, Value Addition, GDP, India

JEL: E00, E01, E24

* Amey Sapre is Assistant Professor at the National Institute of Public Finance and Policy. The views expressed are of the author and not of the institute. He is thankful to the referee for valuable comments and suggestions for improving the paper.

Introduction

The emergence and recognition of the concept of blue economy in the recent decade have fostered developments in a variety of fields ranging from environmental sciences, geo-politics, trade and commerce, valuation of environmental resources to social and sustainable economic goals. Over the years, several institutional efforts have been made to contextualize and to provide an operative framework for the blue economy [see Park, Kwang Seo & Kildow, Judith (2014), World Bank (2017) for a brief overview]. To narrow down onto an operational framework, the essential task is to put forward an estimation procedure, which is based on economic activities and methods that are consistent with measurement of several macroeconomic and national income variables.

Globally, several countries have adopted frameworks within the national accounts to identify and estimate the contribution of the blue economy. The national accounts are based on the guiding principles of the UN-System of National Accounts (UN SNA) that provide a theory and institutional-based approach for estimation of key macroeconomic aggregates. Within the SNA, countries use dedicated datasets such as the Structural Business Statistics (SBS) and the EU Data Collection Framework (DCF) to identify major economic activities in the blue economy.

In the Indian context, initial efforts have been made to provide an estimate of the size (relative to GDP) of the blue economy. Government of India (2019, 2020) in its report on the National Accounting Framework for Blue Economy and Ocean Governance presented the first estimates of value addition accruing from blue economy activities and outlined the procedure for estimation. Between 2011–12 and 2016–17, the contribution has been around 4% of the total value added in the economy. While these estimates are preliminary and may require a wider and deeper estimation framework, the process also requires constructing macroeconomic indicators that can capture the trends of activities in the blue economy on a higher frequency and eventually on a real time basis.

Building on this theme, the paper is structured as follows: Section 2 discusses the landscape of the blue economy; Section 3 describes the process of locating the activities related to blue economy within the national accounts; Section 4 describes the data sources that could be used for estimation; and Section 5 concludes with a discussion on the need to build data sources for regular estimate of the blue economy.

Defining and Identifying the Landscape of Blue Economy

In general, the words ocean economy, blue economy or the sea economy are used interchangeably, but from an estimation point of view the approach requires qualifying goods, services and activities related to oceans and other water bodies. For instance, Park and Kildow define the blue economy as "economic activities that take place in the ocean, receive outputs from the ocean, and provide goods and services to the ocean" [see Park, Kwang Seo & Kildow, Judith (2014)] while others have propounded similar definitions [see Colgan (2014, 2017), Dash (2018), Mohanty et al. (2017, 2019), and Pauli (2010)]. The World Bank defines blue economy as "the sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem" [see World Bank (2017) for a detailed discussion]. The European Commission (EC) defines it as "all economic activities related to oceans, seas, and coasts. Blue economy also covers a wide range of interlinked established and emerging sectors," [see EC (2020)]. The Center for the Blue Economy describes three related but distinct meanings - the overall contribution of the

oceans to economies, the need to address the environmental and ecological sustainability of the oceans, and the ocean economy as a growth opportunity for both developed and developing countries [see CBE (2018)].

Despite several efforts to precisely define the blue economy, some of the distinguishing features remain elusive. For instance, similar to any other sector in the economy, the blue economy also involves multiple stakeholders, such as individuals, public and corporate firms, governments, public and regulatory institutions, internal security and multilateral and/or maritime jurisdiction that involves international laws and regulations. Other than individuals and institutions, natural resources are the most important components of the blue economy. While definitions attempt to include all forms of water bodies, analysing natural resources from an economic point of view is far more complex. Natural resources require a consistent framework for economic valuation that takes into account their sustainable use, conservation, replenishment, and overall health.

Taken together and with a holistic perspective, the word 'economy' offers a much wider domain of activities that includes domestic, international and environmental issues, which go beyond the general construct of estimation of value addition or aggregate GDP. However, in practice and also from an accounting perspective, there is a broad consensus among official statistical systems to include a host of activities within the domain of the blue economy. Broadly, such activities include (in terms of production/manufacture of goods and supply of services) the following:

- Food
  - » Fishing and fish products, aquaculture, and other sea foods
  - » Food processing, cold storage, packaging, shipment, and transport
- Energy
  - » Oil, natural gas, renewable energy, pipelines, etc.
  - » Raw materials (extraction of salts, minerals, precious stones, sea corals, etc.)
- Transport
  - » Shipbuilding, maritime monitoring and surveillance, commercial, cargo and passenger vessels, and other transport-related ancillary activities
- Tourism
  - » Coastal tourism, recreational activities, adventure sports, etc., and related ancillary activities
- Health and ecosystem services
  - » Natural medicines, plantation
- Environmental monitoring and protection of maritime areas
  - » Naval and defence activities
- Financial intermediation
  - » Insurance

In parallel, the SBS and DCF [see EC (2020), OECD (2016) for a complete list and framework] describe the 'sectors' and the associated data sources that are included in preparation of the blue economy estimate. For example, SBS data are based on enterprise data grouped under the declared main activity of each enterprise according to the statistical classification of economic activities in the European Community (NACE Rev.2). Out

of the 615 classes of activities singled out through a four-digit NACE code, 50 classes have been identified that have a principal or significant maritime component [see EC (2020) for classification at the sub-sector level]. Despite identification of activities, defining the scope and coverage in each sector is a challenge, especially in face of limited data availability. From a compilation point of view, there are two main challenges:

- National accounts across countries are primarily designed to capture contribution of economic activities at an institutional and sectoral level and
- National accounts measure contribution of economic activity (as opposed to products), produced capital (and not natural capital) and other related activities for building several macro aggregates.

The literature in this domain recognizes two major frameworks for estimating economic contribution of the blue economy. The following section describes the method and the process of compilation.

A Possible Estimation Framework

Across countries, the case of the blue economy is similar to the estimation framework of satellite accounts of tourism, health, media, etc., as they encompass several activities across sectors. Within the available disaggregation in the national accounts, some of the industries can be directly identified with the blue economy, such as marine fishing, water transport, off-shore extraction of oils/ fuels/gases, shipping and ship building, and several others. Other activities may relate indirectly to the blue economy and may be considered as incidental, ancillary or indirectly related to the main activity. In such cases, a partial allocation of value addition from such activities can be considered based on an appropriate scheme of allocation. The practice followed in the NAS is to divide the economy into several sectors comprising primary (agriculture), secondary (industry) and tertiary (services) and use alternate methods for estimation, depending on the level and extent of data availability.

Locating the Blue Economy in the National Accounts

Following the conventions of the Organisation for Economic Co-operation and Development (OECD), 10 major ocean-based industries have been identified as associated with the blue economy. The scope may differ from each country as several ancillary activities may also get included depending on their data availability. For representative purposes, the national accounts use an institutional classification, such as private households, general government, non-profit institutions, among others. Thus, to locate the activities of the blue economy in the national accounts, first a schematic representation of the sectors can be considered as the broad (2 digit) NIC classification [see NIC (2008) for the scheme of sectoral list of economic activities]. The other side of capture are entities that operate in different institutional sectors. These are broadly classified into four categories: general government (GG), departmental and non-departmental (DE & NDE) of the government, private corporate, and the household sector. In terms of their operative status, households are said to represent the informal sector (as they do not function as unincorporated enterprises and do not maintain full set of books of accounts and operate without formal contracts), whereas other entities in the public sector (GG, DE and NDE) and the private corporate sector are considered as organized.

Break-up of type of institutional sectors within the economy

Sectors	GG	DE	NDE	Pvt. Corp.	HH
NIC sections		Organized			Unorganized

GG is general govt.; DE and NDE are departmental and non-departmental enterprises of the govt.; and HH are households

Conceptually, national accounts capture activities within the confines of the production boundary and hence relate mostly to market activities. Several activities within the general government and households may not relate to market activities (administrative services, etc.) as such activities do not have a price or are produced for self-consumption at the household level. The private and public sector (DE+NDE+ pvt. corporate) are the two broad institutional sectors that participate in market activities as their production of goods and services are for commercial purposes. However, activities in the public sector (particularly GG) overlap with the non-market activities such as national security, defence, etc., and those related to the blue economy would have to be identified and estimated separately.

From an estimation point of view, the nature of organized and unorganized sectors can be distinguished from the point of data capture. Typically, organized sector forms the part of entities that are registered as incorporated entities under prevailing regulations and maintain books of accounts, such as profit/loss and balance sheets. On the other hand, entities in the unorganized sector are un-incorporated enterprises that do not maintain complete set of financial accounts. Thus, the information of such entities is not available in a similar fashion as that of the organized sector. The second feature that distinguishes these two sectors is from the point of view of employment. While the employment in the organized sector can be tracked via the registered entities, the number of individuals engaged in various economic activities in the unorganized sector is far more difficult to capture on a routine basis and can only be estimated through periodic surveys.

Complete vs. Partial Contribution of Activities

The estimation framework is based on compiling value addition from economic activities. In principle, gross value added (GVA) is computed as the difference between gross value of output (GVO), intermediate cost (IC) and taxes, i.e., GVO less IC and taxes. Within this framework, the notion of complete vs. partial contribution of activities is based on the premise that certain activities can be fully or completely attributed to the blue economy as they are directly related to oceans or associated water bodies. A similar method has been used by the Govt. of India (2019) which prepared the first estimates of the blue economy. For several identified activities, the contribution is assumed as partial as they are indirectly associated or are incidental/ancillary to the main activity. Hence, their contribution has to be apportioned using a suitable allocation scheme. One of the possible approaches is to use a weighting scheme for partially attributable activities. However, in deciding the weight of such activities, the choice is largely dictated by the level of data availability. In general, the most appropriate method would be to identify activities at a granular level of disaggregation [e.g., National Industrial Classification (NIC)-2008 5 digit]. The method, however, has a practical limitation. Given the spread of entities in each industrial or service sector, it may not be possible to find enterprises at such a disaggregated level. Hence, the second alternative could be to estimate GVA at a higher level of aggregation (NIC 3 or 2 digit) and use a weighing scheme to allocate GVA to activities identified in the blue economy.

Assigning weight to partial activities would require a host of physical indicators at a compilation category level. For instance, indicators such as estimates of number of employees for each compilation category, GVO/GVA ratio, geographical indicators relating to coastal areas, marine fishing, number of vessels, power consumption, tourist arrivals, indirect tax collections, among others could be used. Such indicators can provide a means to build a weighting diagram for benchmarking of the estimate in the base year and subsequently the base year estimate can be projected over time as per the growth in the indicator. Given such indicators and their respective data sources, the weights can be revised based on results of new surveys. Such an estimation scheme assumes that for the intra-years, i.e., between the years of the survey the partial contribution and hence the weight does not change. The approaches to compile the overall estimate can be outlined as given in Table 1.

Table 1 Possible approaches for estimation of total value added by activities in the blue economy

Method 1	Method 2
Using sectoral aggregates	**Using persons employed**
1. Identify activities across sectors (such as agriculture, manufacturing, mining, trade, transport, tourism, public adm., etc.) 2. Allocate percentage of value addition from each activity assuming fully or partial contribution and aggregate across sectors 3. The process is same for each year	1. Identify persons engaged in different economic activities across sectors 2. Estimate value addition per worker engaged 3. Identify fully attributable activities 4. Allocate percentage of value added of partially contributing activities 5. Aggregate contribution of fully and partially attributable activities 6. Extrapolate value added for future years based on representative indicators

The first method relies on a top-to-bottom wherein sectoral aggregates are used to compile the blue economic account. This approach is similar to the concept of a 'satellite' account as activities overlap across sectors and cannot be attributed to one particular sector. The second approach is a bottom-to-top approach wherein the estimate is built on the number of persons engaged in identified activities. However, in both methods the notion of full and partial contribution of activities plays an important role. Since the methods use different approaches, the weight of partial activities will differ in both cases and will have to be estimated differently. There are few limitations in using method-2 as employment figures are based on periodic surveys and the same may not be available on an annual basis. For intervening years between two surveys, the estimates will have to be moved forward by assuming that in the short run, the value addition per worker remains same for all categories of labour and hence the same fraction can be used for few years. The GVA per worker estimates can be revised when a new benchmark survey becomes available. The aggregates in the national accounts are prepared at both current and constant prices. In case of the blue economy, both methods can be used for this purpose. However, as there are no specific price indexes especially for blue economy- related products, the existing deflators of wholesale price index (WPI) and consumer price index (CPI) are applied on the current price estimates.

Data Sources and Their Availability

The data sources for a complete and consistent estimation of the blue economy are limited. Presently, within the realm of official statistics there are: (i) No dedicated surveys that capture identified activities and (ii)

Limited high frequency economic or physical indicators to measure the level of commercial activities in the blue economy. Recourse has to be taken to available industrial and employment statistics available through administrative data sources and surveys of the National Sample Survey Organization (NSSO). Some of the relevant ones are as follows:

1. **The Annual Survey of Industries (ASI)**: It covers all factories registered under Sections 2m(i) and 2m(ii) of the Factories Act, 1948, i.e., those factories employing 10 or more workers using power; and those employing 20 or more workers without using power. The primary unit of enumeration in the survey is a factory in the case of manufacturing industries, a workshop in the case of repair services, an undertaking or a licensee in the case of electricity, gas and water supply undertakings and an establishment in the case of bidi and cigar industries [see ASI (2016)].
2. **Unincorporated non-agricultural enterprises (excluding construction)**: Captures economic characteristics of the unincorporated non-agricultural enterprises in manufacturing, trade and other services (excluding construction) at more disaggregated activity category. In the survey, the activities are classified into four broad heads: manufacturing, non-captive electricity generation and transmission, trade, and other services. However, these surveys are not available on an annual basis.
3. **Periodic Labour Force Survey**: It provides estimates of workforce, employment and essential labour characteristics on a quarterly and annual frequency. While the quarterly survey captures only urban areas, the annual survey provides a detailed assessment of employment across economic and institutional sectors.

High Frequency Indicators

One of the requirements of the estimation framework is the need to have physical and economic indicators that can capture short-term movements in economic activity. The necessity is on two counts: (i) Aggregates that are based on survey data may be available with a time lag and (ii) Indicators are needed for extrapolation between survey years. The SBS and DCF [see EC (2020), OECD (2016)] outline several indicators that can provide a near-real time assessment of economic activity in the blue economy. Most of these indicators are - turnover or corporations, production/catch of fish and other aquaculture-related indicators, persons engaged in various sectors, trade and tourism-related indicators, financial flows in blue economy-related activities, and conservation-related indicators.

A similar set-up of indicators also needs to be developed in case of India as most national accounts aggregates come with a considerable time lag and are based on survey data. Alongside high frequency indicators, other statistical data would also be required. For instance:

- Dedicated survey for fishing and related activities that capture volume, value added, firm characteristics and state of persons, entities engaged in such activities
- Survey of services that are attributable to the blue economy, such as mining, off-shore activities, coastal tourism and ancillary services related to oceans and water bodies
- Dedicated studies to estimate the industry/sector-wise partial contribution of blue economy-related activities, which will aid in developing an allocation of value addition
- Survey of natural resources to develop environmental resource accounting accounts and valuation of natural resources

Extended Frameworks

Given the domain of activities, compiling the estimates of the blue economy also requires enlarging the scope of the national accounts, especially in terms of natural resource accounting. One of the frameworks is the System of Environmental Economic Accounting (SEEA) that is aimed at building accounts for environmental resources and valuation. In brief, the SEEA is an internationally accepted framework that integrates economic and environmental data to provide a comprehensive picture of the inter-relations of the economy and the environment.

The SEEA uses concepts, definitions and classifications consistent with the UN SNA to generate a wide range of statistics, accounts and indicators with many different potential analytical applications [See Govt. of India (2019, 2020) and EuroStat (2014)]. The approach is to collate basic statistics on several environmental parameters that can be used to construct accounts that explain stocks, changes, and aid in valuation of environmental assets. These statistics are later translated into indicators that can provide a summary assessment of environmental conditions for policy and research.

International Practices: A Brief Survey

(A) **SEEA**: Natural capital accounts are based on the SEEA principles and are also designed to integrate economic and financial accounts. In this context, there are three major thrust areas:

(i) **Flow of energy and materials**: Traditionally, national accounts are based on the residency principle, i.e., to confine to geographic boundaries. SEEA develops systemic boundaries that include flows that are outside geographic boundaries. This system is based on primarily material balances (or consumption) that takes into account flows of fuels, natural resources, chemicals together with their emissions. It is thus possible to map flows of energy and materials to the emissions they give rise to and thus identify pollution or overall emissions contribution across sectors. However, given data limitations, it may not be possible to identify such a contribution at an entity or institutional level.

(ii) Stock of natural resources: The stock of natural resources can be accounted in physical and monetary terms based on a scheme of valuation of exhaustible (non-renewable), renewable and other forms such as living resources. This approach aims to show changes in stocks, extraction, addition and can even go beyond physical and monetary valuations to account for resources that may not have any market monetary value, such as biodiversity or other cultivated biological resources.

	Additions		Reductions
1	**Opening Stock**		
A	**Additions to stock**	B	**Reductions in stock**
	Growth in stock		Extraction
	Discovery of new		Normal loss
	Reappraisals		Catastrophic loss
	Reclassifications		Reappraisals
			Reclassifications
2			**Closing Stock**

Source: [UN-SEEA 2012 EuroStat (2014)]

The general framework is to account for additions and reductions and to show a net-position of environmental assets that can be integrated with the supply and use tables (SUTs). The accounting can lead to a full sequence of environmental accounts, that includes range of transactions and flows that are of interest, such as payments of rent for the extraction of natural resources, payments of environmental taxes and payments of environmental subsidies and grants from government units to other economic units to support environmental protection activity [see UN-SEEA 2012 EuroStat (2014) for linkages of Asset Accounting with SUTs].

(iii) Environmental statistics: These statistics provide a general and specific analysis of environmental resources. Specifically, within the national accounts, environmental taxes and subsidies, investments, valuation of cultivated biological resources are already included and such statistics can provide a much deeper analysis of environmental protection, conservation, and cost of preservation.

In this domain of statistical work, a substantial contribution has been made by the EuroStat. In 2011, the EU Parliament and the European Council passed a statistical regulation for compilation of annual accounts of material flows. The Economy Wide Material Flow Account (EW-MFA) is a sub-component of the SEEA and compiles statistics on the following major items:

a. Output: Direct material consumption (DMC) and direct material input (DMI);

b. Inputs: Domestically produced output (DPO)

DMC is the total amount of physical material directly used in an economy, which equals domestic extraction of resources plus imports less exports from the rest of the world. DMI captures domestic extraction of resources and the imports, which includes all physical materials that are used in production and consumption activities, except balancing items (net of opening and closing stock). DPO is the total weight of materials which are released back to the environment after having been used in the domestic economy.

The material flows occur at various stages, viz., processing, manufacturing and at the final disposal stage of the production–consumption chain. DPO also includes emissions to air, industrial and household wastes deposited in controlled and uncontrolled landfills, material loads in wastewater and materials dispersed into the environment as a result of product use (dissipative flows). However, recycled material flows in the economy (e.g., of metals, paper, glass) are not included in DPO. Two other measures are also used:

c. **Physical trade balance (PTB)**: It equals physical imports minus exports. These flows are in reverse direction of monetary flows. A physical trade surplus indicates a net import of materials, whereas a physical trade deficit indicates a net export; and

d. **Net additions to stock (NAS)**: It measures the physical growth of the economy, i.e., the quantity of new construction materials used in buildings and other infrastructure and the materials incorporated into new durable goods, such as cars, industrial machinery, and household appliances [refer EuroStat (2018) for detailed account description].

Vision on Blue Economy: The Indian Context

The Draft Policy Framework on Blue Economy (Govt. of India, 2020) has recognized, emphasized and provided a roadmap on capacity building in the area of blue economy. The vision statement of New India by 2030 has also highlighted blue economy as one of the ten core dimensions of growth. The actionable part of the vision statement can be summarized in the following broad points:

(i) India needs to learn from global best practices in the areas of environmental accounting for which there is a need to establish active scientific collaborations with leading countries/institutions to develop suitable scientific tools and methodologies relevant to blue economy measurement and management; (ii) In order to generate reliable data regarding the blue economy, we need to: (a) Enlarge the 2008 National Industrial Classification to accommodate various untapped activities associated with the blue economy; (b) Engage with all relevant ministries for the collection of data; (c) Constitute or identify an official agency to secure relevant data at the dis-aggregated industry level; (d) Intervene in the formative process of the UN International Standard Industrial Classification of All Economic Activities (ISIC) Revision 5 and on data policy; and (e) New National Map and Data Policy balancing emerging requirements of data security and transparency.

The vision statement has also highlighted the importance of environmental sustainability and conservation. To this effect, for impact assessment to assess the impact of tourism, it is necessary to periodically initiate studies to map the tourist arrivals, tourism infrastructure, major attractions/ products in India's coastal areas and island territories, and measure their impact on environmentally- sensitive and ecologically-fragile areas. In addition to these guideposts, it is essential that studies on the lines of Natural Capital Accounting are conducted in the areas of: (i) Ocean health, (ii) Mapping ocean wealth and (iii) Corporate ecosystem accounts that can provide an in-depth analysis of maritime resources, forests, and overall ecology. Studies such as IDEEA's Forico - Publishing Corporate ecosystem accounts can help in building sustainability standards, certification and environmental management practices for all institutional sectors and stakeholders.

Conclusion and Way Forward

This paper deals with a broad methodological framework for estimation of value added in the blue economy. The estimation of value addition is a complex and evolving process, especially with limited data availability. At an operational level, the estimation framework follows the guiding principles of the SNA and integrates similar procedures for estimation of contribution of economic activities that fall within the purview of the blue economy. Within the available framework, two approaches can be considered: one that is based on allocating full and partial contributions of economic activity at a sectoral level, and second to use estimates of value addition per worker who are engaged in blue economy-related activities.

The compilation also requires identification of new data sources that can be integrated into the national accounts framework as existing data sources may be insufficient in their coverage of activities in the blue economy. In this domain, several high frequency indicators need to be identified that can help in capturing short-term movements in economic activities that relate to the blue economy. The compilation of blue economy accounts also needs to be extended and broadened to include environmental and natural resource accounting such that it offers a consistent framework for natural resource valuation and preparation of environmental accounts. The vision statement of the Govt. of India (2020) has given a roadmap for capacity building in areas of blue economy and it is imperative that steps are undertaken to enhance capacities in estimation and regular compilation of environmental accounts for India.

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Chapter 10

Financing Blue Economy Initiatives in Developing Countries

Mani Juneja and Ria Sinha, The Energy and Resources Institute

1. Introduction

Blue economy and sustainability

Oceans are an integral part of the environment, ecology, and economy. They cover around 72% of the earth's surface and nearly 40% of the world's population live within 100 km of the coast. The global oceans-based economy is estimated at USD 3 trillion a year, which is around 5% of the global GDP[1]. Food and Agriculture Organization of the United Nations (FAO) estimates that blue economy industries provide for the livelihoods of over 820 million people worldwide in diverse fields including maritime shipping and related transport, energy generation, mining, construction, trade, tourism, research, among others, not forgetting the very important ecosystem services, such as carbon sequestration. Shipping is responsible for more than 90% of the trade between countries. However, the augmentation of climate change, pollution, and overfishing in the past few decades has caused a rising threat to the sustainability of the oceans and reduced their economic contribution. Therefore, there is an urgent need for successfully strategizing and promoting blue economy since it considerably seeks to promote economic growth, social inclusion, and preservation or improvements of livelihoods, at the same time ensures environmental sustainability.

The concept of 'blue economy' ensures a balance between the increasing demand for marine resources and the economic growth, which is important for sustainable development. Thus, blue economy refers to the 'sustainable use of ocean resources for economic growth, improved livelihoods, employment, and ocean ecosystem health' (World Bank and UNDESA 2017). It encompasses both ocean-based industries (for example, shipping, fishing, offshore wind, and marine biotechnology) and ecosystem services (for example, fish, shipping lanes, and CO_2 absorption) that oceans provide. Therefore, sustainable blue economy activities broadly cater to the activities and projects that:

- restore, protect, and maintain diversity, productivity, resilience, core functions, value, and health of the marine ecosystems
- provide sustained livelihood opportunities and strengthen livelihoods and communities dependent on the marine ecosystems
- reduce stressors to marine ecosystems, such as sources of pollution, which can be from different sectors
- strengthen coastal and marine governance and science and technology for the benefit of ecosystems (BNCFF 2019)

1 https://www.un.org/sustainabledevelopment/oceans/

The present chapter is an attempt to elucidate the financing instruments for blue economy and simultaneously highlight the financing prospects in developing economies. Section 2 of this chapter presents an overview of the blue financing instruments across the globe – its variedness and efficacy. Section 3 states the pertinence of the blue economy finance principles developed jointly by the European Commission, World Wide Fund for Nature, World Resources Institute, and the European Investment Bank. The changing paradigm of sustainable financing including blue finance in developed economies is explored in Section 4. Section 5 provides certain examples of financing instruments in Asian economies such as China and India. The potential deterrents for blue financing including definitional challenges are highlighted in Section 6. Section 7 presents the most important stakeholders who can raise awareness and address financing challenges. Section 8 illustrates a potential framework for blue economy financing in developing economies and Section 9 concludes.

Financing for the Blue Economy

Financing has a crucial role in enabling a sustainable ocean economy. All the various activities and ecosystem services related to oceans such as restoring ecosystems, building offshore wind farms, developing zero-carbon ship fuels or ensuring sustainable fisheries, and aquaculture would require a huge amount of blue finance in the coming decades. However, evidences on the investment activities related to sustainability are still quite low. According to the 2016 Global Sustainable Investment Review, only 26% of the current investments relative to total managed assets were sustainable in 2016 (Accenture 2017).

The United Nations (UN) has estimated a global gap of USD 2.5 trillion annually to achieve SDGs and of all the SDGs it has been estimated that SDG14 receives the minimum funding (UNCTAD 2014). Since 2009, ocean sustainability projects have received just USD 8.3 billion in grants from philanthropic donors and USD 5 billion in financing from development banks, which is insufficient (The Economist Group 2020). The SDG Financing Lab shows that SDG14 receives only 3.5% of the total donor commitments, which is the least among all the 17 SDGs. Out of the total commitment of USD 2876.5 million Official Development Assistance (ODA) in 2017 to SDG14, only USD 1707.3 million was disbursed (OECD 2020a). It has been estimated that to achieving SDG 14 by 2030 requires resources of the value of USD 174.52 billion annually; however, currently, only USD 2505 billion is spent per year. This indicates a financing gap of USD 149.02 billion per year (Johansen and Vestvik 2020).

The major sources of funding for blue economy have been ODAs and philanthropy grants. In the past 10 years, philanthropy has the maximum share in the funds, followed by ODA globally (WEF and FOA 2020). A total funding of USD 8 billion has been received from philanthropy and USD 5 billion from ODAs in the past one decade for blue economy, but this funding is now not enough to fund even the conservation and sustainability activities of the sector (WEF and FOA 2020). Therefore, not just the investment in sustainable oceans is required due to of their increasing need but also because of the certain regulatory, market, and physical risks associated with the current levels of unsustainable activities in the blue economy. Such risks have certain ramifications for the business sector and might lead to serious consequences if not mitigated and managed appropriately. In fact, businesses tend to lose out if they fail to leverage upon these risks. The potential risks are stated in Table 1.

Table 1 Potential financial impacts associated with unsustainable investments in the blue economy

Type of Risk	Related Risk	Potential Financial Impacts
Policy and Legal	• Increased regulations/fines to protect marine life • Increased climate regulations, fees, fines • Better enforcement of marine legislation	• Increased cost of operations and compliance • Reduced size of operations • Greater insurance and/or legal costs
Market	• Changing customer and/or investor preferences • Reduced supply of ocean goods and services	• Reduced demand for conventional goods and services • Higher cost of scarce ocean-based raw materials • Less income/employment from ocean goods and services • Opportunity costs of lost bioprospecting opportunities
Technology	• Improved monitoring technologies • Innovations in sustainable technologies • Substitution of conventional technologies	• Less opportunistic profit; greater risk of fines/ litigation • Shift in R&D and CapEx to sustainable options • Loss of returns from sunk costs into seafaring assets
Reputation	• Increased stakeholder concern • Negative publicity	• Reduced access to top talent and/or collaboration • Damage to brand value; increased cost of marketing • Disruption in production capacity (e.g., protests, etc.)
Region specific	• Coastline erosion and storm damage • Dead zones • Local/regional food shortages • Pollution of food chains, waterways, etc.	• Damage to real estate and coastal infrastructure • Long-term reduction in overall marine productivity • Weakened local communities and economies • Culpability for environmental and public health damages
Cross-border	Ocean acidification Warmer water, frequent storms Changing distribution of living resources Ecosystem services	Biochemical degradation of ocean resources; reduced CO_2 absorption capacity Costly safety measures, emergency response, insurance Greater uncertainty in deployment of operations Loss of resource base for extraction and raw materials

Source: Accenture (2017)

2. Blue Financing Mechanisms at Work Globally

Review of blue finance mechanisms and instruments

There are various types of blue finance instruments available to support the ocean health and its related activities. However, to date, public funding has played a big part in ocean conservation and investment in sustainable ocean activities, both domestically and internationally through ODA and other concessional financing (OECD 2020b). Though, a few private investors have become important players, to ensure the growth of the blue economy it is required to move beyond these non-returnable investments and create a market for commercial capital. This would require action on a number of fronts, including enhanced policy and regulation to realign incentives and deployment of a range of innovative financing instruments.

It can be stated that innovative financing mechanisms are underdeveloped because of the lack of investment-ready, bankable projects that are supported by a revenue model. However, growing appetite in the venture capital and impact investment for ocean investments has resulted in the establishment of a number of new funds in recent years. The different types of financing instruments can be listed as follows:

Public Financing

This is a type of capital that is provided by a national or sub-national governmental body for goods, services, and infrastructure that serve public interest and is a non-return seeking capital. This has been the most important contributor to the resources that fund the ocean and an estimated amount of USD 8.3 billion in the last 10 years have been funded from this (Funding the Ocean 2019).

Grants

Philanthropic grants are a type of non-return seeking public finance that is provided by non-governmental sources including NGOs, foundations, and corporations through their corporate social responsibility (CSR) funds. Grant providers for ocean sustainability fall under the three broad categories; philanthropy (notably through high-net-worth individuals and philanthropic foundations), those provided by the public sector as ODA, and grants provided by corporations as part of their CSR.

These grants are often directed towards one purpose and aligned with the interests of the funders. The importance of such funds is quite high as they play a crucial role in financing sustainable development by focusing on the projects and regions that do not receive attention from private finance. Especially in case of blue finance, grants have played an important role till date. Despite multiple benefits of these grants and their importance, there are challenges such as they are usually spread across a finite time period without any guarantee of renewability. Thus, sometimes projects supported by grants collapse in long run.

The funding for the 'Sustainable Management of the Bay of Bengal Large Marine Ecosystem Programme' – jointly done by the FAO and the Asian Development Bank (ADB) – was a kind of grant given for marine conservation to eight countries, including India in 2018. The grant size was USD 179 million, which was disbursed through the financial institution Global Environment Facility (GEF) to tackle unsustainable fisheries (Gulati 2018).

Official Development Assistance

ODAs are a type of public finance that can be transferred both domestically and internationally through bilateral or multilateral institutions. Similar to grants they are disbursed for particular projects especially from developed countries to developing or low-developed countries. It is also a vital financing instrument for sustainable development and after grants, it is the most important form of funding for ocean-related activities and services. The Quintana Roo Trust was established in 2018 for the management of beaches and the maintenance and repair of coral reef in Mexico's Quintana Roo state. The trust fund involved The Nature Conservancy, state government, National Parks Commission, and the local hotels. The trust collected funds not just through public sources but from private sources as well. The public sources include philanthropy; however, the private sources include fees levied on the private sector. Moreover, these ODA are often being blended with other forms of capital like equity and debt. Circulate Capital Ocean Fund is one such type of fund which involves development agencies such as USAID, The Ocean Conservancy, and industries including PepsiCo, Procter & Gamble, Danone, Unilever, The Coca-Cola Company, Dow, and Chevron Phillips Chemical.

Corporate Social Responsibility

CSR funds are also a prominent source of public finance for blue economy. They have the potential to fund all the sectors of blue economy, however, they are mostly linked to the objectives of the corporate they are housed in. Usually, CSR is a means for corporations to build new markets for their activities but they are unregulated, therefore their scope remains limited. While much CSR activity in the blue economy focuses on the supply chain interventions, there are numerous opportunities to scale-up the existing supply chain activity and identify new areas to pursue CSR investments.

As a part of CSR, Godrej & Boyce Manufacturing Company in India established the Soonabai Pirojsha Godrej Marine Ecology Centre (Vikhroli, Mumbai) in 1985 to protect the 750 ha of mangroves. The main objective of the Centre was the conservation of marine diversity through research, education, raising awareness, and regular monitoring. Now, it plays a considerable part in supporting the several marine faunal species of fishes (Baroth and Mathur 2019). Many such CSR projects have been successful in promoting oceanic health.

Debt

Debt-based instruments involve acquisition of ownership rights with an obligation to make a payment. They are low risk, low reward type of capital that offer freedom to both the borrower and the investor, and such investors are tend to be more risk-averse.

Loans

These are the most common type of financing instrument used in the traditional sectors of blue economy like small-scale fisheries and aquaculture. However, with climate change and unsustainable practices, loans are facing a few challenges, notably in linking the provision of credit to sustainable fishing practices, which is directly tied to the profitability of the sector. Additionally, many small-scale fisheries struggle with financial independence from middle men who typically provide loans as well as buy fish from the fishers. In this case, credit facilities need to work within the context of the local community and be sensitive to local dynamics in reforming access to the finance and achieving long-term success (WEF and FOA 2020). Also, loans can be of different types, such as microfinance loans, revolving loan fund, and commercial bank loans.

Bonds

Bonds are high-security debt instruments that enable an entity to raise funds and fulfil capital requirements. It is a category of debt that borrower's avail from individual investors for a specified tenure. They can be issued by both the private sector and the public sector, and recently blue bonds were introduced as a debt instrument to finance ocean health. The first 'blue bond' was issued in 2018 by the Republic of Seychelles for an amount of USD 15 million with a maturity of 10 years and a coupon (annual interest payment) of 6.5%. Through this blue bond, the proceeds from the transaction will be used to support the expansion of the marine-protected areas, improve governance of priority fisheries, and the development of the Seychelles' blue economy.

Impact bonds are one of the innovative financing mechanisms, which are now being used for the conservation of marine resources and ecosystems. The Rhino Impact Bonds introduced in 2020, supported by the United Nations Development Programme and Global Environment Facility and implemented through the Zoological Society of London, is one of the innovative financing mechanisms implemented for the conservation of biodiversity. This not only modelled and demonstrated the feasibility of such mechanisms, it was structured to promote sustainable and diversified financing. Such impact bonds have been successful in the blue economy as well.

The first blue bond was launched in the Republic of Seychelles in 2018, which was facilitated by the World Bank. The bond aimed at marine protection and conservation.

In 2020, China launched Asia's first blue bond to aid the development of ocean-related sustainability projects. The bond is also used for the financing and refinancing of marine-linked green projects.

Equity

Equity-based instruments are like debt, which are based on taking an ownership stake in the investment. Sometimes they carry more risk than debt instruments. For instance, venture capital is a high-risk, high-reward financial instrument with an expectation of a failure in at least some of the investments. These can be broadly divided into public and private equity, wherein the public equity is open for trading through public exchanges, and in the case of private equity, investment is done in firms that are not listed on a public exchange.

Impact Investing

This is a type of capital investment that is usually made to generate positive, measurable social, and environmental impact alongside a financial return. This is prominent in both green and blue economy financing. It was estimated that a total of USD 200 million was raised for the blue economy sectors which include plastic waste, fisheries, aquaculture, and the development of coastal and marine-protected areas. The key stakeholders are philanthropic foundations, NGO's, international financial institutions, corporations and ODA. (Sumaila et al., 2021).

One of the successful impact investments in the fisheries sector is the Encourage Capital under the Bloomberg Philanthropies' Vibrant Oceans Initiative and The Rockefeller Foundation. It involves six investment blueprints developed to serve as a roadmap for the growing number of investors, entrepreneurs, and fishery stakeholders seeking to attract and deploy private capital to scale-up and accelerate fisheries reforms. The investment blueprints constituted financing plans to not only scale-up fisheries in the industrial sector but also at the small scale and the national level to ensure sustainable fisheries and generate financial returns.

Similar to Encourage Capital, which ensures impact investment in the fisheries sector, the Coalition for Private Investment in Conservation ensures private investments in conservation. This initiative focuses on enabling conditions that support a material increase in private, return-seeking investment in conservation by creating models for the successful delivery of investable priority conservation projects.

Seed financing

This is another type of equity-based financing and is the earliest stage of a capital-raising process of any start-up. Like other equity-based investments, investors commit their capital in exchange for an equity interest in the firm in seed financing, however, this involves a much informal way of financing compared to other forms. In terms of blue economy, seed financing can help innovative entrepreneurs in raising funds for technologically driven products and services. Companies such as Coral Vita provide examples of entities with novel approaches to solving unique blue economy and conservation challenges, which can attract seed capital to scale-up and grow.

Crowd Investment

It is also a type of equity-based financing where funds from a large number of investors are pooled together to finance a new business venture. Usually, in crowd funding, vast networks of people with the help of an online platform are used to bring investors and entrepreneurs together, where people usually choose to invest

very small amounts. However, this type of funding is very less developed in blue economy as these projects are mostly made available on big crowdfunding sites only. One of the best-known crowd investments took place in a sustainable blue economy project – BlueRise. In this, a Dutch renewable start-up working on ocean thermal energy conversion (OTEC) successfully raised €657,000 in seed capital through a crowd investment campaign which offered a 6% interest rate on a crowd platform – Symbid.

Hybrid Financing

The hybrid financing models include the characteristics of both debt and equity models and offer their benefits to investors. The advantages and disadvantages of hybrid financing align with the positives and negatives associated with debt and equity. The risk is akin to any investment, regardless of the type, but the benefits include access to cash and assets connected with both equity and debt for investors.

Conservation Trust Funds

Conservation trust funds (CTFs), also known as environmental trust funds, are the private legal entities that provide grant funding for conservation activities with a focus on conservation-specific projects and activities. In reference to ocean economy, this can be considered for financing mechanisms to support marine-protected areas. However, CTFs require a lot of local political and government willingness to take up such ecosystem conservation projects. Since this is a hybrid form of fund, it can be an endowment fund, sinking fund, revolving fund or a combination of any of these. Their funding mechanism can include both public and private sources. For instance, the Mesoamerican Reef Fund used direct donation as well as investment funding to raise funds. Likewise, the Caribbean Biodiversity Fund, which is a regional endowment fund, was supported by investments from donors and the financial resources gained by charging a 'user fees' in the region, which led to the establishment of a revolving fund.

Carbon Credit Schemes

A carbon credit is a tradable permit or certificate that provides the holder of the credit the right to emit one tonne of carbon dioxide (CO_2) or an equivalent of another greenhouse gas. In the context of ocean-based carbon crediting, offset markets can provide a framework through which private investment can support ecosystem restoration, conservation, and protection by placing a price on the cost of carbon sequestered. The Blue Carbon Resilience Credit (BCRC) supports adaption and resilience building of vulnerable coastal communities where the corporations seeking to offset their carbon footprint can buy credits to fund coastal restoration and conservation projects. The BCRC also integrates mitigation metrics in the form of avoided CO_2 equivalent emissions; and adaptation metrics in the form of flood protection benefits that a wetland provides nearby coastal communities (The iLab 2019).

Debt Swaps

The debt swaps are a refinancing deal in which a debt holder gets an equity position in a company in exchange for the cancellation of the debt. They have been used in biodiversity financing in the past few years and are now gaining traction in the blue economy. Similar to CTFs, they also need political willingness from the crediting country to recognize the value of conservation outcomes and within the jurisdiction of the debtor, there is the need for supportive environmental policies. The Seychelles Conservation and Climate Adaptation Trust was created by The Nature Conservancy to raise grant and loan capital for the debt conversion and, in exchange, the Seychelles government committed to improved policies and increased investment around marine conservation and climate adaptation (Convergence 2017).

Table 2 Sources of capital for blue economy with examples

Type of Model	Type of Financing Mechanism	Suited to Blue Economy Sectors	Example
Impact-only model	Grants	Coastal infrastructure, conservation projects	Funding by the Government of Luxembourg to the Blue Natural Capital Financing Facility, Conservation International Ventures (for the use of grant money as investment capital); funding for the work of the Monterey Bay Aquarium Research Institute (MBARI)
	Philanthropic grants	All sectors, though particularly well-suited to supply chain-linked sectors (payments for ecosystem services, fisheries, aquaculture, and waste management)	Meloy Fund raised by Global Environment Facility, the Dutch development bank (FMO) and others, Mars' Coral Reef Rehabilitation
Debt models	Microfinance loan	Small-scale fisheries and aquaculture, local applications of ecotourism, and waste management	Commercial bank: Grameen Bank
	Revolving loan fund	Fisheries, community conservation projects, and protected areas	California Fisheries Fund
	Bank loans	Fishing, coastal tourism, R&D	
	Conservation impact bond	Fisheries; carbon sequestration; marine-based infrastructure	Louisiana Wetlands EIB; Rhino Impact Bond
	Project bonds	Maritime transport, ocean-based renewable energy	Gode Wind (Ørsted); Nippon Yusen Kaisha Shipping Green Bond
	Sovereign bonds	All sectors	Seychelles Blue Bond; Norges Investment Bank Baltic Blue Bond
Equity models	Impact investing	Blue carbon, marine ecosystem services, fisheries, aquaculture, marine-protected areas	Althelia's Sustainable Ocean Fund; Sky's Ocean Ventures
	Seed financing	Bio-prospecting, renewables, aquaculture, shipping	Coral Vita, EU's BlueInvest programme
	Crowd investment	Bio-prospecting, renewables, and technological applications	BlueRise
Hybrid models	Conservation Trust Funds	Fisheries, blue carbon; payments for ecosystem services	FMCN; BACoMaB; Blue Abadi Fund
	Carbon credit schemes	Marine ecosystem services	Blue Carbon Resilience Credit; SeaGrass Grow; Association for Coastal Ecosystem Services
	Debt Swaps	Wild caught fisheries; marine spatial planning	Seychelles Debt Conversion

Source: WEF and FOA (2020)

3. Implications of Blue Economy Finance Principles

According to the Organization for Economic Co-operation and Development (OECD), the blue economy can provide unprecedented development and investment opportunities and outperform the growth of the global economy by 2030 (OECD 2016). However, in order to tap these opportunities, a transparent and well-drafted framework is necessary. In 2018, to guide the sustainable blue economy decisions, 14 voluntary principles were proposed for the finance and investment community. They are developed jointly by the European Commission, World Wide Fund for Nature, World Resources Institute, and the European Investment Bank and are hosted by the United Nations Environment Programme Finance Initiative as part of the Sustainable Blue Economy Finance Initiative. These are believed to be the gold standard to invest in the ocean economy and are the world's first global guiding framework for banks, investors, and insurers to finance the blue economy sectors and services. They promote the implementation of SDG 14 (Life Below Water), and set out ocean-specific standards, allowing the financial industry to mainstream sustainability of the ocean-based sectors. The 14 principles cater to being protective, compliant, risk aware, systemic, inclusive, cooperative, transparent, purposeful, impactful, precautionary, diversified, solution driven, science led and partner oriented. Cumulatively, these principles aim to:

- Throw light on 'sustainable investment' in the ocean context.
- Support the development of financial instruments and development models that would prove the most effective in the blue economy.
- Help in providing a necessary investment framework and support the finance community in unlocking a greater understanding of the risks.
- Foster cooperation and communication.
- Provide a framework for securing long-term health and integrity of the oceans.
- Moreover, these principles are a foundation for a shared progress. Hence, it is envisaged that the blue economy financial principles would establish the theoretical underpinning of an inclusive investment framework to facilitate the integration of blue economy factors.

4. Changing Paradigm of Sustainable Financing in Developing Economies

Sustainable financing has been a growing steadilysince the past few decades. The financial market has matured to accommodate sustainable financing and its innovative forms, and investments in sustainable development are no longer dominated by philanthropies and grants. The need to improve corporate and other issuers' alignment with the social and moral considerations has majorly driven the demand of environmental and sustainable investments (Boffo and Patalano 2020). Even societal trends mirror the growing recognition of the importance of realigning global financial mechanisms towards sustainability. However, these innovative financing mechanisms have grown more in the developed countries. In 2019, sustainable investments reached USD 30.7 trillion in assets under management in developed countries alone, which is 90% of the total funds (GSIA 2019 and UNCTAD 2020).

Sustainable funds in developing economies remain a relatively new phenomenon. Among the developing countries, China leads in the sustainable investments with a total of 95 sustainable funds, with assets under management of nearly $7 billion as of 2019. Most of them were created in the last 5 years. These funds now

experience growing traction in developing markets such as Brazil, Singapore, and South Africa, albeit from a relatively low level (UNCTAD 2020). They are still dominated by ODAs and grants for sources of development finance..

Similar fate is of the blue financing, which is also being currently dominated by ODAs and grants and private investments remain low as their potential remains undermined. Public sector financing contributes 70% of the total financing for ecosystems and biodiversity (UNCTAD 2019). Though private capital commitments have shown an increasing trend between 2004 and 2015, many opportunities still remain untapped in the private sector investmentsBlue finance, which is a sub-sector of impact investing, is in an infancy stage, it is maturing gradually. This is illustrated in Figure 1. There is a lot of potential for innovative financing mechanisms in the blue economy, however, they are yet to be identified and harnessed (Wabnitz and Blasiak 2019).

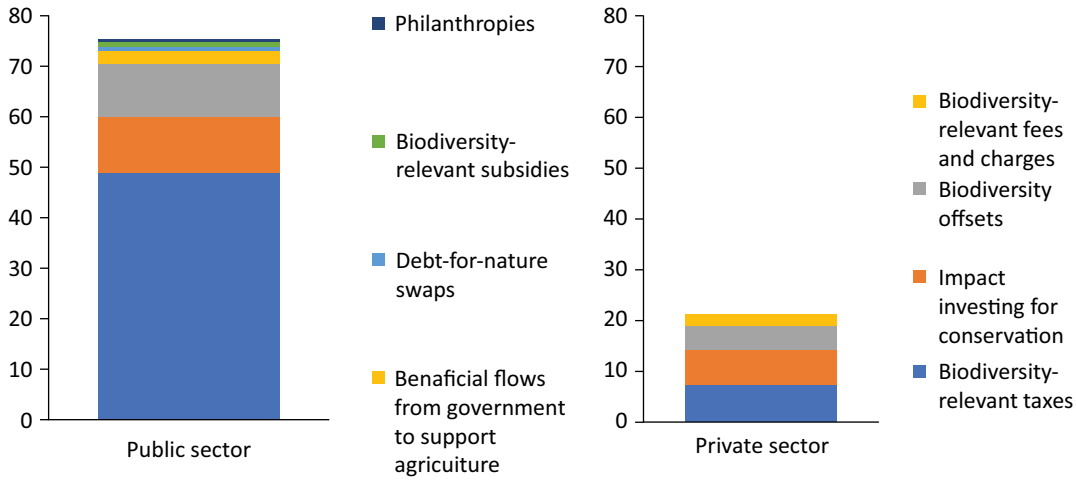

Figure 1 Sources of investment for SDG14 and SDG15
Source: UNCTAD (2019)

Surveys support the claim that investors are keen to invest in sustainable blue economy, however, information and knowledge asymmetries are the biggest barriers currently. A promising step towards integrating sustainable blue economy themes into the mainstream finance is the emergence of blue bonds, which is successfully demonstrated in Seychelles.

5. Blue Economy Financing Instruments in Asia

The blue financing instruments as elaborated in the aforementioned section have been implemented globally with desired results. However, several challenges deter its application in developing economies such as India. There are limited evidences of private capital mobilization in developing economies. Certain Asian economies such as China have started experimenting with blue financing products. Since 2016, China has been exploring marine resources through implementing the Blue Bay project which covers the coastal regions and marine ecosystems. In the first phase of this project, 8 Chinese cities were approved by the Ministry of Finance and the State Oceanic Administration and have received a central government subsidy of about RMB 300 million. In the second phase, a similar amount of subsidy was received by 10 more Chinese cities. Moreover, several local governments support has also been received in the form of CSR funds in the tune of RMB 5 million to 4.5 billion. By the end of 2018, the Blue Bay project covered approximately 169 km of coastline, 2270 hm^2

of coastal wetlands, 11 islands, and 38 km of beaches that were rehabilitated and restored. Most Blue Bay projects include monitoring capacity building activities to track remediation effects, including observatory construction, on-line monitoring, and drone monitoring for water quality, hydrology, and sea area utilization real-time data.

In September 2020, a blue bond was issued by the Bank of China with an issuance value of US$942.50 million equivalent, aimed at financing marine-related green projects. The proceeds will be used to aid the development of ocean-related sustainability projects, as well as to finance and refinance marine-linked green projects. Other uses may include projects related to renewable energy, sustainable water, waste management, and sewage treatment segments. Certain other prominent examples of long-term blue bonds which have been issued recently are mentioned in Table 3.

Table 3 Issuance of blue bonds globally

Issuer	Year	Amount	Coupon Rate		Purpose	Stakeholders Involved
Seychelles Government	2018	15 million	6.5%	10 years	Achieving a transition to sustainable fisheries and safeguarding oceans	The Nature Conservancy, World Bank, Global Environment Facility, SeyCCAT, and DBS
Nordic Investment Bank	2019	200 million	0.37%	5 years	Focus on investments within water resource management and protection	Nordic Investment Bank
World Bank	2019	10 million	2019: 2.35% 2020: 2.70% 2021: 3.15%	3 years	Address the challenge of plastic waste pollution in oceans	Morgan Stanley

Source: ADB Institute (2020)

Some other blue financing practices have emerged in the recent years, as indicated in Table 4.

Table 4 Blue finance practices launched in 2018 2019

Agent	Name	Year	Scale	Duration
World Bank	PROBLUE Umbrella 2.0	2018	29 million as of fiscal 2019	-
Asian Development Bank	Oceans Financing Initiative	2019	5 billion	5 years
The Nature Conservancy	Blue Bonds for Conservation	2019	1.6 billion	5 years

Source: ADB Institute (2020)

Two recent examples of the application of private funds in Asian economies include Circular Capital Ocean Fund and SIFFS Microfinance Model. The details of the applicability of these funds are provided in Table 5.

Table 5 Examples of private funds in Asian economies

Name of Fund	Capital Type	Investor Type	Fund Size	Year	Economies Catered to	BE Sector	Stakeholders
Circular Capital Ocean Fund	Equity, quasi-equity, debt	Venture capital	US$106 million	2018	India, Indonesia, Philippines, Thailand, and Vietnam	Waste management	USAID, The Ocean Conservancy, PepsiCo, Procter & Gamble, Dow, Danone, Unilever, The Coca-Cola Company, and Chevron Phillips Chemical
South Indian Federation of Fishermen Societies (SIFFS) Microfinance Model	Microfinance loan	Commercial banks	INR 86 million	-	India	Fisheries and aquaculture	SIDBI, SBI, Canara Bank, Indian Overseas Bank, Axis Bank, and Cordaid, Netherlands , European Central Bank (ECB)

Source: Ocean Finance Handbook (2020)

6. Deterrents to Blue Financing

There are various challenges pertaining to blue financing in developing countries. Some of the prominent ones are highlighted as follows:

- Lack of investment-ready, bankable projects that are supported by a revenue model.
- Lack of specialist capacity to bridge the sectors of finance and economics with ocean science and management.
- There are definitional challenges relating to the overlap of blue economy and ocean economy. The definitions at present vary (Smith-Godfrey 2016). According to the UNCTAD (2014), in many instances the two terms are used interchangeably. However, according to OECD (2016), World Bank, and UNDESA (2017), the blue economy focuses firmly on the sustainability of ocean resource use, while the ocean economy simply indicates the development and growth of ocean-related industries. According to the World Bank's definition of ocean economy, the purview of activities includes sustainable marine energy, fisheries, maritime transport, waste management, climate change, and tourism. Moreover, there exist definitional inadequacies relating to blue finance. Some of the existing frameworks for blue financing include ADB Oceans Financing Initiative and European Commission's Blue Economy Finance Principles; Lack of universal standards and metrics to integrate issues pertaining to blue economy. Some of the other deterrents are as follows:

- Low private sector investments into the blue economy
- Low level of awareness and capacity building
- Lack of understanding of potential risks emanating from issues pertaining to blue economy.

7. Stakeholders Collaboration in facilitating Blue Finance

The considerable rise in green bonds in the Asia and Pacific is indicative of the increased consciousness on sustainable issues and environmental concerns. The consciousness is highly imperative for the behavioural change of the stakeholders towards such issues. However, the success of these instruments depends largely on varied aspects of governance, in other words, as sustainable governance. Some of the prominent stakeholders who can induce change in the existing state of blue finance are stated in Table 6.

Table 6 Potential stakeholders

Stakeholder	Potential Role	Strength	Weakness
Institutional Investors from asset managing companies	Selection of stocks based on Blue Finance (B)F criteria	i. Being obliged to fiduciary duty, institutional investors undertake additional measures to safeguard clients' financial interests ii. Diversify risks based on non-financial factors	i. Lack of awareness and clients' low-risk perception relating to BF factors ii. Lack of a BF financing framework and standard practices
Investment bankers	Advising and conducting due diligence based on the blue economy	i. Bounded by fiduciary duty to safeguard clients' financial interests ii. Potential to merge financial returns with non-financial returns	i. Lack of awareness on sustainable issues ii. Lack of an integrated framework for integration of non-financial issues iii. Lack of proper monitoring frameworks
Bilateral agencies	Providing funds for blue economy infrastructure projects	-	-
Multilateral development banks	Provide funds for Blue Economy (BE) projects	Can act as a guarantor for government funds	Depend on the credibility of the issuing institution
Commercial banks	Encourage and incentivize investment towards BE projects	Design financial products to attract investments from different categories of investors	i. Low awareness on BE issues ii. Low-risk perception iii. Less to no demand of financial products catering to BE
Impact investors	Link and integrate financial returns with BE	Have potential to change the culture of investing from traditional to issue based	Lack of awareness on blue economy issues

Stakeholder	Potential Role	Strength	Weakness
Credit rating agencies	Include sustainability issues as one of the parameters for credit rating	Linking sustainability risks to financial returns	Low-risk perception emanating from sustainability/blue economy issues
Academia	Conduct research and propagate	Facilitate understanding on blue financing issues to students	Issues on blue financing/ sustainability financing are not included as mainstream courses at school/college/university levels
Civil society	Conduct research and advocacy on BE and BF issues	Exert influence on different categories of stakeholders	Faced with financing deterrents for project implementation
Policymakers	Develop a regulatory framework for financing the BE – this entails designing policies and regulations	Induce transparency and credibility in financing frameworks	-
Stock exchange	Design market indices through integrating BE issues.	Harnessing the market sentiments and bridging the gap between companies and investors	i. Lack of any regulatory authority, ii. Lack of financial products
Companies	Funding through CSR	CSR is one of the channels of creating a social impact	Legal complexities and lack of any regulatory framework

Source: Based on authors' understanding

8. Proposed Framework on Blue Financing

The proposed framework as illustrated in Figure 2 is adapted from the Blue Financing Framework developed by Asian Development Bank, 2020. This is a regulatory-driven framework, implying that the sovereign states should issue blue bonds inviting private investors with guarantees provided by the multilateral development banks such as the World Bank. This type of bonds is also known as social impact bonds or more precisely development impact bonds. The crucial difference between these bonds and a traditional bond is that the return on the bonds to investors is linked to the achievement of outcomes, thereby increasing the competitiveness and credibility of the bonds. Moreover, this is another way of ensuring efficient utilization of public money.

The other channel of utilization of public money is through direct allocation by way of budgets.

Although the deployment of CSR funds for the implementation of blue economy projects is still a far-fetched idea, it can be a potential opportunity for companies to ensure effective allocation of their CSR money.

9. Prospects and Concluding Remarks

This chapter is an attempt to throw light on the existing financing instruments for blue economy. It reflects on the inadequacy of the market to price such issues, especially in developing economies. It is worthwhile to mention that among the various aforementioned challenges to finance blue economy, countries are often faced with jurisdictional challenges for protecting ocean resources. Hence, a regulatory-driven financing framework is the need of the hour. The chapter elucidates on the efficacy of financing instruments such

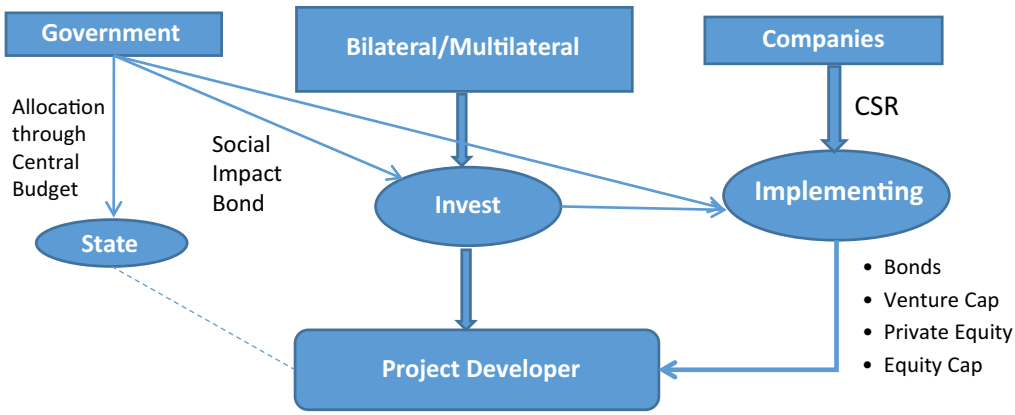

Figure 2 Proposed blue financing framework in developing economies
Source: Author's illustration

as blue bonds for financing the blue economy. However, lack of awareness and uncertainty on returns discourage investors from investing especially in developing economies. The sources of finance are mostly driven by loans and grants in developing economies, thereby losing out on the potential gains accrued through market forces. Having said this, it is also emphasized that a market on blue economy issues needs to be created in developing economies with the government acting as the primary stakeholder and incentivising the private sector to invest in the blue financing products. As stated in the preceding section, the multilateral development banks/bilateral agencies can act as a guarantor in such cases. Efforts also need to be done to channelize CSR money into blue economy projects. Lastly, there are considerable prospects for generating returns from investing in the blue economy in developing economies, however, opportunities need to be explored further.

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4.

MANAGING ENVIRONMENT, CLIMATE CHANGE AND MARINE ECOSYSTEM

Chapter 11

Climate change threats to India's holistic maritime security and their implications for the Blue Economy

Dr Pushp Bajaj, Research Fellow, National Maritime Foundation, New Delhi, India

1. Introduction

Arguably, India's success as a major economy in the world in near future would, in large part, be determined by how efficiently it utilizes its maritime space. Yet, for many decades the population and the governments in India have struggled with 'sea-blindness'. Only in recent years the country has begun to acknowledge and take greater responsibility for more sustainable advantage of its marine living and non-living resources. It has initiated a transition to a 'Blue Economy' through the first few tentative steps that will enable it to move away from the 'Brown Economy' which has prevailed for decades, if not centuries.

In his inaugural speech at the Maritime India Summit 2021 held in March 2021, Prime Minister Narendra Modi promulgated India's ambition to become a leading blue economy in the world. He highlighted the efforts that are being made to make existing maritime infrastructure more efficient and sustainable, build new state-of-the-art infrastructure, and improve land-based connectivity through railways and roadways. Some of the key active endeavours and policies in the maritime sector include the *Sagarmala* initiative which was launched in 2016 to promote port-led development; Shipbuilding Financial Assistance Policy 2015 which encourages domestic shipbuilding; expansion of coastal and marine tourism; *Pradhan Mantri Matsya Sampada Yojana* 2020 which was launched to bring about a 'Blue Revolution' through sustainable and responsible development of the fisheries sector; *Sagar Manthan*: Mercantile Maritime Domain Awareness Centre, launched in 2021 for real-time tracking of vessels; and the comprehensive Maritime India Vision 2030, launched in 2021, under the Ministry of Ports, Shipping and Waterways.

While these ambitious developmental projects and the supporting policies are critical in transitioning to a blue economy, this transition is being and will continue to be seriously impeded by contemporary environmental challenges that threaten India's holistic maritime security and, in turn, the blue economy. From the impacts of climate change such as rising ocean temperatures and ocean acidification that lead to changes in distribution of fish populations to sea-level rise, extreme weather events damaging coastal infrastructure and ecosystems, and disrupting human activities such as widespread plastic pollution, the problems are growing at an accelerating pace and becoming harder to manage with each passing year. These changes pose complex and serious threats to food, economic, and human security of the Indian population. Therefore, efforts to mitigate these environmental challenges, which are currently lacking, need to be built-in to the blue economy model to protect and preserve the natural resources that are essential to all the major sectors such as fisheries, ocean tourism, marine biotechnology, and offshore renewable energy. The blue economy model must go beyond the 'economic' model and rigorously account for the value added by natural coastal and marine ecosystems and the biodiversity.

This paper discusses in detail, in Section 2, the three major threats posed by climate change. These threats, if left unchecked, would have widespread and long-term impacts on the blue economy, namely, rising sea levels, increasingly intense, frequent, and less predictable extreme weather events, and declining marine biodiversity due to dramatic physical and chemical changes in the oceans. Further, in Section 3, the paper outlines the complex ways in which these threats are limiting the growth of almost every sector of India's blue economy. These challenges are fundamentally complex in nature and do not have a single, straightforward solution. Ironically, pursuing a truly sustainable, holistic blue economy is also one of the most effective ways to mitigate future climate change and make the economy more resilient to the changes that have already occurred. In this context, Section 4 concludes with some key policy recommendations to move forward to tackle the daunting challenges arising from climate change while facilitating India's blue economy.

2. Contemporary Threats to India's Holistic Maritime Security from Climate Change

Climate change is quickly emerging as a major, imminent security threat for all nations, which is also being increasingly acknowledged by many countries (Guy, Conger, Keys, *et al*. 2020). Particularly vulnerable are coastal and island states due to the irreversible threat of partial or complete inundation from sea-level rise and the globally rising numbers of extreme tropical revolving storms. The three major climate threats to India's holistic maritime security, namely, sea-level rise, changes in extreme weather events, and deteriorating marine biodiversity, are further discussed in detail.

2.1 Sea-level Rise

One of the most alarming of all challenges arising from climate change is sea-level rise (SLR), for a number of reasons: (i) SLR is irreversible through natural processes on timescales of hundreds of thousands of years; (ii) there is no practical, economically feasible way to protect the coastlines from SLR – the only 'adaptation' measure for the immediate coastline population is to retreat to a higher ground; (iii) there are a number of 'tipping points' in the cryosphere which, when crossed, would commit us to multiple meters of global SLR over a period of decades to centuries to millennia and there is no certain way to determine where these tipping points lie in terms of the level of global warming; and (iv) the current rate of SLR is already far greater than ever observed in recent paleoclimatic history and it is accelerating.

Figure 1 shows the change in global mean sea level (GMSL; denoted as sea height variation) since 1993 – when satellite measurements began. Clearly, globally the sea level is rising at an accelerating pace. There are three major sources for SLR including the thermal expansion of ocean water due to rising temperatures, melting of the Greenland and Antarctic ice sheets, and melting of the world's mountain glaciers. While Figure 1 shows the rise in GMSL, similar trends have been observed in the Indian Ocean. In the northern Indian Ocean, as per a recent climate change assessment report released by the Ministry of Earth Sciences, Government of India, the rate of SLR increased from 1.4 mm/year during 1874–2004 to 3.3 mm/year in 1993–2017 (Raghavan, Jayanarayanan, Gnanaseelan, *et al*. 2020). This happens to be similar to the rate of increase in GMSL, however, in general, the sea level does not and will not rise uniformly across all of the world's ocean basins. In fact, the Bay of Bengal is experiencing SLR that is faster than the global average and anywhere else in the world. This, of course, has huge implications for the Indian states along the east coast and its neighbour Bangladesh (Dhara 2019), even more so since the region already suffers from multiple powerful cyclonic storms almost annually.

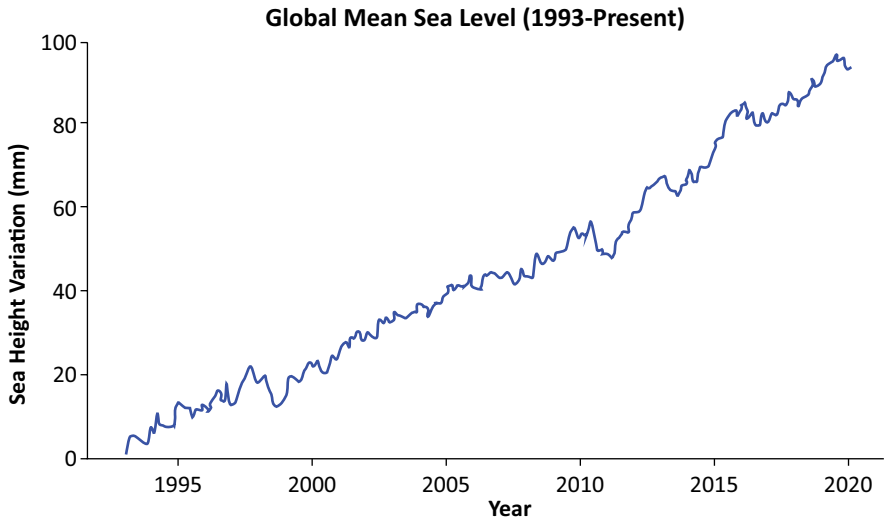

Figure 1 Change in global mean sea level from 1993 to 2020
Image Source: Image created by the author

Data Source: GSFC. 2017. Global Mean Sea Level Trend from Integrated Multi-Mission Ocean Altimeters TOPEX/Poseidon, Jason-1, OSTM/Jason-2 Version 4.2. Details available at http://dx.doi.org/10.5067/GMSLM-TJ42

As alluded to before, sea levels will continue to rise for many centuries to millennia as long as global warming continues unabated. However, it is extremely difficult to predict with accuracy the magnitude and rate of future SLR. There are two main ways in which scientists estimate future sea levels, one is through computer models-based simulations of the climate and the other is through paleoclimatic data by studying warmer climates in the past and using them as proxies for the future.

In its 2019 special report on 'The Ocean and Cryosphere in a Changing Climate', the United Nations' (UN) Intergovernmental Panel on Climate Change (IPCC) projected that the GMSL could rise by around 0.84 m (likely range: 0.61–1.10 m) by 2100, if no mitigation action is taken (scenario referred to as 'Representative Concentration Pathway 8.5' or RCP8.5), which was derived from climate models-based projections. In the most optimistic scenario where all nations take immediate and drastic measures to slash down global greenhouse gas emissions (referred to as RCP2.6), the potential sea-level rise could be brought down to around 0.39 m (likely range: 0.29–0.59 m) (Oppenheimer, Glavovic, Hinkel, *et al*. 2019). Some observational scientists believe that these future SLR estimates may be too optimistic considering just the current rates of ice loss from the Greenland and Antarctic ice sheets, and these ice loss rates are only accelerating (Bajaj 2019).

The other approach is to study past climates and draw inferences about what a warmer future might hold for humanity (Tierney, Poulsen, Montañez, *et al*. 2020). Currently, the global average temperature is nearly 1.1–1.2°C above the pre-industrial levels. This means that the world is getting dangerously close to the global warming targets of 1.5°C and 2°C agreed upon by over 190 countries in the Paris Agreement signed at the 21st Conference of Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC) in 2015. The best historical analogue to a 1.5°C/2°C warmer (above pre-industrial level) world is the last interglacial period, around 129–116 thousand years ago, when the global average temperature was about 0.5–1°C higher than today. Sea level during the last interglacial period was 6–9 m higher than the present levels. Scientific estimates suggest that it is quite likely that we will cross the Paris Agreement targets by the middle of the century unless we take drastic measures to both rapidly reduce our carbon emissions and simultaneously

extract and sequester large amounts of carbon dioxide (CO_2) from the atmosphere. As we approach 3°C and higher global average temperatures above the pre-industrial level, we enter into a climate that was last experienced around 3.3–3.0 million years ago, during the Pliocene Epoch, when the sea level was around 25 m higher than today. These sea-level estimates correspond to stable 'equilibrated' climates. Sea-level rise occurs over many centuries to millennia; therefore, it is not that we will suddenly have a multi-metre rise in the sea level, but it means that if the global average temperature remains at 1.5°C or 2°C or 3°C levels, then the sea level would gradually but inevitably rise by 6–9 m to 25 m in the long term.

For policymakers and other stakeholders, it is absolutely critical to remember that neither of the two approaches mentioned above can be trusted blindly. While computer models provide us extremely useful insights into how the climate could look like in the future depending on the different greenhouse gas emissions scenarios, there are inherent limitations on the accuracy of climate models. In many cases, we do not know enough about the natural processes and/or we do not have enough observational data to accurately model the complex air–water–land interactions that determine how the ice sheets would respond to a rapidly warming world. When it comes to using historical climates as proxies for the future estimates, we must remember that to the best of our collective scientific knowledge current rates of greenhouse gas emissions and subsequent temperature rise are much faster than the planet has ever experienced through natural processes throughout its history. Therefore, we cannot directly compare the ongoing human-caused climate change to the natural climatic changes that have occurred in the past because there is no 'real analogue' to present conditions. Considering these facts and the extremely high stakes, it would be prudent, and, in fact, it is necessary to err on the side of caution and prepare for the worst-case scenarios of SLR.

In the short term already, the relatively small amounts of SLR when combined with increasing cyclonic storms and storm surges pose a direct threat to the infrastructure and population along India's vast coastline. In the long-term, a metre or more SLR by the end of the century would lead to major disruptions in the national and global order, and literally reconfigure the coastlines. According to estimates from a 2019 study, nearly 35 million Indians will be exposed to annual flooding by 2050 and that the number will grow to 51 million Indians by 2100 (based on 2010 census) in the worst-case scenario. The study also states that, coastal regions that are currently inhabited by 21 million Indians will be permanently inundated by SLR by mid-century, and regions inhabited by nearly 38 million Indians will be permanently inundated by the end of the current century (Kulp and Strauss 2019).

In addition to the direct impacts of increased tidal flooding, storm surges, and erosion, SLR also affects the food and water security in India in general and the coastal residents in particular through indirect ways such as saltwater intrusion into land. Saltwater contamination in coastal agricultural lands due to SLR presents a unique challenge for coastal agriculture which is compounded by rising temperatures and changing rainfall patterns (Gopalakrishnan, Hasan, Haque, *et al*. 2019). Sugarcane and rice are the two important crops grown in low-lying coastal regions, which are highly vulnerable to the changes in soil salinity levels. Moreover, saltwater intrusion into underground water aquifers could potentially damage an important source of freshwater. What these impacts mean for India's blue economy is discussed in detail in Section 3.

2.2 Changing Extreme Weather Patterns

With fast emerging attribution techniques that determine the contribution of climate change in exacerbating a specific extreme weather event, there is mounting scientific evidence to support the assertion that climate

change is making extreme weather events more extreme, more likely, and less predictable. Increasing atmospheric temperatures have 'supercharged' the natural water cycle. With every 1°C rise in temperature, the atmosphere holds around 7% more water vapour. This is leading to increasing likelihood of both droughts and heavy precipitation events. Rising ocean temperatures and heat content are enabling the occurrence of more intense marine heat waves and tropical revolving storms. Unequal warming of land and ocean has resulted in decreased temperature gradient between the Indian Ocean and mainland India which has changed air-circulation patterns and made monsoonal rains more erratic and unpredictable. There is also growing empirical evidence which suggests that abrupt warming in the Arctic compared to lower latitudes is changing the behaviour of the jet stream which may be responsible for the freakish extreme weather events in recent years, particularly at mid-latitudes. Against the backdrop of gradual but continuous SLR, these changes in extreme weather patterns pose a serious security threat to maritime India.

Extreme weather events lead to heavy socio-economic losses over a short period of time, while taken in aggregate over time they could lead to long-term impacts on the economic and social order. For instance, the east coast of India is now experiencing severe to extremely severe cyclonic storms (ESCS) almost annually. In 2020, cyclone *Amphan* caused tremendous damage to residential, commercial, and municipal infrastructure in the state of West Bengal, amounting to over ₹1.02 lakh crore (Singh 2020). Soon after that, the west coast witnessed its strongest tropical cyclone since 1981, cyclone *Nisarga*, which hit Maharashtra in June (Gangan and Venkatraman 2020). In 2021, while the country was still reeling with the disruptions caused by the ongoing COVID-19 pandemic, two powerful cyclones battered the coasts again. Cyclone *Tauktae* hit the west coast in mid-May as an ESCS at its peak intensity and a week later cyclone *Yaas* hit the east coast as a very severe cyclonic storm (VSCS). Kerala, Karnataka, Goa, Maharashtra, and Gujarat were all heavily impacted by *Tauktae* which killed at least 104 people, becoming the deadliest cyclone from the Arabian Sea in over a decade (Marar 2021). This made 2021 the fourth year in a row when a cyclone was recorded over the Arabian Sea which has historically been considered to be a relatively 'calm' sea.

The latest and first-of-its-kind climate change assessment report by the Ministry of Earth Sciences (MoES), released in 2020, noted that 'the frequency of VSCSs during the post-monsoon season has increased significantly (+1 event per decade) during the last two decades (2000–2018)' (Raghavan, Jayanarayanan, Gnanaseelan, *et al*. 2020). The increasing frequency of powerful cyclones over the Arabian Sea primarily due to continually rising sea surface temperatures poses a major threat to all the states along the west coast that are relatively less prepared and ill-equipped to deal with cyclones compared to the states on the east coast (Ghanekar 2021). Heavy monsoon flooding events in the southern states of India are also increasing in frequency. In both 2018 and 2019, Kerala saw two of its worst floods in a century caused by well-above-average monsoon rains resulting in damages of tens of thousands of crores (Jacob 2019). Overall, as shown in Figure 2, there is a rising trend in severe flood events over India since the last three to four decades as highlighted by the 2020 MoES Climate Change Assessment Report.

In addition to the immediate monetary losses due to infrastructural damages, the rise in extreme weather events and the changes in temperature and precipitation distributions have a major impact on the agriculture sector, which affects both economic and food security of India. India's fast-growing economy and a large part of the population are heavily dependent on agriculture. Indian agricultural practices have historically evolved around the robust nature and consistency of the Indian monsoon. The country receives nearly 70% of the annual rainfall during monsoon. Around 50% of the agriculture in India does not have access to artificial

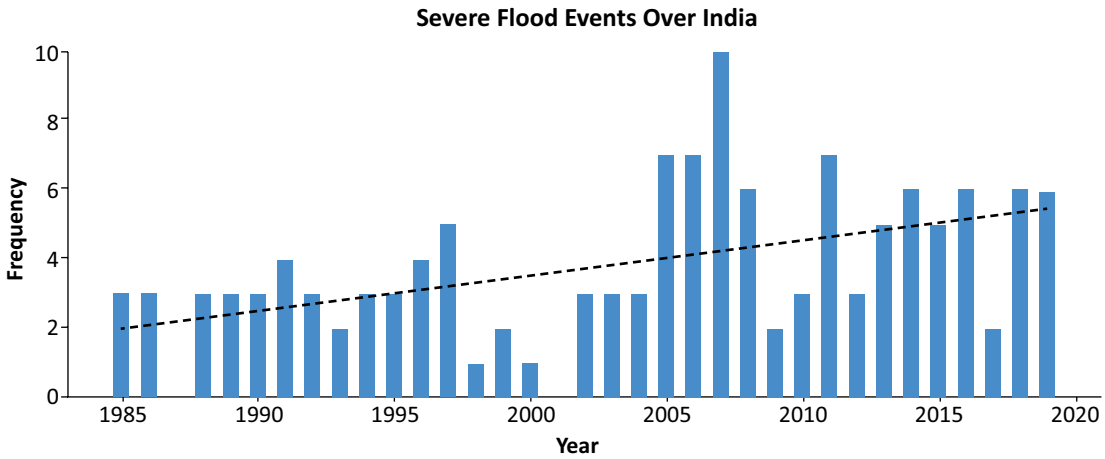

Figure 2 Time series of severe flood events over India during 1985–2019. The black dashed line is a linear trend line
Source: MoES (2020)

irrigation facilities, in other words, it is at the mercy of the natural rainfall patterns. With climate change altering the Indian monsoon in a way that is increasing the likelihood of extreme precipitation events and making it less predictable, the historically robust agriculture sector could breakdown in the near future (Mukherjee, Aadhar, Stone, *et al*. 2018 and Vogel, Donat, Alexander, *et al*. 2019). This threat is not limited to India, in fact, it is becoming a major concern around the world. In a 2019 study, experts from around the world warned of the growing risk of simultaneous collapse of the major global 'breadbaskets' in the event of a series of multiple extreme weather events experienced simultaneously, in a short period of time (Gaupp, Hall, Hochrainer-Stigler, *et al*. 2019). Decline in land-based agricultural yields put more pressure on marine and coastal fisheries to meet the ever-growing food demands of the country. The fisheries sector deals with own challenges that are being exacerbated by climate change-induced extreme weather events as discussed further.

The global ocean plays a key role in regulating carbon and water cycles and, thus, the climate. The ocean has absorbed nearly one-third of all human-caused CO_2 emissions since the industrial revolution and around 90% of the excess heat generated by greenhouse gases in the atmosphere. Observational trends in global ocean heat content from late 1950s to 2020 show that the ocean heat content has been rising relentlessly since the mid-20th century. This is leading to increasing ocean temperatures and, in turn, increasing the frequency and intensity of marine heatwaves, as was established in the 2019 UN IPCC's special report on 'The Ocean and Cryosphere in a Changing Climate' (IPCC 2019). Similar to terrestrial heatwaves, a marine heatwave corresponds to a state of abnormally high ocean temperatures over a sustained period of time. Marine heatwaves could last a few weeks to months, they can extend up to thousands of kilometres and can penetrate hundreds of metres deep into the ocean. Prolonged marine heatwaves can significantly damage marine ecosystems and fish species, and they can even lead to mass die-offs. Some of the impacts on the marine biodiversity are discussed in detail in the following section. According to a 2019 study, climate models-based future projections show a significant rise in both marine heatwave intensity and average number of annual heatwave days, globally (Oliver, Burrows, Donat, *et al*. 2019). The same study also concluded that many parts of the global ocean could reach a near-permanent heatwave state during the course of this century, as compared to the 1982–2005 baseline climatic conditions.

2.3 Declining Marine Biodiversity

In recent decades, oceans have undergone remarkable chemical, physical, and biological changes due to a number of human activities including contemporary climate change, pollution, shipping, resource exploitation, etc. All these changes have significant long-lasting impacts on the natural biodiversity. In the specific case of climate change, ocean acidification due to increasing CO_2 concentrations and rising ocean temperatures due to increased greenhouse warming present two major challenges for all marine species. Additionally, sea-level rise and increasing extreme weather events such as droughts, cyclones, marine heatwaves, etc., also pose a threat to marine and coastal ecosystems such as mangroves, coral reefs, saltmarshes, etc., which provide critical habitats and breeding grounds for vast numbers of fish species.

Both land-based and marine animal species react in a similar way to temperatures. There is a narrow range of temperatures that is amenable to a particular species. If the temperature goes outside of this range, the typical response of the species is to migrate to regions with more hospitable conditions. Of course, this happens already annually when many species migrate to different locations with changing seasons. But, with rising annual average temperatures the geographical distributions are changing permanently. Marine fish species, in particular, have a narrower range of habitable temperatures compared to land-based species (Pinsky, Eikeset, McCauley, *et al*. 2019). Unlike land animals, however, marine species generally have the option to move both horizontally and vertically in the water column. Some species also adapt by altering their biological functions and physiological characteristics (Pörtner and Gutt 2016 and Mohanty, Vivekanandan, Mohanty, *et al*. 2017). In any case, the changing distribution would have significant impacts on the fisheries sector and fisherfolk population. At the local level, there will likely be some 'losers' and some 'winners' in terms of fish catch. In some cases, the fishermen would have to traverse greater distances or acquire new equipment to adapt to the change in fish distribution. At the international and regional level, movement of fish species could raise an additional set of legal and governance challenges. If and when species move out of or into India's exclusive economic zone (EEZ) to or from the high seas or one of our neighbours EEZ, there could be increased competition or disputes over legal claims on those resources. Similar cases of conflict over fish stocks have been observed in recent decades and they could increase in future with the expected changes in ocean conditions (Spijkers and Boonstra 2017; Pinsky, Reygondeau, Caddell, *et al*. 2018). It is important to note that while fish populations can adapt to gradual changes in temperature over time, extreme and sudden temperature changes like those experienced during prolonged marine heatwaves have resulted in mass fish die-offs. Such heatwaves are expected to grow in intensity and frequency.

Collectively, a large number of marine species rely on the critical marine habitats and ecosystems such as mangroves, corals, and seagrass, during different biological stages of their lives. All of these ecosystems are under severe climate-related due to rising ocean temperatures and ocean acidification along with human-caused stress from pollution and intrusive coastal construction. Coral reefs are arguably the most vulnerable marine ecosystem. Recent studies suggest that all of the world's coral reefs could be wiped out by the end of the century, or sooner, if climate change continues unabated (Davidson 2020). When ocean temperature rises above a certain threshold, corals undergo a process called 'bleaching'. In this process, corals expel microscopic algae living within them in a symbiotic relationship. Corals provide them nutrition and unique colours. Corals and algae cannot survive without each other. Typically, as temperatures cool down, the algae particles return to the corals and the habitat returns to normal. With rising ocean temperatures and consequently increasing frequency of marine heatwaves, bleaching events are becoming more common and lasting longer, allowing less time for coral reefs to recover completely. Further, increasing ocean

acidification also prevents re-growth of the corals' calcium-based skeletal structures. According to a 2009 study, 'bleaching would become an annual or biannual event for almost all reef regions along the Indian coast in the next 30–50 years' (Vivekanandan, Hussain Ali, Jasper, *et al*. 2009).

Mangrove forests are another example of a highly valuable coastal ecosystem that is under threat from climate change and human exploitation. In addition to providing an essential habitat to numerous terrestrial, marine, and bird species, mangroves also hold great socio-economic value (Himes-Cornell, Grose, and Pandleton 2018). They are an important source for fuelwood, charcoal, timber, and wood chips. They also act as extremely effective natural barriers against high tides, cyclonic storms, and storm surges. Moreover, they store large quantities of CO_2 from the atmosphere during their lifetime. According to estimates, mangrove forests can store up to four-times more carbon than tropical forests, including rainforests (Donato, Kauffman, Murdiyarso, et al. 2011). Their deforestation for various purposes is estimated to account for as much as 10% of carbon emissions from deforestation globally, even though they only account for around 0.7% of the tropical forest area (Donato, Kauffman, Murdiyarso, *et al*. 2011). India holds around 3% of the global mangrove forest area and 8% of Asia's mangrove forest area with a total area of 4975 km^2. West Bengal alone accounts for over 42% of the total mangrove forest cover in India (Gujarat, at the second place, accounts for over 23%). The West Bengal coast is also experiencing one of the fastest rates of sea-level rise and is frequently hit by powerful cyclonic storms. Mangroves are highly adaptive species and quite tolerant to salty ocean water. However, beyond a certain threshold excess salinity levels in the soil due to rising sea level and storm surges can hinder growth and damage the ecosystem. Considering the numerous, unmatched services that they provide, it is absolutely essential to conserve mangrove forests from climate change and human stressors. In fact, efforts needs to be put in to expand their area to utilize their carbon capture and flood-attenuation abilities to mitigate and adapt to the impacts of climate change.

Stress on marine biodiversity is further exacerbated by the ever-growing human interventions including over-fishing, unsustainable shipping, poorly designed coastal development projects, industrial pollution, untreated sewage discharge, plastic pollution, etc. These interventions affect all trophic levels of the marine food chain. Untreated sewage and other industrial effluents can lead to a phenomenon called 'eutrophication', wherein the added organic matter containing large quantities of nitrogen and phosphorous results in unnatural and excess algal blooms. Instances of such harmful algal blooms are being increasingly observed particularly in the Arabian Sea, along the west coast of India in recent years. These algae then consume large amounts of dissolved oxygen when they rot and decompose, leading to oxygen depletion in the ocean water. Plastic pollution, particularly micro-plastics, can be consumed by marine species, poisoning them gradually and causing them to die. Poorly planned development projects can also cause damage to marine ecosystems and disrupt marine life. For instance, one of the mega development projects – *Sethusamudram Shipping Canal Project* – aims to create a shipping route between India and Sri Lanka, through the shallow Palk Strait. The ambitious project, which has been a subject of constant debate for many decades now, will involve dredging a channel for cargo ships to reduce shipping times and consequently, save fuel and money. While the future of the project remains uncertain amid political and socio-economic concerns, if implemented, the construction of the canal will cause significant damage to the coral reefs in the Gulf of Mannar and Palk Bay and the incredibly rich biodiversity that depends on the reefs. The region is already a hotspot for illegal, unreported, and unregulated fishing, which leads to frequent conflicts between the local fishing communities of India and Sri Lanka.

3. Implications for India's Blue Economy

The myriad of impacts of climate change on India's holistic maritime security described in the previous section will have wide-ranging and far-reaching implications for almost every sector of the blue economy. Some of them would be more direct while the others may be very complex and cascading in nature.

Without extensive and proactive adaptation strategies, SLR and increasingly intense extreme weather events will lead to progressively frequent damages to critical maritime infrastructure, including port infrastructure, electricity infrastructure, coastal oil refineries, offshore assets, railways and roadways, transport infrastructure, etc. As mentioned in the previous section, these impacts could force millions of coastal residents to migrate due to complete inundation and/or frequent flooding as we move towards the second half of this century. This steadily increasing migration will result in significant decrease in the local workforce in these areas. Strictly in economic terms, a 2018 global study estimated that coastal flooding in India could result in annual economic losses anywhere between 1.5% and 2% of the annual GDP by 2100, depending on how far we let global warming continue (Jevrejeva, Jackson, Grinsted, *et al*. 2018). Additionally, the growing frequency of floods and subsequent infrastructural damages will inevitably lead to higher insurance rates for properties and businesses in coastal regions. In long term, these risks would discourage investments in coastal development projects that have almost invariably been highly lucrative in the past. Naturally, this would not bode well for the Government of India's push for 'port-led development' and 'port-led industrialization' under the *Sagarmala* initiative launched in 2016.

As discussed in Section 2.3, the overall decline and geographical redistribution of the marine species due to changing chemical and physical conditions of the oceans will adversely impact the fisheries sector of India's blue economy. The sector is a source of livelihood for over 16 million fishers and fish farmers at the primary level and almost twice of that if we include the jobs in the supply chain and distribution services. According to the 2018-19 data, the gross value added (GVA) of the fisheries sector is around ₹212,915 crores which amounts to 1.24% of the total national GVA and 7.28% of the agricultural GVA (MoFAHD 2019). These numbers do not reflect the full potential of the fisheries sector in contributing to the economic and food security of India. This fact is not lost on the central and state governments that are making ambitious plans to boost this sector of the blue economy. In May 2020, the Government of India approved the '*Pradhan Mantri Matsya Sampada Yojana*' that is envisaged to bring about a 'Blue Revolution' through sustainable and responsible development of the fisheries sector (MoFAHD 2020). The policy will be implemented over a period of 5 years from 2020-21 to 2024-25 with an extraordinary, estimated investment of ₹20,050 crores over that time period. The basic policy framework emphasises on capacity enhancement through expansion and diversification, strengthening of value chain, and sustainable, responsible, and inclusive exploitation of resources, among other promising objectives. However, it does not propose any mechanism to address the impacts that rising ocean temperatures, ocean acidification, extreme weather events, and sea-level rise have and will continue to have on the marine biodiversity. Without an effective short-term strategy aligned with the long-term projections to deal with the impacts of climate change, the goal of a 'sustainable fisheries sector' will always remain incomplete.

Another sector that suffers greatly from deteriorating ecosystems and biodiversity is the marine and coastal tourism sector (also referred to as ocean tourism). Globally, ocean tourism accounts for nearly 26% of the total global ocean economy. It is a source of livelihood for millions of people in all coastal nations (OECD 2016). Of course, when it comes to ocean tourism, the major tourist attraction is the ocean itself and the natural

biodiversity, including ecosystems such as mangroves and coral reefs and also individual species such as dolphins and whales. As earlier mentioned, the natural ecosystems are under threat due to climate change, and this threat is being compounded with a number of other anthropogenic activities. These activities include pollution (plastic and other industrial effluents), unsustainable resource extraction, unplanned construction along the coasts by clearing mangrove forests and damaging coral reefs, exploitative shipping practices such as dredging, etc. As India continues to expand the ambit of its blue economy, coastal and marine tourism will be critical to this growth. Along with this, the protection and preservation of coastal and marine ecosystems will be key in ensuring long-term sustainability of the tourism sector.

Importantly, India's blue economy cannot and should not be considered in isolation. It is, in many ways, reliant on the broader Indian Ocean region. There are several indirect, yet significant, ways in which the deleterious impacts of climate change on the broader region could affect India's blue economy. Most Indian Ocean littoral states fall under the 'developing' or 'least developed' categories. Depending on the geographical, political, and socio-economic conditions some of them may be more vulnerable to climate change than others. For instance, the small island developing states, such as the Republic of Maldives and the Republic of Seychelles are particularly at risk from sea-level rise, extreme weather, increasing water scarcity, etc. Like other middle- and low-income nations in the region, these states lack the necessary financial resources to take adequate mitigation and adaptation measures and, therefore, look up to other nations for the economic and technological support. While this creates an opportunity for stronger regional cooperation, if we do not take timely action to seize this opportunity, other major players inside or outside the region, such as China, could exploit this gap and use it to establish a stronger presence in the region.

Similarly, relatively weaker nations in West Asia and East Africa, which are already stressed for resources and prone to conflicts, could be destabilized due to growing impacts of climate change leading to geopolitical vulnerabilities in the Western Indian Ocean. For India, this is crucial for its blue economy as large quantities of its annual mercantile trade passes through the Strait of Bab-el-Mandeb, which connects the Red Sea and the Gulf of Aden, and the Strait of Hormuz, connecting the Persian Gulf and the Gulf of Oman. These already sensitive chokepoints could become even more vulnerable as the intra- and inter-state competition increases due to diminishing resources in the region.

4. Way Forward: Key Policy Recommendations

Unfortunately, there is no silver bullet when it comes to climate change, there are not even a few silver bullets, we will need all the bullets, and the grenades! There is a need to simultaneously drastically reduce greenhouse gas emissions to prevent further heating, adapt to the climatic changes that have already occurred, and draw down carbon from the atmosphere to bring the atmospheric concentration of greenhouse gases to the 'safe' levels (to stay within the 1.5°C global warming target of the Paris Agreement). As alluded to before, pursuing a holistic blue economy that is centred around protection, preservation, and sustainable utilization of the natural marine resources, guided by the latest science and technology, is one of the most effective ways to mitigate and adapt to climate change while promoting sustainable economic growth. In this context, some of the key policy recommendations are highlighted as follows:

a. While India has made great strides in the installation of renewable energy infrastructure, both solar and wind energy, challenges remain in scaling to meet the ambitious targets due to land requirements and intermittency problem of onshore solar and wind installations. To meet the growing energy demands

without increasing carbon emissions, the renewable energy basket needs to be diversified. The ocean holds vast untapped potential in this regard in the form of tidal energy, wave energy, ocean thermal energy, offshore wind, solar energy, etc. (Guduru and Chauhan 2020b). These technologies are still in their nascent stage in India which means that the initial financial and research investment may be high. Nevertheless, they could significantly complement land-based solar and wind energy with additional capacity and fewer limitations in the long term.

b. Ocean renewable energy resources (ORERs) could be seamlessly integrated into the Sagarmala initiative to power the ports and other coastal infrastructure with low-carbon, renewable energy (Choudhury, Honmane, Guduru, et al. 2021).

c. The transport sector is a major contributor to greenhouse gas emissions. In the maritime domain, the shipping sector is a notoriously difficult sector to decarbonize due to lack of alternative fuels and practical limitations of electric batteries for application in large cargo vessels (Bajaj, Guduru, Honmane, *et al*. 2020). Decarbonizing the shipping industry will be critical in achieving the national and global climate targets. The following are the two steps that should be taken simultaneously:

   i. Enhance the fuel efficiency of existing and new vessels in line with the energy efficiency standards set by the UN's International Maritime Organization (IMO). The proposed expansion of the domestic ship building industry in India must ensure high fuel efficiency standards of the vessels produced in this regard.

   ii. Research and development in alternative fuels is essential to achieve net-zero emissions in future. Due to its high calorific value and zero carbon content, liquid hydrogen, produced from electrolysis of water using renewable energy (could be ORERs as well), offers a promising zero carbon solution for ships. Hydrogen could also be used to decarbonize other long-haul land-based transportation systems such as trucks and railways, and even the aviation sector. There are some concerns related to safety and economic viability, but hydrogen as a fuel is gaining a lot of traction globally. India has the opportunity to enter the market early by investing in making hydrogen cost-competitive and safe to use, and establish itself as one of the pioneers (Guduru and Chauhan 2020a).

c. Further in the efforts to mitigate climate change, protection and preservation of coastal and marine ecosystems would play a key role. As mentioned before, the ocean, as a whole, acts as a major carbon sink, however, the mechanisms that are responsible for the carbon capture capacity of the ocean are under threat from climate change and human exploitation (Youdon 2020). Coastal and marine ecosystems such as mangroves and coral reefs across India must be declared as marine-protected areas and conserved at all costs to maintain the carbon sink.

d. Additionally, innovative and experimental approaches could be explored to enhance the carbon capture capacity of the ocean. Some of the seemingly radical techniques proposed by scientists include enhanced weathering of rock minerals in the marine environment and ocean fertilization with iron to increase primary productivity. Since these techniques have only been studied in controlled laboratory settings so far, more research is required to understand their effects on the marine environment and the food web.

e. Importantly, some of the impacts of climate change are unavoidable now due to the temperature change that has occurred and continue to occur due to already accumulated greenhouse gases in the atmosphere. Sea-level rise and changing extreme weather patterns are among such impacts that are already occurring and will continue to get worse. There is a need to develop a dynamic and comprehensive adaptation strategy to protect India's vast coastline and the millions of coastal residents.

f. The very first and crucial step for any adaptation strategy is a rigorous risk assessment analysis. A comprehensive nationwide city-level climate risk assessment must be conducted to identify the most vulnerable regions, take stock of their assets, the kinds of risks that they will be facing, and the possible solutions to enhance their resilience. This would require participation of all stakeholders, from different levels of government to the private sector and local communities.

g. Some low-lying coastal areas may be completely inundated due to sea-level rise during the course of this century or may be facing frequent flooding and will have to be abandoned. This would mean relocation of thousands of residents and decommissioning or relocation of critical infrastructure to hinterland areas. An appropriate and comprehensive policy framework would be needed to manage this internal migration in a peaceful, just, and equitable fashion. This should be acknowledged and incorporated in the coastal states' individual State Action Plans for Climate Change and the National Action Plan on Climate Change, which are overdue for revision. Similarly, appropriate institutional and legal frameworks must be adopted to deal with human migration from neighbouring countries such as Bangladesh, Sri Lanka, Maldives, etc.

h. Insofar as extreme weather events are concerned, improved weather forecasting and early warning systems must be established, along with robust emergency protocols, to minimize socio-economic losses. Weather prediction is an inherently challenging problem due to a large number of variables and limited understanding of local-level atmospheric dynamics. Therefore, greater investments should be made to support research and innovation in weather forecasting science and technology. Better, more accessible warning systems are also necessary to ensure effective, large-scale communication in case of emergencies.

i. Natural coastal wetlands play a critical role in protecting coastal areas against storms and sea-level rise, in addition to serving as highly effective carbon sinks as mentioned before. The myriad of societal and economic benefits necessitate that the protection and expansion of these ecosystems must be a core component of any climate change adaptation strategy.

j. Finally, it is important to realize that climate change is a global problem that can only be 'solved' with collective efforts. The conventional 'national-interests-first' approach can no longer be the primary approach since national interests are now deeply intertwined with the actions of other nations. This, of course, exacerbates the challenges, but it also presents a new range of opportunities for regional collaboration towards the common goal of continued security and prosperity in the face of fast-moving climate change. India must strengthen and broaden its collaborations with more advanced nations to accelerate its transition to a sustainable blue economy and address climate change. India must simultaneously also provide support to the less-equipped states, particularly the ones in our maritime neighbourhood, to alleviate their climate-related problems in order to ensure a secure and stable Indian Ocean region.

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Chapter 12

Healthy Oceans for a Healthy Economy: Biodiversity, Climate Change, and Livelihoods in Blue Economy

Swati Ganeshan, Mani Juneja, Christina de Souza, and Asha L. Giriyan,The Energy and Resources Institute

Increasing environmental challenges are associated with ocean degradation that could be irreparable and irreversible in the coming decades. In addition to environmental challenges, climate change is leading to temporal changes that are causing transformations in nutrient and oxygen presence. This climate change is also affecting biodiversity and aquatic life, creating imbalances by endangering species survival and loss of natural habitats.

Food and resources from the ocean are prerequisite for survival and the availability of these resources is dependent upon a thriving biodiversity and ocean climate that is conducive for all species to thrive. Biodiversity and climate change concerns equally affect traditional and emerging sectors, including fishing, shipping, deep sea mining, offshore energy, and tourism. Blue economy sectors provide livelihoods to millions in India; however, the future of all industries depends upon the environmental challenges that would occur and their impact. This paper focuses on the major issues of biodiversity and climate change that affect livelihoods. It further elucidates the pathways to address these issues in the blue economy framework.

Biodiversity and Its Significance for Healthy Economy

Coastal and marine ecosystems are some of the most productive areas on Earth and home to a wealth of biodiversity. The health of the oceans is strongly dependent upon this marine biodiversity and therefore requires special attention. The depletion of fish stocks, conservation of marine biodiversity, ocean acidification, destruction of habitats, and occurrence of alien invasive species are therefore of major concern.

To mitigate threats posed to oceans, policy managers have started to implement various ecosystem management tools. The Sustainable Development Goals (SDGs) are intended to address sustainable development processes and facilitate action with all actors to strengthen the capacity of the State to achieve desired outcomes, the most popular being marine protected areas (MPAs).

Blue economy is a tool for sustainable development that focuses on utilizing marine resources to provide new economic opportunities as well as poverty alleviation, food security, and sustainable livelihoods, through which multiple SDGs can be advanced. It looks at larger ocean jurisdictions for new sources of economic opportunities.

Mainstreaming biodiversity into the plans, strategies, and policies of different economic sectors is key to reversing declines arising from climate change that emphasize the importance of global biodiversity for human well-being and ocean health. An estimated annual loss of USD 50 billion results from overfishing and could increasingly be recovered through stock restoration. The implementation of established management measures encourages increased sustainable catches and lower energy utilization and costs, thus securing livelihood and enhancing food security.

Recently, MPAs have been described as one of the main means to achieve marine conservation targets. They provide both direct and indirect benefits for nature and humans, such as replenishing fisheries stocks, along with biodiversity, education, research, culture, and economic value.

National Biodiversity Strategies and Action Plans (NBSAPs), which support the mainstreaming of biodiversity into the policies of key economic sectors, such as agriculture, forestry, and fisheries, are important. Within the blue economy purview, India has an opportunity to accentuate its marine spatial planning and utilize biodiversity focusing on ecosystem services to generate income and involving communities for the management of biodiversity zones. Such implementation mechanisms would serve a dual purpose of ensuring livelihoods and preserving biodiversity.

The Indian Ocean plays a vital role in the economy through a significant contribution to livelihoods, cultural identities, fisheries, offshore oil and natural gas resources, tourism, and maritime industries. New opportunities exist in established sectors of capture and exploitative resource industries; hence, there is a need for sustainable development by sharing of skills, knowledge, and governance for commercialization and industrial growth. Based on its enormous potential, the blue economy concept has been well elaborated for expansion in the Indian Ocean, driven by the Indian Ocean Rim Association (IORA) and individual countries, including the Seychelles, Mauritius, India, and Australia. As a key figure in the IORA, India could rally other countries to strengthen biodiversity measures to ensure long-term protection of the regional ocean and livelihoods dependent on it.

Ocean as a Provider: Food Security

The global fish production increased to about 171 million tonnes in 2016 with 47% resulting from aquaculture. According to FAO 2019, the percentage of stocks fished at biologically sustainable levels increased from 10% in 1974 to 33% in 2015, with most of the increase taking place in the 1970s and 1980s.

India would need 18 million metric tonnes of fish production by 2030 to meet its domestic demand; however, the current capture fisheries production will not be sufficient to address this challenge. India is focusing on enhancing fishing with budgetary inclusions for aquaculture and these efforts need to be extended to capture fisheries to ensure sustainable fisheries. According to the United Nations, around 195 million people in India are undernourished with 47 million being children. Though India has become a net food exporter and is self-sufficient, access and affordability are the major concerns that the country needs to address. Fisheries is a significant source of nutrition and could aid in reducing malnutrition. A concerted effort to promote aquaculture is required to fill the gap while addressing the capture fisheries challenges to tackle food security and malnutrition.

Healthy Oceans and Climate Change

Oceans and coastal ecosystems provide essential services that are socially and culturally vital to coastal communities. Since pre-industrial times, the oceans have absorbed one-third of the human emissions of CO2, causing the surface ocean layers to become an average of 26% more acidic. If this trend continues, the business-as-usual scenario indicates that acidity will increase by 100% or higher by the year 2100. Ocean acidification is also raising concern due to increased stress on marine life and the heightened damage that would be caused to corals and other reef building taxa and hard shelled organisms resulting from the decreased availability of calcium carbonate in seawater.

Warm water and increased nitrogen levels can lead to the formation of red tides or harmful algal blooms (HABs), which in turn can cause die-offs, on the large scale, of fish and of marine mammals and birds that are dependent on the marine food web. Increased sea surface temperatures and upwelling events are also linked with the formation of HABs and associated shellfish and fish poisoning (Patz et al. 2006). Table 1 indicates the potential impacts of climate change on fisheries. Hence, there is an urgent need to take necessary steps to mitigate and counteract the impacts of climate change.

Table 1 Potential Impacts of Climate Change on Fisheries

Types of change	Climate variable	Impacts	Potential outcomes for fisheries
Physical environment	Ocean acidification	Negative effects on calciferous animals, including the slowed rate of coral growth	Declines in production
	Warming of upper ocean layers	Poleward shifts in plankton and fish species	Changes in production and availability of fished species
		Changes in timing of phytoplankton blooms	Potential mismatch between prey (plankton) and predator (fish species) and decline in production
		Changes in zooplankton composition	
	Sea level rise	Loss of coastal habitats	Reduced production of coastal marine and freshwater systems and related fisheries
		Saline intrusion into freshwater habitats	
Fish stocks	Higher water temperatures	Changes in physiology and sex ratio of fished species	Changes in timing and levels of productivity across marine and freshwater systems
		Altered timing of spawning, migrations, and peak abundance	
		Increased invasive species, diseases, and algal blooms	Reduced production of target species in marine and freshwater systems
Ecosystems	Reduced water flows and increased droughts	Changes in lake water levels	Reduced lake productivity
		Changes in dry water flows in rivers	Reduced river productivity
	Increased frequency of ENSO events	Changes in timing and latitude of upwelling	Changes in pelagic fish distribution
	Higher water temperatures	Increased frequency and severity of coral bleaching events	Reduced coral reef fisheries productivity
		Changes in stratification, mixing, and nutrients in lakes and marine upwellings	Changes in productivity

Types of change	Climate variable	Impacts	Potential outcomes for fisheries
Coastal infrastructure and fishing operations	Sea level rise	Coastal profile changes, loss of harbours and homes	Costs of adaptation make fishing less profitable, increased costs of insurance and/ore rebuilding, increased vulnerability of coastal households
		Increased exposure of coastal areas to storm damage	
	Increased frequency of storms	Fewer days at sea, increased risk of accidents	Reduced viability of fishing and fish arming as livelihood options for the poor, reduced profitability of larger scale enterprises, increased costs of insurance
		Aquaculture installations (coastal ponds, sea cages) at greater risk of damage	
Inland fishing operations and livelihoods	Changing levels of precipitation	Where rainfall decreases, reduced opportunities for farming, fishing, and aquaculture as part of rural livelihood systems	Reduced diversity of rural livelihoods, increased risk in agriculture, greater reliance on non-farm income
	More droughts or floods	Damage to productive assets (fish ponds, weirs, rice fields, etc.) and homes	Increased vulnerability of riparian and floodplain households and communities
	Less predictable wet/dry seasons	Decreased ability to plan seasonal livelihood activities	

Source Allison et al. (2009)

Blue Carbon Habitats: Mangrove Ecosystems and Other Coastal Wetlands

Important regional and site-specific functions are fulfilled by coastal wetlands, including mangrove ecosystems. In addition to being highly productive, these habitats exhibit extremely high rates of carbon burial, at levels that can be much greater than that exhibited by terrestrial ecosystems. The loss of mangroves due to the changing climate will reduce the quality of coastal waters, reduce biodiversity, wipe out the nursery habitats of fish and crustacean species, adversely affect the adjacent coastal habitats, and remove a primary resource for those human communities that are dependent on mangroves for various products and services.

The flora of coastal wetlands, including mangroves, seagrasses, and salt marshes, comprises plants with high rates of photosynthesis that engineer reductions in CO2 concentrations at the localized level, thus raising the pH of the surrounding water and, in this manner, provide refuge in the daytime to vulnerable calcifying organisms. Organic carbon is stored by coastal wetlands in underlying sediments for millennia, a factor that accounts for almost 50% of carbon stored in ocean sediments in spite of covering less than 1% of the ocean area. Based on estimated costs of the products and services provided by mangroves, their annual economic value is in the order of US$200,000–900,000 ha–1 (Gilman et al., 2008). The role of blue carbon habitats is essential to combat climate change impacts, preserve fragile habitats, and stimulate the growth of several aquatic species.

Marine Reserves as a Tool to Mitigate and Promote Adaptation to Climate Change

With the emissions of greenhouse gases (GHGs) and their impacts accelerating, significant consequences will occur for wildlife and put many of the benefits received from the environment at risk. Therefore, apart from taking aggressive measures to reduce GHGs, there is an urgent need to enhance ecosystem resilience, preserve its wildlife, and secure its ability to provide essential goods and services. Roberts et al. (2017) suggest that this may be achieved by the highly practical and cost-effective strategy of creating MPAs. In conjunction with strong fisheries management practices outside them, MPAs have effectively served, as a nature-based tool, for repairing damage to habitats and overexploited fish stocks and for biodiversity conservation. Marine reserves, by providing a strategic refuge and suitable habitat, are able to increase reproductive output, thereby increasing dispersal distances that are ecologically meaningful, improving connectivity between populations, while concurrently reducing the risk of populations getting destroyed, increasing resilience to stress, and also supporting populations found outside the boundaries of the reserve. However, the benefits accrued from an MPA are largely dependent on the efficacy of implementation and management and in particular to the level of protection accorded to it, and thus a marine reserve generates the highest conservation benefits (Roberts et al. 2017). India needs to increase its MPA areas, and in this regard, the Blue Economy Working Group reports and draft blue economy policy specifically focus on marine spatial planning that would greatly benefit the formation of MPAs.

Major Impact Sectors

With around 4.1% of the India's economic activities dependent on marine resources, the generation of livelihood from marine resources is significant. All the ocean-based economic activities such as fisheries, coastal tourism, offshore oil and gas, shipbuilding, and maritime equipment, have been key contributors to employment and there is significant employment potential in marine aquaculture, capture fisheries, fish processing, offshore wind, and port-based activities (Ninawe 2019). Traditional sectors have driven the ocean economy where the majority of people involved in these sectors come from coastal communities with vulnerable economic and social background. Fisheries sector in India largely consists of such vulnerable populations that lack literacy and skill development.

With new emerging sectors such as deep-sea mining and offshore energy among others, the milieu of people joining the ocean economy workforce would become significant. The new emerging sector requires a highly skilled workforce and the transitions in traditional sectors require a specific type of skilling as well. Creating a synergy between the two sectors to ensure that livelihood opportunities for both the skilled and unskilled labour are enhanced is imperative. Although one can emphasize that sectors such as fishing also require high skills, the current Indian population involved in sectors such as fishing and tourism would require skill development and technological awareness to compete with their global counterparts.

The effects of climate change are expected to be severe on the traditional sectors of blue economy. For example, the fisheries sector is largely dependent on the climate and the natural ecosystem, and thus climate change will have a strong impact on the sector with serious consequences on food security and livelihoods of the people dependent on the sector. The effects of climate change have been in the form of ocean acidification, sea level rise, increased frequency of storms, warming of upper ocean layers, and so on, and any such events directly impact fish production; for example, the warming of water may impact fish diversity, distribution, abundance, and finally the phenology of fish (Rao and Vivekanandan 2008). It has been

estimated that ocean warming has led to a reduced catch potential by a net 4% over the past 80 years. It has been proven that the warming of oceans has also affected the availability of key prey species (Free 2019). The impact of rising sea surface temperatures has been studied in parts of Andhra Pradesh and Maharashtra, where it has been observed that the fish composition in the catch has altered. The small-scale gillnet fishers of Andhra Pradesh have reported that the depth of surface gillnets, which was four fathoms in the 1980s, has now gone up to nine fathoms; the fishers contend that the pelagic species have descended to the lower layers from the surface due to variation in surface water temperature (Salagrama 2012). Acidification of water also affects the calciferous animals and the unpredicted storms, floods, and droughts will severely impair the fisheries and aquaculture sector, thus increasing the livelihood and economic vulnerabilities for the communities both directly and indirectly dependent on them.

The dependence of both traditional and non-traditional sectors on the oceans for economic revenue and livelihood is huge. Blue economy accounts for around 4.1% of the total Indian economy (BE Working Group Report 3 (2020)). According to the working group report on National Accounting Framework and Ocean Governance by the Economic Advisory Council to the Prime Minister of India, the total gross value added (GVA) of blue economy has increased from ₹3.3 lakh crore in 2011–12 to ₹4.6 lakh crore in 2016–17 (Figure 1). In addition to the rising GVA, blue economy has shown a steady annual growth rate as well and is currently growing at a higher rate than the overall economy.

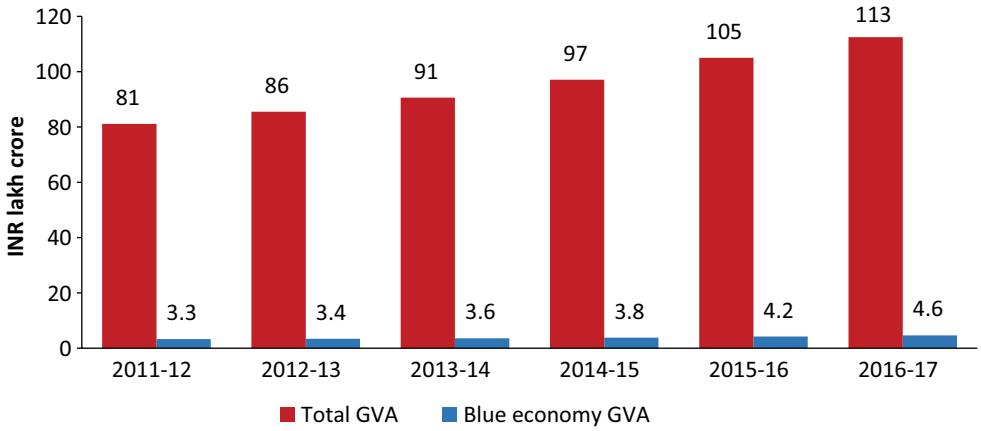

Figure 1 Total gross value added and the blue economy GVA
Source BE Working Group Report 3 (2020)

From a livelihood perspective, the fisheries sector provides livelihood to about 16 million fishers and fish farmers at the primary level and almost twice the number along the value chain (NFDB 2020) and as envisioned by the government, the sector has immense potential to more than double the income of fishers and fish farmers. Besides these, fish processing industries also provide a major source of employment, especially to women in rural areas. Among the coastal states, Tamil Nadu, Odisha, Kerala, Karnataka, Andhra Pradesh, and Gujarat are the most heavily dependent states on fisheries for employment as it is one of the oldest and largest economic activities for coastal communities. Table 2 gives the number of people dependent on fisheries for livelihood among these states.

From a livelihood perspective, the inland sector is also important and it steadily grew at a compound annual growth rate (CAGR) of nearly 6% between 1979 and 2015, and the overall fish production has registered an average annual growth rate of more than 7% in the past few years. This highlights the possibilities of further

Table 2 Population dependent on fisheries for livelihood among coastal states in India

State	Fishing villages	Fishing families	Fisherfolk population
Andhra Pradesh	555 (16.2)	163,427 (18.7)	605,428 (14.9)
Gujarat	247 (7.2)	62,231 (7.1)	336,181 (8.3)
Tamil Nadu	573 (16.7)	192,697 (22.0)	802,912 (19.8)
Odisha	813 (23.7)	114,238 (13.1)	605,514 (14.9)
Karnataka	144 (4.2)	30,713 (3.5)	167,429 (4.1)
Kerala	222 (6.5)	118,937 (13.6)	610,165 (15.0)
Goa	39 (1.1)	2,189 (0.3)	10,545 (0.3)
Maharashtra	456 (13.3)	81,492 (9.3)	386,259 (9.5)
West Bengal	188 (5.5)	76,981 (8.8)	380,138 (9.4)

Source Blue Economy Working Group Report, Economic Advisory Council to the Prime Minister 2020

livelihood opportunities; however, aquaculture requires significant investments in skill development and technological adoption.

The shipping sector is also one of the key livelihood providers in the blue economy as India has one of the largest merchant shipping fleets among the developing countries and ranks 17th in the world. The number of Indian seafarers who are employed on Indian and foreign flag vessels crossed over two lakhs in 2018, showing an unprecedented increase of 35% over the previous year. Seaports are also a large source of employment. Unlike India's major ports, jobs in smaller ports have increased over the years from 1933 in 2003 to 19,102 in 2017 (Blue Economy Working Group Report 4). In the past 5 years, smaller ports have edged out the major ports in growth of cargo volumes as well. This is because they tend to be at more strategic locations, with modernized infrastructure and more efficient operations.

Table 3 Employment in non-major ports of India

State/UTs	2003	2008	2014	2019
Andhra Pradesh	109	69	1195	2278
Tamil Nadu	110	62	35	35
Pondicherry	79	33	485	245
Karnataka	99	55	124	53
Kerala	316	191	683	262
Maharashtra	173	153	117	53
Gujarat	2662	1718	1723	1056
Goa	166	146	144	136
Andaman and Nicobar Islands	477	452	641	623
Lakshadweep	217	–	111	–
Daman and Diu	22	22	10	6
Odisha	–	118	759	361
Total	4430	3019	5097	5108

Source Ministry of Shipping, Road Transport and Highways

Tourism is also one of the fastest growing sectors of not only the global but also Indian economy, which has multiple forward and backward linkages by way of infrastructure, transport, food, capacity building, and a host of other services. Tourism also generates a large number of quality jobs and promotes local development and growth opportunities.

Developing and encouraging coastal and marine tourism is also receiving massive impetus from the centre and states. Important initiatives such as promoting cruise tourism by developing special port facilities at Mumbai, Goa, Cochin, and Chennai for both domestic and international cruises, creation of 'Special Tourism Zones', and Ministry of Tourism's initiative Swadesh Darshan Scheme are aimed at promoting beach and coastal tourism. Recently, India's eight beaches across five states and two UTs have been awarded the prestigious 'Blue Flag' certification also. 'Blue Flag' is one of the world's most recognized voluntary awards for beaches, marinas, and sustainable boating tourism operators and it is a representation of India's conservation and sustainable development efforts in the coastal regions. Particularly in coastal states such as Kerala, Karnataka, and Tamil Nadu, coastal tourism has contributed largely to both state economies and livelihood creation. According to the Ministry of Tourism, the total number of jobs created directly and indirectly by the sector between 2009 and 2012 turned out to be around 23.52% of the total employment in Kerala (SPBK 2016). The total share of tourism in Tamil Nadu's employment was more than 22% in 2016 and 23% in case of Karnataka (MoF 2020).

This sector has been among the worst hit because of the COVID-19 fallout, but now coastal states are restrategizing to attract local and domestic tourists with focus on single or small groups interested in adventure and ecotourism. In an example of appealing to new interests, a campaign named 'Keralam Kanaam' was launched by the Tourism Department of Kerala that aimed to offer luxury staycations at affordable rates to people from the state itself. Similar initiatives are being taken up in other coastal states to increase tourism.

Providing electricity from cleaner energy fuels is one of the important aspects when it is comes to sustainable development and blue economy is an emerging large reservoir of such energy. The ever-increasing demand for energy for the purposes of household and industrial consumption in most parts of the world, especially in India and other emerging markets, necessitates alternative sources of energy, most importantly the renewable energy. Offshore regions have tremendous potential to provide renewable energy, such as offshore wind, waves, ocean currents, including tidal currents and thermal energy. About 350 GW of offshore wind energy is estimated within the exclusive economic zone (EEZ) of India (Atmanand, Jalihal, Ramanamurthy, et al. 2019). In terms of employment as well, the offshore segment is gaining traction and could build on expertise and infrastructure in the offshore oil and gas sector (IRENA 2019). A total of 0.7 million people were employed both directly and indirectly in the renewable energy sector in 2018, out of which around 48% were in the hydropower and 8% were in the wind energy; however, no clear estimates are available for the tidal or wave or ocean energy (IRENA 2019).

Other than the above subcategories, marine biology and biotechnology are also providing significant revenue generation to the Indian economy. India has projected the revenue generation of US$100 million by 2025 through biological and bio-technology industrial growth, and therefore there appears to be enormous potential for livelihood opportunities as well. Many opportunities also exist for entrepreneurs who may make use of the potential of ocean-based industries for promotion of biobusiness in India.

However, it has to be noted that various climatic and environmental changes are leading to substantial disturbances in the traditional sectors of blue economy, resulting in economic losses in the short and long

run. The pre-existing skill sets, especially in the fishing and tourism sectors, would not be able to comply with the changing dynamics of the sectors owing to climate crisis. Similarly, shipping and ports require skilled manpower, but to meet the growing and changing demands in this sector, re-skilling and upskilling would be required in the future.

The demand for new and emerging sectors in blue economy is also increasing like never before. It includes various types of energy generation, ocean thermal energy conversion (OTEC), marine biology, and biotechnology. Of all the different renewable energy sources from oceans, offshore wind energy is the most developed. With the increasing instances of climate change impacts on marine ecosystems, the role of marine biologists is also becoming important to help address many of these issues. Their work ranges from working for offshore oil and gas companies to reduce the negative impact of their operations on marine life to developing designated marine reserves and creating artificial reef/wrecks in order to encourage marine wildlife into an area.

Therefore, looking at the increasing incidents caused by climate change and the damaging marine ecosystem, it is now important to consider them both in the traditional and in the new and emerging sectors of blue economy. Skill development along with re-skilling and upskilling will be imperative in the blue economy sectors like fisheries, aquaculture, shipping, and tourism, but investments and the role of both public and private sectors are also quite significant here. Similarly, investments and an initial push from the government for the new and emerging sectors of blue economy would be equally important to adapt to the changing environmental and ecosystem dynamics of the oceans.

Recommendations

Biodiversity and climate change need to be tackled by each impact sector in blue economy. It is essential to undertake concrete steps that improve sustainability and ensure economic gains. A healthy ocean is the backbone for all blue economy sectors and India should undertake stringent measures to save the oceans. Some of the key recommendations are as follows:

- Implementation of various ecosystem management tools. The marine spatial planning under the blue economy framework needs to be implemented on urgent basis to map and assess ecosystem vulnerabilities.
- Creating MPAs and marine reserves to be operated in conjunction with strong fisheries management practices outside them.
- Giving detailed attention to the inclusion of biodiversity into plans, strategies, and policies of different economic sectors.
- Implementation of established management measures for fish stock restoration.
- Taking appropriate measures for enhanced biodiversity conservation by mitigation and counteraction of repercussions of climate change.
- Conserving and enhancing coastal wetland cover as blue carbon ecosystems.
- Development of NBSAPs to support the mainstreaming of biodiversity into the policies of key economic sectors and undertake active implementation mechanisms such as marine spatial planning.
- Enhancing sustainable development by sharing of skills, knowledge, and governance for commercialization and industrial growth.

- India could take the lead to rally other IORA countries to take biodiversity measures to ensure long-term protection of the regional ocean and livelihoods dependent on it.
- Educational programmes on both traditional and emerging sectors of blue economy should be offered at universities and engineering/technical institutes for sustained supply of trainer personnel.
- Vocational and on-the-job training should be regularly conducted in both universities and industrial training institutes (ITIs) to help disseminate knowledge at the local level.
- The level of awareness on employment opportunities in blue economy and the future prospects needs to be increased at the central and state levels. This can be done by conducting frequent sessions with the target audience at the school and university levels.
- The government should support in providing the required infrastructure for skill development in the blue economy sectors. This can be done by financially supporting the initiatives and programmes that focus on expanding human resources for the sectors of blue economy.

India needs to take urgent steps for the blue economy sectors as the future for all countries lies in ocean preservation and sustainable management of marine resources. India has emerged as a strong geopolitical leader in the Indian Ocean region; hence, it needs to work towards integrating sustainability within the strategic aspects and gaining the maximum benefits from oceans. A clean ocean is way to a cleaner life.

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Chapter 13

Blue Economy in the Context of Coastal Disasters and Climate Change in the Indian Ocean Region: A Review

Prasoon Singh, Department of Natural Resources, TERI School of Advanced Studies, India

Abstract

United Nations Conference on Trade and Development (UNCTAD) defines the blue economy or ocean economy as 'a subset of, and complement to, the evolving development paradigm emphasizing greener and more sustainable and inclusive economic paths. It seeks to expand the economic frontiers of coastal countries beyond their land territories. The oceans economy encompasses a sustainable economy for the ocean-based marine environment, related biodiversity, ecosystems, species, and genetic resources including marine living organisms (from fish and algae to microorganisms) and natural resources in the seabed, while ensuring their sustainable use and hence, conservation.'The sustainability, preservation, and inclusiveness are the key to realize the benefits of the blue economy. This is only possible when maritime affairs and operations are disaster resilient.

The Indian Ocean Region (IOR) in and around constitute 28 countries with a global population share of nearly 35% stretched across East Africa to West Australia and occupies around 20% of the global ocean area. As per the Global Ocean Commission, the estimated value of the global blue economy is around 5% of the global GDP. The IOR's contribution to the global GDP has seen a significant increase in recent years; from 6% in 1980 to 19% and is expected to increase to 22% by 2025. Also, the global trade is expected to increase from 13% to 16% by 2025. In spite of having the great potential of growth in contributing to the global trade and global GDP, the IOR maritime or ocean economy faces several challenges. The article tries to examine the IOR's ocean economy in context to coastal disasters and climate change. It also looks into the science and technology development and its use in disaster mitigation. It deliberates on the science and technology's importance in ensuring sustainable ocean economic development of Indian Ocean rim countries.

Keywords: Disaster Profile of Indian Ocean; Blue Economy; Coastal Disasters; Indian Ocean Rim Association (IORA); Climate Change; Indian Ocean Observation System

Introduction

The IOR faces the issues of huge population growth, inadequate resources,lack of access to advanced technology, geopolitical instability, poor governance, and collaborations. In addition, the region is highly vulnerable to natural disasters and climate change. The cumulative impact of these factors results in loss of lives and livelihoods, economic opportunities, loss of marine ecosystem, habitat degradation, and loss of natural protection of coastal areas. IOR in context to climate change is particularly more vulnerable to natural disasters as the intensity and frequency of these disasters show increasing trends in near, mid, and distant future under all emission scenarios (IPCC 2014). Owing to these issues, pursuing the goal of blue economy would be challenging for IOR countries.

The IOR is critically important for the sustainable, secure, and resilient economic development of India and its neighbouring countries. The ocean-based industries and allied activities provide millions of jobs and contribute around 5% in the global GDP. The IOR's contribution to global GDP has seen a significant increase in recent years, from 6% in 1980 to 19% at present, and is expected to increase to 22% by 2025. Also, the global trade is expected to increase from 13% to 16% by 2025 (Bouchard and Crumplin2010).

The IOR consists of many small and fragile island countries whose financial well-being is dependent on the ocean-based economic activities. Tourism and fishing industries are the main sources of income for those countries. The poorly managed ocean, overexploitation of marine resources, encroachments, and irreversible damage to natural coastline protection systems have led to the loss of businesses and economic opportunities, disasters, diminished ocean primary productivity leading to food insecurity, and negative impact on marine ecology. In addition, global climate change intensifies the vulnerability of these regions in the form of sea-level rise, more intense and frequent tropical cyclones, and uncertain weather systems. Furthermore, it is evident that human-made emissions highly contribute to the changing regional climate. The impact of human-induced regional climate change reflects in the form of marine heat waves, changing rainfall patterns, and regional sea-level rise (Roxy, Ghosh, Pathak, et al. 2017).

The compounding impact of the aforementioned scenario has severe repercussions on the ocean economy and trade. Therefore, it is important to understand the reasons behind these changes across IOR and what could be their implications for the future. The assessment can help in planning adaptation and mitigation alternatives, policy,and collaborations to build climate and disaster resilience for a sustainable ocean economic development. The subsequent sections in this article discuss the current and future challenges and threats to the IOR region in terms of climate change and disasters. The possible solutions to overcome these challenges are also examined.

Climatic variability in Indian Ocean Region

The global climate change and resulting increase in global mean surface temperature (GMST)[1] has been well-documented and proven to be instrumental in defining the pattern and magnitude of natural climatic variation and their impacts. The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report concluded that it is certain that GMST has increased since the late 19th century. Figure 1 shows the evolution of GMST from 1850 to 2020, which suggests that the world is on a trajectory of rising temperature.

1 The GMST is the combined assessment of global land surface air temperature and sea surface temperature (Krishnan, Sanjay, Gnanaseelan, et al. 2020)

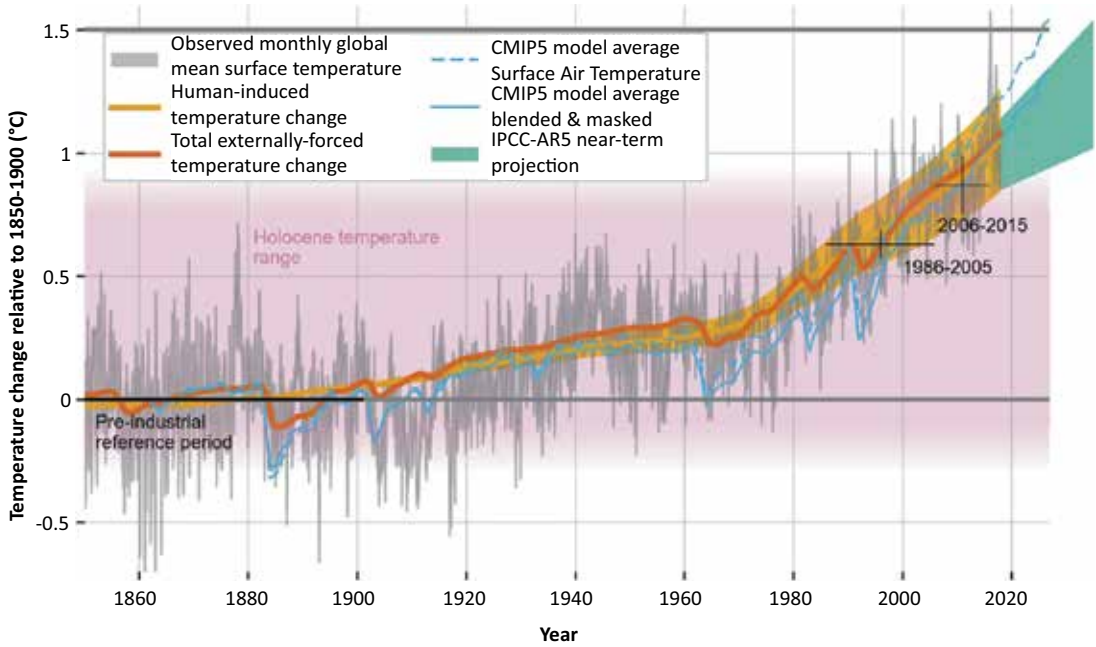

Figure 1 Evolution of GMST from 1850 to 2020 (Krisnan, Sanjay, Gnanaseelan,et al. 2020)

The ocean–land interaction determines the climatic conditions of a region and strongly influences climate patterns and spatio-temporal variations. The sea surface temperature (SST) of the tropical IOR has risen by 1°C during the period 1951–2015 (0.11°C/decade) as compared to the global average SST of 0.7°C (0.15°C/decade) over the same period,making it the most rapidly warming ocean basin(Roxy, Gnanaseelan, Parekh,et al. 2020, Gnanaseelan, Roxy, and Deshpande2017). It was observed that the heat content has also risen in the upper IOR since 1950sandthere has been a sudden rise in the trend since 2000(Roxy, Gnanaseelan, Parekh, et al. 2020). An assessment of the data, from 1870 to 2007, of monthly SST along the ship tracks from Gulf of Aden through the Malacca Strait reveals a 1.4°C temperature rise during the period in the region(Beal, Vialard, Roxy,et al. 2019). The reason for this higher warming is attributed to anthropogenic emissions. Also, researchers have observed a decline in phytoplankton population along with a decrease in oxygen concentration in the tropical IOR due to rise in SST. The acidification of the Indian Ocean due to excess CO2 uptake has impacted the ecosystem of western India Ocean (Roxy, Gnanaseelan, Parekh, et al. 2020].

The global climate model projections show an increase in SST ranging between 1.2 and 1.6°C under RCP4.5 and 1.6and 2.7°C under RCP8.5 emission scenarios for the near and far futures as compared to the baseline warming trends of 0.1–0.18°C per decade during 1976–2005, also shown in Figure 2, for tropical IORwith maximum warming trends over the northern Arabian Sea (Chowdary, John, and Gnanaseelan2014).

The impact of ocean warming on climate and hydro-meteorological phenomenon has been extensively studied. The rapid warming of the ocean along with emissions and land use change has altered the Indian summer monsoon due to tropospheric thermal contrast. This led to a decline in monsoon rainfall in central and north India and heavy precipitations over Western Ghats due to warming induced by enhanced moisture transport from the Arabian Sea (Singh, Ghosh, Roxy,et al. 2019; Mishra, Smoliak, Lettenmaier,et al. 2012; Saha, Ghosh, Sahana, et al. 2014; Roxy,Modi, Murtugudde, et al. 2016;Roxy, Ghosh, Pathak, et al. 2017).

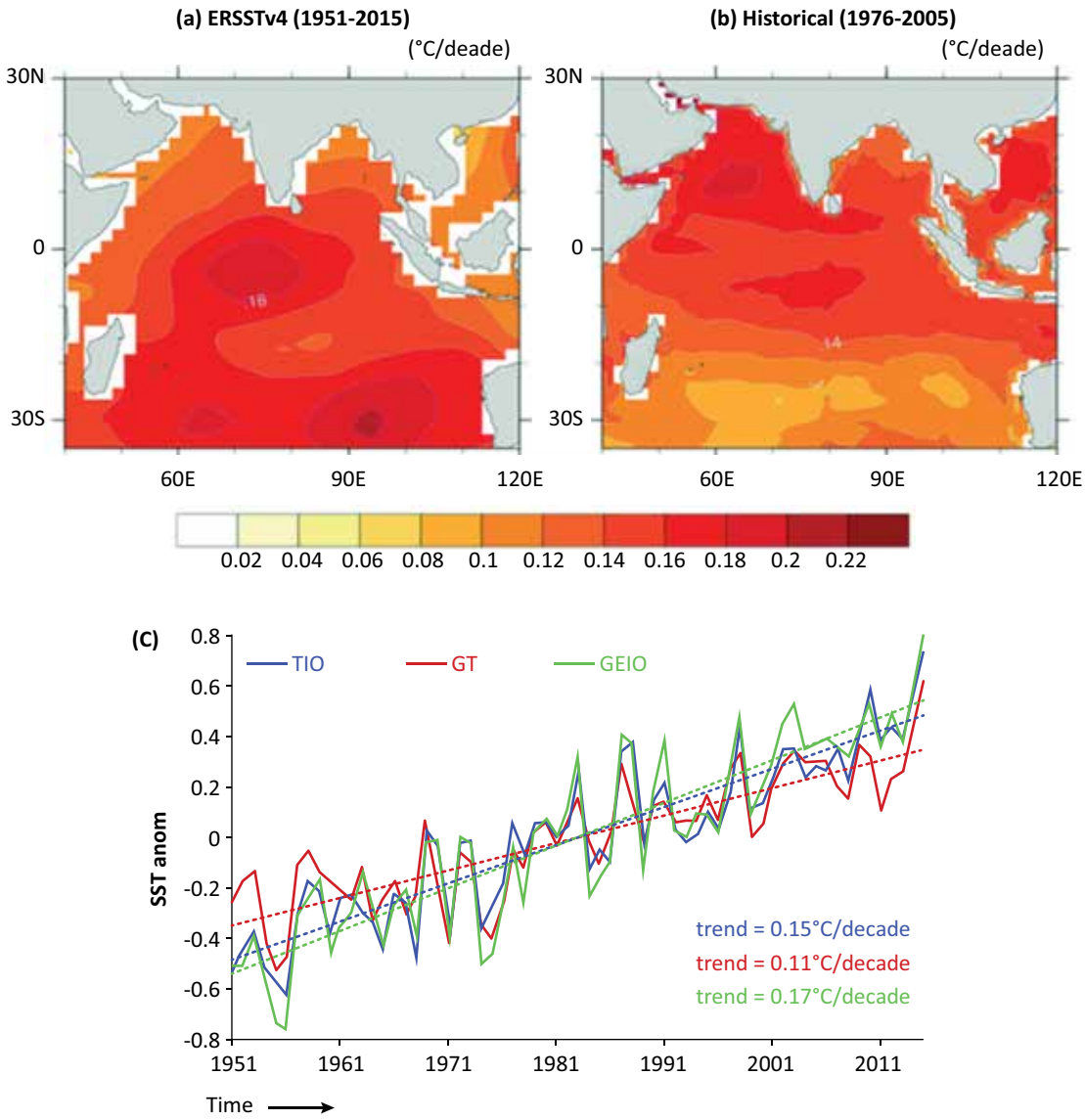

Figure 2 Sea surface temperature trend (°C/decade) –a)Observed extended reconstructed sea surface temperature during 1951–2015; b) CMIP5 historical simulations for 1976–2005, and; c) Time series of sea surface temperature anomalies (solid lines) and their linear trends (°C/decade) (Roxy, Gnanaseelan, Parekh, et al.2020)

Indian Ocean warming is also found to reduce rainfall over India during the onset phase and increase it during the withdrawal phase (Chakravorty, Gnanaseelan, and Pillai 2016).Indian Ocean SSTs have a role in regulating the surface air temperatures over the Indian subcontinent (Chowdary, John, Gnanaseelan,et al. 2014). Associated with the basin-wide warming and frequent El Niños, the frequency and duration of the heat waves have increased over the Indian subcontinent (Rohini, Rajeevan, Srivastava,et al. 2016).

Lastly, the average sea surface temperature of IOR increased by 1°C during the observation period of 1951–2015 and the global climate model projects an increasing trend of SST in both RCP4.5 and RCP8.5 warming scenarios. The SST in the region is very likely to further increase due to increased warming from GHG

emissions as the oceans function as the largest thermal sinks and absorb more than 90% of warming. The consequences of this warming would result in more intense and frequent tropical cyclones, alteration in monsoon leading to erratic and unpredictable rainfall, global sea-level rise, and increased glacier melt.

Disaster Profile of Indian Ocean Region

IOR is an important lifeline to International trades and transports as it controls half of the container ships and oil shipment of the world, one third of the world's bulk cargo traffic and two thirds of the world's oil shipments [Sirimanne et al., 2019]. The region has a diverse population of around 230 billion people with diverse regional languages, culture, ethnicity, and unique challenges. Moreover, IOR is also one of the most hazardous regions in the world. If we look into the disaster profile of IOR it includes all possible kinds of natural and human-made disasters. This section provides the regional perspective of disasters in IOR.

Tropical Cyclone

As per the IMD's long-term records (for over 100 years) of cyclone tracks, on an average there have been 5.2 cyclones per year and 2.4 severe cyclonic storms (SCSs) per year over the north Indian Ocean (Niyas, Srivastava, and Hatwar2009). In north Indian Ocean, the SCSs, super cyclonic storms, and depressions are found to increase in recent years compared to cyclonic storms (CSs) and deep depressions (Dee, Uppala, Simmons,et al. 2011). The Bay of Bengal region accounts for almost 80% of the global fatalities due to tropical cyclones (TCs) alone in IOR (Beal, Vialard, Roxy,et al. 2019).

The frequency of storms(depressions + CSs + very SCSs) over Bay of Bengal (BoB) is higher than the storms over north Indian Ocean in Arabian Sea (AS). The number of storms in the post-monsoon period of the climatology is higher compared to pre-monsoon over AS (IMD eAtlas (http://www.imdchennai.gov.in/cyclone_eatlas.htm)) (Figure 3).

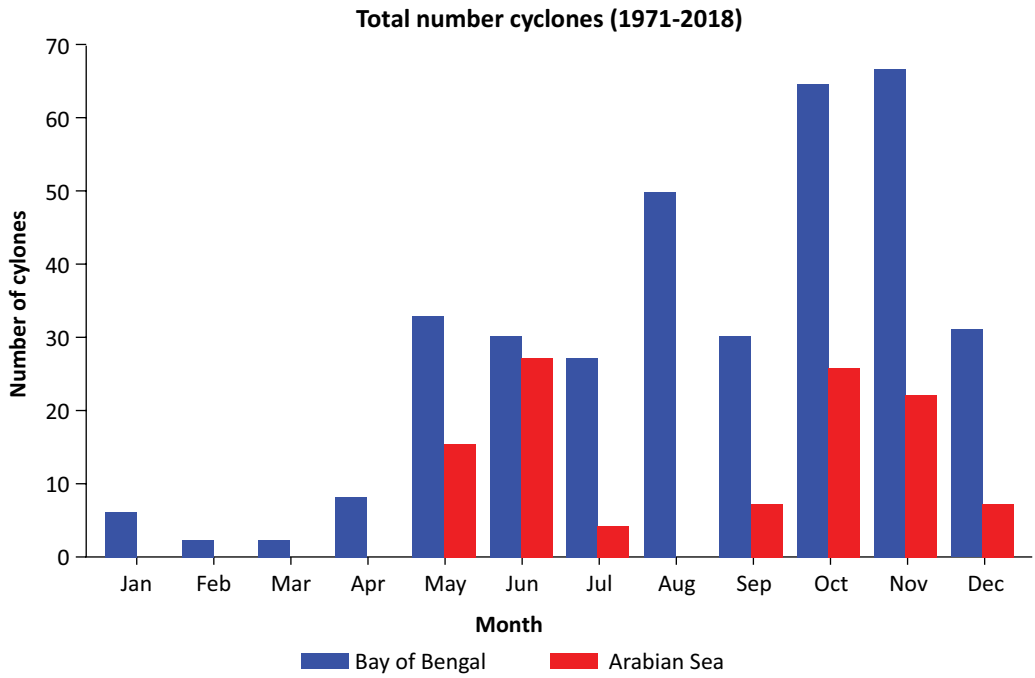

Figure 3 Comparison of storm frequency of tropical cyclones (depression +cyclonic storm + severe cyclonic storm) over Bay of Bengal and Arabian Sea region from 1971 to 2018
Source: IMD-eAtlas

It can be observed from Figure 4 that since depressions are a category of the cyclones with wind speed, they are more common and record a greater frequency in the BoB compared to AS, which records a lesser frequency of the TCs. The severe and very severe cyclones frequency is more over BoB as compare to AS and the frequency of cyclones are more in post and pre monsoon months over AS, as shown in Figure 5.

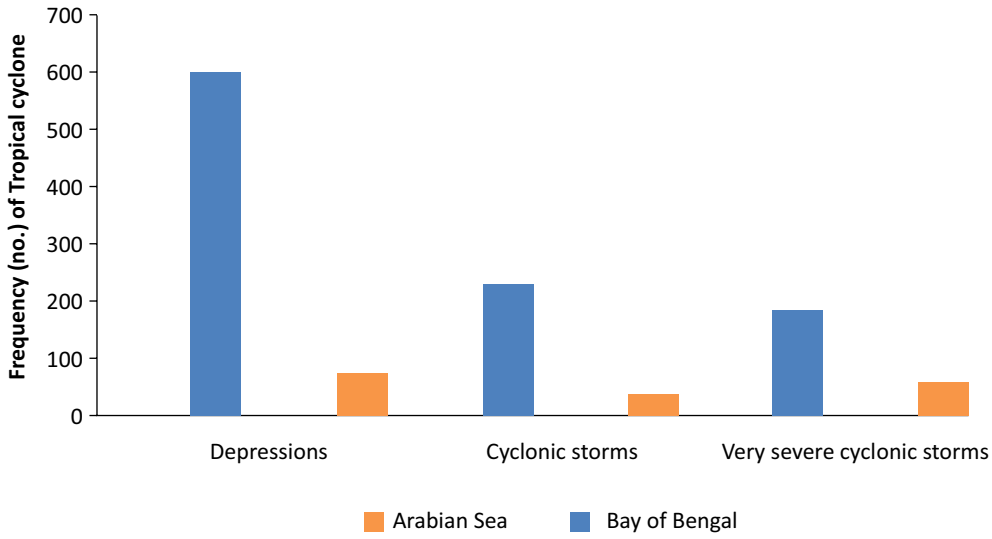

Figure 4 Frequency of tropical cyclones (depressions, cyclonic storm + severe cyclonic storm) over Bay of Bengal and Arabian Sea regions from 1971-2018

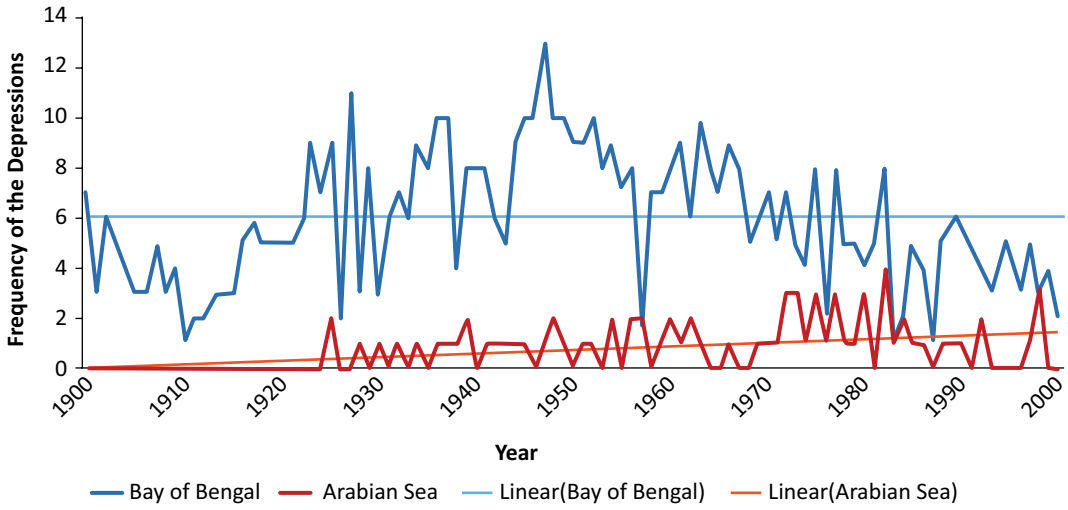

Figure 5 Frequency of severe cyclone over Bay of Bengal and Arabian Sea regions from 1971-2018

Figures 6 and 7 show the trends in the frequency of different types of TCs over the north IOR (Arabian Sea and Bay of Bengal) during the 20thcentury. The overall frequency, as discussed before, is relatively higher for BoB compared to AS. On analysing the trends for individual categories of TCs, a very peculiar pattern was found. The AS, though maintaining a lower number, shows a linear increase in the frequency. The CS constantly decreased in BoB, while it remained more or less stable for Arabian Sea, as shown in Figure 7.

The frequency trends of very SCSs are very crucial for risk assessment and loss and damage proneness of a region. The trend analysis of very severe cyclones, as shown inFigure 8,reveals confounding results for the first decade of the 20th century (1900–1910). AS recorded greater or almost comparable number of storms hitting its coast as that in the BoB, but as the years passed, the frequency increased in the BoB linearly and almost a stable trend was seen over AS for the entire century.

The number of depressions, cyclones, and SCSs over Arabian Sea shows the differences in the pre-monsoon (May–August) and post-monsoon (September–November) seasons over these regions, also shown in Figures 9–11. As per the seasonal analysis, the high intensity TCs over the AS are relatively more pronounced in the post-monsoon months. Figure 12 shows CSs crossing over Gujarat coast during 1951–2018. The data reveals that 10 depressions, 2 cyclonic storms, and 6 severe cyclonic storms crossed over Gujarat coast during the period.

As per the future cyclone projections,it is likely that there would be increase in the number of extremely severe tropical cyclones in response to climate change and warming of Indian Ocean, though the frequency remains uncertain. Moreover, the increase would be more in AS than in BoB and north Indian Ocean Territory.

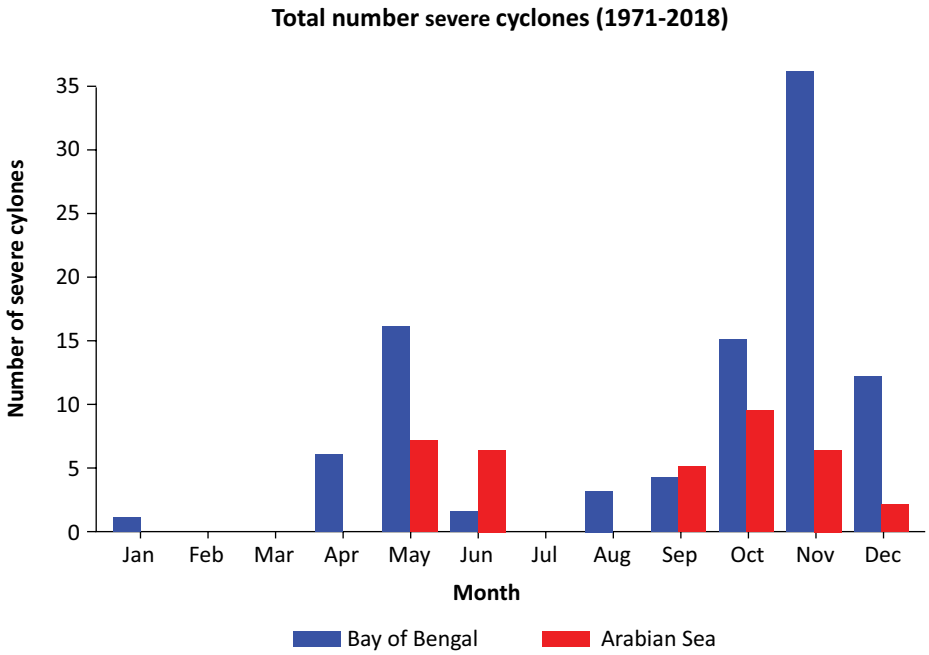

Figure 6 Frequency of depressions over Bay of Bengal and Arabian Sea regions from 1971 to 2018
Source: IMD-eAtlas

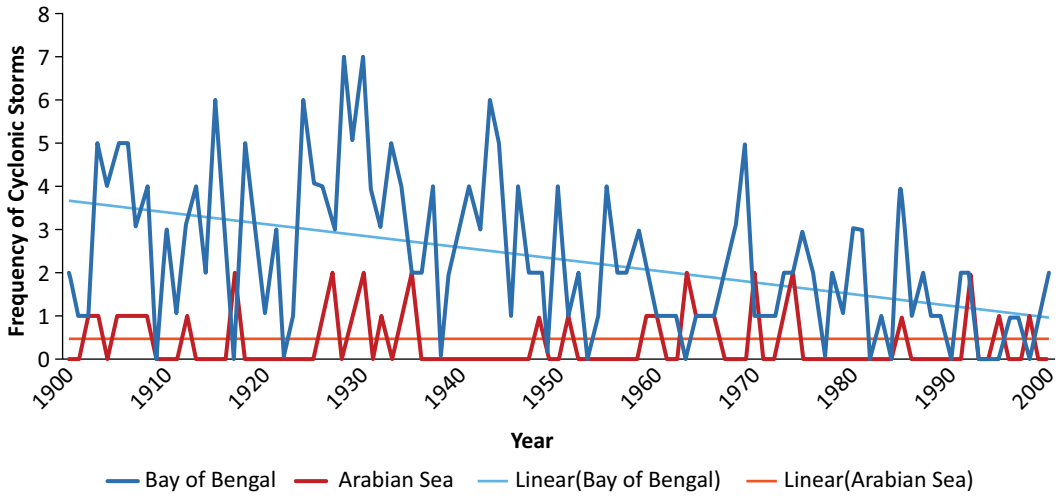

Figure 7 Frequency of cyclonic storms over Bay of Bengal and Arabian Sea regions from 1900 to 2000
Source: IMD-eAtlas

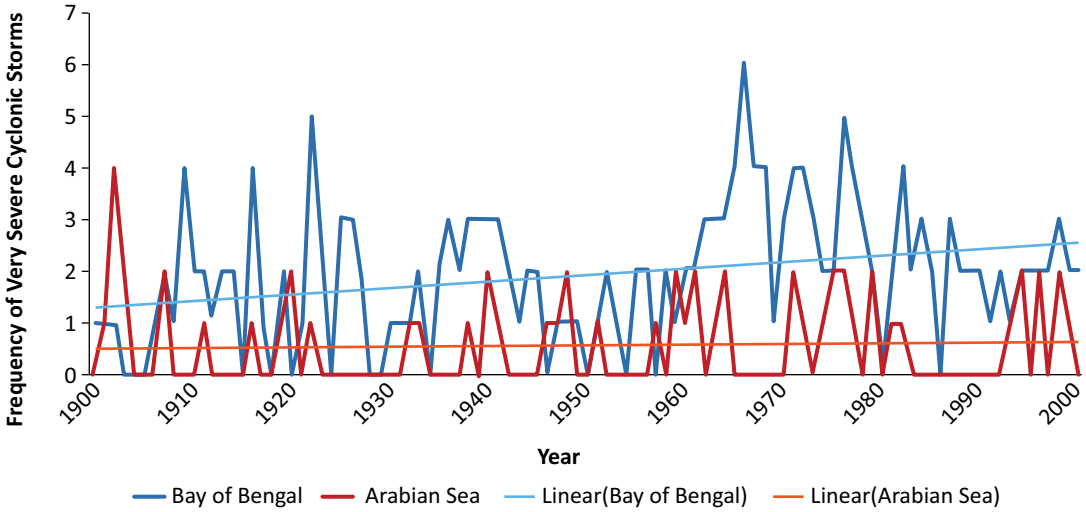

Figure 8 Frequency of very severe cyclonic storms over Bay of Bengal and Arabian Sea regions from 1900 to 2000
Source: IMD-eAtlas

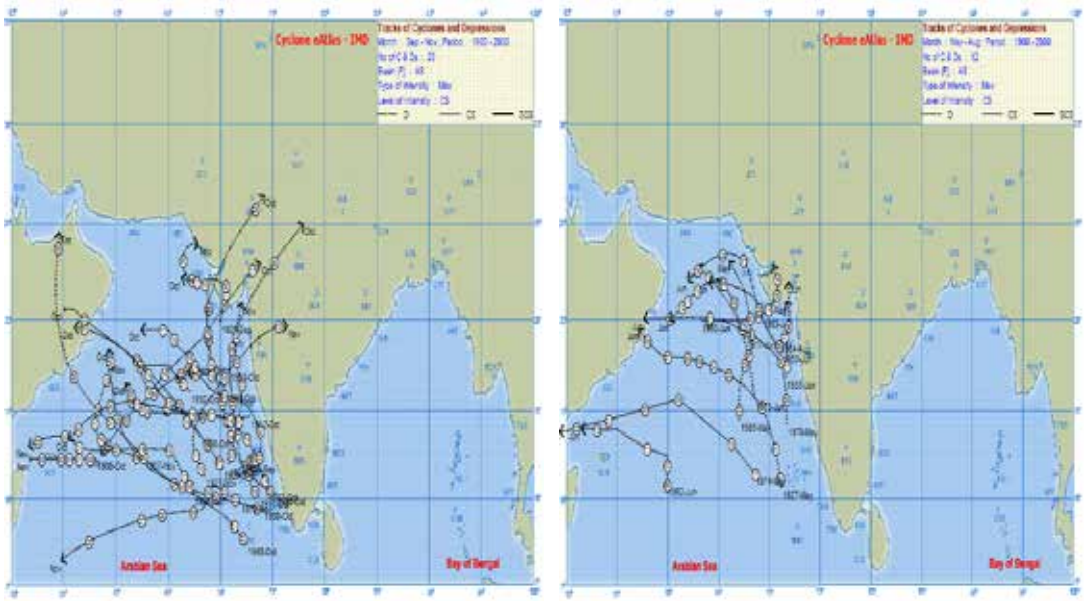

Figure 9 Frequency of cyclonic storms over Arabian Sea – ***a)*** from March to August and ***b)*** from September to November
Source: IMD-eAtlas

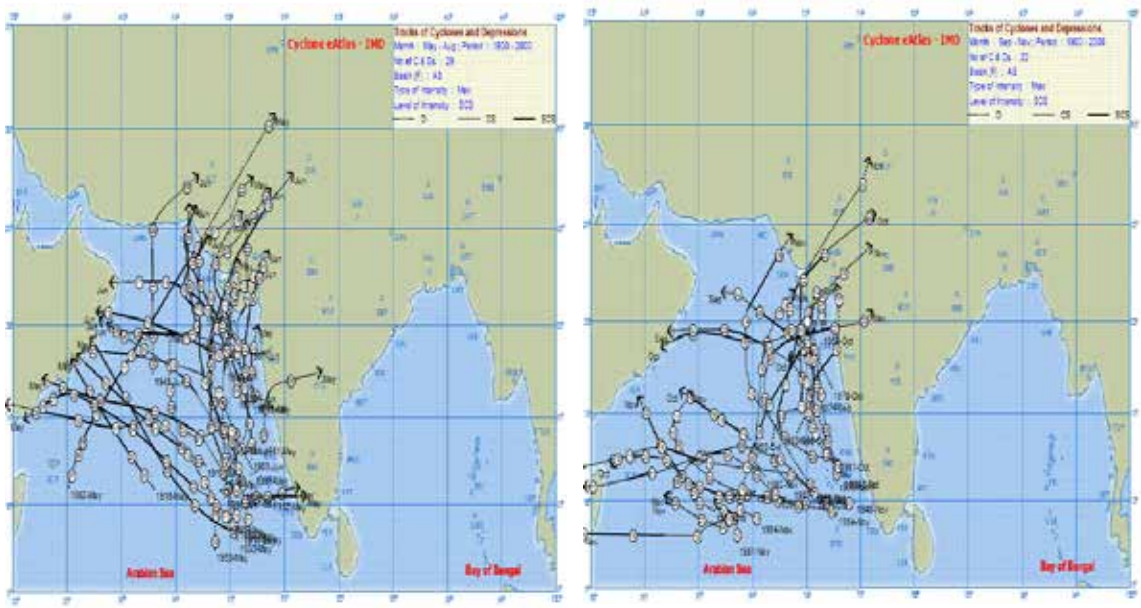

Figure 10 Frequency of very severe cyclonic storms over Arabian Sea – ***a)*** from March to August and ***b)*** from September to November
Source: IMD-eAtlas

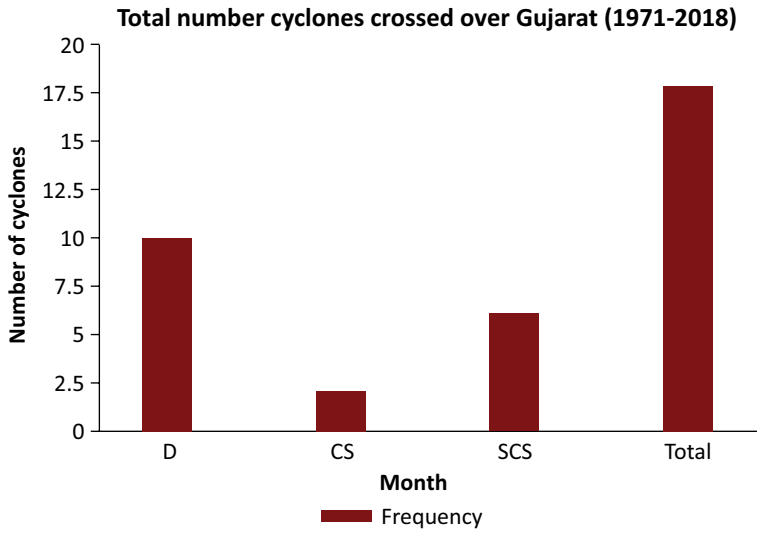

Figure 11 Number of cyclonic storms crossing over Gujarat coast

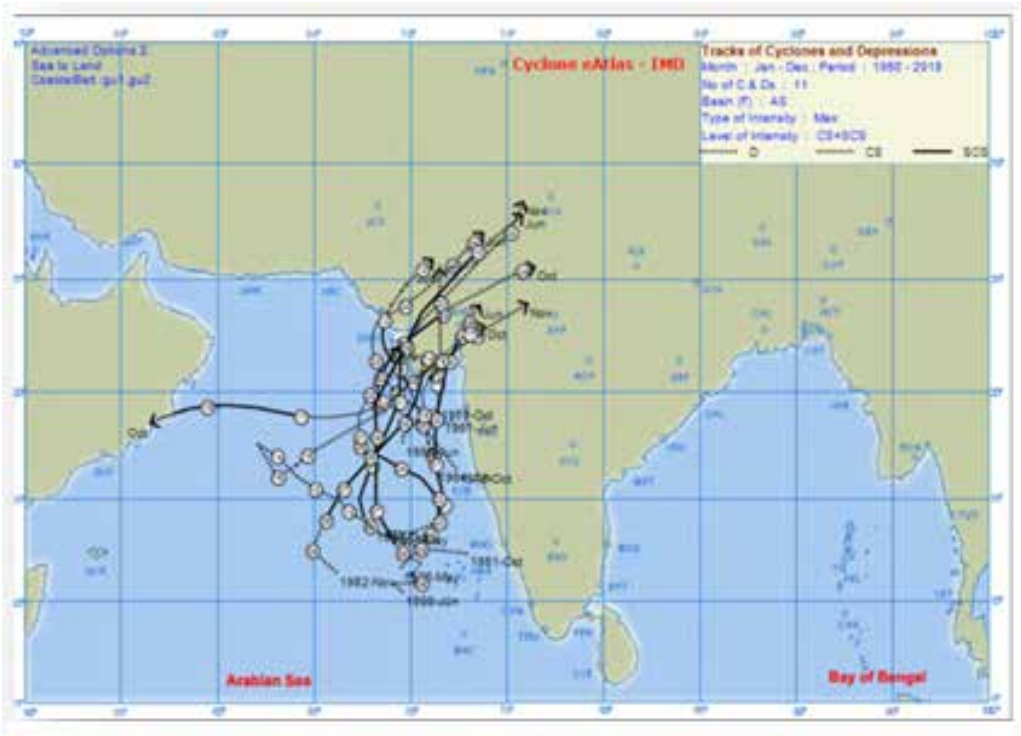

Figure 12 Frequency of cyclonic storms crossing over Gujarat coast
Source: IMD-eAtlas

Tsunami

Tsunamis can cause significant damage to coastal facilities such as sea ports, oil terminals, and jetties during their construction and operation. Significant loss of life and damage to properties, ecosystems, and marine facilities can occur due to tsunamis. Typical examples of such coastal and marine structures and facilities

are flood and coastal protection structures, revetments, seawalls, quay walls, dykes, retaining structures, piers, breakwaters, port and dry dock buildings and facilities, ferry terminals, wharf, dolphin, barges, gates, warehouses, boats, small ships, and larger vessels including cargos, oil tankers, bulk carriers, and passenger carriers. Damage due to collision among boats, small ships, or larger vessels is common during a tsunami (Sarker2018). Furthermore, such natural hazards put lives and properties in coastal areas at great risks through flooding and submergence of low-lying areas. Very high tides during a tsunami may damage installations, dwellings, transportation and communication systems, trees, etc., and cause fires resulting in considerable loss of life, damage to properties and ecosystems. Destruction of transportation or communication infrastructures hampers clean-up and rescue efforts (Sarker2018).

Tsunamis also cause secondary damage from floating debris, drifting trees and vessels, sediment erosion and deposition, and spreading of fire. As per several literature available, the 1960 Valdivia earthquake (Mw 9.5), 1964 Alaska earthquake (Mw 9.2), 2004 Indian Ocean earthquake (Mw 9.2), and 2011 Tōhoku earthquake (Mw 9.0) are the recent examples of powerful mega thrust earthquakes that generated tsunamis (known as tele-tsunamis or distant tsunamis) that can cross entire oceans.

The 2004 Indian Ocean tsunami was among the deadliest natural disasters in human history with at least 230,000 people killed or missing in 14 countries bordering the Indian Ocean (Telford, John, and John Cosgrave 2006). The 2011 tsunami in Japan lead to 15,894 deaths, 6152 injured, and 2562 people missing. It damaged many buildings, dams, bridges, nuclear power stations, and many other infrastructures. The World Bank's estimated economic cost due to the 2011 tsunami was US $235 billion, making it the costliest natural disaster in history.

The future source zones of earthquakes that can generate tsunamis in the Arabian Sea vis-à-vis Tsunami in west coast of India based on past seismicity and gap areas along the subduction zones and zones of compression are identified as (Jaishwal et al.2009)

- Makran coast
- Indus Delta
- Kutch-Saurashtra regions

These three zones are considered as the possible epicentres of tsunamis in west coast. Specifically, the Makran coast is particularly vulnerable to high-magnitude earthquakes which result in tsunamis. As reported by Heidarzadeh, Pirooz, Zaker, et al. (2008), the last tsunami that hit the AS was originated in Makran coast in 1945. The deaths from the 1945 earthquake in the Makran subduction zone, which generated tsunamis along the coastlines of Iran and Pakistan, were reported to be as many as 4000 people. Besides, the tsunami caused catastrophic damage to properties and other coastal facilities. The earthquakes in1765, 1851, and 1945 indicate that great earthquakes repeat every hundred years or so in a stretch of about 500 km in the Makran coast. They can recur sooner as the 1864 earthquake occurred on the same segment as that of 1851 rupture within a gap of mere 13 years (Byrne, Sykes, Davis, et al. 1992; Jaishwal et al., 2009). The AS coast is vulnerable to tsunamis and may experience a similar impact in coming years.

Sea-level Rise

The global mean sea level has been steadily rising and has risen by 21–24 cm since 1880. In 2019, the global mean sea level was87.6 mm above the 1993 average. The global sea level alarmingly rose to 6.1 mm from2018 to 2019 (Lindsey 2021). Although the global mean sea level rise has been extensively studied, there still exists very limited information on regional sea-level rise assessments. This is primarily due to data unavailability,

non-uniform distribution of tide gauges around the world, and vertical land movements along the coasts, which makes the determination of regional changes a challenge (Krishna, Sanjay, Gnanaseelan, et al. 2020). Several assessments have indicated high variability over the north Indian Ocean. Many studies have estimated the regional sea-level changes in the north IOR to a value close to 2.0 mm/yearand4 mm/year in the Bay of Bengal region (Krishna, Sanjay, Gnanaseelan, et al. 2020). Observational evidence on the sea-level rise along the Indian coast shows that the sea level is rising at arate of 1.3mm/year on an average. For region-specific observations, the rise in India's east coast is as high as 5.74mm/year as reported for Kolkata as per the past 50-year tide gauge data availability (Krishna, Sanjay, Gnanaseelan, et al. 2020). Tide gauge data corroborates the increasing sea level of the Indian Ocean, such as Kolkata, Mumbai, Kochi, Visakhapatnam on the Indian coast and Durban, Fremantle, and Port Hedland on the Australian coast. This increasing trend of sea-level rise, along with increasing incidences of high-intensity cyclones have been causing greater surges and much more severe impacts to coastal infrastructure and ecosystems in recent years.

Marine HeatWave

Rise in SST and enhanced warming in IOR have led to the instances of marine heat waves. Marine heat waves are the periods of extremely high ocean temperatures that persist for days to months (Collins, Sutherland, Bouwer, et al. 2019). The recent event of marine heatwave was observed in 2016, which was also the year of extreme El Niño (Collins, Sutherland, Bouwer, et al. 2019). As per the climate projections under RCP8.5 (high emission scenario), the probability of the occurrence of 1-in-100-day heatwave event will become 1-in-4-day event by 2031–2050 (Collins, Sutherland, Bouwer, et al. 2019). Moreover, the satellite observations also show an increase in marine heat waves, and the frequency of these events doubled during 1982—2016. Marine heat waves are one of the main reasons of mass bleaching of coral reefs and have adverse effects on aquaculture and marine productivity along the Indian Ocean rim countries (Collins, Sutherland, Bouwer, et al. 2019). The warming also leads to acidification of ocean water due to change in biochemical properties with the increase in oceanic uptake of CO2. Since pre-industrial era,oceans have absorbed nearly 30% of the anthropogenic CO2 emissions (Canadell, Le Quéré, Raupach, et al. 2007). In IOR, the surface ocean's pH value has declined by about 0.1 units to the current mean of 8.1 as compared to the pre-industrial levels; also, more variation is observed over the western Indian Ocean (Sreeush, Rajendran, Valsala, et al. 2019).

The change in biochemical properties of ocean water has severe repercussions on oceans' primary productivity. Several studies report a declining trend in marine phytoplankton population in the western India Ocean by 30% as per the1998–2013 observation data (Roxy, Modi, Murtugudde, et al. 2016). Decrease in phytoplankton population eventually hits the fishing industry the most (Lee, Chen, Tzeng, et al. 2005). Moreover, increased acidification may be responsible for the corrosion of reef building corals. Therefore, it is advisable to build a network of observatories for in situ measurements and observations in the Indian Ocean to gather substantial evidence to put up an understanding based on these complex bio-physical interactions.

Role of Science and Technology in Ocean Disaster Management

For a sustainable growth of blue economy, it is eminent to have disaster-resilient, safe, and secure maritime operations throughout the IOR. As already discussed, it is important to have a robust monitoring and observation system in place to understand the dynamic and complex nature of the ocean system. Also, it is important to counter lack of accurate and high resolution (both temporal and spatial) observations and data over IOC. The system needs to be strengthened with a combination of available technologies for earth

and ocean observations. Figure 13 shows the status of India Ocean Observation System (IndOOS) in 2018, comprising Argo, RAMA, XBT/XCTD, surface drifting buoy, and tide gauge networks. It is supported by satellite observations and the GO-SHIP program (Beal, Vialard, Roxy,et al. 2019).

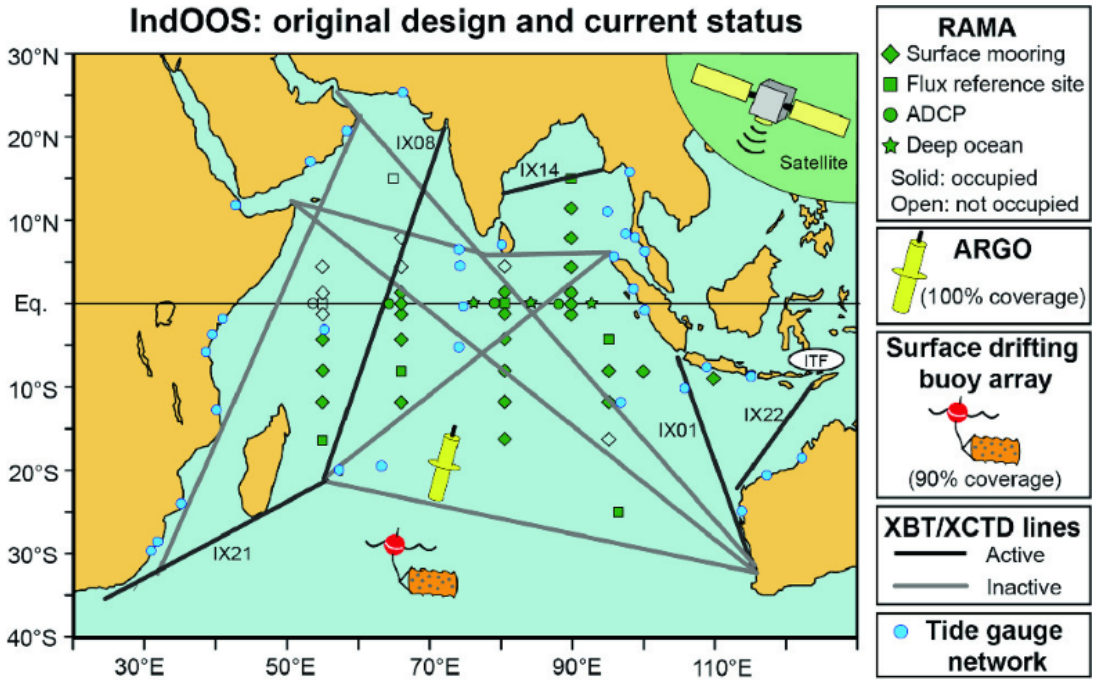

Figure 13 Status of Indian Ocean Observation System in 2018
Source: Beal, Vialard, Roxy,et al. 2019

Apart from these monitoring networks, there is an Ocean Moored Buoy Network for northern Indian Ocean (OMNI) established by the Ministry of Earth Sciences, Government of India. The OMNI network records high-resolution ocean and near-surface meteorological data, as shown in Figure 14, which includes coastal wave rider buoys, acoustic Doppler current profile moorings, deep ocean wave buoys, offshore and coastal-located moored surface buoys, equatorial current meter moorings, and tsunami buoys for deep-sea water-level measurements (Srinivasa, Venkatesan, Vedachalam, et al. 2016). In June 2018, the Government of India announced that the data collected from the OMNI network will be made freely available outside India's exclusive economic zone. The combined observation from these two networks enhances ocean observation in the region and helps in more accurate forecasting of ocean disasters. Also, for tsunami detection and early warning, the tsunami buoys are moored at strategic locations close to the Andaman–Sumatra subduction fault in the BoB and Makran fault in the Arabian Sea, as shown in Figure 15. The collected data are transmitted to the National Institute of Ocean Technology (NIOT) mission control centre located at NIOT in Chennai and to the Indian Tsunami Early Warning Centre (ITEWC) in Indian National Centre for Ocean Information Services, Hyderabad. During a tsunami event, the system simulates a model predicting the tsunami wave propagation time and wave height to disseminate the tsunami advisory for Indian coasts (Vedachalam, Ravindran, and Atmanand 2018).

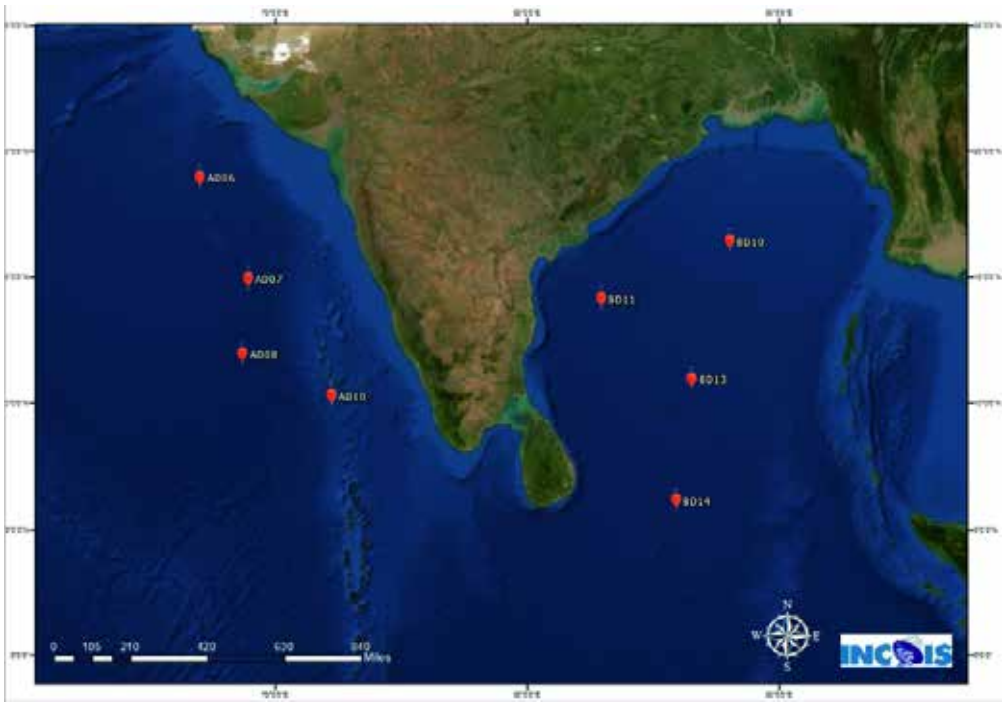

Figure 14 Status of the Ocean Moored Buoy Network for northern Indian Ocean(OMNI) moorings as on October 2019 in the north Indian Ocean

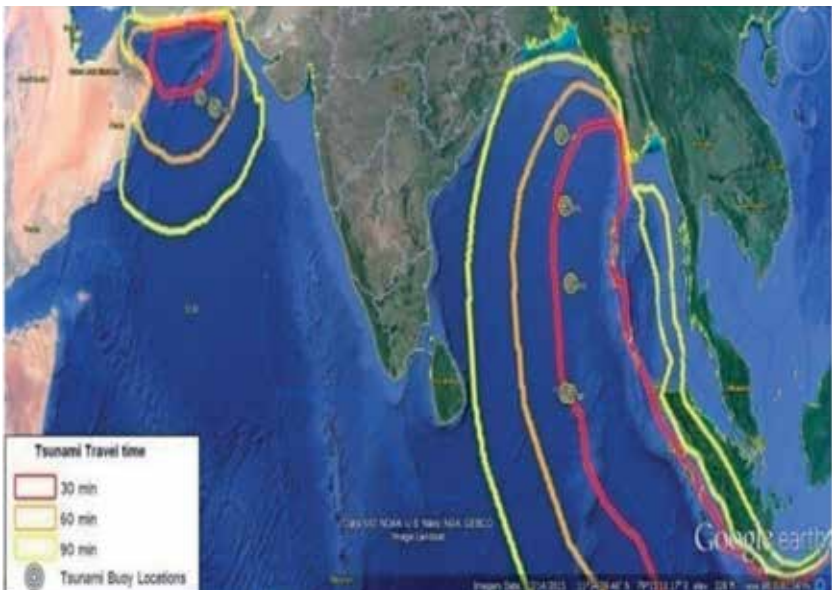

Figure 15 Strategic placement of the tsunami buoys
Source: Vedachalam, Ravindran, and Atmanand 2018

More such efforts are needed at a large scale to cover the entire India Ocean rim countries for better and skilful observation and monitoring. There is a lacuna in observation and monitoring, particularly in west IOR,

which requires concerted efforts from all the member countries of IORA. Therefore, continuous pursuit in monitoring and observation of changes in the oceanic system is required to enhance the disaster resilience through effective adaptation and mitigation strategies. It is worth mentioning that the efforts in these directions are already in process at various levels for collaboration, technology transfer, data and knowledge sharing, and also for capacity building with a focus on designing and implementation of DRR strategies for disaster-resilient maritime affairs. The technologies developed for managing the oceanic disasters and hazard mitigations are essential to keep the ocean ecosystem and the blue economic activities in balance for sustained utilization of India Ocean resources.

Economic Consequences of Disasters in Indian Ocean Region

Healthy oceans and coasts are crucial for blue economic growth. Oceans primary productivity and all the allied services and industries linked to oceans depend on the sustainable resource utilization. However, the increasing vulnerabilities from various hazards have put the oceanic system and maritime affairs at risk of direct and indirect losses. This includes monetary losses and the degradation and loss of oceans ecosystem, leading to a decline in oceans primary productivity. Assessing the financial loss and damage from such disasters in terms of direct/indirect typology is complex and problematic due to inherent uncertainties in evaluation methodologies. The loss and damage also depend on the geographical location, status of development – whether it is a developed nation or a poor nation,and insurance schemes – whether they are inclusive or not. In case the insurance scheme is not very inclusive, the estimation of financial losses becomes more difficult. However, the loss and damage estimation related to disaster impact on businesses and services have been assessed through an alternative or rather complimentary manner to direct/indirect loss assessment in the form of:

- Direct asset loss due to disaster event
- Disruption of supply chain both at demand or supply side
- Interruption in business continuity or production
- Loss of human resources and associated compensations
- Permanent shutdown of operations/business due to non-reparable damage to infrastructure and assets

Most of the assessments available so far for IOR are event based, where in large-scale disruptions and losses and the assessments done by individual-affected entities for their own loss and damage that are not available in the public domain have been reported. Some of the financial-loss estimates collected from various sources are summarized in Table 2.

Every year, oceanic disasters amount to billions of dollars of financial losses. The international collaborations such as IORA should develop a mechanism for loss/damage estimation and reporting of disaster-related financial losses to help understand the actual economic consequences of such disasters. Moreover, these assessments would help in prioritizing disaster mitigation efforts in terms of resource mobilization and need assessments, and also in evaluating the returns and net benefits of each mitigation measure that is already implemented. The assessments would also help in establishing the basis for more investments in disaster-resilient infrastructure development in and around coastal areas.

Table 2 Financial cost assessment of loss and damage due to disasters in the Indian Ocean regions

Year	Event	Cost ($billions)	Fatalities	Source
2020	Cyclone Amphan	14	128	WMO Provisional Report on the State of Global Climate, December 2020
2016	Cyclone Winston	1.4	44	*Newswire*, June 2016
2011	Thailand floods	45.7	815	*The World Bank Supports Thailand's Post-Floods Recovery Effort, World Bank. 13 December 2011*
2008	Cyclone Nargis	12.9	138,366	Asian bloc to handle Burmaaid.Toronto Star. 19 May 2008
2007	Cyclone Gonu	4.4	78	India Meteorological Department (2008). Report on Cyclonic Disturbances over North Indian Ocean during 2007
2004	Indian Ocean tsunami	15	230,000	Joint evaluation of the international response to the Indian Ocean tsunami: Synthesis Report; July 2006.
1974	Cyclone Tracy	0.8–1.1	71	*Tropical CycloneExtremes, www.bom.gov.au*

Conclusion

The blue economy plays a very important role in the economic development of IOR, particularly the economic survival of small-island nations which are mostly dependent on the ocean-based industries. It is discussed in detail how the climate change and disasters impact the ocean system and how they would behave in future. The climate change and disasters are the imminent and most spiteful threat to our ocean system vis. blue economy. The loss and damage due to these disasters has huge implications on the overall socio-economic well-being of the countries in and around IOR. The analysis reveals that the regions which were not vulnerable earlier have now become more vulnerable to various hazards and disasters. In other words, the existing coping mechanism in place will not be sufficient in coming years. Hence, a new financial mechanism is needed for investments in disaster-resilient infrastructure and services, collaborations in science and technology development, capacity building, monitoring and knowledge sharing to understand, plan, and execute climate and disaster management for the entire IOR. Moreover, development of the tools and technologies for regional spatial mapping and planning to guide decision-making including coordinated actions by government agencies for ocean conservation and sustainable resource utilization is required. This would be the way forward to ensure the development of a vibrant, inclusive, disaster-resilient, and sustainable blue economy.

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5.

REGIONAL FRAMEWORK FOR BLUE ECONOMY: Examining Sustainable Development Approach

Chapter 14

Preserving Marine Biodiversity for Economic Growth: India and IORA

Fraddry D Souza and Asha L. Giriyan, The Energy and Resources Institute

Introduction

The coastal and marine ecosystems contain some of the world's most diverse and productive biological systems. They include areas of complex and sophisticated ecosystems, such as enclosed seas and tidal systems, estuaries, salt marshes, coral reefs, sea grass beds, and mangroves that are sensitive to human activities, impact, and interventions. About 80% of all marine species occur in the coastal zones (Keesing 2005). The concentration of diversity is associated with these complex habitats. Biodiversity is a basic determinant of the structure and function of all ecosystems and provides the foundation on which the future well-being of human society rests.

The coastal and marine environments play a vital role in the world economy by virtue of their resources, productive habitats, and wide biodiversity. The Indian Ocean countries have a combined coastline of 66,526 km, which is only about half that of the Pacific and Atlantic Oceans (Keesing 2005). Furthermore, the Indian Ocean Region (IOR) is landlocked in the north, and the resultant differential heating between the landmass and the sea causes a wind circulation that reverses direction twice a year (Wafar, Venkataraman, Ingole, *et al*. 2011). This monsoon effect has a direct bearing on the climatology of the northern Indian Ocean, which, in turn affects the biological productivity and the economy of the regional countries.

IOR, the third-largest oceanic region, is home to a population of 2538.41 million (36.40% of the global population). It covers an area of more than 70 million km^2, which includes extensive exclusive economic zones (EEZ) of different countries and large 'high seas'.(Dominique Benzaken.2017) It is a highly diverse region, culturally and politically, with widely different socio-economic statuses. The IOR harbours a diversity of coastal and marine ecosystems, from coastal coral reefs, mangroves, and sea grasses to productive pelagic ecosystems and poorly known deep sea ecosystems, some of which are of global importance. It accounts for 30% of the global coral reef cover, 40,000 km^2 of mangroves, some of the world's largest estuaries, and 9 large marine ecosystems. The IOR economy is dominated by the productivity of living marine resources, with estimated annual yields of 8 million tonnes of capture fisheries and 23 million tonnes of culture fisheries, equivalent to 10% and 90%, (German CR et al.2011) respectively, of the world's production. Thus, the Indian Ocean's health and resources are critical to the region's economy and well-being of the dependent coastal populations.

Biodiversity, which forms the basis of ecosystem functions, is key to delivering ecosystem services. The Millennium Ecosystem Assessment identifies the following four categories of ecosystem services: provisioning, regulating, cultural, and supporting services. Provisioning services are the products obtained from ecosystems, including food derived from animals, plants, and microbes, and biological material for medicines or as food additives. Regulating services are the benefits obtained from the regulation of

ecosystem processes, including climate and water regulation, erosion control, water purification and waste treatment, regulation of human diseases, biological control, and storm protection. Cultural services are the non-material benefits obtained from ecosystems including spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences. And, supporting services are those that directly influence human well-being, and as such, can be an object of economic growth and development.

The valuation of environmental resources began to gain attention in recent years and a significant amount of literature has been published on the valuation of biodiversity (Mendonca, Sachsida, and Loureiro 2003; Kettunen and Brink 2006, Tacchoni 2000; Nunes, van den Bergh, and Nijkamp 2003). The ecosystem services of biodiversity, such as the provision of food, can be easily recognized, while some, such as climate regulation, have a rather unclear standing. Some of the benefits of the marine biodiversity include ecological benefits such as resilience and adaptive potential, provisioning benefits such as fisheries, commercial benefits such as drugs from sea, nutraceuticals, cosmetics, aquaculture, and food additives, and tourism as cultural ecosystem services. It is apparent that the benefits of biodiversity are innumerable, and that human livelihood and even industrial production are directly dependent on ecosystem services from the ocean. However, the fully functioning marine and coastal ecosystems and their biodiversity are threatened by the intensification of human activities, increasing population, and ultimately, climate change impacts that contribute to a rapid loss of biodiversity in marine ecosystems.

Often biodiversity degradation and loss is seen as just a biological or ecological problem. Far from this, it is also a critical economic and development problem, due to the extremely high value of biodiversity. The loss of marine biodiversity weakens the ocean ecosystem and its ability to withstand disturbances. The health of the oceans strongly depends upon the marine biodiversity and, therefore, requires special attention on the depletion of fish stocks, conservation of marine biodiversity, ocean acidification, destruction of habitats, and occurrence of alien invasive species. There is a lack of knowledge about biodiversity and ecosystem functioning and the importance of ecosystem services. Besides, there is an increasing acknowledgement of the detrimental effects that humans have on marine and coastal ecosystems. One of the most serious implications of under-valuing biodiversity is that it is not accorded a sufficient priority in national policies, planning, and budgets as an economically productive sector. Current investment in biodiversity does not adequately reflect its immense value to the national economy and future development. Mainstreaming biodiversity into the plans, strategies, and policies of different economic sectors is important to reverse these declines. Also, emphasizing on the importance of global biodiversity is vital for human well-being and ocean health. Recently, marine protected areas (MPAs) have been described as one of the main means to achieve marine conservation targets. They provide both direct and indirect benefits for nature and humans,

Value of biodiversity and ecosystem services

The source of ecosystem services depends on many attributes of biodiversity. The species' variety, quantity, quality, and dynamics, distribution of biodiversity, which is required to enable ecosystems to function, and providing benefits to people vary between services. Biodiversity contributes directly and indirectly to livelihood security and is a crucial buffer against extreme climate events. It also acts as carbon sinks and filters for water-borne and airborne pollutants. In coastal areas, mangroves and other wetlands are particularly effective in providing shoreline stability, reducing erosion, trapping sediments, toxins and nutrients, and acting as wind and wave breaks to buffer against storms.

such as replenishing fisheries stocks, biodiversity, a means of imparting education on the importance of biodiversity and its conservation, research, culture, and economic value.

Marine Biodiversity Loss

Marine and coastal environments are subjected to multiple stressors that can impact their sustainability and biodiversity. Rapid urbanization and infrastructure development in coastal areas encroach on natural habitats and modify the functioning of ecosystems, where marine species are sensitive to the physical and chemical conditions of the ocean. Thus, warming, acidification, de-oxygenation, and other climate-related changes directly affect their physiology and performance. Climate change-induced impacts include the appearance of warm-water species, increased mortality of marine mammals, and unprecedented harmful algal blooms, and these factors, when combined, produce economic stress. Changes in biodiversity in the ocean are underway, and, over the next few decades, would likely transform marine ecosystems. For example, the impact of warming on fish stocks is becoming more severe. Marine fisheries and fishing communities are at high risk from climate-driven changes in the distribution, timing, and productivity of fishery-related species. Fisheries management that incorporates climate knowledge can help reduce the impacts, promote resilience, and increase the value of marine resources in the face of changing ocean conditions.

Governance of coastal and marine ecosystems and biodiversity

The Conference of the Parties (CoP) identified marine and coastal biological diversity as an early priority. The three RIO Conventions – Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC), and the United Nations Convention to Combat Desertification (UNCCD) have their relevance to coastal and marine biodiversity. The CBD is a comprehensive, binding, and global agreement aiming at conservation and sustainable use of biological diversity. The convention establishes three main goals: conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of the benefits from the use of genetic resources. Another convention adopted at the 'Rio Earth Summit' in 1992 along with CBD is UNFCCC as a means of mitigating the climate change impacts on coastal and marine biodiversity. As the dynamics of land, climate, and biodiversity are intimately connected, the third convention, i.e., UNCCD collaborates closely with the other two Rio Conventions to meet these complex challenges of conservation of marine and coastal biological diversity with an integrated approach and the best possible use of natural resources. A related convention to biodiversity is the the United Nations Convention on the Law of the Sea (UNCLOS). It deals with navigational rights, territorial sea limits, economic jurisdiction, legal status of resources on the seabed beyond the limits of national jurisdiction, passage of ships through narrow straits, conservation and management of living marine resources, protection of the marine environment, a marine research regime, and a binding procedure for settlement of disputes between states.

Areas beyond national jurisdiction (ABNJ) cover about 64% of the total ocean surface area and provide over 90% of its volume. (FAO, 2020b)They comprise the water column beyond 200 nautical miles EEZ of coastal states, i.e., the high seas, areas of deep seabed, ocean floor, and subsoil that are not subject to national jurisdiction. In recent years, the international community has become increasingly aware of the range of services provided by marine ecosystems and of the rich biodiversity of pelagic and benthic ecosystems beyond the limits of national jurisdiction, namely in the high seas. Key development policy objectives in many countries, therefore, must address both poverty reduction and the conservation of biodiversity and

ecosystem services. In ABNJ, where little is known about the specific features and functioning of ecosystems, the establishment of MPAs can be an important safeguard against irreversible biodiversity loss. They can provide a mechanism for protecting not just what is known at present to be important, but what may turn out to be important in the future.

Blue Economy Opportunities in IOR Based on Marine Biodiversity

Role of Fisheries in Economic Growth

The fisheries sector in the IOR provides food to hundreds of millions of people and is an important contributor to food security and income generation. IOR fisheries include national, artisanal, and semi-artisanal fisheries under national laws and management, and trans-boundary fisheries managed through Regional Fisheries Management Organizations, such as the Indian Ocean Tuna Commission (IOTC) for tuna fisheries and the South West Indian Ocean Fisheries Agreement (SWIOFA) for non-tuna fisheries. Out of the estimated 28.5 million people directly employed by the marine fishing sector (both industrial and artisanal) worldwide, artisanal fishing comprises 90% of all fishing jobs globally, representing approximately 45% of the world's fisheries, livelihoods of the poor (FAO 2020a).

It is well known that societies benefit in numerous ways from ecosystem services generated by fish populations. Fish are part of food chain dynamics, nutrient cycling, and ecosystem resilience. They generate a large number of services related to their movement patterns, including daily, seasonal, and yearly migration patterns in lakes, rivers, estuaries, and oceans (Polis, Anderson, and Holt 1997). They also transport nutrients across spatial boundaries and thereby link different ecosystems. Marine-derived carbon and nutrients are delivered to the river through fish excretion, production of gametes, and fish carcass decomposition, which contribute to the production of algae, insect larvae, microbial decomposers, and other fish in the rivers (R. Blasiak2020 *et*). Cultural services generated by fish populations are based on human preferences, for supplying aesthetic and recreational values, and for ameliorating human health. Fish in public aquaria and wild species in tropical reefs, crowded streams during spawning, or in lakes and along coasts generate highly valued aesthetic services (Moyle and Moyle 1995). In economic terms, the global aquarium industry is estimated to generate USD 7 billion per year (Moyle and Moyle 1995).

Role of Marine Protected Areas in Economic Growth

To maintain biodiversity, ecosystem functions, and the flow of ecosystem services, MPAs are being established worldwide. They are used as a management tool to promote the sustainable use of marine resources. MPAs support provisioning services through their effects on fisheries and diversity. MPAs provide protection to foundation species such as coral reefs, sea grass, kelps, and mangroves. These species produce physical structures that act as natural barriers to waves, hurricanes, typhoons, and elevated sea levels, thereby providing coastal protection to people and critical coastal habitats. Thus, MPAs can contribute to maintaining the ecosystem service of coastal protection through safeguarding habitat-forming species and communities.

Several studies have highlighted the positive effects of MPAs on some aspects of ecosystem functions, such as functional diversity and redundancy.

MPAs are in the first stage of development and are partially protected allowing extractive activities to occur at differing degrees. Many MPAs still lack effective management and proper conservation measures to provide effective biodiversity protection. Degradation or loss of ecosystem services provided by MPAs contributes to fisheries depletion or collapse, especially with overfishing, and the economic activities that depend on them. Fisheries management can maintain the natural capital or build it by investments in sustaining or rebuilding fish stocks and safeguarding essential fish habitats.

Marine-based Tourism

Ocean-based marine tourism is a growing industry, especially in IOR island countries such as Mauritius, Seychelles, Maldives, Réunion, and Madagascar. Tourism as a multifaceted service industry has the potential to provide much-needed job opportunities in hospitality, and also in supporting services, infrastructure development, and maintenance (water and energy supply, and waste disposal facilities).. Developing new tourism products and attracting new markets, particularly in China and Southeast Asia, and targeting emerging middle classes offer great commercial benefits.

Marine Protected Areas Boost Blue Economy

Tourism and fishing are among the sectors mostly benefited in the blue economy.

No-take zones are recognized as an effective management tool both for biodiversity conservation and regeneration of fish stocks. There has been a strong increase in fish production from 861,000 tonnes in 1950 to 11.5 million tonnes in 2010 due to MPA's in the IORA region.(Leenhardt P.et al 2015)

Blue carbon ecosystems have an immense capacity to sequester carbon – a feature that makes them a good candidate for efforts to mitigate climate change.

The Indian Ocean contains a disproportionate amount of the world's blue carbon ecosystems, and the countries of the Indian Ocean have an opportunity to lead the world in harnessing the benefits they provide.

IORA member states should adopt ecosystem-based approaches to sustainably manage and use their marine resources, while protecting and conserving the marine environment.

The region has over 4400 protected areas that cover about 5 million km^2, i.e., about 22% of the region is marine protected area.

Marine Genetic Resources

Bio-prospecting refers to the exploration of biological material in the marine environment for commercially valuable genetic and biochemical properties for pharmaceuticals, cosmetics, and the food industry. So far, due to the high costs of bio-prospecting and commercialization of the resultant products, combined with a low level of scientific and technological capacity, insufficient knowledge of biodiversity, and the lack of a robust regulatory framework, most exploration has been undertaken by developed countries, with limited collaboration from Indian Ocean countries (except South Africa and Kenya). An analysis of patent data shows that the exploration takes place mostly within jurisdictions, with the highest concentration being in areas such as the Mozambique Channel and around the island countries in north of Madagascar, which is not surprising as they are the areas of high biodiversity.

Discussion and Way Forward

The resilience of marine systems is threatened by multiple, interactive, and cumulative stressors, including climate change (Crowder, Osherenko, Young, *et al*. 2006). There are challenges associated with marine biodiversity conservation that bridge governance scales at international, national, state, and local levels, across sectors (tourism, commercial and recreational fisheries, oil and gas, shipping), and geographic areas (marine bioregions and provinces, species range). Numerous studies have identified institutional fragmentation as a key issue in managing coastal and marine resources (Young, Osherenko, Ekstrom, *et al*. 2007; Cicin-Sain and Belfiore 2005). There is a need for marine biodiversity governance structures to function across multiple scales and levels (local, sub-national, national, and global) (Mahon, Fanning, McConney, *et al*., 2010). Alignment between organizations and across boundaries (jurisdictional, sectoral and geographic) is required for system coherence in purpose, strategy and action. There is the need for marine biodiversity governance structures to function across multiple scales and levels (local, sub-national, national, and global) (Mahon, Fanning, McConney, *et al*. 2010).

Marine biodiversity cannot be successfully managed in seclusion. MPAs hold the potential to help in maintaining healthy ecosystems and sustainable fisheries. MPAs are one type of tool in a larger tool box that also includes fisheries management, shipping regulations, climate change policies, and more (Cicin-Sain and Belfiore 2005; Kriwoken, 2011). The governability of many MPAs depends on the interactions and relationships between marine and land-based management authorities, which are critical for effective management outcomes. It necessitates greater interaction between protected area governors and locals from resource-based sectors such as fisheries and nature-based tourism, as well as authorities responsible for land-use planning and management in adjacent catchments (Gill, Kriwoken, Dodson, *et al*. 2003). Policy networks and partnerships are needed to coordinate policy direction, conservation planning, and transboundary management. Marine biodiversity conservation needs to be undertaken as part of an integrated approach to coastal and ocean management.

The Indian Ocean plays a vital role in the blue economy through a significant contribution in livelihoods, cultural identities, fisheries, offshore oil and natural gas resources, tourism, and maritime industries. New opportunities exist in established sectors of capture and exploitative resource industries; hence, there is a need for sustainable development by a way of skills sharing, knowledge enhancement, and governance for commercialization and industrial growth. Based on its enormous potential, the blue economy concept has been well-elaborated for expansion in the Indian Ocean driven by the Indian Ocean Rim Association (IORA) and individual countries including Seychelles, Mauritius, India, and Australia. As a key figure in the IORA, India could rally with other countries to strengthen biodiversity measures to ensure long-term protection of the regional ocean and livelihoods dependent on it. Recently, the World Bank introduced blue bonds as an innovative financing mechanism for aiding sustainable blue economy initiatives wherein countries could collectively focus on leveraging blue bonds or initiating similar innovative financing mechanisms in the short term to address the urgent need to continue ocean conservation efforts.

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Chapter 15

Marine litter : plastic pollution in IORA: regional and sub-regional levels' initiatives

V.N. Attri, Member, FICCI Task Force on Blue Economy, Former Chair in Indian Ocean Studies, Indian Ocean Rim Association (IORA), Mauritius

Introduction

Marine litter is a threat to marine life, the ocean, and humanity.[1] Globally, greater plastic accumulation in marine environment has been caused due to increased global production of plastic. The ocean is the Earth's life support, with 97% of the world's water, regulating our climate, absorbing CO_2, and is the number one source of protein for over a billion people. According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO), around 220 million tonnes of plastic are produced each year, with around 8-20 million metric tonnes per year of plastic (United Nations Development Program, 2017) are reaching our oceans, making an irreparable damage to our marine life and ecosystem. Our actions during the next 10 years will determine the state of health of the ocean for the next 10,000 years to come. It is estimated that by 2050, the number of plastics will be more than the number of fish present in the ocean, showing the extent of damage already done by marine litter to our ocean and the degree of seriousness to find solutions to keep marine litter within the manageable limits so that the productivity of the ocean as a development space for improving the life on our planet Earth is preserved. Our oceans need to be healthy. It needs to be maritime pollution free because the marine ecosystem provides food and jobs to all the 23 Member States of the Indian Ocean Rim Association (IORA) in various sectors such as tourism, fisheries, shipping, and ports. The possible health risk damage to marine ecosystems and the blue economy (tourism and other marine sector) due to plastic litter are enormous. UNEP (2019) emphasizes "ASEAN in need to comprehensive approach to plastic pollution." Plastic accounts for 47 to 65 percent in deep Arctic sea floor at the HAUSGARTEN. Small sized plastics increased between 2002 and 2014 indicating fragmentation of plastic clutter. The Arctic faces a pollution problem and that is spreading to the North since the 1990s. Between the years 2000 and 2013 mean ice-sea thickness has decreased by 0.58 million (Lindsay and Schweigr, 2015) and it has decreased in the month of September by 24% (Meier *et al.* 2014). The paper concludes that considering the importance of the Arctic region for global climate and ecosystem health, identifying the changes in anthropogenic stress and its direct or indirect sources provide important information for future projections to regulate human activities.

The awareness about the marine debris and its harmful economic impacts began in the early 1990s when some of the regional groupings started discussing the issue in their Ministerial Meetings. The prominent among them are APEC (1990), SACEP (2005), ASEAN (2019), UNEP (2009), Ocean Conservancy's International Coastal Clean-up (2017), and the World Bank (2018). Apart from these, the other prominent studies include: Jambeck *et al*., 2015; Dris *et al*., 2015a; Free *et al*., 2014; Dris *et al*., 2015b; Eriksen *et al*., 2014; GESAMP, 2015 Van Cauwenberghe *et al*., 2015 ; Cole *et al*., 2013 ; Camedda *et al*., 2014 ; Van Cauwenberghe *et al*., 2015 ; Browne

1 About 150 years ago, in 1870, Jules Verne described the accumulation of debris in the convergence zone of the North Atlantic Ocean in his famous novel entitled "Twenty Thousand Leagues under the Sea." Many scientific reports have added this topic.

et al., 2008; von Moos *et al*., 2012 ; Dussud and Ghiglione, 2014; Deudero and Alomar, 2015; Harrison et al., 2011; Pham et al., 2012 ; Maso et al., 2003; and UNEP Report (14 Nov., 2019).

Laurent Hebreton and Anthoney Andrady (January 2019) published by Palgrave Communciations entitlied "Future scenario of global plastic waste generation and disposal", A quantative study using GDP, population concludes that

"The accumulation of mismanaged plastic waste (MPW) in the environment is a global growing concern. Knowing with precision where litter is generated is important to target priority areas for the implementation of mitigation policies. The study using country-level data on waste management combined with high-resolution distributions and long-term projections of population and the gross domestic product (GDP) provides projections of global MPW generation at ~1 km resolution from now to 2060. The study estimated between 60 and 99 million metric tonnes (Mt) of MPW were produced globally in 2015. In a business-as-usual scenario, this figure could triple to 155–265 Mt per year by 2060. The future MPW load will continue to be disproportionately high in African and Asian continents even in the future years. However, the study shows that this growth in plastic waste can be reduced if developing economies significantly invest in waste management infrastructures as their GDP grows in the future and if efforts are made internationally to reduce the fraction of plastic in municipal solid waste. Further the paper says that the majority of MPW (91%) are transported via watersheds larger than 100 km^2 suggesting that rivers are major pathways for plastic litter to the ocean."

Marine litter impacts economies, ecosystems, animal welfare, and human health worldwide. The majority, about 80%, of marine litter, also known as marine debris, originates from land-based sources; the remaining 20% comes from sea-based sources. Every year, millions and millions of tonnes of litter end up in the ocean worldwide, posing environmental, economic, health and aesthetic problems.

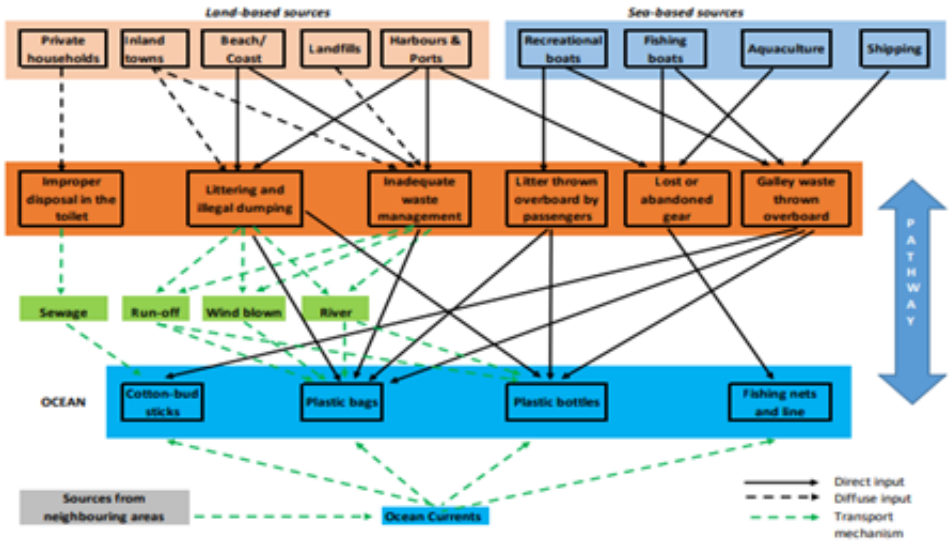
Sources of Marine Litter

There are two major sources of marine litter: land based; and sea based.

The land-based sources are landfills and littering of beaches and coastal areas (tourism), rivers and floodwaters, industrial emissions, discharge from storm water drains, and untreated municipal sewerage. The treated sewage contains micro plastics as proper technology is not available. The sea-based sources of marine litter are fishing and aquaculture, illegal or accidental dumping at sea from shipping (e.g. transport, tourism), and offshore mining and extraction. Furthermore, in certain cases, natural hazards, and events such as inundation due to Tsunami and storm surge, flooding events can act as the carriers of litter from land.

Economic Impacts of Marine Litter

Marine litter has become a growing global environmental challenge, but it also presents as an economic threat. Marine litter, distributed on coasts, in ports, on the surface of seas, on the seabed, and in the bodies of marine species, includes fishing nets, traps, rope, and plastic bags eventually wash up on beaches, and accumulate in oceans. This litter directly or indirectly arises from various economic sectors and activities. Some of these sectors include aquaculture and fisheries, shipping, cosmetics and personal care products, textile and clothing, retail and tourism.



Source: Adapted from J.M. Veiga et al., 'Identifying Sources of Marine Litter. MSFD GES TG Marine Litter Thematic Report' (JRC Technical Report, EUR 28309, Luxembourg: Publications Office of the European Union, 2016), 11, doi:10.2788/018068.

Figure 1: Multiple sea- and land-based sources of four common items of marine litter and their potential pathways of entrance into the marine environment

Marine litter can lead to a reduction in the volume of fishing due to entanglement, ingestions, and exposure to toxic materials, Ghost Fishing as a result of loss of nets and the contents of micro plastic in the catch; shipping vessels can also disrupt the supply chains and similarly, polluted beaches may discourage visitors leading to the loss of revenue by tourism, implying that it may affect the optimal utilisations of marine resources available in our oceans.

In another instance, according to the United Nations Environment Programme's *Marine Litter Socio-Economic Study* published in 2017**,** marine litter poses as a threat to the human health, such that there is a risk from nano particles passing through cell walls but also through chemical contamination in fish and shellfish eaten in the future, and possible transfer of pathogens. Furthermore, there is a concern regarding the health of the community's environment such as cost of clean-up and the loss of well-being due to degraded environment.

Extent and Size of the Marine Litter Problem

It is estimated that more than 150 million tonnes of plastics have accumulated in the world's oceans, while 4.6 -12.7 million tonnes are added every year. It is broadly assumed that approximately 80% of marine litter is land-based, with regional fluctuations (For example, in the Northeast Atlantic; shipping and fishing are very important litter sources. Considering its accumulation and dissemination, marine litter may be one of the fastest growing threats to the health of the world's oceans. Recent litter evaluations in open oceans, resulting from 248 dives/trawls at deep sea sites (seamounts, banks, mounds, and ridges) in the Atlantic Ocean around Europe, together with concentration measurements above the Arctic Circle, indicate respective densities of 180 and 36.5 plastic debris items per square km. Other studies in the Indian Ocean and Atlantic Ocean indicate densities of 555 and 483 debris items per square km. The volume of litter in the three main oceans,

which cover a deep-sea surface area of 300,875,000 square km may range roughly from 10,982,000.00 (#11 billion) to 54,157,500,000 (#54 billion) items, excluding the Arctic and Antarctic Ocean, where litter is less frequent.

Little information exists however on the global freshwater input, with high quantities reported, up to 106 particles/m3 in developed countries. Atmospheric inputs, also, cannot be ignored. Micro-plastics fallout ranged from 29 to 280 particles m^2 day^{-12} (average 118, fibres accounting for 90% of the total particles) depending on the period when rainfall occurred. This will support new research, enabling a better understanding of fluxes to the oceans. Various recent studies have revealed that the well-recognized oceanic gyres, improperly defined as "plastic continents," are less affected than coastal areas such as the Bay of Bengal and Mediterranean coast. Recent assessments of floating large debris and micro-particles have shown that quantities located on the surface are limited and that the presence of sinks should be considered.

Regarding coastal waters, 6631 samples collected during 14 surveys from relevant areas (California, Japan, Hawaii, China, Korea, Florida, the North Sea, Azores, Portugal, the Gulf of Mexico, Brazil, and Red Sea) indicate a mean and balanced concentration of 723 plastic items/square km. As the average margin area is 84,245,000 km^2, this represents 60,909,135,000 items (#61 billion). Taking into account the additional 525,615,958 (#0.5 billion) plastic items over an area of 2,936,000 km^2 in the Mediterranean and Black Sea found (295 samples collected during seven surveys), we obtain a very rough estimated global range of 71.5–116 billion large plastic debris items on the sea floor, without consideration to micro-plastics that are largely distributed in deep sea sediments. More accurate estimates, also considering weight, are the next challenges. Moreover, the location of deep-sea floor debris needs to be more precisely pinpointed; although debris is present on all ocean floors, we do not possess any inventories of significant debris accumulation in deep and remote areas. We know very little about deep sea currents and probable deep convergence zones. Additional "patches of plastic" and "deep sea gyres" remain to be discovered.

Although scientists have focused on micro-plastics in recent years, the study of smaller debris has proved difficult due to limited methods. Microplastics represent just 10% of the total weight of floating plastic particles. This percentage may be lower for nanoparticles. Then, in view of the specific impact potentially caused by chemical release, larger debris are more important and should be a priority study topic. On the contrary, in view of the dispersion of rafted debris, the vast quantities of small particles (5 trillion micro-plastics and nano-particles must equally be given priority status, as quantities may be even higher than currently thought. The grant opportunities for marine debris are rising in 2021 in the USA, Europe and other regions globally to manage impact of microplastics <5mm in size or marine wild life, sneks, steel head, trout and blue crab babies etc.

Circular economy and the Marine Litter in IOR

"Circular Economy is an economy that is restorative and regenerative by intention. It is a new way of creating value through extending product lifetime and relocating waste from the end of the value chain to the beginning – in effect using products and their resources more efficiently by using them more than once. Systemic innovation is at the core of circular economy practices."[2] The European Union and Japan promote a circular economy and life cycle approach to packaging, UNEP (14th Nov., 2019), the role of packaging regulations and standards in driving the circular economy.

2 United Nations Industrial Development Organisation, "Addressing the challenge of Marine Plastic Litter using Circular Economy methods Relevant Considerations Inclusive and Sustainable Industrial Development, Page 8, A Working Paper UNIDO – United Nations Industrial Development Organisation, Department for Environment, Vienna, Austria, April 2019.

The paper highlights that the problem of marine plastic litter may be overcome by implementing circular economy practices, optimizing landfill management measures to tighten the management of the marine based sources of marine litter; and clean-up operations where increased plastic pollution of oceans may be prevented. In addition to this, innovative ways of product designing, production usage and end of first life as well as final disposal may be applied. The Circular Economy has the potential to address our unsustainable production, consumption and poor waste management and reduce marine litter. EU, 0-7, 0-20 and many other countries in IORA are applying Circular Economy Package to address marine litter; and to increase resilience of our ocean biodiversity fighting climate change and enhancing well-being of citizens. It is suggested that IORA Member States may apply innovative circular economy package to reduce 50% of marine litter by 2025.

Marine Litter at Global and IORA Level

Marine litter reflects inefficiency in the utilization of the resources at our disposal. Since nothing is waste in nature, a circular economy approach which puts the emphasis on preventing waste and on recycling and reuse of materials and products may be the best solution to the marine litter problem. The European Union adopted on March 4, 2019 a comprehensive report on the implementation of the Circular Economy Action Plan. The report presents the main achievements under the Action Plan and sketches out future challenges to shaping our economy and paving the way towards a climate-neutral, circular economy where pressure on natural and freshwater resources as well as ecosystems is minimised. The key success of circular economy is to focus on the design stage, instead of trying to deal with waste at the end of the product's life. When it comes to plastic, the aim is to change practices and encourage innovation so that there is less use of plastic, designing plastic in such a way so that they can be reused, such as devise and use safer alternatives to traditional plastics. Furthermore, policy measures can be implemented to incentivize circular economy practices. Many countries, particularly China and Japan are focusing on the building blocks of the circular economy for increasing the efficiency of their resources since the 1990s and 2000s.The discussions on circular economy has become prominent since 2012 and the G7 has a group called Resource Efficiency Alliance. It is imperative for IORA to have deliberations on circular economy in the forthcoming meetings to tackle the problem of marine litter in the Indian Ocean Region. In ASEAN - Indonesia, Philippines, Vietnam and Thailand have been the biggest polluters of the oceans. Two of these countries: Indonesia and Thailand are also the member states of IORA. According to Ocean Conservatory, 60 percent of the debris comes from China and four ASEAN nations. The Bangkok Declaration "On Combating Marine Debris in ASEAN Region" may be seen as a big step to curb plastic debris (June 21, 2019).

Zero Waste Management in IORA

The following initiatives may be undertaken:

(i) Communities in IOR may be encouraged to practice a waste free lifestyle in addition to pragmatic policy making to address the issue which need to be given top priority.

(ii) A common marine plastic curbing policy may be adopted after preparing its structure in the Working Group on Blue Economy (WGBE) within the next 2-3 years. And by 2030 IORA may aim at plastic free rivers, seas, and ocean as well as on zero waste management.

(iii) Marine debris is a common problem in all IORA's region and sub-regions. Therefore, it is recommended that IORA may adopt a collaborative approach with other regional groupings such as ASEAN, SADC, GCC, COMESA, SAARC, IOC etc.

(iv) Packing accounted for 36 percent of total MPW in 2015 followed by construction at 16 percent.

(v) Substitution of plastic by metal, wood, ceramics and glass, turning to paper and fabrics for packaging and boosting recycling rates could slash planet-warming green house gas emissions by 2050.

The UN Department of Economic and Social Affairs and the World Resources Institute (WRI) in their report 'Communities of Ocean Action (COA) (February 2017) report provide a detailed analysis of 369 voluntary commitments states registered in 2018, addressing target 14.1 and 14.2, focus on preventing and significantly reducing marine pollution of all kinds by 2025 and sustainably managing and protecting marine and coastal ecosystems by 2020 respectively.[3]

A recent survey carried out by the National Centre for Coastal Research (NCCR), the Ministry of Earth Sciences (MoES) along the east coast of India (22 waters and 38 sediment samples) indicates that on an average 25 micro-plastics particles per sampling within 10 kms of coastal waters and 192 items/kg of dry weight of sediments ae observed. Furthermore, a national programme under the aegis of the MoES has been initiated since 2019. A standard protocol for water, sediment, and biota sampling has been formulated in collaboration with the Centre for Environment, Fisheries, and Aquaculture Sciences (Cefas), UK for sampling along the Indian Coast. In a pilot study made by AlphaMERS Pvt Ltd, Bengaluru to quantify the litter using a floating trash barrier in the Cooum River mouth, Chennai indicates that about 22,000 metric tonnes of litter was trapped out of which 2000 metric tonnes of plastics are retrieved.

In India, MoEFCC, Central Pollution Control Board, and State Pollution Control Boards have major and important roles to play in the context of containing the litter on the landward side. Floating booms like structures can be recommended and fixed in the smaller size/creek/canals which are flowing through major cities. Waste management on landside and sewage management capabilities of the state government needs to be addressed and needs to be increased, otherwise, the targets cannot be achieved. Similarly, fishery related departments of Federal and State government need to work out a strategy for retrieving the unused nets and recycle it. There are some successful case studies in Asian countries.

According to the *Marine Litter: A Global Challenge* report published by the United Nations Environment Programme in 2009, no data or references on the sources, causes, quantities, and distribution of marine litter at the regional level in the East Asian Seas region have been identified. In this regard, Indonesia proposes Joint Research for identifying sources, causes, quantities, and distribution of marine litter at the regional level coordinated and facilitated by IORA mechanism. Overall, the current state of knowledge about the extent of the marine litter problem is very poor in the East Asian Seas Region, and extensive work is required to address this significant information gap for marine litter management and abatement. There are currently no regional legal instruments such as multilateral treaties addressing marine litter or even marine environmental management in general.

3 "14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution

14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and act for their restoration in order to achieve healthy and productive oceans"

The Government of Kenya effected: i) The ban on the use, manufacture or import of plastic bags in 2018 and ii)The ban on single-use plastics in beaches, national parks, forests, and conservation areas from 5th June 2020. The United Nations Environment Programme (UNEP), the National Environment Management Authority (NEMA), Kenya Marine and Fisheries Research Institute (KMFRI) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) carried out a coast wide survey on Marine Litter inventory for Kenya in 2019. The Western Indian Ocean (WIO) Region has an existing Action Plan on Marine Litter that is currently being implemented.

Additionally, Kenya Manufacturers Association (KMA) has developed the Kenya Plastic Action Plan. This is a private sector-led Action Plan that seeks to enable a circular economy for the environmentally sustainable use and recycling of plastics. The International Union for Conservation of Nature (IUCN) is carrying out a review of the existing frameworks in several countries, including Kenya on estimation of plastic leakages to the environment.

The report further acknowledges that there is a lack of published, quantified information about marine litter in all of the WIO countries, except for South Africa. There have been no comprehensive assessment studies done locally or internationally on persistent solids, such as plastics, vessels dispose of at sea in most of the IORA countries. At the last Indian Ocean Rim Academic Group (IORAG) Meeting, there was a session on plastic pollution. This could also be noted along with the mention of Australia's project proposal pertaining to the international and national laws around plastic pollution. It is advisable that the social and health aspects of marine litter also need to be researched for IORA.

The World Bank report on waste 2.0, published in 2018 recognized that poorly managed waste is contaminating the world's oceans which is clogging drains and causing flooding, transmitting diseases through breeding vectors, and is further affecting economic development. The report calls upon urgent actions at all levels of society to mitigate unmanaged and improperly managed wastes.

As per the SACEP (2007) report, it is to be noted that in the entire South Asian Seas (SAS) region, data of some utility on marine litter is only available for India, Sri Lanka, and Maldives, while for the rest of the region, data still needs to be made available. It is further to be noted that there is no standardized methodology available throughout the region to assess the issue. Currently, there are no specific national or regional projects that focus exclusively with marine litter in the SAS Region.

Furthermore, the *Compendium of Policies and Preventive Measures to Reduce Land-Based Marine Debris in APEC Economies* (2019) noted that an estimate of 80% of all marine debris comprises of plastics and roughly 80% of plastic wastes originate from land-based sources. The compendium was developed to initiate preventive measures for marine debris control in APEC countries. The key finding was that many economies have implemented economy-wide policies to prevent marine debris through the 3Rs (Reduce, Reuse, and Recycle). However, it is to be noted that there is still a lack of coordinated efforts and an absence of targeted awareness-raising across known marine debris sources, such as industry sectors.

The African Marine Waste Network focuses on preventing marine pollution in Africa at its source, i.e. on land. It does so by building networks between governments, industry, and the civil society, and knowledge sharing within countries and across the borders in Africa.

The Western Indian Ocean Marine Science Association aims to advance regional cooperation in all aspects of costal and marine sciences, and management, and to support sustainable development in the WIO Region. The coastal zones of the WIO region hosts major cities, harbours, and other development infrastructures that are posing a threat to the integrity of marine ecosystems. Those major cities contribute to significant amounts of wastes generated, which contributes to the marine litter problem, as well as discharges into rivers. Those four major cities include the mainland coast of East Africa, namely Mombasa, Dar es Salaam, and Maputo. Given that there is a lack of data for the WIO region, Western Indian Ocean Marine Science Association (WIOMSA) in collaboration with the Sustainable Seas Trust through the African Marine Waste Network and country partners are implementing a marine litter monitoring programme in the region, namely in Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Tanzania, and South Africa.

IORA and Marine Litter

IORA Action Plan 2017-2021 under Blue Economy, medium term initiatives focuses on developing "appropriate mechanisms of cooperation for sustainable development of Blue Economy sectors including training and capacity building programmes." Further, the first meeting on the Working Group of the Blue Economy (5 - 6 December 2019, Mauritius) session two on climate change and marine pollution came up with main outcomes/recommendations which includes focuses on plastic pollution.

The first and second IORA Ministerial conference on Blue Economy set out the foundation to elaborate on strategic areas for cooperation on ocean-based growth in the Indian Ocean. Building upon that, the third Ministerial meeting partly focused on the sustainable exploration and exploitation of various living and non-living resources from the seas and tackling the menace of marine pollution and plastic debris.

As per the IORA Action Plan 2017 - 2021, a Working Group on Blue Economy was established. The first Working Group on Blue Economy, (held on 5-6 December 2019 in Mauritius) considered mechanisms to include the aspects related to climate change and marine pollution. Member States were encouraged to create awareness campaigns with regards to plastic pollution. Australia expressed that they are currently undertaking the CSIRO's Global Plastic Pollution Survey for which Member States further expressed their interest in: Member States are encouraged to create awareness campaigns with regard to plastic pollution, including among fishermen; to stop single use plastic; IORA Member States to develop coastal water quality programme; Member States to explore joint efforts to have regional mechanisms to combat marine plastics; Member States to explore the use of technology to reduce marine plastic; Australia to extend its existing Global Plastic Pollution Survey to other Member States; Member States to express interest in participating in the Global Plastic Pollution Survey.[4]

Under the WGBE work plan, short term, and medium term goals were put forward in order to measure the progress in mitigating marine pollution in IORA Region. The two short term activities were: (i) share best practices and lessons learnt in management of plastic waste, including micro plastics and marine debris; (ii) provide training programme on management of plastic waste and marine debris in IORA region. The medium-term activities were: (i) identify plastic sources within Member States and the region, so that support can be provided to Member States to ensure upstream point source controls are implemented: (ii) Engage other regional bodies that are undertaking research on marine pollution issues. Through these different activities and timeframe outlined, the objective "*to address marine pollution issues in IORA Region*" will be achieved with proper follow-up.

4 First Working Group on Blue Economy meeting held 5 - 6 December 2019

Proposed Global IORA's Pathways for Marine Litter

1. Involving IORA future Action Plan on the pattern of ASEAN, APEC, and other regional economic groupings in developing and implementing an IORA Action Plan, building from the various Blue Economy Ministerial conference as well as the from the recent Work Plan of the Working Group of Blue Economy (5 - 6 December 2019)
2. To develop clear, harmonized methods and protocols for assessments of plastics leakage into river systems and along coastlines for implementation in IORA member states.
3. Undertake regional studies to assess economic impacts related to plastics pollution in the IORA region, and disaggregated analysis across countries. The focus may be on Marine and Fresh water projects and Sea.
4. To create a regional architecture to find optimum solutions for marine litter through application of economic instruments as well as incentive mechanisms, as well as downstream, through technology and innovations.
5. To create networking among the similar institutions working on the problem of Marine Litter in the Indian Ocean and other regional ocean and seas such as ASEAN, APEC, SADC, EU, AU, the World Bank, ICUN, SACEP, WWF, etc.
6. To Encourage IORA Member States to develop national approaches to deal with the matter including awareness and training campaigns.
7. To implement national initiatives of IORA Member States such as India's 'Clean Ganga' programme to control litter and build a sustainable environment.
8. To align IORA's 'Marine Litter or Debris' initiatives with Goal SDG 14.1, under which countries have to prevent and significantly reduce marine pollution of all kinds including marine litter or debris.
9. To include the role of non-state and commercial stakeholders to contribute to awareness building on Marine Litter or Debris.
10. To harness technologies such as Artificial Intelligence, Bigdata, Blockchain, etc., for instance for monitoring fishing gear use/disposal.

The number of different species affected by marine debris is ever increasing as worldwide more than 800 species of marine life have been harmed with impacts that include injury, illness and death. Since 2014, the UN has been paying great attention to the pollution and curbing of micro plastics by formulating rules and taking relevant actions to strengthen the control of micro plastic such as calling on governments and industries to reduce the production of overuse of plastics

Contrary to this IORA is only mentioning of plastic pollution in Working Group on Blue Economy in December 2019 and did not take any substantive action to reduce the plastic pollution. A comprehensive IORA policy for combating plastic pollution is required through deliberations by the member states in the forthcoming meetings of Committee of Senior Officials (CSO).

Conclusions

i. It is highly recommended that IORA should aim at evolving a regional pragmatic and comprehensive policy for management of plastic waste (MPW) in line with UNESCAP Report (2021), even if many member states in IORA have their national policies on MPW.

ii. Circular Economy Approach (CEA) focusing on current production and consumption patterns in conducive business models may be adopted. This is likely to generate enormous employment opportunities and private investors could save USD 2.9 trillion by the year 2030 globally including IORA, as a consequence of lowered costs of raw materials and technology and innovations. IORA needs to take initiatives in Accelerated Technological Change (ATC), in line with the latest United Nations recommendations, strengthening. National innovation systems, building capacity for Science, Technology & Innovation (STI) policy making and creating a regional network of experts.

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Chapter 16

Understanding and Integrating SDG Goal 14 in the Blue Economy Framework: Challenges, Progress, and Next Steps for Asia-Pacific

Yugraj Singh Yadava[1] and **Rajdeep Mukherjee** , Bay of Bengal Programme Inter-Governmental Organisation[2]

Introduction

The blue economy is an evolving concept primarily aimed at harnessing benefit streams from the ecosystem and other services of the ocean while ensuring ocean health. The Sustainable Development Goals (SDGs), especially SDG 14: Life Below Water, on the other hand, are well-defined targets primarily aimed at (1) stopping further degradation of marine lives, (2) improving marine ecology and environment, and (3) harnessing the benefits from marine ecological services. Both these concepts have their root in the 2012 Rio+20 United Nations Conference on Sustainable Development (UNCSD). Though originating from the same root, their inspiration differs in the sense that while SDGs are built on the Millennium Development Goals that had been established following the Millennium Summit of the United Nations in 2000, the need for blue economy was espoused by the small island developing states (SIDS) and the coastal states in line with the green economy concept proposed in the Rio+20.

The Rio+20 Outcome Document the "Future We Want" states that "we consider green economy in the context of sustainable development and poverty eradication as one of the important tools available for achieving sustainable development and that it could provide options for policymaking but should not be a rigid set of rules. We emphasize that it should contribute to eradicating poverty as well as sustained economic growth, enhancing social inclusion, improving human welfare and creating opportunities for employment and decent work for all, while maintaining the healthy functioning of the Earth's ecosystems." Subsequently, the United Nations Environment Programme (UNEP) and its partner agencies brought out the "Green Economy in a Blue World"[3] arguing that ocean-based sectors such as fisheries, tourism, and maritime transportation can take steps to reduce their impact on the marine environment, and in doing so these industries themselves can become more efficient, profitable, and sustainable and can contribute directly to the sustainability and productivity of other businesses and livelihoods that depend on healthy oceans and coasts.

The first global Blue Economy Conference was held in November 2018 in Nairobi, Kenya. The Conference was jointly organized by the Kenya, Canada, and Portugal governments setting the stage for approach to the blue economy framework. This was followed by the adoption of the blue economy concept by various international and regional organizations and subsequently by the national governments. In spirit, the blue economy is a case of joint optimization aimed at improving economic benefits from the ocean services while

1 Director, Bay of Bengal Programme Inter-Governmental Organisation, 91, St Mary's Road, Abhiramapuram, Chennai 600 018, Tamil Nadu, India

2 Policy Analyst, Bay of Bengal Programme Inter-Governmental Organisation, 91, St Mary's Road, Abhiramapuram, Chennai 600 018, Tamil Nadu, India

3 UNEP, FAO, IMO, UNDP, IUCN, World Fish Center, GRID-Arendal. 2012. Green Economy in a Blue World. www.unep.org/greeneconomy and www.unep.org/regionalseas. ISBN: 978-82-7701-097-7

preventing further degradation of ocean health and, if possible, improving the ocean health. Within this broad philosophy, organizations and national governments are free to adopt any blue economy strategy as it suits their need.[4]

On the other hand, in January 2015, the United Nations General Assembly (UNGA) began the negotiation process on the post-2015 development agenda. The process culminated in the subsequent adoption of the 2030 Agenda for Sustainable Development, with 17 SDGs at its core, at the UN Sustainable Development Summit in September 2015. The SDGs are fixed targets. While they are voluntary in nature, that is, they are not legally binding, countries are expected to take ownership and establish a national framework for achieving the 17 goals. Countries are also not free to modify the targets as they are globally accepted limits. However, SDGs are also basis of subsequent international negotiations and are backed by various international treaties, such as United Nations Law of the Sea and Convention on Biological Diversity, which gave these targets a considerable degree of legal validity. They are subject of high interest in media and global forum and such moral persuasion has also worked in favour of their implementation *in toto*.

Blue Economy Framework

The growing realization of the importance of ocean services in economic development started with the development of economic valuation of non-marketed services. Costanza, d'Arge, de Groot, *et al*. (1997) in their study estimated that for the entire biosphere, the ecological services and natural capitals generate about US$16–54 trillion ($10^{12}$) per year, with an average of US$33 trillion per year, most of which is outside the market.[5] About 43% of this value comes from the coastal estuaries, coastal wetlands, beds of seagrass and algae, coral reefs, and continental shelves.[6] However, blue economy emerged as a development concept during the Rio+20. At the Rio conference, blue economy was described as an ocean economy that aims for the "improvement of human well-being and social equity while significantly reducing environmental risks and ecological scarcities." The blue economy concept goes beyond the term ocean economy and is defined as "any economic activity which directly or indirectly uses sea as an input."[7]

The United Nations (UN) considers blue economy in "a sustainable development framework for addressing equity in access to development of and sharing of benefits from marine resources." The UN further views oceans as "development spaces" where spatial planning integrates conservation, sustainable use, oil and mineral wealth extraction, bioprospecting, sustainable energy production, and marine transport. Thus, blue economy covers several sectors directly or indirectly linked to the oceans, such as fishing, minerals, shipping and port infrastructure, marine biotechnology, marine manufacturing, marine renewable energy, marine tourism, marine construction, marine commerce, ocean governance, and education.

The World Bank further consolidated the definition of the blue economy to imply "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem."[8] The following graphic from the *World Bank* captures the essence of "Blue Economy" in the present context (Figure 1).

4 A compilation of various definitions of the blue economy can be found in Juneja, M., C. De Souza, A. L. Giriyan, and S. Ganeshan. 2021. Contextualising Blue Economy in Asia-Pacific Region: Exploring Pathways for a Regional Cooperation Framework. The Energy and Resources Institute (TERI), India. Details available at https://www.teriin.org/sites/default/files/2021-03/blue-economy.pdf

5 Costanza, R., R. d'Arge, R. de Groot, et al. 1997. The value of the world's ecosystem services and natural capital. Nature 387: 253–260

6 Costanza, R. (1999). The ecological, economic, and social importance of the oceans. Ecological Economics 31(2), 199–213

7 Mohanty, S. K., P. Dash, A. Gupta, and P. Gaur. 2015. Prospects of the Blue Economy in the Indian Ocean. Research and Information System for Developing Countries (RIS), New Delhi

8 The World Bank. 2017. What is the Blue Economy? Details available at https://www.worldbank.org/en/news/infographic/2017/06/06/blue-economy

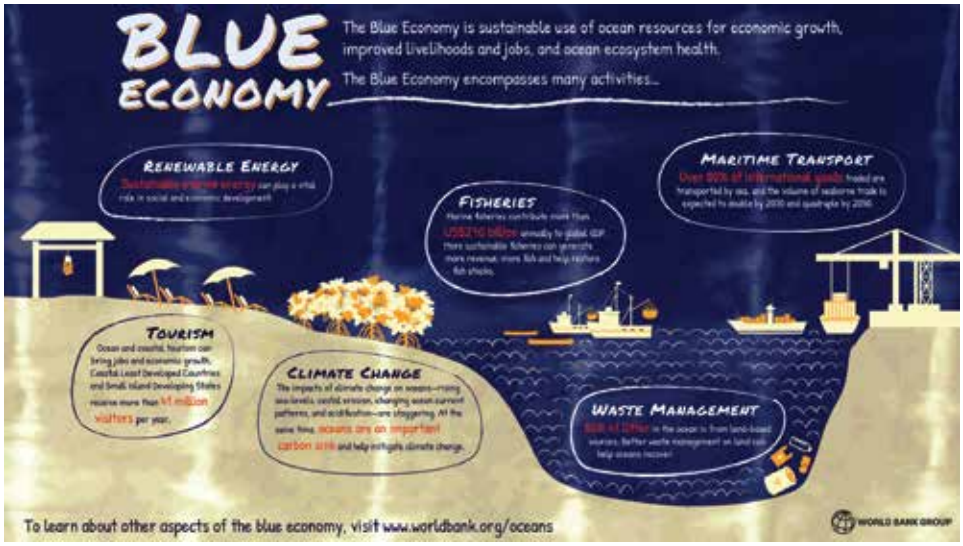

Figure 1 Blue Economy Framework in World Bank terminology

Wenhai, Cusack, Baker, *et al*. (2019) summarized that the discussion on the blue economy has three major traits: (i) to shift resources from scarcity to abundance and to start tackling issues that cause environmental problems, (ii) to achieve long-term sustainable blue growth through collaboration, inclusion, and trust in the marine sector, and (iii) growth of the marine industry from the spatial dimension of blue growth.[9]

When integrated in the national policy, the concept of blue economy can obtain a unique character. For example, the Government of India's Vision of New India by 2030 enunciated in February 2019 highlighted blue economy as one of the 10 core dimensions of growth.

Following the World Bank, the key activities concerning blue economy are given in Table 1. As the table shows, there are competing uses of the ocean space. In April 2013, *The Economist* published an article titled "new bay dawning[10]". It highlighted how a port-led development taking place in the Bay of Bengal is reshaping its economy. For example, the Belt and Road project of China and the Sagarmala project of India are focused on developing multiple modern port facilities both to promote trade and to ensure geopolitical advantages. The growing importance of shipping can be seen from the increasing number of merchant vessels registered. Between 2015 and 2020, the number of merchant vessels registered in the developing economies of Asia and Oceania increased from 37,000 to 44,000 (19%). On the downside, the increasing number of shipping traffic is increasing the risks of conflicts between fishing vessels and merchant vessels. Data collected from the Department of Fisheries, Tamil Nadu, India show that during 2011–13 there were nine such cases. While seven incidences occurred near Tuticorin Port, two accidents occurred near Chennai Port. On March 16, 2013, one merchant vessel while entering the Port of Chennai collided with a traditional fishing vessel (locally known as Vallam) and one fisherman died in the accident[11]. In other cases, damages are mostly in the form of lost or damaged fishing gear.

9 Wenhai, L., C. Cusack, M. Baker, et al. 2019. Successful blue economy examples with an emphasis on international perspectives. Frontiers in Marine Science 6: 261

10 Anon. 2013. New bay dawning. The Economist (Web edition). 27 April 2013. Details available at https://www.economist.com/asia/2013/04/27/new-bay-dawning

11 TNN 2013. "Vessel that hit fishing boat yet to be tracked". The Times of India. 18 March 2013. Details available at: http://timesofindia.indiatimes.com/articleshow/19028270.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

Table 1 Components of Blue Economy

Type of Activity	Ocean Service	Industry	Drivers of Growth
Harvest of living resources	Seafood	Fisheries	Food security
		Aquaculture	Demand for protein
	Marine biotechnology	Pharmaceuticals, chemicals	R&D for healthcare and industry
Extraction of non-living resources, generation of new resources	Mineral	Seabed mining	Demand for minerals
	Energy	Oil and gas	Demand for alternative energy sources
		Renewables	
	Fresh water	Desalination	Demand for freshwater
Commerce and trade in and around the oceans	Transport and trade	Shipping	Growth in seaborne trade; international regulations
		Port infrastructure and services	
	Tourism and recreation	Tourism	Growth of global tourism
		Coastal development	Coastal urbanization
			Domestic regulations
Response to ocean health challenges	Ocean monitoring and surveillance	Technology and R&D	R&D in ocean technologies
	Carbon sequestration	Blue carbon	Growth in coastal and ocean protection and conservation activities
	Coastal protection	Habitat protection and restoration	
	Waste disposal	Assimilation of nutrients and wastes	

The most famous incident that crossed this spatial nature of the conflict and hovered around the issue of sovereignty and human rights violation is the MT Enrica Lexie case.[12] It highlighted the complex nature of spatial use and lack of guidelines to deal with such incidents. On February 15, 2012, two Indian fishermen returning from a fishing expedition near Lakshadweep islands onboard fishing vessel St Antony were gunned down by two Italian marines onboard oil tanker MT Enrica Lexie – an Italian flagged oil tanker sailing from Sri Lanka towards Djibouti. The incident occurred around 20 nautical miles off the coast of Kerala. Shortly after the incident, the Indian Coast Guard intercepted Enrica Lexie and detained the two Italian marines. Italy, however, claimed that as the Indian vessel drew close, the marines assessed that it "was on a collision course with MV Enrica Lexie and that their use of firearm was consistent with a pirate attack." It claimed that the fishing vessel continued to head towards the tanker despite sustained visual and auditory warnings and the firing of warning shots into the water. The incident raised a political storm in both India and Italy. While India wanted to prosecute the marines on murder charges under Indian law, Italy claimed that it was an "incident of navigation concerning a ship on the high seas" outside the territorial waters of India. It cited Article 97 of the United Nations Convention on the Law of the Sea (UNCLOS): "In the event of a collision or any other incident of navigation concerning a ship on the high seas," only the flag state of that ship can launch penal proceedings. On the other hand, India argued that it had jurisdiction over the case as the two fishermen were killed without warning just 20.5 nautical miles from Indian coast, making the area part of India's exclusive economic zone (EEZ).

12 Chowdhury, S. 2016. Italian Marines case: two killings at sea, an international legal battle. Indian Express, January 20. Last accessed on https://indianexpress.com/article/explained/simply-put-2-killings-at-sea-an-international-legal-battle/

On June 26, 2015, Italy instituted proceedings against India before an arbitral tribunal to be constituted under Annex VII of UNCLOS. In May 2020, the court ordered that the marines will not be tried in India and will face criminal proceedings in Italy. The court, based in The Hague, further said that New Delhi was entitled to compensation and asked India and Italy to consult on the amount of compensation due.

While commenting on the legal procedure of this case is beyond our scope and expertise, it still raises the question of how the case can be viewed in terms of Article 295 of UN Law of the Sea, which states that "Any dispute between States Parties concerning the interpretation or application of this Convention may be submitted to the procedures provided for in this section only after local remedies have been exhausted where this is required by international law." However, the question that arises here is whether the local laws and remedial measures are enough to cope with the changing nature of the business and especially in situations as witnessed in the case of MV Enrica Lexie. Further, throughout the case, the place of the incident and approach of the fishing vessel remained a point of contest. This calls for a proper fisheries monitoring, control, and surveillance mechanism. Concrete information on location, direction, speed, and so on of the fishing vessels that can be obtained from the vessel tracking system could have informed the case further and the unfortunate incident might have even been avoided.

The fallout of the incident in the Indian context was issuing of a standard operating protocol (SOP) by the Director General of Shipping. A major observation noted in the SOP was that "the fishing vessel licenses issued by the Department of Fisheries of the state governments are only for the territorial waters (up to 12 Nm from the coast), whereas all the collision incidents of fishing boats reported recently from the Kerala coast are at locations way far from the territorial waters." The other important observations were lack of safety and communication equipment on-board fishing vessels and lack of knowledge of fishermen about the rules of the sea. The SOP suggested following measures to improve the visibility and reduce the risks of fishing vessels venturing beyond 12 nautical miles: (i) Life jackets for all fishing vessel crew onboard, (ii) lifebuoys, at least two numbers for the maximum 10 member crew, and additional buoys to be provided in the same proportion for the number of crew exceeding 10, (iii) navigational lights with adequate battery backup and sound signalling appliances (horn/siren) to attract attention in case of an emergency, (iv) round-the-clock watch-keeping and lookout, (v) licensed radio appliances to communicate directly with shore stations, (vi) wooden and fiber body fishing boats to carry radar reflectors, (vii) Global Positioning System (GPS), (viii) registered fisherman with identity cards issued by the Department of Fisheries, and (ix) installation of distress alert transmitters or automatic tracking devices.

Therefore, although fisheries are an integral part of the blue economy framework, the challenge is to balance different economic activities as well as managing a specific sector like fishing and shipping. The choice will impact both growth and sustainability. For example, the value of global fisheries production in 2018 was estimated at US$401 billion[13] (FAO, 2020), while the value of shipping trade in 2019 was estimated at US$14 trillion[14], which is 35 times more than the global value of fisheries (inclusive of inland and marine capture and culture fisheries). However, the value difference can also be used for conservation purposes. In 2010, the Maldives introduced the shark fishing ban with the tag line that a live shark is three times more beneficial than the dead shark. In this case, the economic benefit of a live shark was derived from the flourishing tourism industry, especially diving with the sharks.

13 FAO. 2020. The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome. https://doi.org/10.4060/ca9229en. P. 2.

14 More details at https://www.ics-shipping.org/shipping-fact/shipping-and-world-trade-driving-prosperity/

SDG 14: Life Below Water

It has been estimated that as much as 40% of the world's oceans are heavily affected by human activities, including pollution, depleted fisheries, and loss of coastal habitats. In the last 40 years, fish stocks removed at biologically unsustainable levels have increased from 10% in 1974 to 33.1% in 2015.[15] Studies at open ocean and coastal sites around the world show that the current levels of marine acidity have increased by about 26% on average since the start of the Industrial Revolution.[16] Global trends point to continued deterioration of coastal waters due to pollution and eutrophication. Of the 63 large marine ecosystems evaluated under the Transboundary Waters Assessment Programme, 16% of the ecosystems are in "high" or "highest" risk categories for coastal eutrophication. They are located mainly in Southern and Eastern Asia, Western Europe, and the Gulf of Mexico. Without concerted efforts, coastal eutrophication is expected to increase in 20% of large marine ecosystems by 2050. Moreover, marine life is now facing conditions more severe than previously experienced from natural variability.

Realizing the crucial role of the oceans for human well-being and the health of the planet, SDG 14 aims to "conserve and sustainably use the oceans, seas and marine resources for sustainable development." Owing to an international recognition of the nutritional and socio-economic importance of fisheries and aquaculture and of the need to reverse the trend in ocean health decline, the SDG 14 has 10 targets and 10 indicators relating to marine pollution, protecting marine and coastal ecosystems, minimizing ocean acidification, sustainable management of fisheries and ending harmful fisheries subsidies, fight against illegal, unreported and unregulated (IUU) fishing, eliminating harmful fisheries subsidies, improving access to markets and resources to small-scale fisheries, conserving coastal and marine areas, and increasing economic benefits to SIDS and least developed countries (LDCs). A global indicator framework has been developed to assess the progress in achieving the goals. The 10 targets in brief are as follows:

Target 14.1: By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.

Target 14.2: By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.

Target 14.3: Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels.

Target 14.4: By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics.

Target 14.5: By 2020, conserve at least 10 percent of coastal and marine areas, consistent with national and international law and based on the best available scientific information.

15 FAO. 2018. The State of World Fisheries and Aquaculture 2018: Meeting the Sustainable Development Goals, 210 p. Rome: FAO

16 IPCC. 2018. Summary for Policymakers. In: Global Warming of 1.5°C, 32 p. IPCC Special Report. World Meteorological Organization, Geneva, Switzerland

Target 14.6: By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation.

Target 14.7: By 2030, increase the economic benefits to SIDS and LDCs from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism.

Target 14.a: Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular SIDS and LDCs.

Target 14.b: Provide access for small-scale artisanal fishers to marine resources and markets.

Target 14.c: Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of "The Future We Want".

Table 2 Indicators and custodians of SDG 14 targets

Target	Indicator	Tier*	Custodian	Year
14.1 Prevent and reduce marine pollution	14.1.1 Index of coastal eutrophication and floating debris intensity	III	UNEP	2025
14.2 Sustainably manage and protect marine and coastal ecosystems	14.2.1 Proportion of national EEZ managed using ecosystem-based approaches	III	UNEP	2020
14.3 Minimize impacts of acidification	14.3.1 Average marine acidity (pH) measured at agreed site of representative sampling stations	III	IOC-UNESCO	–
14.4 Restore fish stocks	14.4.1 Proportion of fish stocks within biologically sustainable levels	I	FAO	2020
14.5 Protect 10% of marine areas	14.5.1 Coverage of protected areas in relation to marine areas	I	UNEP-WCMC	2020
14.6 Reduce subsidies	14.6.1 Progress by countries in the degree of implementation of international instruments aiming to combat IUU fishing	II	FAO	2020
14.7 Increase economic benefits to SIDS	14.7.1 Sustainable fisheries as a percentage of GDP in small island developing states, LDCs, and all countries	III	FAO, UNEP-WCMC	2030
14.a Capacity building in research and technology	14.a.1 Proportion of total research budget allocated to research in the field of marine technology	II	IOC-UNESCO	–

14.b Provide access to small-scale fishers	14.b.1 Progress by countries in the degree of application of a legal/regulatory/policy/institutional framework that recognizes and protects access rights for small-scale fisheries	II	FAO	–
14.c Implementing international law	14.c.1 Number of countries making progress in ratifying, accepting and implementing through legal, policy and institutional frameworks, ocean-related instruments that implement international law, as reflected in the United Nation Convention on the Law of the Sea, for the conservation and sustainable use of the oceans and their resources	III	UN-DOALOS,FAO, UNEP, ILO, other UN ocean agencies	–

Source: Details available at https://unstats.un.org/sdgs/iaeg-sdgs/tier-classification

Comparison between Blue Economy Framework and SDG-14: Tabular Summary

This section provides a tabular summary of the blue economy and the SDG-14 based on the above discussion.

Parameter	Blue Economy	SDG-14: Life Below Water
Origin	2012 Rio+20 Conference: emerged as an ocean equivalent of the green economy concept	2012 Rio+20 Conference: emerged from partial success of MDGs and urgent need for addressing ocean health
Legal backing	UN Law of the Sea that gives coastal states and SIDS right to harness benefit from their territorial water and the exclusive economic zones	Multiple – primarily, UN Law of the Sea, UN Fish Stock Agreement, and Convention on Biological Diversity
Responsibility	Countries are free to choose their blue economy strategy subject to some basic conditions to make it "blue"	Countries are responsible for implementation; UN provides capacity building support
Objective	Economic growth, improved livelihoods, and jobs	Conserve and sustainably use the oceans, seas, and marine resources for sustainable development
Approach to sustainability	Can be weak or strong sustainability; weak sustainability is characterized by a non-declining combined stock of capital and assumes that man-made capital can be replaced with natural capital; strong sustainability, on the other hand, implies that natural capital cannot be replaced by any other capital	Strong sustainability
Time frame	No time frame	Targets have specific time frames. Most targets are to be achieved by 2024
Prescriptive	No	Yes
Technology	A primary aim of the blue economy is reducing poverty and inequality. Although countries are free to choose their technology, it is hoped that the technology should be socially inclusive	Does not use technology explicitly except limiting technology to non-destructive uses of the ocean. Does not explicitly address the issue of income creation, distribution, or possible loss of livelihoods from conservation measures

In essence, the blue economy offers more flexibility to countries to address their economic problems while

ensuring ocean conservation. It is more in line with the Article 56 of UN Law of the Sea on the "rights, jurisdiction and duties of the coastal State in the EEZ," which states that "in the EEZ, the coastal State has: (a) sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living, of the waters superjacent to the seabed and of the seabed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds." The freedom of countries in charting its development path was also acknowledged in the UNGA Resolution on Rights to Development (41/128 of December 4, 1986). The Article 2 of the Rights to Development holds that "states have the right and the duty to formulate appropriate national development policies that aim at the constant improvement of the well-being of the entire population and of all individuals, on the basis of their active, free and meaningful participation in development and in the fair distribution of the benefits resulting therefrom."

In this context, the SDG-14 can be viewed as filter to risky or unsustainable policy elements from the blue economy framework. Integrating SDG-14 in the national blue economy framework will provide the countries necessary rigor to formulate sustainable policies.

Regional Context: Importance of Finding New Economic Frontiers

Food security, inclusive growth, and climate change are amongst the major global challenges that will shape the human civilization in the coming decades. The technology shaping human development is also changing rapidly. During the last two decades (1996–2016), the global trend of reshuffling of economic sectors further strengthened in favour of the service sector. During this period, the global GDP from agriculture declined from 9% to 4%; GDP from industry declined from 35% to 28%, while GDP from the service sector increased from 56% to 68%. Our growing dependence on computers and smartphones is creating a never before demand for rare earth elements.[17] Miller, Thompson, Johnston, *et al.* (2018) noted that the "rising demand for minerals and metals, including for use in the technology sector, has led to a resurgence of interest in exploration of mineral resources located on the seabed."[18]

At the same time, with increasing population and economic growth, there is a growing demand for food. The global population density has increased from about 24 persons per square kilometer in 1961 to about 58 persons per square kilometer in 2019. As land represents only 29% of the Earth, there is a growing concern about the future sustainability of food supply. The oceans, which occupy 71% of the Earth's surface, are now increasingly seen as a panacea to many if not all of the issues plaguing the humanity. From source of food to medium of transportation to sink of carbon and bank of rare minerals, multiple services provided by the ocean are being recognized and shaping the development strategy of the countries.

The Asia-Pacific region (APAC) comprises East Asia, South and Southwest Asia, Southeast Asia, Oceania, and island countries in the Pacific.[19] A working definition of the region can be seen in the form of the United Nations Economic and Social Commission for *Asia* and the *Pacific* (ESCAP) comprising 53 member states, including

17 GlobeNewswire. 2020. The Rare Earth Metals Market is Growing at 10.8% CAGR to 2026, says Global Market Insights Inc. Details available at https://www.globenewswire.com/news-release/2020/06/30/2055207/0/en/The-Rare-Earth-Metals-Market-is-growing-at-10-8-CAGR-to-2026-Says-Global-Market-Insights-Inc.html

18 Miller, K. A., K. F. Thompson, P. Johnston, and D. Santillo. 2018. An overview of seabed mining including the current state of development, environmental impacts, and knowledge gaps. Frontiers in Marine Science 4: 418

19 Wikipedia. Asia-Pacific. Last accessed on https://en.wikipedia.org/w/index.php?title=Asia-Pacific&oldid=1027466067

the United States and the United Kingdom,[20] and Asia-Pacific Economic Cooperation having 22 members excluding South Asia. In terms of economic development, the APAC region mostly comprises developing countries. In the last two decades (2000–18), the region had grown at an average rate of 5% per annum as compared to the global average of about 3% (Table 3). In spite of a relatively positive growth rate, the region is facing developmental challenges to provide for high population (albeit slowing population growth). Ensuring food security and employment for the large population is a major requirement for the region. Over the years, the region, where most of the countries used to be colonies, has made dramatic transition from agricultural to industrial and service economies. At present, industry and service sector contributes about 88% of the gross value added to the GDP in the region. However, at the national level, poverty, inequality, food security, employment, and low level of human development remain the major challenges (Table 4). From political economy perspective, the APAC countries are aiming to achieve high growth. For example, India is aiming at becoming a five trillion dollar economy by 2024 in spite of the setback the country has faced due to the ongoing COVID-19 pandemic.[21] In the region,Bangladesh is also expecting a growth rate of 8% during its 8th Five-Year Plan (2020-25)[22] and the Indonesian president has set a target of 5.6–6.2% annual average growth till 2024.[23]

In the above context, blue economy holds immense possibilities for the countries. However, the blue economy, as envisioned within the UN Framework and as defined by the World Bank, is a concept of constrained optimization (worst case) or joint optimization (best case). However, the larger objective is to ensure the ocean health. The spirit of the blue economy concept is to harness the benefits from the ocean with the minimum condition that no further degradation takes place and also with the expectation that the ocean health will improve. *Prima facie,* this calls for judicious growth strategies as well as putting limits on national aspirations. There lies the challenge! As Keith Lawrence, lead economist of Conservation International's Center for Oceans, said, "The ocean is one of the big economic frontiers right now. Almost all of global trade is moved by shipping. You've got offshore oil and gas and deep-sea mining. As we innovate technologies, we are able to go to — and exploit — places that we weren't able to go before. There's enormous potential for the ocean to provide major solutions to help feed the planet and to provide clean energy and jobs. But if we do this thoughtlessly, we risk damaging the Earth's largest life-support system – a system that provides for people, for animals, for ecosystems."[24] The aim of this report is to address a part of this challenge by examining how SDG 14: Life Below Water can be integrated in the Blue Economy Framework of the region and the challenges therein.

State of Marine Fisheries in the Region

The APAC region harvested about 40 million tonnes (MT) of marine wild captured fish in 2019, which is roughly half of the global marine fisheries production. Tuna, especially skipjack tuna, was the largest fishery in the region, contributing to about 6% of the total production. Miscellaneous marine fishes contributed to about 22% of the production. Yellowfin tuna, along with skipjack tuna, one of the most traded species,

20 For a full list of member states of ESCAP, refer to https://www.unescap.org/about/member-states.

21 Business Today. 2020, October 29. India can still be $5 trillion economy, says PM Modi. Details available at https://www.businesstoday.in/current/economy-politics/india-can-still-be-5-trillion-economy-says-pm-modi/story/420217.html

22 Anon. 2020. Eighth Five Year Plan (July 2020 – June 2025). General Economics Division (GED), Bangladesh Planning Commission, Government of the People's Republic of Bangladesh. Dhaka-1207, Bangladesh. 2020.

23 Details available at https://www.reuters.com/article/us-indonesia-economy-idUSKBN1Z516O

24 Bertazzo, S. 2018. What on Earth is the 'blue economy'? Details available at https://www.conservation.org/blog/what-on-earth-is-the-blue-economy/?gclid=Cj0KCQjwl9zdBRDgARIsAL5Nyn3xGXHsApcgFjjO6CvN0Zg602NYYuJw2LPvqa_nDpKKxPtNDJWQxLYaAvSLEALw_wcB

Table 3 Economic growth in APAC region

Sub-region	2000–09	2010–18
East and Northeast Asia	5.6	5.6
Southeast Asia	5.1	5.4
South and Southwest Asia	5.4	6.1
North and Central Asia	6.1	2.6
Pacific	3.0	2.7
ACAP	5.4	5.3
World	3.1	3.3

Note: GDP at 2015 US dollar; annual average, %
Source: Estimated from ESCAP database

Table 4 Development indicators in selected countries of ESCAP region

Countries (selected)	Population living in poverty at less than $1.90 a day at 2011 PPP (% of population	Gini index (income inequality)	Human Development Index	Severe food insecurity in the population (% of population)	Employment-to-population ratio (15+, ILO estimate) (ratio, total population)
Bangladesh	15	32.4	0.614	10.6	56.56
China	1	38.5	0.758		64.52
Fiji	4	36.7	0.724		55.23
India	21	35.7	0.647		46.51
Indonesia	7	37.8	0.707	0.8	64.21
Malaysia	0	41	0.804	6.7	62.22
Myanmar	6	30.7	0.584		60.42
Pakistan	4	33.5	0.56		50.35
Papua New Guinea	38	41.9	0.543		45.82
Philippines	6	44.4	0.712	17.6	58.36
Solomon Islands	25	37.1	0.557		83.35
Sri Lanka	1	39.8	0.78		51.44
Thailand	0	36.4	0.765		66.5

Source: Estimated from ESCAP database, 2021

contributed to about 2% of the total production. While some countries in the APAC region have distant water fishing vessels, the information here is limited to the production reported from the Pacific and the Indian Ocean. The average decadal production has increased by five times during 1950–2019 (Figure 2). Eastern Asia (China, the largest fish producer) accounted for about 48% of the total marine fisheries production from the region, followed by Southeast Asia (37%, Indonesia the largest producer) and South Asia (12%, India the largest producer) (Figure 3).

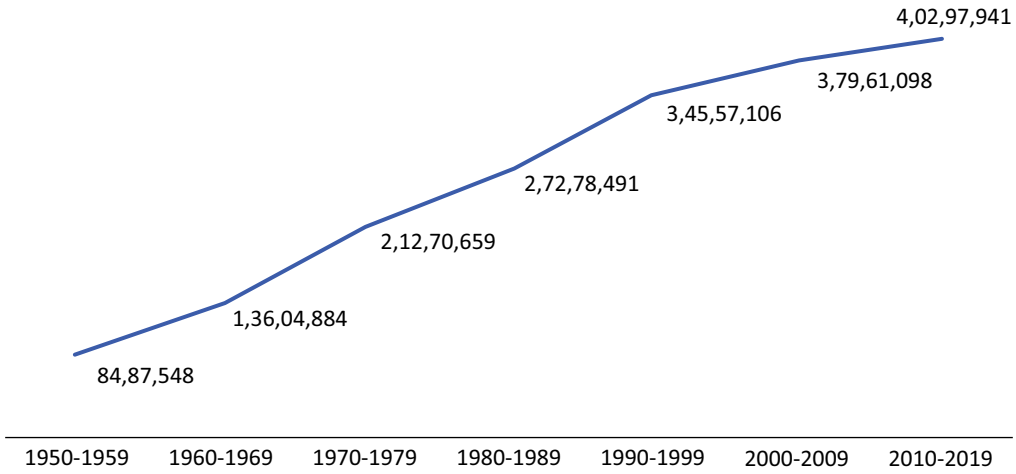

Figure 2 Marine capture production from APAC region (estimated from FAO FishStatJ)

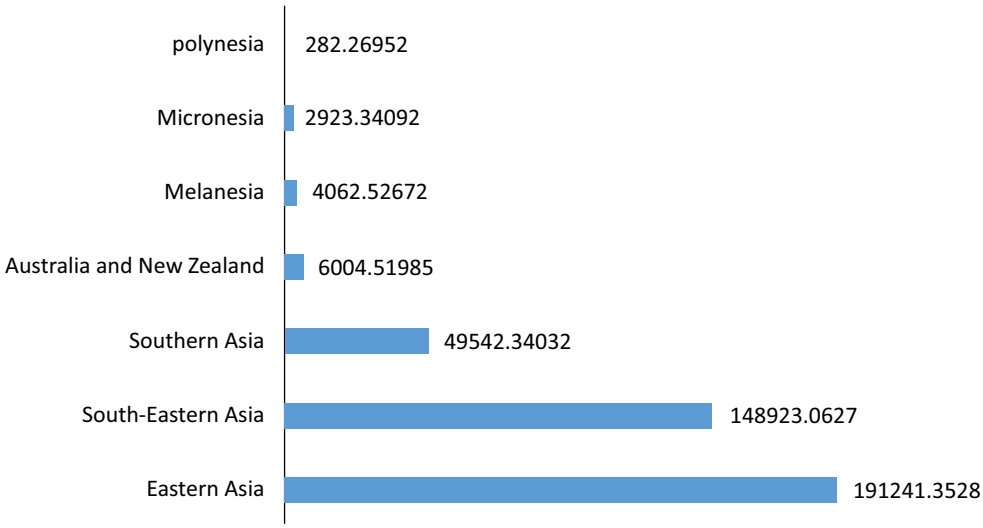

Figure 3 Subregion wise marine capture fisheries production during 2010–19 (values in 1000 tonnes) (estimated from FAO FishStatJ)

The Sea Around Us Project[25] of the University of British Columbia, which independently monitors and reports the state of marine fisheries, reported in 2021 that 30.4% of marine fish stocks in China were collapsed in 2018, while 26.4% stocks were overexploited. In comparison, in the year 2000, it was 17.9% and 32.4%, respectively. However, the situation marginally improved since the year 2008, when 34% of the stocks were collapsed. China is now pursuing a policy of encouraging distant water fishing to give respite to the coastal resources.

In case of Indonesia (Indian Ocean EEZ), 25% stocks were collapsed, while 24% stocks were overexploited in 2018. The situation has improved since 2014. In the case of India, 24% stocks were reported collapsed and 16% stocks were overexploited. In Australia, 20.3% and 40.6% stocks were reportedly collapsed and overexploited, respectively. Comparatively, SIDS have performed better. In case of Sri Lanka, the number of collapsed stocks

25 Details available at http://www.seaaroundus.org/

improved from 22.7% to 8.3% between 2015 and 2018. In Fiji, the number of collapsed stocks improved from 24.5% to 17% between 2013 and 2018.

The IUU fishing is globally identified as one of the major challenges for ensuring sustainable fisheries. The SDG target 14.4 and SDG target 14.6 are directly linked with the curbing of IUU fishing. IUU fishing also impacts well-being of countries, especially SIDS, and hurts small-scale fishers. Hence, the performance of both SDG 14 targets 14.7 and 14.b are affected by the IUU fishing. A recent study[26] reported that the estimated illegal fishing landings across the APFIC (Asia-Pacific Fishery Commission) area,[27] excluding the South China Sea, totalled to 6.6 MT in 2019, with a value of USD 23.3 billion. The study reported that most of the IUU fishing is concentrated around the Arafura–Timor Sea, the Banda Sea, and the Savu Sea. The other hotspots are the Gulf of Thailand and the Bay of Bengal. Altogether, the possibility of IUU fishing has been identified throughout the region (Table 5).

Table 5 Extent of IUU fishing in the APAC region

Zone	Quantity (1000 tonnes)	Value (US$ million)
Gulf of Oman, Arabian Sea, the Maldives	742.9	2 848.1
Bay of Bengal, Andaman Sea, the Gulf of Thailand	1 363.2	4 921.3
Gulf of Thailand, South China Sea	1 548.0	5 497.8
Arafura–Timor Sea, Banda Sea, Savu Sea	2 572.3	8 880.3
Sulu–Celebes Sea, Sulawesi Sea, Makassar Strait, Halmahera Strait	423.2	1 129.5

Source: Reported from Wilcox, C., Mann, V., Cannard, T., Ford, J., Hoshino, E and Pascoe, S. 2021. A review of illegal, unreported and unregulated fishing issues and progress in the Asia-Pacific Fishery Commission region. Bangkok and Hobart, FAO.

The national response to the threat of stock status and curbing IUU fishing varies considerably (Table 6). On an average, most of the countries in the region were found to be under prepared to curb IUU fishing. The progress in this area is measured by the level of implementation of international instruments to combat IUU fishing. The data show that Australia, Fiji, the Philippines, Sri Lanka, and Thailand have made significant progress in this area. For example, the formulation and implementation of a National Action Plan to curb IUU fishing (NPOA-IUU) is usually seen as a basic requirement. In the Bay of Bengal region, Maldives, Sri Lanka, Thailand, Malaysia, and Indonesia have adopted their NPOA-IUU. However, Myanmar, Bangladesh, and India are still in the process of developing their NPOA-IUU. Implementation of international measures should be considered as the first step towards addressing IUU fishing although it is not a guarantee to curb the same. To provide a measure of the degree to which states are exposed and effectively combat IUU fishing, Macfadyen, Hosch, Kaysser, *et al*. (2019)[28] developed an independent IUU Fishing Index. The IUU Fishing Index provides an IUU fishing score between 1 and 5 for all coastal states (1 being best and 5 worst). The index is based on 40 indicators for which data are collected from both publicly available information and expert opinion. As can be seen from Table 6, Australia, Fiji, Thailand, Sri Lanka, and the Philippines have scored 5 out of 5 in terms of implementation of international instruments to combat IUU fishing as of 2018 (SDG indicator 14.6.1, ESCAP

26 Wilcox, C., V. Mann, T. Cannard, J. Ford, E. Hoshino, and S. Pascoe. 2021. A review of illegal, unreported and unregulated fishing issues and progress in the Asia-Pacific Fishery Commission region. Bangkok: FAO and CSIRO. Details available at https://doi.org/10.4060/cb2640en

27 It includes Australia, Bangladesh, Cambodia, China, France, India, Indonesia, Japan, Malaysia, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Republic of Korea, Sri Lanka, Timor-Leste, Thailand, United Kingdom, United States, and Vietnam.

28 Macfadyen, G., G. Hosch, N. Kaysser, and L. Tagziria. 2019. The IUU Fishing Index, 2019. Poseidon Aquatic Resource Management Limited and the Global Initiative Against Transnational Organized Crime

Table 6 State of IUU fishing readiness in the region

Country	Implementation of international instruments to combat IUU fishing (level of implementation from 1 (lowest) to 5 (highest) in 2018)	IUU Fishing Index (score from 1 to 5, lower is better)
Australia	5	1.91
Fiji	5	2.2
Maldives	3	2.23
Pakistan	3	2.26
World	3	2.29
Thailand	5	2.33
Bangladesh	3	2.41
Malaysia	3	2.52
Sri Lanka	5	2.61
Indonesia	4	2.7
Philippines	5	2.71
Myanmar	3	2.73

Sources: Column 2: Compiled from Asia-Pacific SDG Gateway, https://dataexplorer.unescap.org/?lc=en;. Column 3: Reported from Macfadyen, G., G. Hosch, N. Kaysser, and L. Tagziria. 2019. The IUU Fishing Index, 2019. Poseidon Aquatic Resource Management Limited and the Global Initiative Against Transnational Organized Crime.

2021). This score is based on the national reporting of the countries in line with the reporting requirement under the SDGs. However, in terms of IUU Fishing Index, they were quite far apart. On the other hand, Bangladesh with an implementation score of 3 performed better in terms of IUU Fishing Index over Sri Lanka and the Philippines. This shows that in general a positive correlation exists between higher implementation score and lower IUU Fishing Index.

Conclusion

From the above analysis, it can be concluded that although blue economy and SDGs share the same origin, their compatibility is a matter of policy design. Unless blue economy is founded in the concept of strong sustainability, it is uncertain that blue economy will contribute to the achievement of SDGs.

In essence, the achievement of SDG-14 targets could be a test case for the blue economy framework. Unlike blue economy, which combines traditional and modern uses of ocean, fishing is a familiar activity in terms of governance. The problems are better researched and various models for addressing them exist. Some of the important strategies evolved in fisheries sector during the last three decades that can ensure integrating SDG-14 in blue economy are discussed next. Novelty lies in their effective implementation.

Building strong fisheries

Application of Ecosystem Approach to Fisheries Management

Ecosystem approach to fisheries management (EAFM) is a way of managing fisheries and aquaculture that balances the different objectives of society (e.g., ecological and economic objectives) by applying an

integrated approach across geographical areas that reflect natural ecosystems.[29] The cardinal principle of EAFM is co-creation where all stakeholders should pool resources and knowledge to arrive at a common goal and strive for it. Co-management can be seen as a functional way to move towards an ecosystem approach.

Towards a More Sustainable Seafood Value Chain

By intervening at all stages along the seafood value chain, blue economy measures can improve the process, reduce losses and waste, and minimize the carbon footprint while adding value to the final product. At the end of the seafood value chain, consumers can contribute to sustainable development through their purchasing choices and their efforts to reduce food waste. Good governance and strong policies facilitate the implementation of changes throughout the entire value chain.

In the same vein, ensuring traceability of fish products from the point of origin to the point of consumption is becoming important. The benefits of traceability have been increasingly recognized by governments, consumers, and various stakeholders throughout the value chain. Many countries have introduced mandatory traceability requirements as an explicit obligation to enforce food safety regulations. Traceability mechanisms are also critical to several market-oriented issues, such as catch documentation schemes to combat IUU fishing among others.

Pursuant to the European Union Regulation on IUU Fishing of 2010,[30] which made catch certification compulsory for any export consignment to the European Union, exporting developing countries established procedures for catch certification of EU consignments as a form of traceability. However, such measures are yet to be extended to the domestic market.

Managing inter-sectoral resource allocation

Marine Spatial Planning

According to IOC-UNESCO, marine spatial planning (MSP) is a process of analyzing and allocating parts of three-dimensional marine spaces (or ecosystems) to specific uses or goals to achieve ecological, economic, and social objectives that are usually specified through a political process. MSP is a process that is ecosystem based; integrated across economic sectors and among governmental agencies; place based or area based; adaptive (capable of learning from experience); strategic and anticipatory (focused on the long term); and participatory, with stakeholders actively engaged in the process.[31] In the APAC, Australia, Bangladesh, China, Indonesia, Philippines, Palau, and Solomon Islands have developed their MSP, while it is in progress in other countries.[32] India recently signed an MoU with Norway to develop MSP. The key part of MSP remains the inclusiveness of the process as well as balancing weak and strong sustainability objectives.

Citizen Buy-in

The most challenging aspect of blue economy and SDG integration is, of course, the involvement of citizens in the national policymaking process and their understanding and voice for sustainability. Moving

29 Staples, D. and S. Funge-Smith. 2009. Ecosystem approach to fisheries and aquaculture: implementing the FAO Code of Conduct for Responsible Fisheries, 48 p. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand. RAP Publication

30 Council Regulation (EC) No 1005/2008 of 29 September 2008 establishing a community system to prevent, deter, and eliminate illegal, unreported, and unregulated fishing, amending Regulations (EEC) No 2847/93, (EC) No 1936/2001, and (EC) No 601/2004, and repealing Regulations (EC) No 1093/94 and (EC) No 1447/1999

31 Details available at http://msp.ioc-unesco.org/about/msp-facts/

32 Details available at http://msp.ioc-unesco.org/

towards sustainability is a long-term process often beyond the political cycles of election. It is often argued that government policies and programmes are influenced by the short-term goal of re-election. In such an environment, in the short run, the move towards sustainability may bring more pain in the form of loss of livelihood, change in business practices, and so on, making the government of the day unpopular. However, once citizens are aware of such processes, their logic, and need, they can take informed decisions to support sustainability initiatives. Unless there is a demand for sustainability from the bottom up, it is difficult to see how sustainable practices can be implemented. The publicity around SDGs can perhaps help in that regard.

Contact
Vice Admiral Pradeep Chauhan , National Maritime Foundation (Email: directorgeneral.nmfindia@gmail.com)
Souvik Bhattacharjya, The Energy and Resources Institute, New Delhi (Email: Souvik.bhattaharjya@teri.res.in)
Swati Ganeshan, Consultant, The Energy and Resources Institute, New Delhi (Email: swatiganeshan@gmail.com)
Sushma Nair, Federation of Indian Chambers of Commerce & Industry (Email: sushma.nair@ficci.com)