Indian Council
of World Affairs

IPOI
INDO-PACIFIC OCEANS INITIATIVE

Towards a Sustainable and Prosperous Indo-Pacific Region

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Indian Council of World Affairs
Sapru House, New Delhi

The Indian Council of World Affairs (ICWA) was established in 1943 by a group of eminent intellectuals led by Sir Tej Bahadur Sapru and Dr. H.N. Kunzru. Its principal objective was to create an Indian perspective on international relations and act as a repository of knowledge and thinking on foreign policy issues. . By an Act of Parliament in 2001, the Indian Council of World Affairs has been declared an institution of national importance. The Council today conducts policy research through an in-house faculty as well as through external experts. It regularly organizes an array of intellectual activities including conferences, seminars, roundtable discussions, lectures and brings out a range of publications. It has a well stocked library, an active website, and publishes the journal 'India Quarterly'. ICWA has over 50 MoUs with international think tanks and research institutions to promote better understanding on international issues and develop areas of mutual cooperation. The Council also has partnerships with leading research institutions, think tanks and universities in India.

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Contributors

Dr. (Cdr) Arnab Das is Founder & Director, Maritime Research Centre (MRC), Pune.

Ms. Sulagna Chattopadhyay is Editor-in-Chief of 'Geography and You'.

Dr. Yugraj Singh Yadava is Director, Bay of Bengal Programme Inter-Governmental Organisation, Chennai.

Professor V N Attri is former Chair, Indian Ocean Studies, University of Mauritius.

Commander Prakash Gopal is a PhD scholar at the Australian National Centre for Ocean Resources & Security (ANCORS), Australia.

Dr. TVS Udaya Bhaskar and BV Satyanarayana are scientists at the Ocean Data Management, Indian National Centre for Ocean Information Services (INCOIS), Hyderabad.

Professor Prabir De is the Coordinator of ASEAN-India Centre (AIC) at the Research and Information System for Developing Countries (RIS), New Delhi.

Introduction

The Indo-Pacific is a large maritime space encompassing the Indian and the Pacific Oceans. The contemporary strategic discourse and economic developments in this region impact on global security order and prosperity. While all stakeholders in the Indo-Pacific region appear to be committed to promoting peace and stability, the spiralling competition between major powers is beginning to generate politico-diplomatic-economic-strategic alignments.

Amid the respective competitive agendas, a promising discourse that moves beyond traditional military or political spheres has emerged in the form of Indo-Pacific Oceans Initiative (IPOI). It is an initiative of the Government of India and builds upon the "Security and Growth for All in the Region" (SAGAR) initiative announced by Prime Minister Modi in 2015. SAGAR encourages States to cooperate and synergise efforts towards a safe, secure and stable maritime domain as also take meaningful steps for the conservation and sustainable use of the maritime domain.

The IPOI is premised on the liberal theoretical vistas and endorses an open, inclusive, non-treaty-based global initiative for mitigating challenges especially in the maritime domain through practical cooperation. It seeks to build a sense of community by creating new partnerships with like-minded countries through practical cooperation. India is encouraging other countries to join the IPOI and also lead some thematic areas under the Initiative.

The IPOI comprises of seven thematic areas that cover a wide spectrum of issues spanning the 'security-development-capacity building' continuum in diverse areas spanning security, safety, resource development, science and technology, resilient infrastructure and marine environment-ecology. The seven pillars of the IPOI are : (a) Maritime Security; (b) Maritime Ecology; (c) Maritime Resources; (d) Capacity Building and Resource Sharing; (e) Disaster Risk Reduction and Management; (f) Science, Technology and Academic Cooperation; and (g) Trade, Connectivity and Maritime Transport. Each pillar of the IPOI involves significant issues and therefore merit attention.

The Indian Council of World Affairs (ICWA) in collaboration with the Ministry of External Affairs (MEA), India organised National Consultation on IPOI in September 2021. The Consultation was held virtually and experts from India participated. The speakers constituted a multi-disciplinary group of academicians, scientist and naval analysts specialising in maritime affairs. This volume emerges from the papers presented by the above experts during the Consultation. The seven chapters relate to the different pillars of the IPOI.

Dr. (Cdr.) Arnab Das is of the view that the conventional understanding of Maritime Domain Awareness (MDA) has remained focussed on the surface of the ocean and the underwater component has been largely neglected. The author proposes Underwater Domain Awareness (UDA) Framework that encourages pooling of resources and synergizing efforts across multiple stakeholders associated with maritime security, blue economy, marine environment & disaster management and science & technology. Also, a focus on the acoustic capacity and capability with enhanced UDA framework will be a game changer for the IPOI.

Ms. Sulagna Chattopadhyay alludes to the fact that a large number of ocean stressors are anthropogenic in nature and include ocean acidification and warming, coastal pollution and subsequent alteration of ecological structures and processes. These interact with each other, resulting in cumulative detrimental oceanic interactions. Also, macro and micro-plastics in the ocean are another significant stressor that are exacerbating the already distressed global ocean ecosystem. Several nations have put in place legislation in an effort to curb plastic pollution in the oceans. India has recently upped its scientific endeavours towards mapping marine litter and collaboration between India and Japan aims to share scientific knowledge and data at a regional level as part of a joint effort to reduce marine litter.

Dr Yugraj Singh Yadava warns that overfishing and Illegal, Unreported and Unregulated (IUU) fishing are the biggest threats to the sustainability of marine fisheries. These issues are perhaps the most discussed topics in global forums on fisheries and are part of the ongoing negotiations on fisheries subsidies at the World Trade Organization. The Sustainable Development Goal 14 (SDG-14; Life below water) and its sub-goal 14.4 inter alia talk about regulating harvesting and ending overfishing and IUU fishing. Similarly, sub-goal 14.6 further exhorts the global community to regulate certain forms of subsidies that contribute to overfishing and IUU fishing. The growing IUU fishing in the Indo-Pacific region is a major cause of concern and necessitates optimization as well as reduction in the fishing fleet which can significantly reduce overfishing.

Professor V N Attri cautions that the increasing level of human activity in the ocean is causing severe threats to marine ecosystem(s), ocean habitats, including overexploitation of, climate change and other stressors such as ocean warming, acidification, large scale species extinction and ecosystem collapses, etc. A holistic view is required by adopting a combination of new multidisciplinary research, infrastructure solutions and innovative financial instruments. Studies have been undertaken on different shades of blue financing such as the Blue Bonds and other innovative instruments. The author provides a critical review of the existing sources of financing the Blue Economy with a view to come up with some innovative and new pathways of financing for the Indo-Pacific region by making reference to case studies from other regional economic groupings.

Dr. Prakash Gopal notes that the Indo-Pacific region exceeds four billion people, most of whom live in close proximity to the coast. The coastal urban agglomerates and commercial infrastructure is vulnerable to threats arising out of natural disasters and accidents which makes the people vulnerable to threats from natural disasters and accidents. The author suggests mitigation strategies for risks, using the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-20130 to evolve policy suggestions at the national and multilateral levels. It is posited that the nature of such risks extends across state boundaries, and hence their mitigation strategies need to be necessarily based on models that promote cooperation across the Indo-Pacific region.

Dr. TVS Udaya Bhaskar and BV Satyanarayana highlight the role of Indian National Centre for Ocean Information Services (INCOIS), Ministry of Earth Sciences in obtaining marine data through ocean observations by using from heterogeneous sources such as Argo floats, moored buoys etc. The data is translated into information through analysis and modelling and is disseminated to users using variety of means. The INCOIS is now using state of the art technologies viz., AI/ ML based techniques, big data and data Analytics in variety of applications for data analysis.

Professor Prabir De notes that nearly about 65 per cent of world trade is from Indo-Pacific countries and the regional countries have strong interdependence in trade, which is the key potential strength of economic integration in the region. However, non-tariff measures (NTMs) are one of the major trade barriers in the Indo-Pacific. Also, maritime trade is a crucial building block for greater economic integration in the Indo-Pacific. The author identifies challenges of maritime transportation such as ports, shipping and supply chain, logistics, regulatory barriers and investment. It is argued that India and Japan are poised for strengthening the Indo-Pacific partnership through supply of technology and proving finance and promote collaboration in digital trade in the region.

This volume provides an in-depth perspective of some of the themes under the seven pillars of the IPOI for consideration of policy makers. So it has something for all. It is also a must read for experts who follow the Indo-Pacific region, and academics engaged in study and teaching regionalism and multilateral institutions.

Welcome Address

Amb. Vijay Thakur Singh
Director General, Indian Council of World Affairs, New Delhi

Mrs. Riva Ganguly Das
Secretary (East), Ministry of External Affairs

Dr. Malini V Shankar
Vice Chancellor, Indian Maritime University (IMU), Chennai

Distinguished Participants

Allow me to extend to all of you a very warm welcome to the "National Consultations on Indo-Pacific Oceans Initiative (IPOI)". This is being hosted by the ICWA in collaboration with the Ministry of External Affairs.

India is an ancient maritime nation and home to some of the oldest sea ports in the world. For millennia, our people have transversed the waters of the oceans carrying with them goods, ideas and religion, establishing civilizational links from Africa to Gulf across Malacca Straits to South East Asia. Oceans and seas have deeply influenced India's history and will shape its destiny as well. Today, 90% of our trade by volume takes place through seas. We have a coastline of 7,500 kilometres, 1200 islands and 2.4 million square kilometres of Exclusive Economic Zone. With such a long maritime tradition and such a wide maritime footprint, it is but natural for India to have extensive stakes in the peace, prosperity, stability and security of the oceans around it.

India, therefore, has made and continues to make seminal contributions to shape the global discourse on many issues of importance relating to the maritime space.

Many of you may recall that in March 2015, during his visit to Mauritius, Prime Minister Modi articulated the concept of SAGAR, i.e., Security and Growth for All in the Region. It is a vision for advancing cooperation and building partnerships to ensure a safe, secure and stable Indian Ocean region that delivers prosperity to all, through orderly and sustainable use of oceans.

At the Shangrila Dialogue in Singapore in 2018, Prime Minister Modi spoke of Indo Pacific region as a natural region extending from the shores of East Africa to the Western Pacific region, with ASEAN centrality wherein two large bodies of water – the Indian Ocean and the Pacific Ocean flow, in a seamless continuum. India's approach to the Indo Pacific, is one of a free and open; inclusive and rule based region, with respect for territorial integrity and sovereignty; and where

the principles of freedom of navigation and overflight; unimpeded flow of lawful commerce and peaceful settlement of disputes in accordance with international law, are upheld.

Subsequently, on 4 November, 2019, at the East Asia Summit in Bangkok, Prime Minister Modi announced the Indo-Pacific Oceans Initiative (IPOI), which is focused on practical cooperation in seven thematic areas, viz. : (i) Maritime Security; (ii) Maritime Ecology; (iii) Maritime Resources; (iv) Capacity Building and Resource Sharing; (v) Disaster Risk Reduction and Management (vi) Science, Technology and Academic Cooperation; and (vii) Trade, Connectivity and Maritime Transport.

IPOI seeks to build a community of stakeholders by creating partnerships. While taking lead on several pillars of the IPOI, India is encouraging other countries to join this initiative. Some of the thematic areas under the Initiative, already have other countries taking lead on them.

ICWA is one of the Knowledge Partners/Think Tanks for the promotion and implementation of three pillars of the IPOI viz., (i) Maritime Security; (ii) Capacity Building and Resource Sharing; and (iii) Science, Technology & Academic Cooperation.

However, the purpose of these national consultations is to discuss all seven pillars and come up with concepts and practical ideas that will take forward the implementation of all pillars with partner countries.

IPOI will contribute immensely to various other initiatives for maritime security and sustainable use of oceans. We believe that it would also be an important contribution in the coming years, to the UN Decade of Ocean Science for Sustainable Development being observed from 2021-2030.

India is committed to the maritime agenda at the global level. Recently under its Presidency of the UNSC, India identified maritime security as a priority area. Prime Minister Modi participated in the high-level UNSC Open Debate on 'Enhancing Maritime Security: A case for International Cooperation'. India's focus on maritime issues continues.

Let me once again welcome you all. This National Consultation on IPOI is one of many similar events that will follow in the coming months, including an International Conference scheduled in November this year.

We look forward to constructive and fruitful discussions on this important subject.

Thank you.

Special Address

Dr. Malini V Shankar I.A.S. (Retd.)
Vice Chancellor, Indian Maritime University (IMU), Chennai

Suggested by the Prime Minister in the 14th East Asian Summit, the first move towards Indo-Pacific partnership was made in 2015, when a Joint Vision Statement was issued by New Delhi & Tokyo. A new IOR Division was created in MEA.

Linked with the "Look East" Policy and SAGAR Mission, the aim of the Indio Pacific Oceans Initiative is to facilitate maritime cooperation and partnership with like-minded nations, strengthen maritime boundaries, with stress on free trade and sustainable use of maritime resources. Wealth creation, promotion of welfare and a win-win cooperation form part of the strategy.

The 7 pillars of the Indo Pacific Oceans Initiative, as enunciated in the November 2019 East Asia Summit held in Bangkok, are the following:

- Maritime Security
- Maritime Ecology
- Maritime Resources
- Capacity Building & Resource Sharing
- Disaster Risk Reduction Management
- Science, Technology & Academic Cooperation
- Trade, Connectivity and Maritime Transport

In 2019 maritime security dialogues were held with Australia, European Union, France, Japan, Myanmar, USA, and Vietnam.

In June 2020, in a Joint Statement on Comprehensive Strategic Partnership, India and Australia recognised that "many of the future challenges are likely to occur in and emanate from the maritime domain". Thus Indo-Pacific emerged as a new geographic space and a perceived shift by India to address a new security environment.

Maritime Domain Awareness, a component of the Initiative, was recognized as a key area for collaboration, "being cognizant of positions and intentions of all actors, on/ over/ under the seas".

Earlier, in 2014, the IMAC (Information Management and Analysis Centre) was established as the nodal point for National Command Control Communication and Intelligence Network. The Regional MDA covers Maldives, Mauritius, Seychelles and Sri Lanka.

The information sharing was upgraded (White Shipping Agreement) and in Dec 2018, the Information Fusion Centre, IFC-IOR was put in place. The shared information covered a wide spectrum – piracy, illegal fishing, drug smuggling,

human trafficking, maritime terrorism, environmental hazards, natural disasters etc. The IFC-IOR is just one component of MDA, focussing on commercial shipping and fishing vessels.

The importance of the Indo Pacific Region is evident from the fact that the region encompasses 38 countries, 44% of the global surface area, 64% of the population, 62% of the global GDP, 50% of global trade and that 40% of world's oil passes through the Indian Ocean.

The proposals to propel the cooperation initiative are 3-pronged:

- G-to-G covers dialogues on maritime security (peacekeeping, counterterrorism, piracy, fishing, disaster relief); coordinated patrols and implementation of AIS.
- The P-to-P looks towards exchange in education & training; research; think tank; workshops on capacity building, MDA and familiarity with UNCLOS; academic collaborations (coastal engineering, marine habitat conservation etc.); climate change management.
- B-to-B looks towards coastal shipping and cruise tourism.

The success of the Indo Pacific Initiative lies not in convergence of policies alone, but in the coordination of issue-based partnerships and burden sharing.

Even as promotion of trade, sharing of technologies (LRIT for instance), simplification of procedures, and cultural tourism enable to propel the Initiative, "soft interventions" (capacity building) play a critical role. These primarily include the establishment of think tanks, student exchanges and collaborations in education and research.

IMU has inked a MoU with the RIS (Research and Information Systems, a unit within the ambit of the Ministry of External Affairs) to establish partnerships in policy making and capacity building in maritime sector. This initiative deserves to be supported by the MEA; the IMU can be the repository of information and data for the maritime sector.

The P-to-P aspects have great relevance in laying the foundations of cooperation. The clarity of protocols and easing of procedures for students from the Indo-Pacific Region to gain admission for studies and research would facilitate in building such partnerships. In the earlier decades, India used to grant generous scholarships to students from some countries for studies in India, and this was successful in creating a community of friends of India when they returned to their home countries and occupied influential positions.

Sharing of knowledge and joint research projects in areas of common interest need to be supported. The LRIT (Long Range Identification & Tracking) is one successful attempt, this needs to be expanded. Actively supporting/ enabling research collaborations would be helpful in promoting partnerships.

Thank you for inviting me to share my thoughts in the webinar.

Keynote Address

Smt. Riva Ganguly Das
Secretary (East), Ministry of External Affairs, Government of India, New Delhi

Ambassador Vijay Thakur Singh,

Distinguished guests, ladies and gentlemen

I am delighted to participate in the Virtual Conference on National Consultations on Indo-Pacific Oceans Initiative (IPOI). I would like to congratulate ICWA for holding these National Consultations by engaging Indian experts and stakeholders on IPOI to explore areas of cooperation and collaborations under its seven pillars.

The Indian and Pacific Oceans have always enjoyed a deep connect, facilitating the flow of goods and people, and building trade and cultural linkages. In the 21st century, the interconnectedness of the Indo-Pacific is finally coming into full play. A motivating factor for this is the region's emergence as a driver of international trade and prosperity. With greater globalization and a rebalancing of power, this vast region has experienced strong and sustained growth spreading from across the Pacific Rim, to South-East Asia, South Asia, the Gulf region, and all the way to East Coast of Africa.

The Indo-Pacific ocean system now carries an estimated 65 per cent of world trade and contributes 60 per cent of global GDP. Ninety per cent of India's international trade travels on its waters. For India, and for many other countries, the shift in the economic trajectory from the Atlantic to the Indo-Pacific has been hugely consequential. This is reflected by the fact that like India, several countries and regions have now articulated their own concept and vision for the Indo-Pacific, including Japan, U.S., Australia, ASEAN, France, Germany, the Netherlands, UK and most recently the EU.

India's Indo-Pacific geography can perhaps be best described as a succession of semi-circles. The innermost semi-circle incorporates our closest neighbours. These are South Asian countries that share with us the waters of the Indian Ocean and with whom we share civilisational and cultural heritage. The arc of our outer neighbourhood covers the Gulf states to our west and Southeast Asia and the ASEAN countries to our east. In a sense, this too is a rediscovery of old maritime associations, but contemporary world of trade, investment, energy and skill flows have added new dimensions. Moving further, India has created partnerships and mechanisms with countries whose opportunities, concerns and stakes intersect

with ours. This is a broad sweep, from the Pacific Islands to the archipelagos of the western Indian Ocean and off the eastern coast of Africa.

India formally articulated its vision for the Indo-Pacific at the Shangri La Dialogue in June 2018 where Prime Minister Modi spoke about a free, open, inclusive Indo-Pacific region, which embraces all countries in a common pursuit of progress and prosperity. India's Vision for the Indo-Pacific builds on our Act East Policy and the doctrine of Security and Growth for All in the Region (SAGAR) announced by PM in 2014 and 2015 respectively.

India's Indo-Pacific Vision envisages a free, open, inclusive, peaceful, and prosperous Indo-Pacific region built on rules-based international order, sustainable and transparent infrastructure investment, freedom of navigation and over-flight, unimpeded lawful commerce, mutual respect for sovereignty, peaceful resolution of disputes, as well as equality of all nations. For India, the Indo-Pacific is that vast maritime space stretching from the western coast of North America to the eastern shores of Africa. India's vision for the Indo-Pacific is a positive one that includes all nations in the geography and beyond who have a stake in it. ASEAN centrality and unity lie at the heart of this Indo-Pacific.

The Indo-Pacific Oceans Initiative, announced by Prime Minister at the 14th East Asia Summit (EAS) held in Bangkok, Thailand on 4th November 2019, is practical implementation of this Vision with a focus on collaborative effort to better manage, conserve, sustain and secure the maritime domain. IPOI envisages cooperation and collaboration under its seven pillars namely, Maritime Security, Maritime Ecology, Maritime Resources, Capacity Building and Resource Sharing, Disaster Risk Reduction and Management, Science, Technology and Academic Cooperation and Trade, Connectivity and Maritime Transport. Such coordinated efforts among countries on the seven pillars of IPOI have potential to pay rich dividends. For instance, safeguarding the maritime space against piracy, technology-based solutions for addressing marine pollution, efficient response to natural and environmental disasters, sustainable management of marine resources, promoting the Blue Economy, capacity building etc. create an overall enabling environment for promotion of peace and prosperity in the Indo-Pacific. A rules-based international order is achievable only with a rules-based Indo-Pacific.

IPOI does not envisage creating a new institutional framework. It is aimed to promote practical cooperation by drawing on existing regional architectures like the ASEAN-led East Asia Summit (EAS) framework, IORA, BIMSTEC, PIF etc. While the other networks and coordination mechanisms have their utility, the centrality of ASEAN resonates with India's idea of the Indo-Pacific. By virtue of its location, its longevity and its social and economic achievements, ASEAN has emerged as a platform where various interests can meet and differences can be rationalized.

While these qualities cannot be discounted, however, it is also an acknowledgment that institution formation in the Indo-Pacific is still at an incipient stage.

While India will be the driving force behind all areas identified under the IPOI, we are also actively seeking partnerships with like-minded countries to lead on any of the pillars of IPOI. Given India's inherent strengths in the region, India has taken the lead on two pillars, namely, (i) Disaster Risk Reduction and Management and (ii) Maritime Security. We are happy to note that IPOI has been welcomed by several countries in the region. Australia has taken lead on the Maritime Ecology Pillar, Japan on Connectivity Pillar, France and Indonesia on the Maritime Resource Pillar of IPOI.

India along with the partner countries is undertaking various activities under the various pillars of the IPOI. We have sought to strengthen security and freedom of navigation in the Indo-Pacific by becoming a net security provider – for instance in anti-piracy operations in the Gulf of Aden. Training and capacity building is another aspect of our cooperation in the region. The Information Fusion Centre for the Indian Ocean Region in Gurgaon has been engaged in enhancing maritime domain awareness among partner countries. In the area of humanitarian assistance and disaster relief (HADR), India has not only built robust capacities it has also established itself as an instinctive and unstinted early responder, including in the times of the current pandemic. The Coalition for Disaster Resilient Infrastructure (CDRI), co-founded by India and the United Kingdom in 2019, and International Solar Alliance, co-founded by India and France are intrinsic to India's regional and global commitment to climate change agenda.

India is also promoting and contributing to infrastructure development, connectivity, economic projects and supply chains in the region, always prioritizing the needs of the host community and the ethic of equity, environmental sustainability and social viability. The Supply Chains Resilience Initiative between India, Japan and Australia is one of the steps in this direction. Sustainable development of the marine resources, cooperation on the protection of global marine commons, combating issues such as illegal, unregulated and unreported fishing, marine wildlife trafficking and marine plastic pollution which are damaging ocean's ecology are also our area of focus under the IPOI.

Nationally we are seeking cooperation of various stakeholders both from the government and academia to progress cooperation on each of the seven pillars of IPOI. We are seeking support of institutions with expertise in these areas in form of our knowledge partner to do academic research, generate ideas and develop academic linkages with similar institutes in the region. We are happy to work with institutes from all over India such as Indian Council of World Affairs, National Maritime Foundation and RIS in New Delhi, National Centre for Coastal Research and National Institute of Ocean Technology in Chennai, Indian National Centre for

Ocean Information Services in Hyderabad, National Institute of Oceanography in Goa and Fishery Survey of India in Mumbai, to name a few.

Friends,

Today's webinar, bringing together all these different stakeholders, provides a good platform to deliberate upon ways and means for effective promotion and implementation of IPOI as well as to promote collaboration in the Indo-Pacific under its seven pillars.

With these words, I wish the event a great success. I am confident that the discussions in the event would come up with useful suggestions to facilitate organisation of an international conference on IPOI later this year.

Thank you.

Chapter 1

Maritime Domain Awareness in the New Global Order

Arnab Das

Introduction

The Indo-Pacific Region is a critical strategic space in the new global order and an increasing number of nations are trying to maintain strategic presence in the region. In its maritime construct, the Indo-Pacific is spread across the tropical littoral waters of the Indian Ocean and the Pacific Ocean. The region presents unique challenges and opportunities on all the three fronts, namely political, economic and strategic.

The Maritime Domain Awareness (MDA) is a term associated with enhanced understanding of the underlying dynamics for effective ocean governance. However, post the 9/11 incident, it remained security driven, and in India in the aftermath of the 26/11 incident. The security driven formulation limits the participation of the other stakeholders and thus falls short of being inclusive. Furthermore, globally, the conventional MDA has remained focussed on the surface of the oceans; however, the underwater component remains unaddressed. The Underwater Domain Awareness (UDA) framework, proposed by the Maritime Research Centre (MRC), Pune, India encourages pooling of resources and synergizing efforts across five domains i.e. maritime security, blue economy, marine environment, disaster management, and research & innovation. It focusses on the critical aspects of policy and technology interventionsas well as acoustic capacity and capability building. It is worth mentioning that the SAGAR vision of Prime Minister Narendra Modi can be highly effective with the UDA framework.

This Chapter elaborates on the local R&D challenges, academic programs, skilling requirements, innovation possibilities and the policy gaps with regard to UDA. India has a good opportunity of projecting itself as a knowledge and skill hub in the Indo-Pacific Region. Focus on the acoustic capacity and capability building with enhanced UDA framework will be a game changer for the Indo-Pacific Ocean Initiative (IPOI).

The Indo-Pacific strategic construct has begun to resonatewith global powers. Initiated by the Japanese Prime Minister Shinzo Abe, while delivering his address to the Indian Parliament in 2007, he referred to the “confluence” of the Indian and Pacific Oceans as “the dynamic coupling as seas of freedom and of

The Maritime Domain Awareness (MDA) is a term associated with enhanced understanding of the underlying dynamics for effective ocean governance. Conventional MDA has remained focussed on the surface of the oceans; however, the underwater component remains unaddressed

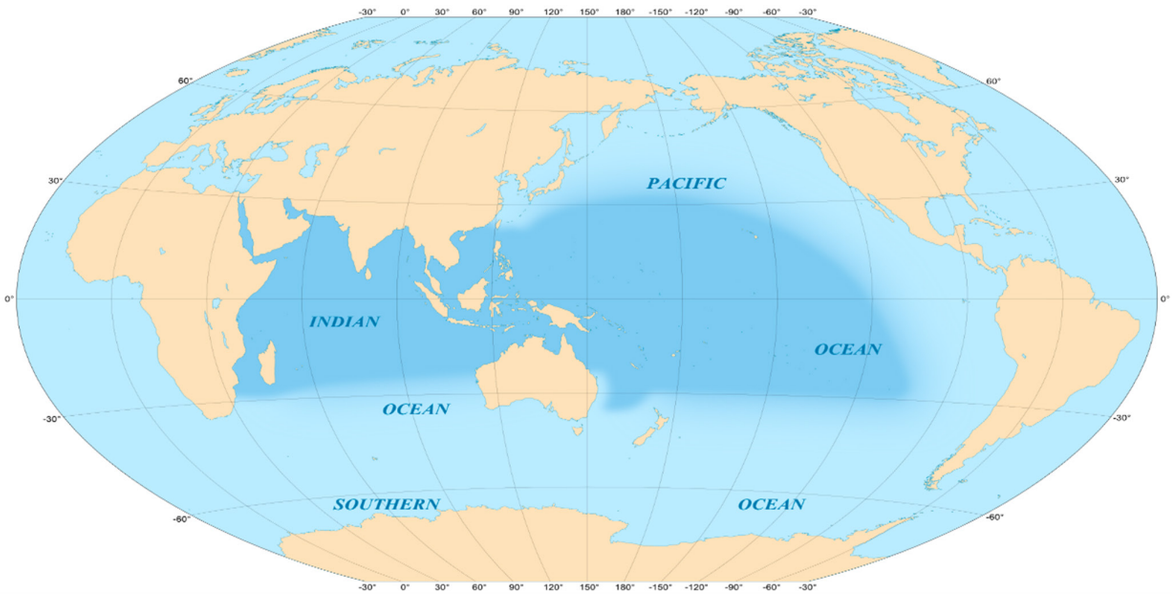

Figure 1: The Indo-Pacific Region: Tropical Littoral Waters

prosperity" in the "broader Asia" [1]. It got symbolically linked to the "Quadrilateral Security Dialogue" comprising of Australia, Japan, India and the US, and is referred to as the Quad. The Quad regained geopolitical relevance during the pandemic, with the growing assertion by China in global matters. The obvious belligerence from China has probably brought the erstwhile dominant global powers to align themselves either way. The Germans and the French have also announced their participation in the Indo-Pacific strategic interaction [2].

The role of India in the Indo-Pacific strategic construct is significant in many ways. It brings India in the centre stage of global power play and India can no longer choose to remain a silent spectator. The Indo-Pacific is defined as the tropical littoral waters (Figure 1) of the Indian Ocean and the Pacific Ocean [3]. The term tropical littoral water brings with it multiple unique challenges and opportunities. The "Indo" part of the Indo-Pacific demands that India invests significantly in its maritime capacity and capability building to remain a major player in the Indian Ocean region (IOR and beyond [4].

The Government of India on its part has displayed significant strategic intent to alter the continental policy outlook, and the SAGAR vision is regarded as the most significant strategic declaration with a regional outlook, far beyond its national boundaries. The salient aspects of the SAGAR vision are as follows: [5, 6]

- Acknowledges the security concerns that India faces in the region due to the political;
- Instability and the socio-economic status of the IOR rim nations;

Figure 2: Recent Marine Mammal Stranding along the Indian Coast

Left: 42 feet Blue Whale Stranding off the Alibaug Coast in Jun 2015; Centre: 50 ftBryde Whale Stranding off the Mumbai Coast in Jan 2016; Right: Over 90 Short-Finned Pilot Whales Stranding off Tuticorin Beach in Jan 2016.

- Recognizes the tremendous economic potential that exists for the nations in the region to harness;
- Emphasises the need for regional consolidation and bringing together nations in the region and prevent extra-regional powers from meddling in our internal matters;
- Attempts to revive the rich maritime heritage we shared and rekindle the sense of pride in our rich culture and traditions.

The Government of India has matched up the SAGAR with mega projects like the "Sagarmala", "Bharatmala", "Inland Water Transport (IWT)" to prioritise the maritime capacity and capability building. Significant policy incentives have also been offered and additionally, multiple legislations have been brought-in, to demonstrate aggressive push by the government on multiple fronts [7, 8].

India's maritime infrastructure push is creating unregulated activities both within and also at the regional level, thereby causing sustainability concerns. Acoustic habitat degradation is a major fallout of the rising maritime activities without comprehensive regulatory framework. The increasing maritime activities are accompanied by higher noise levels in the ocean. Acoustic signals or sound waves being the only signal that propagate efficiently underwater, also means that the marine species use sound for multiple biologically critical functions like foraging, navigation, communication, finding mates and more. Thus, increasing noise in their habitat interferes with their ability to perceive the environment around them, thereby causing acoustic habitat degradation.

The frequent stranding of marine mammals along the Indian coast is a manifestation of the catastrophic acoustic habitat degradation. Figure2 presents recent incidents of stranding that is manifestation of the severe acoustic habitat degradation. Such stranding are attributable to the navigation failure due to high ambient noise leading to disorientation [9].

A safe, secure, sustainable growth model is required to balance the multiple dimensions of the maritime surge. The safety is from the natural disasters to develop early warning systems and measures to minimize the loss of life and property. The security is from man made threats and challenges in a politically volatile region. The sustainability is not limited to ecology, but involves other dimensions of resources. Growth must be inclusive and should encourage peace and harmony among the communities. The MDA must address all these issues to be able to enhance maritime governance in the true sense.

Challenges and Opportunities

The Indo-Pacific Region has its unique challenges when looked at through the framework of safe, secure, sustainable growth models. The tropical littoral waters need to be dissected to understand the issues while we plan our way forward. The socio-economic and the socio-political factors have their own bearing on the strategic outlook [10].

Tropical waters translate to rich bio-diversity and attract significant economic interest among groups within and outside. In the absence of mature regulatory framework and effective monitoring mechanism to manage the resources, sustainability is a big casualty. The local communities are not getting value for their catch, extra-regional elements are exploiting the resources, and the local communities for their vested interest. The mineral resources are also abundantly available in the undersea domain and there is significant interest among extra-regional powers. The nations in the region are pre-modern states with limited resources and know-how, and thus making them vulnerable to manipulations [11].

The tropical waters have significant impact on the sonar performance as well. The depth of sound axis determines the availability of the SOFAR channel that is found at a greater depth compared to the polar region. The sound axis is found at

Tropical waters translate to rich bio-diversity and attract significant economic interest among groups within and outside. In the absence of mature regulatory framework and effective monitoring mechanism to manage the resources, sustainability is a big casualty.

close to 2000 meters depth near the Equator compared to 50 meters at the poles. This leads to multipath propagation in tropical waters even at depths like 2000 meters. The conventional hypsometric definition of deep waters for depths greater than 200 meters, corresponding to the edge of the continental shelf is not valid acoustically in the tropical waters. The tropical region also means higher surface disturbances and large variation in the bottom types. This combined with higher multipath propagation translates to significantly high acoustic signal deterioration. Thus, the Indian Ocean Region (IOR) can be considered to be shallow waters acoustically even up to 2000 meters depth, which translates to sub-optimal sonar performance for most of the region. The high bio-diversity further leads to volume distortions and high ambient noise due to biological noise [12, 13].

An interesting example is the impact of biological noise in the IOR. In 1988, India deployed its first Nuclear Submarine, the INS Chakra, on an operational mission off the east coast in Visakhapatnam. The boat sat down in position to detect the incoming fleet as per the instructions for the exercise. After a while the sonar screen blanked out and a blast sonar transmission was considered to be the most suitable remedy (transmission for a submarine during operational mission is suicidal as it will reveal its position) and it proved successful. The blinding was assessed to have occurred due to Snapping Shrimps.

In 1946 the Scripps Institute of Oceanography in the US undertook a detailed Snapping Shrimp mapping for the oceans in preparation for the launch of the first nuclear submarine Nautilus in 1952. The study revealed that tropical waters are the habitat for Snapping Shrimps. The IOR nations are aggressively going for submarine acquisition lately, and this example will have some value for them. Acquiring high value military hardware at the behest of extra-regional powers may not solve the problems [14]. UDA has multiple dimensions and need to be understood comprehensively.

The shipping traffic also has impact on the low frequency ambient noise in the region. This rise in ambient noise has two fold implications on sonar performance due to deteriorating Signal to Noise Ratio (SNR) and also changing migration pattern for the marine mammals that will affect biological noise patterns. With increasing submarine fleet and requirement to deploy them effectively, the SNR and the Snapping Shrimp beds is a major factor that deserves attention. Ambient noise assessment is a critical requirement that cannot be imported, but will require indigenous efforts involving field work.

The frequent big whale stranding being observed in the IOR is a manifestation of the severe acoustic habitat degradation due to unregulated maritime activities along with absence of proper Environment

Impact Assessment (EIA) while planning mega development projects in the maritime sector. The author has investigated few of the recent big whale stranding and attributed them to the anti-piracy operations and increasing shipping traffic. The developmental plans need to be more nuanced and backed with comprehensive EIA [9, 15]. Security and growth are interconnected as stated in the SAGAR vision and need to be dealt with comprehensively.

Maritime Domain Awareness

Joseph L. Nimmich and Dana A. Goward of the US Coast Guard have noted that "Maritime security is burdened by thousands of years of history and tradition" [16]. This statement describes the nature and complexities of the maritime domain for any attempt at managing the maritime environment, whether for security or conservation. The authors of "Maritime Domain Awareness: The Key to Maritime Security" [16] have brought out the key reasons for the limitations of the global maritime security management scenario. The starting point for any initiative towards effective maritime governance with a coherent and systematic approach would be MDA which is rooted in the ability to effectively monitor what is going on, at any moment in the entire maritime space.

The International Maritime Organization (IMO) defines MDA as the effective understanding of anything associated with the maritime domain that could impact the security, safety, economy or the environment [17]. The maritime domain has been defined as "all areas and things of, on, under, relating to, adjacent to, or bordering on a sea, ocean, or other navigable waterway, including all maritime-related activities, infrastructure, people, cargo and vessels and other conveyances"[18]. The global commons are being effectively utilized to export terror and contraband across the globe [19].

The awareness term in MDA is the key for an effective MDA. In conventional understanding of the MDA, the underwater part is usually ignored that results in underestimating the threats and opportunities in the undersea domain [20, 21]. The underwater threat in the maritime domain is increasingly getting real and far more devastating than ever before. The easy access to technology and knowhow has made it easy for States and non-state actors to deploy sophisticated underwater devices forprecise attacks on adversaries with large scale damages. The asymmetry

The IOR with its strategic relevance is seeing multiple security threats, more from the non-state actors rather than the maritime forces representing the littoral states

in the underwater threat makes it extremely difficult to counter by conventional means [22].

The MDA globally has remained a security construct and continues to be driven by the maritime forces with far less transparency and minimal involvement of other stakeholders. The Indian establishment with its continued continental outlook has ensured complete sea blindness in maritime policies and infrastructure. This is further highlighted by the fact that a Military Maritime Strategy was announced before a comprehensive National Maritime Strategy (still work in progress) [23, 24, and 15]. Even from a security construct, the underwater component of the MDA has remained neglected and fragmented even on a global scale [25].

The IOR with its strategic relevance is seeing multiple security threats, more from the non-state actors rather than the maritime forces representing the littoral states. The intermingling of the subversive elements with some of the nation states involved in Low Intensity Conflicts (LIC) is encouraging large scale piracy, maritime terrorism and other means that are hard to counter through conventional means [26]. Navies and Coast Guards are ill equipped to handle such threats. Also, the maritime forces are always the first responders to any natural disaster or environmental emergency; however they are least equipped to handle such events. The lack of clarity is attributable to the absence of a comprehensive maritime strategy since independence in India [27].

The concept of UDA in a more specific sense translates into a human eagerness to know what is happening in the undersea realm. This keenness for undersea awareness from the security perspective, means defending our Sea Lines of Communication (SLOC), coastal waters and varied maritime assets against the proliferation of submarines and mine capabilities intended to limit the access to the seas and littoral waters. However, just the military requirement may not be the only motivation to generate UDA. The earth's undersea geophysical activities have a lot of relevance to the wellbeing of the human kind and monitoring of such activities could provide vital clues to minimize the impact of devastating natural calamities. The commercial activities in the undersea realm need precise inputs on the availability of resources to be able to effectively and efficiently explore and exploit them for economic gains.

The regulators on the other hand need to know the pattern of exploitation to manage a sustainable plan. With so much of activities, commercial and military, there is significant impact on the environment. Any conservation initiative needs to precisely estimate the habitat degradation and species vulnerability caused by these activities and assess the ecosystem status. The scientific and the research community needs to engage and continuously update their knowledge and access

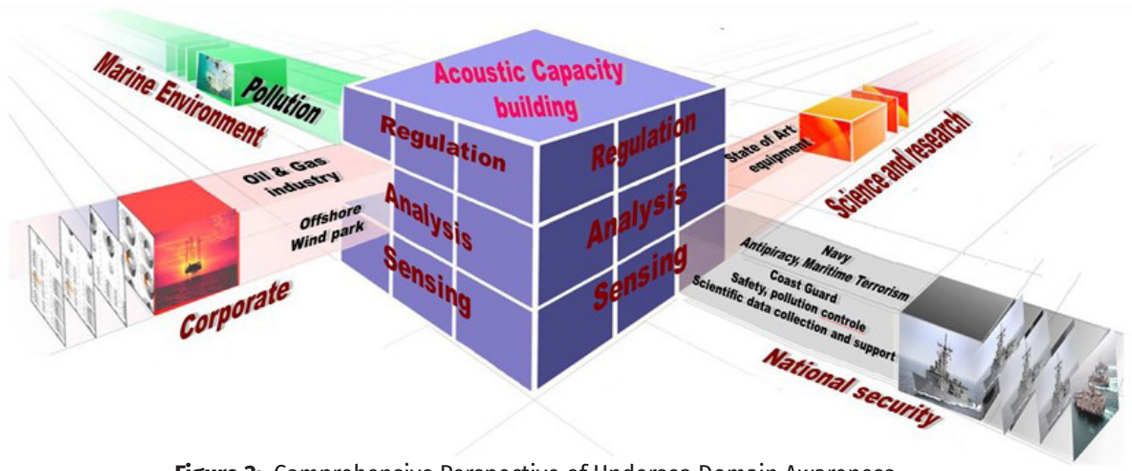

Figure 3: Comprehensive Perspective of Undersea Domain Awareness

of the multiple aspects of the undersea domain. Figure3, presents a comprehensive perspective of the UDA. The underlying requirement for all the stakeholders is to know the developments in the undersea domain, make sense out of these developments and then respond effectively and efficiently to them before they take shape of an event.

The UDA framework on a comprehensive scale needs to be understood in its horizontal and vertical construct. The horizontal construct would be the resource availability in terms of technology, infrastructure, capability and capacity specific to the stakeholders or otherwise. The stakeholders represented by the four faces of the cube will have their specific requirements, however the core will remain the acoustic capacity and capability. The vertical construct is the hierarchy of establishing a comprehensive UDA framework. The first level or the ground level would be the sensing of the undersea domain for threats, resources and activities. The second level would be making sense of the data generated to plan security strategies, conservation plans and resource utilization plans. The next level would be to formulate and monitor regulatory framework at the local, national and global level.

Figure 3 gives a comprehensive way forward for the stakeholders to engage and interact. The individual cubes represent specific aspects that need to be addressed. The User-Academia-Industry partnership can be seamlessly formulated based on the user requirement, academic inputs and the industry interface represented by the specific cube. It will enable more focused approach and well defined interactive framework. Given the appropriate impetus, the UDA framework can address multiple challenges being faced by the nation today. Meaningful engagement of Young India for Nation Building, probably is the most critical aspect that deserves attention. Multi-disciplinary and multi-functional

entities can interact and contribute to seamlessly synergize their efforts towards a larger goal.

Acoustic Capacity and Capability Building

The serious acoustic capacity building globally happened during the Cold War period [28]. Multiple projects were initiated and these were led by the national security apparatus with unquestioned support from the political establishment. The geopolitical realities were such that budget allocations for national security requirement never had to compete with others and long term projects with massive investments were cleared on fast track basis. National security was prioritised over everything else and these projects were immune to environmental clearances and any other resource or policy constraint [29].

The first project was the Sound Surveillance System (SOSUS), started by the US Navy in 1949 to track soviet submarine. It is a chain of Underwater Sensor Arrays placed in the Atlantic Ocean near the Greenland, Iceland and the United Kingdom (the GIUK gap) and at various locations in the Pacific Ocean. Over a period of time multiple agencies contributed to the larger system development under various project names. MIT, in 1950, worked on Project Hartwell, Bell Labs on Project Jezebel and Project Colossus, Columbia University on Project Michael, Royal Navy and US Navy on Project Caesar, and more.

SOSUS monitoring stations went by the acronym NAVFAC (Naval Facility). The SOSUS stabilized by mid 60s and played a remarkable role in multiple operational activities like localization of USS Thresher when it sank in 1963, detection of Victor and Charlie class Soviet submarines in 1968, and Delta class submarine in 1974, localization of the wreckage of US Nuclear Attack submarine the USS Scorpion and many more [30].

The SOSUS also contributed to acoustic capacity building for non-military applications with the involvement of multiple academic and R&D institutions like the University of Washington Applied Physics Laboratory (APL) for Ocean Acoustic Tomography (ATOC), National Oceanic and Atmospheric Administration (NOAA), Woods Hole Oceanographic Institute (WHOI),Texas Applied Research Lab and several other organizations for varied acoustic programmes. In the beginning, the SOSUS was a top secret project however, towards the end of the Cold War era, in 1991, the system mission was declassified and in 1993 a program for reporting whale detections was started [31].

The Surveillance Towed Array Sensor System (SURTASS), started in 1973 to detect Soviet Submarines at very low frequencies (100 to 500 Hz) and were long arrays towed miles behind the ships. It was the mobile version of the

SOSUS. When the submarines started becoming more silent and the passive systems were getting ineffective, the Low Frequency Active (LFA) component was added. However, towards the end of the Cold War period, the Natural Resources Defence Council (NRDC) pushed the Navy to file Environmental Impact Statement (EIS) for the project. In 1996, the Navy published a notice for EIS and spent $16 million on scientific research on the effects on marine mammals and mitigation systems. The afloat version of the SURTASS was a small fleet of civilian crewed ships that could sail as far as the South China Sea (SCS). These ships came to limelight when SURTASS ship USNS Impeccable was harassed by Chinese Maritime Militia while operating in the vicinity of China's SCS submarine bases in Hainan Island [32].

The peak of the Cold War period had 30 NAVFACs under the Integrated Undersea Surveillance Systems (IUSS) of the SOSUS programme, however that has been cut down to 3 operational today. The SOSUS system also faced neglect and could not keep pace with the state-of-the-art technology due to lack of resources. However, with the growing submarine threat from both China and Russia, the upgraded version called Deep Reliable Acoustic Path Exploitation System (DRAPES) is being progressed now by General Dynamics under a contract from the Office of Naval Research (ONR) [33].

The end of the Cold War marked a major shift in naval theatre of operation from the deep temperate waters to tropical littorals. The deep water acoustics that was achieved from the mega SOSUS programme was no more valid and new efforts were required. In the late 90s the US realized the growing Chinese submarine fleet threat and initiated the Asian Seas International Acoustics Experiment (ASIAEX) in early 2000, funded by the ONR and few other agencies. It was a massive Shallow Water Acoustic Measurement (SWAM) project to understand the underwater propagation behaviour in the South China Sea (SCS) and the East China Sea (ECS) [34].

The first phase of the project to identify the locations for field experiments was initiated by six US universities led by University of Washington with significant acoustic capabilities built during the SOSUS project. In the second phase, close to 20 academic and research institutes for China, Korea and others in the region participated to make it look more broad based. The take away for the US was very clear and that was to collect oceanographic data in the tropical littoral water of SCS and ESC.

However, the Chinese acknowledged their limitations of acoustic capacity and participated whole heartedly to learn SWAM at such large scale. Then, there was no looking back and the Chinese initiated massive undersea experimental work. The Underwater Great Wall Project was a fall out

of ASIAEX and the Chinese have progressed significantly there after [4, 15].

Digital Oceans

The broad Digital Oceans initiative needs to be dissected into individual S&T areas that have relevance across multiple sectors and applications. A few areas that are representative of the vast UDA framework across the marine and the freshwater systems are discussed below.

Underwater Radiated Noise (URN) Management

It is one of the most critical areas across military and non-military applications. The increasing shipping traffic across varied sectors starting from cargo in the high seas to coastal and inland waterways has huge impact on the underwater acoustic characteristics. The radiated noise from the marine vessels generates low frequency sound that overwhelms the low frequency spectrum of the ambient noise in the water bodies. The low frequency noise suffers minimum attenuation in the underwater domain so has significant impact over thousands of kilometres. Any underwater deployment of sonars for surveillance or marine mammal monitoring gets severely degraded due to poor Signal-to-Noise Ratio (SNR).

Acoustic stealth for military deployment of platforms and acoustic habitat degradation for marine mammal conservation requires effective URN management. The shipbuilding and ship repair also needs to take note of the URN management aspects and deliver ships with requisite URN levels. Opportunities in this domain exist from URN measure & analysis to prediction and deception/alteration.

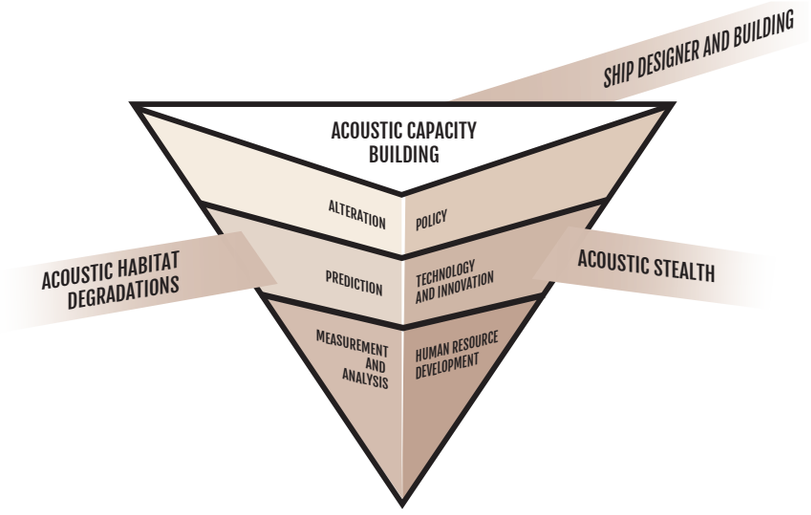

Figure 4: Underwater Radiated Noise (URN) Framework

Given the size of the shipping fleet in the merchant marine and the naval warships this is a huge area available for technology as well as policy intervention. Acoustic capacity & capability building has innumerable dimensions. The Figure 4 presents the multiple aspects of the URN management. It also brings all the stakeholders together in a seamless manner [35].

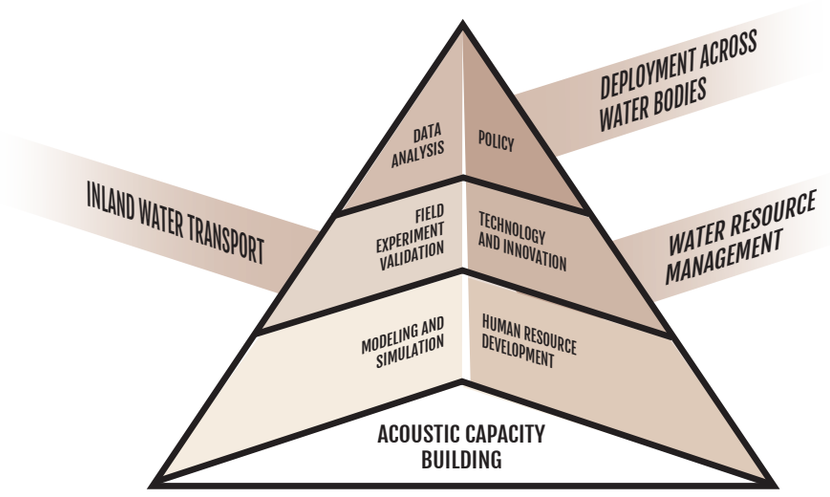

Figure 5: Sediment Management Framework

Sediment Management

This is another major opportunity for significant military and non-military applications. The broad areas of concern are freshwater resource management, flood control, navigation for inland water transport, port management, deployment of military vehicles in water bodies and more. There is significant military requirement in terms of logistics and movement of military assets across water bodies. Maintaining safe navigation and all weather access across these water bodies could be a major challenge. There has been significant focus on port led growth under the Sagarmala initiative and also the multimodal connectivity across waterways. These require massive acoustic capacity and capability building to ensure uninterrupted operations in our water bodies.

Sediment management originates from prediction and prevention of the siltation process, de-siltation and also disposal of the silt. The tropical littoral waters have very high flowwhich causes high siltation. De-siltation needs to be done in a scientific manner to ensure viability of the projects. The acoustic survey and sediment classification is the key to the entire process. The volume of silt is a huge challenge from the perspective of removal and disposal. The dredging has multiple options with varying cost based on the nature of the silt. The disposal of the silt has become an impediment given the logistics cost and non-availability of dumping ground. Precise sediment classification can ensure economic viability of the entire de-siltation process. There is significant wealth

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in the silt and with proper sediment management, this could turn out into waste to wealth story. Figure 5 presents the multiple aspects of the sediment management framework. The stakeholders can seamlessly synergise and pool their resources to manage this effectively. The policy and technology interventions can be managed efficiently with enhanced acoustic capacity and capability building for sediment management [36].

Aquaculture and Digital Oceans

The aquaculture industry in India has significant potential as a blue economy opportunity. The tropical littoral waters are known breeding grounds for shrimp farming and given the high value of shrimps in the global market, it a huge opportunity. However, shrimp farming is a high risk venture due to disease outbreaks, environmental fluctuations, lack of scientific awareness and more. The small farmers are unable to sustain these ventures, in the absence of financial support from the insurance companies and banks. The un-organized sectors have a challenge to grow due to inadequate policy support from the governments as well. India, with a coastline of over 7,500 km, has a massive opportunity to build this industry and help the community to engage in productive ventures. Digital oceans is the only way forward to develop deeper understanding of the underwater conditions and fluctuations.

The uncertainties of the environment and the production outputs can be minimized with better interventions. The lower uncertainties and enhanced predictability of the entire process will encourage participation of the financial entities to support such sectors. The policy and technology interventions for enhanced and sustainable aquaculture is a major requirement. India has failed to take advantage of its vast tropical littoral waters due to lack of prioritizing of the digital ocean initiative. The acoustic capacity and capability building is again a key requirement for Digital Ocean, and if managed well could be a significant export opportunity of the skill India initiative [37].

There is a substantial strategic angle to shrimp habitats and generating deeper understanding of their soundscape. They are known to be the loudest of the creatures with vocalization ranging beyond 200 dB ref 1 µPa at 1 m. Even the biggest mammal on earth, the blue whale vocalization is of the order of 196 dB ref 1 µPa at 1 m. The whales are in

few numbers (in single digits) in a group, whereas the shrimps are in millions in a shrimp bed. There have been incidents in the past when a submarine has been acoustically swamped due to snapping shrimp vocalization.

The Indo-Pacific region is going to be a major maritime theatre for submarine deployment. Several navies in the region have acquired strategic submarines but the UDA capability is weak. There are multiple other aspects of UDA that need to be prioritised for strategic security purposes ranging from maritime intelligence against undersea intrusions, effective deployment of subsea vehicles, mitigating the sub-optimal sonar performance to more demand high priority in the ongoing geopolitical and geostrategic developments.

CONCLUSION

The high-end technology developments globally have taken place during the Cold War period. Even the underwater technology developments have largely taken place as part of the super-power rivalry. The Americans and the Russians had deployed huge resources to generate better understanding of the undersea domain for ensuring enhanced sonar performance.

However, the engagement during the Cold War period were in the temperate and polar regions. The Cold War had different geopolitical and geostrategic realities. Military spending was not questioned and military projects did not require any environmental clearances as well. The post-Cold War era has completely different political scenario. Even in the US and other democracies, the leaders have to balance socio-economic requirements along with national security requirements. The environmental clearances cannot be bypassed for national security projects. Pooling of resources and synergising of efforts across the stakeholders is the only way ahead. Geo-economics has taken the high ground and geopolitics has to match the economic growth engine trajectory.

The tropical littoral challenges and opportunities have to be driven by S&T and site-specific R&D. This requires high infrastructure investments and long term commitment to develop the know-how. User-Industry-Academia partnership is inescapable. All the stakeholders have to be committed on a long term basis to this model. Beyond the nations,

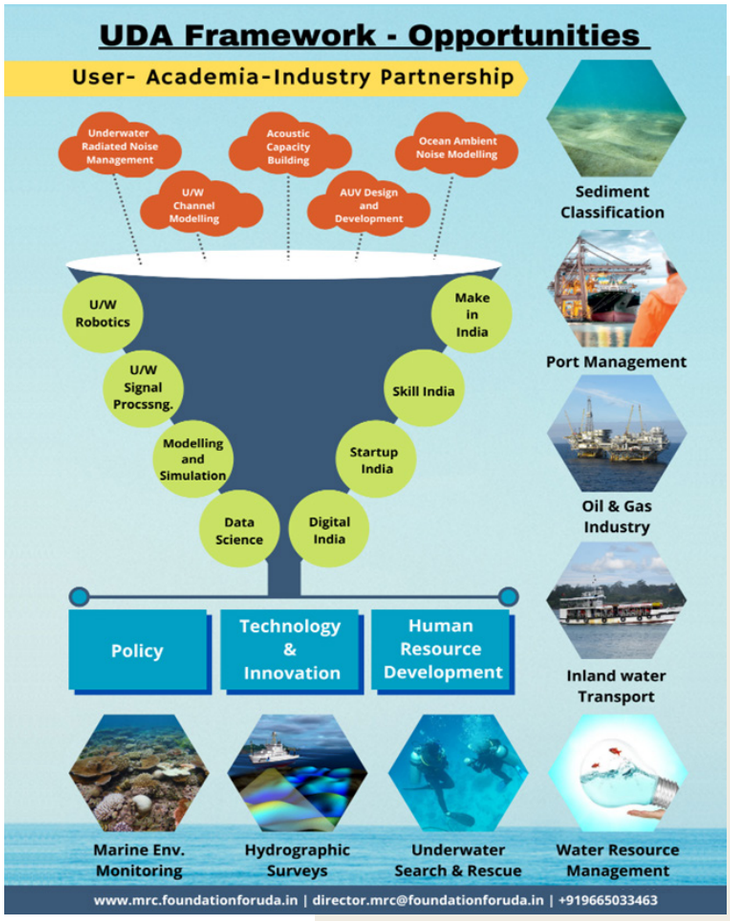

Figure 6: User-Academia-Industry Partnership for the UDA Framework

the regional frameworks will make more sense and also keep the extra-regional powers at bay. The fragmented stakeholder interactions within the nations and also in the region is a major impediment to ensuring higher synergy.

Digital Oceans driven by the UDA framework can be a game changer. It will be a paradigm shift for ensuring safe, secure, sustainable growth for all in the Indo-Pacific Region. India has taken multiple steps to build maritime infrastructure and the SAGAR vision does demonstrate significant seriousness on the part of the Government of India. A User-Academia-Industry partnership model is presented in figure-6 for realising the Digital Ocean dream. It binds together multiple announcements from the Government of India and also the stakeholders both in the marine and the freshwater systems.

Figure 6 brings all core R&D domains on one side of the funnel and the government initiatives on the other, to provide the three main pillars of the UDA framework. The effective policy intervention, innovative technology support and the acoustic capacity & capability all seamlessly will come together across the stakeholders. The UDA framework proposed by the MRC has significant merit for a whole of nation approach. The above User-Academic-Industry can be implemented on ground with the setting up of a Centre of Excellence to build on all the five major requirements of research, academia, skilling, incubation and policy.

The SAGAR vision of the Honourable Prime Minister is better served by effective realization of the UDA framework in a comprehensive manner. The IPOI is a significant initiative to project India as a knowledge and skill hub in the Indo-Pacific region. All the seven pillars of the IPOI are effectively addressed by the UDA framework, proposed by the MRC. The Centre of Excellence, as discussed above, can effectively drive the entire IPOI initiative.

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Chapter 2

Marine Plastic Pollution and the Indo-Pacific Region

Sulagna Chattopadhyay

One of the tangible and often used methods to understand the disruptions by humans is by regularly monitoring and analysing mangrove and coral species degradation and reduction. This provides a clear snapshot of the far-reaching anthropogenic impacts

The coastal and marine regions of the world suffer from unsustainable exploitation and the situation is further exacerbated by the impacts of global warming. It has been estimated that about 60 per cent of the world's marine ecosystems are unsustainable (UNEP, 2011). Population pressures overlain with climate change have deeply affected the ocean systems so much so that even remote areas are not devoid of its impacts. The overarching drivers for degradation include population growth and demographic changes; pollutants released into oceans and seas; economic activities such as overfishing and illegal fishing; shipping; extractive mining on land and sea; run-offs laden with chemicals that cause nutrient loading (eutrophication) and sedimentation; technological advances such as destructive fishing methods and physical destruction of coastal areas to aid technologies; changing governance structures and geopolitical instability; and climate change that leads to unprecedented changes in the ecosystem, precipitating marine invasive/alien species events, parasites and diseases (World Ocean Assessment II, 2021).

The increased levels of carbon dioxide in the atmosphere due to anthropogenic activities is another important issue at hand. It is well documented that this leads to increased absorption of carbon dioxide in the oceanic waters, turning it acidic (NOAA 2020). The acidification is more pronounced in certain regions and adversely impacts on marine species and oceanic ecosystems (Wilkinson et al, 1994 and Obura et al, 2009). This 'climatic disruption' negatively alters ocean productivity and the food web dynamics.

One of the tangible and often used methods to understand the disruptions by humans is by regularly monitoring and analysing mangrove and coral species degradation and reduction. This provides a clear snapshot of the far-reaching anthropogenic impacts. In just 4 per cent of the earth's land on the coasts, more than a third of the global population is housed, accounting for 90 per cent of the marine catches (Barbier, 2017). The 2021 World Oceans Assessment report by the United Nations points out that in the past three to four decades the coral cover decline is to the tune of 50- to 75 per cent. An interagency IOC/ UNESCO 2011 Blue Paper cites that "mangroves have been reduced to 30 to 50 per cent of their historical

cover, impacting biodiversity, habitat for inshore fisheries and carbon sequestration potential".

Perhaps the more startling is the report that over 80 per cent of the world's 232 marine eco-regions have reported invasive species (A Blueprint for Ocean and Coastal Sustainability, 2011). The 2021 World Oceans Assessment report takes it a step further, revealing that a whopping90 per cent of mangrove, seagrass and marsh plant species have been assessed to be at risk of extinction. The underlying reasons for such detrimental impacts on marine ecosystems are related to intense human activities that generate large volumes of pollutants and hazardous wastes. It is with this in mind that the Sustainable Development Goal Target 14.1 of the United Nations intends to prevent and significantly reduce marine pollution of all kindsby 2025, in particular from land-based activities, including marine debris and nutrient pollution.

For example, the three densely populated coastal megacities (Mumbai, Chennai and Kolkata) are floundering to manage the escalating levels of waste. Rapid urbanisation and increased shipping activities result in the coastal areas being heavily polluted due to increasing sewage discharge, agricultural run-off and industrial wastes. An estimate for 2015 by the CPCB reveals that sewage generated from domestic sources was about 61,754 million liters per day (MLD), of which 38,791 MLD (62 per cent) was untreated, directly released into the open waters (EnviStats India, 2019).

Among the many pollutants that impact oceanic ecosystems, a few need to be monitored closely. These include petroleum, fertiliser based nutrients, toxic contaminants from industry and plastics. Though ecosystems have an inherent capacity to cleanse themselves by assimilating the pollutants that arise from the land, toxic and non-biodegradable pollutants such as plastic stay in the environment for extensive periods resulting in degradation of the oceanic environment. Therefore, in a backdrop of escalating pressures the effective management of the oceans is crucial, as the United Nations Decade of Ocean Science for Sustainable Development (2021-2030) outlines, "[for] a clean ocean where sources of pollution are identified and reduced or removed".

This chapter addresses the problem of plastic pollution in a holistic manner in three sections. The first identifies the extent of marine plastic pollution and attempts to identify the spatial distribution of waste generating nations. The second section builds on the understanding of the Indo-Pacific region and the pathways of marine plastic waste with reference to its geographical backdrop of being large riverine regions. The third section deals with how the international fora are engaging with the Indo-Pacific region. Finally, the way forward section revisits the concept of the

Indo-Pacific region, chalking out future trajectories of collaboration towards mitigating marine plastic pollution.

Section 1

The Extent of Global Plastic Pollution

Plastic is a unique, cheap and versatile material, capable of providing a range of functions that address various societal challenges. From maintaining food quality and ensuring its safety to its use in medical innovation (3D printing) and in the reduction in fuel usage by providing lightweight materials for locomotives, plastic usage is almost ubiquitous in our daily lives. Plastics production in the last 65 years has outpaced any other manufactured material. The trade-offs between plastics and the substitutes that are available at the present are complex and could also pose additional risks to the environment and therefore may not be completely feasible (Ritchie and Roser, 2018).

The waste generated due to the increased use of plastics is a more recent problem. Polish geologist Jan Zalasiewicz and his co-authors have suggested plastic as a geological indicator of the Anthropocene era (Zalasiewicz et al, 2016). As of 2015, Roland Geyer,a professor of industrial ecology, and his colleagues estimated that 8,300 million metric tonnes (MT) of virgin plastics have been produced globally. The study further estimates that of the 6,300 MT of plastic waste generated till 2015, 9 only 9 per cent was recycled, 12 per cent incinerated, and a colossal 79 per cent either found its way into landfills or into the natural environment due to poor end of life management. The authors project that at the current rate of production and waste management it is likely that 12,000 MT of plastic waste will be in landfills or in the natural environment by 2050. A World Bank report notes that in 2016 alone, the world generated 242 MT of plastic waste, which constituted 12 per cent of the global municipal solid waste (Geyer et al., 2017).

With the growing visibility of plastic waste due to its increased accumulation in select environments, there is a rising global concern about its negative impacts on human health. As opposed to organic waste, plastic waste can take hundreds to thousands of years to decompose in nature (New Hampshire Department of Environmental Services, not dated). It is increasingly clear that plastic waste is clogging drains and precipitating devastating floods, causing respiratory issues when incinerated, killing animals when consumed and degrading biodiversity when dumped into oceans. Also emerging toxicological science, especially related to micro-plastics (GESAMP 2015), reaffirms that plastic waste has the potential to cause harm to human health.

Plastic marine litter constitutes between 80 and 95 per cent of all litter and comprises roughly 5 per

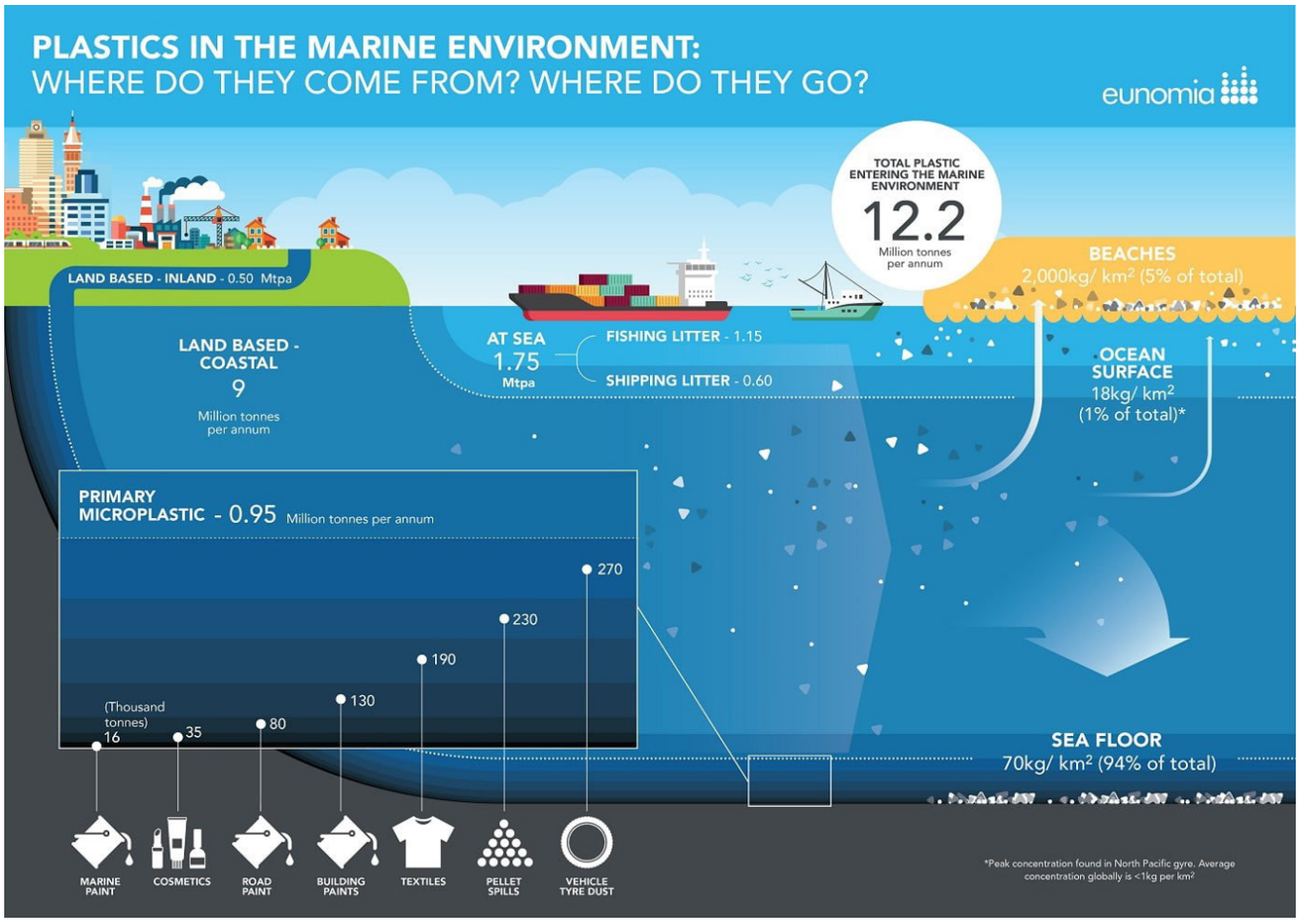

Figure 1: Plastics in the Marine Environment

The info graphic outlines that 94 per cent of the plastic that enters the ocean ends up on the seafloor. There is now on average an estimated 70 kilogram of plastic in each square kilometer of the sea bed. Barely 1 per cent of marine plastics are found floating at or near the ocean surface, with an average global concentration of less than 1 kilogram per square kilometer. This concentration increases at oceanic gyres. Beach litter comprises 5 per cent of mismanaged plastic waste. (Source: Eunomia)

cent of the MPW (Fig 1) (Eunomia, not dated). It is defined as any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment. Marine litter consists of items that have been made or used by people and deliberately dumped into the sea or rivers or on beaches (Kapinga and Chung, 2020).

Plastics in the global ecosystem can be classified into plastics in use, managed plastic waste, and mismanaged plastic waste (MPW) which includes litter (Geyer et al., 2017). Plastics used for packaging have a brief usage period, thus constituting a significant portion of municipal plastic waste and therefore also of MPW. As managed waste is quantified and disposed off by incineration or landfilling, there are clear estimates and accounts that nations keep. It is seen that affluent nations are better able to manage plastic waste (Lebreton and Andrady, 2019). However, in countries where populations are large, such as India

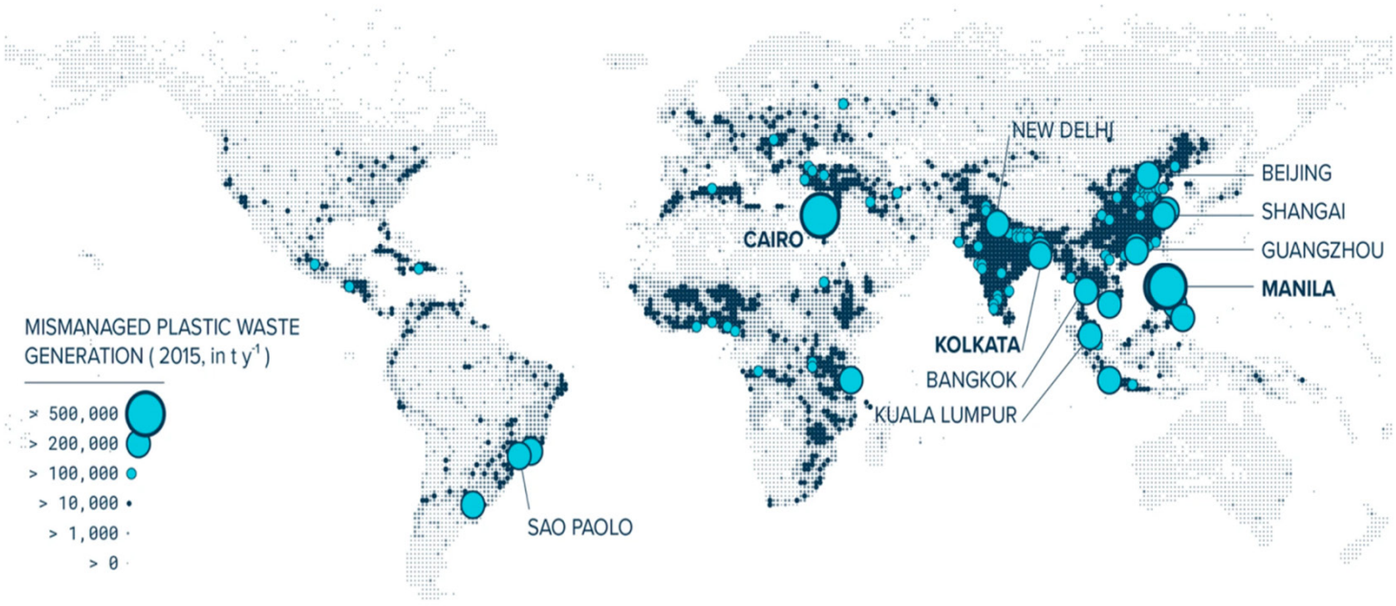

Figure 2: Mismanaged Plastic Waste Generation - Region-wise and Urban Centre-based.

Computations of 188 nations for 2015 show that the Asian region produced the largest volumes (82 MT) of mismanaged plastic waste and was responsible for 52 MT being released into the environment, including the oceans. Of the global urban centres ranked by MPW generation, Manila was the largest contributor followed by Cairo and Kolkata. Sao Paolo in Brazil was ranked fourth, while the rest of the top 10 cities were in Asia with Bangkok, New Delhi, Shanghai, Kuala Lumpur, Beijing and Guangzhou. (Source: Lebreton and Andrady, 2019)

and China, despite a relatively low per capita plastic use, it still generates a large tonnage of plastic waste, a sizable fraction of which is MPW. A study (Jambeck et al., 2015) based on the World Bank country-wise dataset by Hoornweg and Bhada-Tata in 2012revealed that the MPW reaching the oceans ranges from 4.8 to 12.7 MT of plastics in 2010 from populations living within 50 km from the coastline.

With paucity of data for municipality-level waste generation from various nations around the world, there are limitations to computing the actual country-level generation of MPW. However, a study by Lebreton and Andrady in 2019 provides likely 'global hot spots' for plastic waste (Figure 2). They also point out that increased migration into urban areas in developing nations would exacerbate these hot spots. The study estimates plastic waste generation at the local level for 188 countries, differentiating between consumption rates in urban and rural areas. The authors based their estimate on self-reported levels of inadequate disposal, calculating that between 60 and 99 million metric tonnes (MT) of municipal plastic waste were inadequately disposed globally into the environment during 2015 (Figgure 2), which is nearly 47 per cent of the global annual waste generated. It is evident from their calculations that the Asian countries topped the charts in MPW contribution in 2015.

Lebreton and Andrady's 2019 study shows Asia, especially South Asia, to

be the largest offender and leading plastic waste generating region with 82 MT, followed by Europe at 31 MT and Northern America at 29 MT. Latin America (including the Caribbean) and Africa each produced 19 MT of plastic waste while Oceania generated about 0.9 MT, they estimate.

Not only is Asia the leading plastic waste generator, but it is also responsible for releasing this waste into the environment. Asia released 52 MT of plastic waste into the environment, representing 65 per cent of the global MPW generation. Africa, on the other hand, despite being a low plastic producing region marks 17 MT of MPW, possibly due to the practice of importing waste, especially e-waste, from developed nations. Global urban centers ranked by MPW generation showed that Manila was the largest contributor followed by Cairo and Kolkata. Sao Paolo in Brazil was ranked fourth, while the rest of the top 10 cities were in Asia with Bangkok, New Delhi, Shanghai, Kuala Lumpur, Beijing and Guangzhou.

Plastic degrades into 'microplastics' that are almost impossible to recover and are increasingly disrupting food chains and degrading natural habitats (NOAA, 2021). In the open environment, fragments of plastic are exposed to chemical, biological, physical, and mechanical processes that change the typical properties of plastics such as structure and integrity, degrading plastics into minute plastic fragments. Fundamental forces that create micro-plastics are degradation through ultra-violet (UV) radiation and physical degradation through wave turbulence and abrasion, especially pronounced on the beach where the interplay of both these factors are at its peak (Andrady, 2011).

Also important are the oxidative characteristics in the atmosphere and hydrolytic properties of seawater (salinity) which profoundly affect the degradation rate of plastics. It is almost impossible to identify where these micro-plastics originated once they fragment into 'micro-plastics' or even 'nano-plastics'. At the same time, an emerging imperative is to measure the concentration of micro-plastics in food and other products such as sea salt. In fact, micro-plastic has been detected even in the traditional salt producing ponds in Indonesia (Tahir et al. 2018).

A study by Ghent University in 2017 reveals how plastic travels through seafood to humans, with shellfish consumers eating up to 11,000 plastic fragments in their food each year (Smillie, 2017). Multiple mackerel, anchovies, mullets and croakers were discovered to have ingested small pieces of plastic which end up inside the humans eating them.

In another study, scientists have discovered micro-plastics in seals, marine top predators, which most likely came through the fish it feeds on (Nelms et al., 2018). Experts opine that the "risk assessment of micro-plastics in foodstuff is still at a very

To fully comprehend plastic waste in the oceans a matrix of interlinked factors needs to be analysed, such as population or important urban centers along the coast, rivers and waterways leading into the oceans, the country's waste management regulations and strategies, dumping grounds along the coast and extent of plastic litter.

early stage and very few studies on the monitoring of micro-plastics in foodstuff and their effects on human health are available" (Rainieri and Barranco, 2019). Although an increased interest in micro-plastics in marine environments is seen, there is little understanding of how the entire functioning of the marine ecosystem is likely to be impacted [D'Alessandro et al, 2018].

Section 2

The Indo-Pacific Region

The Indo-Pacific or alternatively known as the Indo-West Pacific is both a biogeographic region, as well as an economic one, especially with its rising geostrategic importance. It comprises primarily the tropical Indian Ocean and the western and central Pacific Ocean, including the many seas that connect the two. The region encompasses three marine realms - the Western, Central and Eastern Indo-Pacific, comprising 78 eco-regions [Buonocore et al., 2020]. The oceanic space extends from the Horn of Africa, through the Arabian Sea, the Bay of Bengal, the Indonesian archipelago up to the volcanic islands of the central Pacific holds within it a gamut of nations that are included or excluded based on specific strategic goals and preferences (Spalding et al., 2007).

To fully comprehend plastic waste in the oceans a matrix of interlinked factors needs to be analysed, such as population or important urban centers along the coast, rivers and waterways leading into the oceans, the country's waste management regulations and strategies, dumping grounds along the coast and extent of plastic litter. However, it is pertinent to reiterate that plastic waste enters the oceanic waters when it is poorly managed. It is true that many countries lack the capacity to process plastic waste, even when the waste is collected. However, not all of the plastic waste the world generates is at high risk of entering the oceans—for many countries the plastic waste which does end up in the ocean is very small. In fact, many countries across Europe and North America have high rates of per capita plastic generation, yet their contribution to MPW at risk of polluting the ocean is significantly low.

Pathways of Plastic Pollution

Over the last decade, there has been an increased understanding of how plastic pollution needs to be scientifically assessed over national

and international waters (Haward, 2018 and Pauna et al., 2019). Although huge quantities of plastic waste generated globally is astounding, it is important to understand exactly how much reaches the marine environment through myriad pathways.

Plastics enter the marine ecosystems as primary plastics that are released directly and termed as mega or macro plastic debris. It can also enter as secondary plastics i.e. larger fragments of plastics debris, due to different forces acting upon it, breaking it down into tiny plastic bits. Studies have documented that only a small fraction of lightweight larger plastics float on the surface of the oceans, while the remaining high-density plastic sinks into the benthic environment of the ocean (Fig 2). Also, the biodegradability of plastics determines their fate and destination in the respective environment. The open oceans now have islands of plastic that have accumulated in swirling gyres (Abdulraheem, 2021).

In the Indo-Pacific region, one of the worst affected areas is in Indonesia, where seafloor debris of up to 690,000 per square kilometers, has been recorded. In Ambon Bay (eastern Indonesia), floating debris has been estimated to be greater than 4000 items per square kilometers (Worldwatch Report 174, 2007-20). The missing Malaysian Airline 370 in 2014 made ocean trash the global headline when rescue aircrafts spotted a large amount of litter floating in the Indian Ocean, including a huge garbage patch, spread over 5 million square kilometers with no clear boundary (Parker, 2021). The Indian Ocean garbage patch is centered roughly halfway between Africa and Australia with the contents circulating in what is known as the Indian Ocean gyre. In an alarming report, the Ellen MacArthur Foundation (2016) notes that there will be more plastic in the oceans, by weight, as compared to fish in 2050, if things continue the way it is.

The pathways of the plastic waste entering the oceans have been analysed by Schmidt, Krauth, and Wagner (2017) using two models (Almroth and Eggert, 2019). One model suggests that marine plastics are exported through rivers from the land bringing with them plastic debris. For instance, there are eight large rivers in Asia (and several smaller ones) that drain into the adjoining seas in the south, southeast and west Indo-Pacific region. Emanating from the Himalayas and washing over fertile plains that support huge populations, these rivers' peak discharge is around June–July primarily because of heavy monsoon rainfall over the South and Southeast Asia during these months. These are also the areas that exhibit a high degree of MPW. The argument is further bolstered by the findings of Jenna R. Jambeck and her colleagues (2015) who add that rivers are perhaps the single major source of MPW and estimate that more than 50 per cent of marine plastic waste emanates from MPW in five East Asian countries.

The other pathway proposed is that of stormwater runoff, wind dispersal, and littering. These pathways, the scientists opine, are significant and bring in a substantial share of plastic waste into the marine environment. Although the plastic exported through rivers seems to be better analysed, emerging studies are also focusing on how plastics are finding their way into the marine environment through extreme event pathways. The plastic accumulation rate in the ocean is understood to be enhanced from land-based sources with increasing extreme climatic conditions such as storms, hurricanes, and flooding (Thompson et al. 2005). A marine water sample collected during storm conditions in California showed a six-fold higher micro-plastic debris density as compared to normal situations (Thompson et al., 2002). The level of coastal debris and beach litter was lower in the wet season compared to the dry season in beaches such as Angsila, along the eastern coast of Thailand, due to the dragging of coastal debris into the offshore or deep-sea region by strong monsoon during the rainy season (Thushari et al., 2017). In a more recent study, the western coastal water of Sri Lanka recorded a mean density of plastic of around 140.3 items by number per meter cube of oceanic water during August–November 2017 (end of south-west monsoon), mainly due to tourism and fishing activities (Athawuda et al., 2018). Also, as per a study [NOAA, 2021], the 2011Japan earthquake and the resulting Tsunami pulled out an estimated 5 MT of debris, sections of which occasionally appear on the Pacific shores of the USA and Canada.

Section 3

Indo-Pacific Outlook and MPW

The Indo-Pacific discourse began in 2006 against the backdrop of strengthening India-Japan political ties on strategic and maritime cooperation. Japan sought an enhanced maritime security role in the Indian Ocean region through cooperation with India (Khurana, 2017). In 2007, Japanese Prime Minister Shinzo Abe further strengthened the argument by addressing the Indian Parliament, speaking of the "confluence of the Indian and Pacific Oceans" as "the dynamic coupling as seas of freedom and of prosperity" in the "broader Asia". In 2010, the US officially mentioned the ‘Indo-Pacific’ for the first time when the US Secretary of State Hillary Clinton spoke about “expanding our work with the Indian Navy in the Pacific because we understand how important the Indo-Pacific basin is to global trade

In recent years, MPW and the health of the oceans are gaining prominence. Statements from political leaders and high-profile officials in international meetings spotlighted ocean plastics pollution.

and commerce". In 2013, Australia released its Defence White Paper, which carried the first government articulation of the 'Indo-Pacific' concept, which marked Australia's eastward orientation.

The issue of MPW and marine plastics in this diverse and unique Indo-Pacific region, therefore, needs to be addressed through various international fora with agendas that are intertwined with various allied concerns in order to synergise targets and achieve environmental milestones. There are various overarching international conventions that have been adopted by the global communities, including India and several other Indo-Pacific nations, especially those in the ASEAN region. They are focused on preventing and restricting the deliberate or accidental release of litter into the sea or ocean and regulating the export of plastic waste to countries where more labour-intensive, low-tech treatment processes are widespread.

Significant among these include the 1982 United Nations Convention on the Law of the Sea (UNCLOS), London Convention (1972), the MARPOL Convention and Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. London Convention bodies adopted a statement on 'Recommendation to Encourage Action to Combat Marine Litter' and carry out various initiatives on plastics. The standards developed under the London Convention are implemented under the1982 UNCLOS. Regarding plastic pollution from vessels and ships, the International Maritime Organisation (IMO) regulates the discharges of garbage from ships in the context of the MARPOL Convention.

In recent years, MPW and the health of the oceans are gaining prominence. Statements from political leaders and high-profile officials in international meetings spotlighted ocean plastics pollution. The United Nations Environment Assembly has adopted a series of resolutions concerning marine plastic pollution and micro-plastics beginning with its first session (UNEA-1) in 2014. The primary aim is to establish a comprehensive and strong global governance structure. Although these resolutions and decisions are not legally binding on members, yet these help guide international policy-making and setting priorities in the marine plastic issue (Garcia et al., 2019).

In February 2021, UN Member States gathered virtually for the Fifth Session of the UN Environment Assembly (UNEA-5). As part of the Science-Policy-Business Forum, the event "Managing Risk: Marine Litter and Micro-plastics Mitigation and Prevention" addressed the policy actions needed and the role of innovation, technology and finance to significantly reduce marine pollution by 2025, as envisaged by the Sustainable Development Goals. The UNEA-5 released the Global Partnership on Marine Litter Digital

Platform to facilitate coordination of multi-stakeholder action towards the long-term elimination, through a life-cycle approach, of discharges of litter and micro-plastics into the oceans using AI capabilities, data mapping and layered functionalities including match-making.

In 2018, leaders from Canada, France, Germany, Italy and the United Kingdom took a pledge in Charlevoix, Canada to combat ocean pollution through the Group of Seven (G7) Ocean Plastics Charter. This substantively strengthened the need to address the problem. The 2021 meeting at the British seaside resort of Cornwall brought together the leaders of Canada, France, Germany, Italy, Japan, the UK and the US, while India, Australia, South Korea and South Africa (countries from the Indo-Pacific regions) joined selected sessions as guest countries. The 2021 G7 statement released after the meeting, presents a continuum of the Charter. The United Kingdom has endorsed the Ocean Plastics Charter in 2018, has allocated 500 million GBP from its Blue Planet Fund to support countries including Ghana, Indonesia and Pacific island states to reduce marine pollution (Brown, 2021). Canada has been spearheading the Oceans Plastics Charter since its G7 Presidency in 2018. The European Union, France, Germany and Italy have all endorsed the Ocean Plastics Charter. Japan too has committed to making the Osaka Blue Ocean Vision universal, which includes the G20 Implementation Framework for Actions on Marine Plastic Litter.

India joined the G7 in affirming support for collective global '30by30' targets, which call for conserving 30 per cent of the country's land and 30 per cent of oceans by 2030. India has committed to achieving domestic land degradation neutrality and restoring 26 million hectares of degraded land by 2030. On biodiversity, India and South Africa, noting the importance of ocean protection, called for nations to act together.

Australia joined the G7 in the endeavour and committed 100 million USD to increase support for blue carbon initiatives and marine protection, also affirming its support towards the '30by30' targets. Republic of Korea too affirmed their support for collective global '30by30' targets by endorsing the High Ambition Coalition (HAC) for Nature and People. The HAC for Nature and People, which is co-chaired by Costa Rica, France and the United Kingdom, brings together over 50 governments

The ORRAA, is a multi-sector collaboration between governments, financial institutions, the insurance industry, environmental organisations and stakeholders from the Global South. Three nations from the Indo-Pacific region i.e. Japan, United States and India have joined Ocean Risk and Resilience Action Alliance (ORRAA) as observers.

from across six continents aiming to secure a global agreement to protect at least 30 per cent of the planet's land and at least 30 per cent of the planet's ocean by 2030 at the Convention on Biological Diversity COP15, which will be held in two phases—virtually in October 2021 and in-person in the April-May 2022 in Kunming, China.

It may also be noted that three nations from the Indo-Pacific region i.e. Japan, United States and India have joined Ocean Risk and Resilience Action Alliance (ORRAA) as observers. The ORRAA, is a multi-sector collaboration between governments, financial institutions, the insurance industry, environmental organisations and stakeholders from the Global South.

The G20 nations have highlighted marine plastic pollution as an important challenge, especially from the marine litter point of view. The vision document, 2021, also points out that the Covid-19 pandemic has led to an additional surge in production and consumption of masks, hand sanitizer bottles and protective equipment, primarily plastic (UNCTAD, 2020). The G20 nations culminated their 2017 action plan into the 'Osaka Blue Ocean Vision' (OBOV) in 2019 which aims to reduce additional pollution by marine plastic litter to zero by 2050 through a comprehensive life-cycle approach [G20 report, 2021]. As of July 2021, the number of countries and regions sharing the Osaka Blue Ocean Vision has risen to 87. Although several of these nations already have suitable legislations in place, on the ground the scale of implementation differs. For instance, Indonesia has a national action plan on marine debris management with five well laid out strategies to combat marine debris; yet it continues to be the worst marine plastic offender in the Indo-Pacific region. The report also highlights high MPW nations such as Sri Lanka having no national action plan on plastic waste management to date and mentions countries such as Myanmar that show no improvement due to the ongoing political unrest in the region.

At the heart of the Indo-Pacific region is the Association of Southeast Asian Nations (ASEAN) nations that have since 2017 attempted to cooperate regionally to reduce MPW. The 2017 ASEAN Conference on Reducing Marine Debris in the ASEAN Region highlighted the urgent need for the ASEAN countries to address the issue of marine plastics through regional cooperation to reduce and prevent land-based waste from entering the oceans. The Association very recently in May 2021 launched the ASEAN Regional Action Plan for Combating Marine Debris in the ASEAN Member States (2021-2025), which provides a scalable, solution-focused joint strategy to address marine plastic debris across the region. Adopted ahead of World Environment Day on June 5 and World Oceans Day on June 8, the Action Plan represents a milestone for ASEAN, signifying a renewed, bolder collective commitment through regional actions, aligned with national agendas towards tackling a critical

environmental challenge. There are also existing regional partnerships in the region including Partnerships in Environmental Management for the Seas of East Asia (PEMSEA), created to manage marine pollution and the Coordinating Body on the Seas of East Asia (COBSEA), with the Action Plan for the Protection and Development of the Marine Environment and Coastal Areas of the East Asian Seas Region.

Two of the high MPW generating nations in the Indo-Pacific region are China and India, both of which are represented through the association of emerging economies—Brazil, Russia, India, China, and South Africa (BRICS). In the recently concluded 7thmeeting (virtual) of the BRICS Environment Ministerial in August 2021, India reiterated BRICS significant role in addressing the contemporary global challenges of climate change, biodiversity loss, air pollution and marine plastic litter, building up to the upcoming COP 15 and COP 26 to be held in November 2021 in Glasgow, UK.

Way Forward

The Indo-Pacific region is a contiguous biogeographic region and holds within it several fault-lines. It produces the highest volume of MPW that find way into the oceans. Furthermore, climate change has led rise in extreme hydrological events, causing floods and storm surges that pull out plastic debris into the marine environment. High temperatures and strong sunlight also allow for the formation of micro-plastics with relative ease. It is imperative for Indo-Pacific countries to measure the extent of MPW that enters the environment. Despite the low per capita consumption of plastic in the region, concerns such aslarge population, dumping from developed nations, and poorly managed plastics, make the Indo-Pacific region vulnerable to a larger volume of MPW entering the environment.

It is true that there are significant improvements in curbing marine plastic pollution in many countries in the region; the efforts are disjointed and state-centric. For instance, the Bay of Bengal Large Marine Ecosystem (BOBLME, 2015) Project which forges a regional partnership in the Indian region, focuses largely on livelihoods and does not have much to offer towards sources, quantities in the environment, distribution, composition, or impacts of marine litter in the Bay of Bengal.

The South Asian Association for Regional Cooperation (SAARC) and the South Asia Cooperative Environment Programme (SACEP) are at best, raising awareness about plastic waste. In 2019 the SACEP and World Bank concluded a successful bi-lateral deliberation on formulating and implementing a 40 million USD regional project on ‘Plastic-free Rivers and Seas for South Asia’ (Petro Kapinga and Chung, 2020). However, these forums are yet to put forward action plans or vision documents for marine environments and their plastic

pollution in the region. On the other hand, ASEAN countries, as well as China and Japan, have a well-honed outlook for the near future. Indonesia, Sri Lanka, Maldives and Myanmar and many other east African nations still do not have a clear connection with the burgeoning problem of marine plastic pollution and micro-plastics.

There is, therefore, a need to cohesively build up the region by first linking the entire region from Africa to Japan. The key to forging this connection would be to initiate an Indo-Pacific Science Forum for low conflict programme initiation, much in the lines of the Antarctic Treaty. It is to be noted that at the peak of the Cold War, amidst extreme distrust and animosity, a treaty was designed that brought the needs of the global commons into focus. The Indo-Pacific region needs to focus on the health of the oceans and human safety to forge a pathway, reposing faith in science.

Science is the key and can address the much-needed knowledge gap that exists and help translate it into an Indo-Pacific Action Plan/Programme (IPAP) for mitigating marine plastic pollution. From scientific endeavours that build interdisciplinary capacities and develop specific technologies using artificial intelligence for monitoring debris, the role of IPAP can be further strengthened as a strategy centre to harmonize agreements beyond bilateral domains. The establishment of IPAP can be the second step towards controlling marine plastic pollution in the region. In the short term, however, a Bay of Bengal Marine Litter forum under the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) constituting seven member states-- Bangladesh, Bhutan, India, Nepal, Sri Lanka, Myanmar and Thailand, may be entrusted with the responsibility of monitoring and reporting marine debris.

In the broader sense, in the global context, the Indo-Pacific region seems to be poised for a shift in the balance of power with two of the world's largest economies- China and India- located within it. Therefore, there needs to be a holistic treatment of the region beyond regional and sub-regional partnerships that bring together an Indian-Pacific Ocean continuum. It would stand to reason then, that the fault lines are addressed through better science and more nuanced assessment of MPW and marine litter. This will indeed fulfill the overarching aim of preserving regional and global stability of the global commons.

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Chapter 3

Sustaining Fisheries in the midst of Overfishing and IUU Fishing

Yugraj Singh Yadava

Overfishing and IUU fishing are considered one of the biggest threats to the sustainability of marine fisheries worldwide. Even in debates in the WTO, these are the two important pillars, along with the third pillar of overcapacity. The fish stocks which are within biologically sustainable levels, the decrease has been alarming from 90 percent, recorded in 1974 to 65.8 percent in 2017. And the sustainable stocks at sustainable levels today are roughly 66 percent. For the period 2000 to 2003, the average annual estimate of IUU fishing is between US$ 10- 23.5 billion, representing between 11 and 26 million tonnes and in the case of Indian Ocean, it is between US$ 627 million to US$ 1378 million (0.7 TO 1.5 million tones; Agnew et al. dated 2009).

Ironically, IUU fishing is almost close to the fish produced or harvested by the developed countries and it is several times more than the fish harvested by the least developed countries. This is an indicator of the magnitude of the IUU fishing worldwide. Recent estimates of overfishing and IUU fishing indicate that in 2018, at the national level, 24 percent marine fish stocks in India had collapsed, and 16 percent were over-exploited. In the context of the Indo-Pacific, in Australia, 20.3 percent stocks collapsed, and 40.6 percent were over-exploited. And in Indonesia25 percent were collapsed, and 24 percent were over-exploited in the Indian Ocean Exclusive Economic Zone alone.

A recent study by FAO and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) reported that the estimated illegal fish landings are high. The Asia-Pacific Fisheries Commission, which is an Article 14 body of the Food and Agriculture Organization, states that excluding South China Sea, 6.6 million tonnes in 2019, with a value of USD23.3 billion were reported as illegal fish landings. The study reported that while IUU fishing is prevalent throughout the region, the concentration is around Arafura-Timor Sea, Banda Sea, Savu Sea, Gulf of Thailand and the Bay of Bengal. Overfishing and IUU fishing is not only causing extensive ecological distress, but it also siphon wealth from nations and small fishers.

In a World Bank Study (The Sunken Billions), the lost economic benefits from poor management of the resources that inter alia include overfishing and IUU practices are estimated to be of the order of US$50 billion annually. During 1974 to 2007, the cumulative global loss of potential

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economic benefit was in the order of USD 2 trillion, which is a huge figure. The losses represent the differences between the potential and actual net economic benefits from global marine fisheries. At micro-level, overfishing and IUU fishing reduces the fish available for the Artisanal and Small-Scale Fishers (A&SSF).It forces the A&SSF to invest more, often through credit, and ultimately the cost of operation also goes up.

The proximate cause of overfishing and IUU fishing can be traced to management failure. However, the root cause could be on over-emphasis on production. It has been examined as the proximate cause as also the root cause. The proximate cause of overfishing and IUU fishing can be traced to management failure, but the root cause which is more important is on overemphasis on production. The fish production system in vogue is a mass production system and fishing at all levels, whether it is the industrial fishing or the artisanal has become highly efficient. While it is agreed that there are limits to fishery, general tendency is to pass the buck, and the bottom line here is that ecological, economic, social and institutional dimensions are often neglected, which ultimately leads to both overfishing and IUU fishing.

As far as the livelihood argument is concerned, it is worth stating that investment in a production centric system is often justified with 'livelihood for the poor' argument, especially in the case of A&SSF. In

The fish production system in vogue is a mass production system and fishing at all levels, whether it is the industrial fishing or the artisanal has become highly efficient.

the Asia and the Pacific region, the artisanal and small-scale fishers constitute the dominant segment, which demands consideration in terms of their livelihood. However the unconstrained increase of A&SSF can lead to low level equilibrium trap where small-scale fishers are forced to invest their surplus in improving the production system to maintain the status quo. This is an example of the low-level equilibrium trap.

For example, in the Indian marine fisheries, the production has increased from 2.29 million tonnes to 3.56 million tonnes in the last 14 years from 2005 to 2019. However, the substantial changes in real variables i.e. education, employment, housing, in terms of the small-scale and artisanal fishers is not very impressive.

The BOBP-IGO advises, moving from production centrism to value centrism, and here it is in reference to the Sustainable Development Goals (SDGs).The SDG 14 cannot be achieved without SDG 12 which is responsible production and consumption.

In a value centric model, the focus is on appropriation of full value of the catch by reducing wastage and promoting value addition. A value centric management comes from moving from management to

governance, where all stakeholders work together to upgrade the value chain. At the BOBP-IGO, to substantiate the hypothesis from volume to value, a pilot project was carried out in Puducherry. Twenty gill netting fisher folk were encouraged to move to tuna hand lining which is a highly selective and a boutique fishing method. These 20 fisher folks were linked with a woman small-scale processor named Anita and her organization with brand name Aurofish, and they were connected to Anita to cater to Puducherry domestic market. The branding was fresh, unspoiled tuna, and the result was that change in technology from gill net to handlining changed and provided nearly double the price for the fisherman. It reduced their production, which was also leading to sustainability of the resources.

CONCLUSION

It is important that we advocate an ecosystem approach to fisheries management, which can sustain fisheries and which pivots on three elements i.e. ecological well-being; human well-being; and effective governance.

The ecosystem approach to fisheries management largely meets our needs, and requires sustainable fishing. A step from production-centric to value-centric approach can bring the change even in a shorter time-frame. As regards IUU fishing, it is a highly complex issue that needs to be tackled at the national front through an effective monitoring, control and surveillance (MCS) system. At the regional and global levels, a cooperative approach, including immediate neighbours and also the distant water fishing nations, is a promising route.

Chapter 4

Recent Developments in Blue Economy Financing
An Overview

V N Attri

Introduction

A growing literature on global, regional and national levels regarding financing of Blue Economy as discussed in U. Rashid Sumaila & et al (June, 2021) "Financing a sustainable ocean economy" the oceans are inevitably for human wellbeing. It also regulates climate and provides vital support to the Earth system and livelihoods. A healthy ocean is needed for a sustainable ocean economy which requires adequate finance. Furthermore, Green Finance Platform (2012-2021) provide sector wise, country wise, theme and initiative wise data and other information on Green Finance which is also increasingly being discussed in Blue Economy as evidenced in E.U's Blue Economy Report (2021) in chapter 3 entitled "The European Green Deal (EGD) and The Circular Economy".

The EGD is a new growth strategy that seeks to transform the EU into a prosperous society, with a modern resource efficient and competitive economy where economic growth is decoupled from resource use in the Blue economy finance for ocean resilience solutions (UNEP, 2021). There seems to be a growing interest from financial institutions and private businesses to invest in the innovation and technology required to develop a healthy ocean economy in according with the social, economic and environmental criteria. A vibrant blue economy is feasible through collaborations at regional and global level. A theoretical and an empirical investigation of the efficacy of trade to optimize the use of oceanic natural resources needs to be undertaken. Blue economy is required to be integrated with trade patterns, emerging as a consequence of "new emerging ocean industries".

Attri V.N. (2018 Nov. 27)[1] New and Emerging Investment opportunities under sustainable blue economy conference. Hoegh Guldberg O. (2020) de Vos, K. D. Hart, B. (2020); UNEP (2020); ADB (2020).

The European Union (EU) established a High-level expert group on sustainable finance (HLEG) on 28thOctober, 2016; and HLEG (December 2016). The group focused is three issues:

1 Mark Spalding President, The ocean foundation, Research Blue Economy global key note at the forum on Ocean, Seas and Opportunities for Sustainable development, 9th October, 2019.

The EGD is a new growth strategy that seeks to transform the EU into a prosperous society, with a modern resource efficient and competitive economy where economic growth is decoupled from resource use in the Blue economy finance for ocean resilience solutions

- (a) Steer the flow of Public and private capital towards sustainable investment.
- (b) Identify the steps that financial institutions and supervisors should take to protect the stability of the financial system from risks related to the environment.
- (c) Deploy these policies on pan European scale.

This reveals that the sustainability consideration of the Blue Economy need to be an integral part of the financial policy in EU or in the any other regional groupings.

The broad objective to the Chapter is to provide an overview with critical inputs whenever necessary on the recent development in Blue Economy financing at global, regional and national levels. This has been the tone both in theoretical as well as practical awakening among the policymakers, corporate sectors and markets about the sustainability and Sustainable Development Goals (SDGs) through innovative blue financing instruments and the blue initiatives being under taken by the United Nations and other institutional organisational.

The chapter has been divided into five sections. Section I deals with Sustainable Blue Economy and Blue Financing: Theory and Practice - Emerging Convergence Trends; Section II is devoted to Sustainable and Unsustainable Finance. In Section III the Role of Financial Sector in Blue Economy is discussed; Section IV provides case studies of regional cooperation groupings/ individual countries in Blue Financing; and Section V presents major conclusions and policy implications policies.

Section I

Sustainable Blue Economy And Blue Financing: Theory And Practice - Emerging Convergence Trends

Theoretical contributions to Sustainable Financing:

In Economics, there are 7 top theories of profits, namely (i) Rent Theory of Profits; (ii) Wage Theory of Profits; (iii) Risk Theory of Profits; (iv) Dynamic Theory of Profits; (v) Schumpeter's Innovation Theory; (vi) Uncertainty Bearing Theory of Profits; and (vi) Marginal productivity Theory of profits. These theories have been criticized; and none of the above theories explain "Profits" determination adequately.

However, significant contributions have been made during 2011 to 2021 to link the businesses, markets, environment and sustainability. The prominent among them are:(i) Jennifer B. Hilton's 11th Feb, 2012, Relationship to Profit: A Theory of Business, Markets, Ecological Economics, Stockholm University, Sweden, (11 February 2021) - A Ph.D. thesis for Economics and Sustainability Science. The thesis offers on explanation of how key institutional elements of business and

markets drive social and ecological sustainable outcomes. Profit and non-profit business, and profit as a means and not an end; C Wicks' Sustainable Business and Management Theories (2012); (ii) J. Horisch's Applying Stakeholder Theory in Sustainability (2014); (iii) MC de Costa Tavares : Theoretical Perspectives on Sustainability Reporting (2018); (iv) S. Kantabutra's Achieving Corporate Sustainability: Toward a Practical Theory (2019); and (v) T. F. Slaper : The Triple Bottom Line: What is it and how does it work?; and Principles of Sustainable Business Model (2011).

These developments in theory do indicate the fact that attempts are being made to ensure that sustainable development, sustainable blue economy and sustainable blue financing are converging with each other to achieve the UN SDGs by 2030; though it is a challenging task.

Asian Development Bank Institute (ADBI) in collaboration with the Australian National Centre for Ocean Resources and Security, University of Wollongong, and Ocean Policy Research Institute Saskawa Peace Foundation and Ocean Affairs council hosted a virtual conference on "Blue Economy and Blue Finance: Towards Sustainable Development and Ocean Governance" on 10-11 November, 2020 to examine policy actions that promote sustainable ocean and coastal development and management, assessing the blue economy and ways to enhance its sustainable growth potential in development of Asia and the Pacific; and exchange experiences and best practices on sustainable ocean development and management. The focus of the conference was on Blue Economy and Blue Finance including risk management, governance, planning etc. In addition, to this innovative ocean financing schemes as well as strategies for mitigating the impacts of climate change and unsustainable practices on communities that depend on healthy ocean and coastal ecosystems.

Markets and policy makers are finally waking up to the challenges and opportunities of protecting marine ecosystem, while simultaneously promoting sustainable development. The world's oceans have been overexploited for a long time, to what economists call the tragedy of commons. "The comparative lack of blue investment'' so far may create interesting possibilities for investors willing up to use their capital and influence for positive change'' out of the 17 UN SDGs, oceans have attracted some of the lowest amounts of private capital so far. It is believed that the comparative lack of "blue investment'' until now could create very interesting possibilities for asset managers willing to focus their capital and influence on making positive change.

According to high level panel for sustainable ocean economy recommends the blending of economic development and environmental protection by focusing on 'three Ps' of effective protection

Markets and policy makers are finally waking up to the challenges and opportunities of protecting marine ecosystem, while simultaneously promoting sustainable development.

sustainable production and equitable prosperity. This approach implies proactively managing human activities to use the ocean wisely rather than using it up. The five key transformations across ocean wealth, equity, knowledge and finance, their actions could by 2050, leads to a 40-fold increase in ocean renewable energy 20 percent of necessary emissions reductions, 6 times more sustainable food, US$ 15.5 trillion in net benefits from investment, 12 million new jobs and restored habitats and bio-diversity.

Section II

Sustainable and Unsustainable Finance

Sustainable finance is about joint approach to the development of financial services that integrate the Environmental, Social and Governance (ESG) dimensions across market practices products and policy frame. It involves reallocating large scale investments to close the sustainable financing gap. Sustainable finance leads to improve the contribution of finance to sustainable and inclusive growth as well as mitigation of climate change.

In brief, it is the finance to support economic growth, while reducing pressures on environment and taking into account social and governance aspects, ensuring transparency on risks related to ESG factors that may impact the financial system. The mitigation of such risks through the appropriate governance of financial and corporate people. E.U established a High Level Expert Group (HLEG) on sustainable finance on 28th October, 2016. The group focused on three issues:

- Steer the flow of public and private capital towards sustainable investment.
- Identify steps that financial institutions and supervisors should take to project the stability of the financial system form risk related to the environment.
- Deploy policies on pan-European scale.

This reveals that sustainability consideration of Blue Economy need to be an integral part of its financial policy in EU or any other regional groupings.

Sustainable Ocean Finance

In 2017 and 2018, the European Commission, World Wildlife Fund (WWF), the World Resources Institute and the European Investment Bank framed and recommended their

adoption and implementation by the finance community. These principles intend to focus on:

- Promote the implementation of the SDGs, in particular the Goal 14 (Life below water).
- Set out ocean specific standards while avoiding to duplicate existing frameworks for responsible investment.
- Comply with the performance standards and EIB environmental and social principle and standards;

Unsustainable Finance in the Blue Economy

Blue Economy offers opportunities for sustainable economic development. The challenge of climate change is coming from marine pollution and unsustainable resources use on illicit activities. The Blue Economy covers a range of traditional and emerging sectors that are essential sources of food, energy, health and leisure for people throughout the world. It is growing fast and attracting investment worldwide. However, businesses often remain unsustainable. Illegal fishing, excessive tourism, pollution from shipping and poorly designed port activities, are examples that threaten marine eco-systems and jeopardize the biodiversity that is essential to the prosperity of the planet. By 2030, one third of investments in the Blue Economy could be unsustainable – i.e., at least 250 billion Euros invested in activities harmful to the oceans and ultimately the planet. Why is money flowing into damaging activities?

This study found many reasons, including a focus on short-term profits, inadequate impact assessments, weak regulatory frameworks and businesses' inability to attract impact investments. How can investments worldwide shift to activities that preserve the ocean and ensure long term prosperity? While development banks are leading the change, they alone are unable to make significant changes. All financial players should be involved, including private equity funds, impact investors and policymakers. A sustainable blue economy is a global challenge that requires swift and coordinated global action. With this in mind, this report includes insights and recommendations for policymakers and investors.

The origins of the Blue Economy concept can be traced back to the 2012 UN Rio+ conference and the report on 'Green Economy in a Blue World'. Building on a growing global consensus on the socio-economic relevance of the concept and its related activities, the term Ocean Economy was more recently adopted by international bodies such

The origins of the Blue Economy concept can be traced back to the 2012 UN Rio+ conference and the report on 'Green Economy in a Blue World'.

as the Organization for Economic Co-operation and Development (OECD), United Nations (UN)4 and World Bank. While the term Ocean Economy often implies a focus on 'in-water' activities, both 'fresh water' and 'inland-water' should also be addressed as essential dimensions of the sector – especially when assessing the financing of sustainable Blue Economy in developing and emerging economies globally.

The concept of Blue Economy as defined by the EU is adopted as the basis for this chapter, as it allows for the inclusion of relevant inland, port, and river/water human-related activities when assessing the sustainability of Blue Economy investments. This definition recognises the relevance of some more 'traditionally' established economic activities to the blue economy, such as extraction and commercialization of marine living resources, shipping and maritime transport, ports activities, shipbuilding and repairs, coastal and maritime coastal tourism, etc. Further, the definition also encompasses a number of emerging but equally relevant innovative activities, such as offshore energy (wind and ocean energy), blue biotechnology, desalination, etc. defined as "finance to support economic growth while reducing pressures on the environment and taking into account social and governance aspects. Sustainable finance also encompasses transparency on risks related to ESG factors that may impact the financial system, and the mitigation of such risks through the appropriate governance of financial and corporate actors."

In line with such an approach, this chapter considers unsustainable financing as any financing practice (public and private) that is inconsistent with international sustainable financing standards (where ESG factors are taken into account) and global definitions of a sustainable financing taxonomy.

These aspects are particularly complex given the many and diverse sectors that comprise the Ocean Economy, and the fact that sustainability can mean very different things within each. Importantly, the concept also includes several ecosystem services that are essential to secure, protect and respect coastal and marine ecosystems (i.e. the natural capital) and related policy activities (maritime spatial planning, ocean governance, maritime surveillance, safety and security, etc.) Beyond these, ecosystem services are essential assets for other blue economy activities to flourish and also a potential source of economic and financial returns on their own. Overall, they can contribute towards a healthy planet and human well-being.

Criteria for a sustainable Blue Economy have been elaborated in a parallel study on 'Sustainability Criteria for the Blue Economy', an EU supported study for a blue economy development framework.

Sustainable Finance vs. Unsustainable Financing

The ocean resources need to be used sustainably to make optimum use of marine and coastal resources. For that we must be able to distinguish between sustainable and unsustainable finance.

Unsustainable Finance

Any financial practice (Public and Private) that is inconsistent with international sustainable financing standards-focusing on ESG factors and global definitions of a sustainable financing taxonomy. The unsustainable finance practice (Public and Private) under pinning Blue Economy activities are:

- Results in local negative impacts therefore destroying valuable natural, human, social or physical capital;
- Is unable to sustain positive returns overtime for current and future generations;
- Does not allow for the development of local capacity towards financial independency of supported practices;

Further, some more examples are illustrated to fully understand unsustainable financing. Although certain activities are unquestionably unsustainable, for example intrusive deep-sea mining and/or natural resources and minerals extraction, the approach proposed in this study deliberately focuses on the financing practice itself rather than the type of activities which are financed. The rationale behind this approach is driven by a belief that it can help identify remedies and potentially steer a greater volume of public and private resources towards fully sustainable investments.

There is an ongoing effort in the definition of a common taxonomy for sustainable investments. We believe that our approach avoids any duplication of efforts and builds on the results of the process. For a specific analysis of the indicators to be selected in assessing the sustainability of the different blue economy activities, the reader can refer to the parallel study on 'Sustainability criteria for the Blue Economy' supported by the European Commission, and to the broader discussion currently ongoing with respect to the blue economy in the context of the EU assessment of a sustainable taxonomy.

Another important consequence of the approach adopted in this study is that tradeoffs amongst impacts of financing practices (intended and unintended) should always be assessed in order to maximize overall benefits. In the case of unsustainable financing, such trade-offs may tend to favor direct financial returns to investors over broader environmental and societal benefits (or damages).

Investments in oil and gas operations, for example, may emphasize certain economic and social returns (e.g.

access to energy and heating for a country) while disregarding relevant additional consequences (e.g. impact on marine ecosystems and/or local communities affected by the financed activities). By the same token, investments in touristic / cruising operations may benefit economic returns while neglecting social or environmental externalities. Apart from deliberate criminal activities, such trade-offs might be the result of suboptimal decisions resulting from limited information on the operations, which may prevent investors from financing activities with uncertain results and high financial risks.

The expected timeframe of the returns foreseen from the investments made (short-term vs. long-term) are also an essential element of sustainability. Despite the presence of positive impacts in the short-term, unsustainable financing may imply a lack of assessment of the longer-term impacts of the investment being made. Even if short-term impacts are positive, these may be neutralized by negative longer-term impacts, resulting in structural concerns for the affected communities and ecosystems. For example, investment in renewable marine energy may not consider the management/ deterioration of infrastructure through time, with substantial longer term impacts for the ecosystem in which they operate. Similarly, while aquaculture practices may provide positive short-term returns (e.g. jobs and local revenues), if investments are not well designed, polluting chemicals may spill out over time and destroy nearby ecosystems (with negative impacts on the environment, local fisheries and local communities). Similar examples can be shown for other maritime activities.

Unsustainable practices (financial returns for investors achieved while supporting locally harmful practices), which may range from intended and particularly harmful (black) investments (e.g. practices explicitly infringing human rights and destroying local communities and ecosystems), to unintended and less harmful, but still negative, (grey) investments (e.g. where negative effects are the result of a lack of full analysis and/or mismanagement).

Missed opportunities (neglected local investment needs, assessed as unprofitable for investors) are the result of failing to acknowledge and address the specific financing needs of the sector i.e.:

- Diversify existing value chains through new products / services that appeal to ever-changing demand;
- Adopt smart technologies (infrastructure) to reduce environmental impacts and address climate change;
- Promote innovative business models that capture high economic value while respecting local assets;
- Foster the adoption of innovative circular blue economy practices towards zero waste;

- Support talent and provide organizational approaches that encourage constant innovation and learning;
- Promote local, regional and global practices (clusters, accelerators, etc.) that address new ideas and needs;
- Preserve ecosystems while accessing valuable ecosystem services.

Section III

Role of Financial Sector in Blue Economy

Banks, insurers and investors have a crucial role to play in the transition towards a sustainable Blue Economy (SBE). To help guide them, the European Commission, European Investment Bank, WWF and the World Resources Institute launched the Sustainable Blue Economy Finance Principles in 2018.

Building on the momentum of these principles, the United Nations Environment Programme Finance Initiative (UNEP FI) hosts the Sustainable Blue Economy Finance Initiative (SBEFI), a new platform bringing together financial institutions to work with scientists, corporates and civil society to facilitate the adoption and implementation of the Sustainable Blue Economy Finance Principles, ensuring they become operational and useful for financial institutions worldwide. The SBEFI seeks to achieve the following:

- Positively influence mainstream ocean-related investment, insurance and lending to drive development that underpins a sustainable blue economy;
- Catalyse finance sector engagement and practical action to deliver a sustainable blue economy and support the ambitions of SDG14 (Life Below Water);
- Develop concrete actions and outputs for insurers, lenders and investors to align lending, insurance and investment decisions with ocean health;

To support the work of the SBEFI, a clarity around the state of financing for the sustainable blue economy, it is essential to define the concept of SBE finance and providing an overview of its current status. It seeks to provide insight into the transition required to realise financing for the SBE across the five key sectors that form the basis of the SBEFI's initial focus:

- Seafood (including fisheries and aquaculture);
- Maritime transportation;
- Port development;
- Coastal and marine tourism;
- Marine renewable energy.

The report maps the current SBE financing landscape, highlighting existing initiatives and resources and identifying some of the key players and initiatives working alongside UNEP FI to build up financing for the sustainable blue economy. Crucially, it also considers some of the gaps

in current focus where greater attention may be worthwhile. This leads into a discussion on needs and opportunities, examining where financial institutions and other stakeholders may play beneficial roles in financing the sustainable blue economy

The report provides five recommendations on the basis of its analysis which are very important in strengthening the structure of blue financing globally as well as at regional and national levels. The recommendations are given below:

- *Wherever possible, leverage existing guidance, standards and best practice for sustainability at the Sectoral level*. For several of the sectors covered in this report, substantial efforts have been made to codify best practice for sustainability with considerable uptake by industry. For example, the Global Sustainable Tourism Council (GSTC) standards and Poseidon Principles for maritime transportation have parameterised sustainability on a number of key topics already. While the guidance being developed for the sustainable blue economy will target financial institutions rather than sector-specific businesses, there nevertheless exist legitimate benchmarks for best practice which, wherever possible, guidance should refer back to or take into account.
- *Complement and expand, rather than duplicate, existing and planned guidance directed towards financial institutions*. In addition to sector-specific sustainability guidance, this report highlights a number of existing and planned initiatives for sustainability guidance directed towards financial institutions, though generally not specifically focused on the blue economy. Nevertheless, guidance should

	General finance initia-tives		Specific finance initiatives					MDB initiatives			Knowledge and research initiatives						UNEP FI SBE	
Area of focus	EU taxonomy	TCFD	ORRAA	CPIC	BNCFF	GERF	CC	ADB ocean	WB PROBLUE	EIB Blue SOS	Planet Tracker	GOAP	UNGC	SO4A	HLP	FOA		Total
Building understanding																		
Defining concepts and framing the issue	x		x	x	x	x	x	x	x			x	x		x	x	x	13
Policy frameworks and enabling conditions			x		x	x	x	x	x	x			x	x	x	x	x	12
Data analysis and measurement		x				x					x	x		x		x		6
Campaigning and/or engagement			x				x				x		x		x	x	x	7
Tools for the financial industry																		
Concessional financing and seed investment			x		x	x		x	x	x								6
De-risking			x	x	x	x		x										5
Replication			x	x														2
Scaling					x													1
Principles/standards	x	x						x				x	x				x	6
Disclosure and reporting		x						x			x	x		x			x	6
Primary ocean focus			x		x	x		x	x	x		x		x			x	9

Adopted from Rising Tide: Mapping Ocean Finance for a New Decade UNEP, 2021

aim to complement these existing resources, in particular the Taskforce on Climate-related Financial Disclosures (TCFD)'s work on climate-related risks, and wherever possible endeavour to ensure compatibility with forthcoming key resources such as the EU Taxonomy and Taskforce on Nature-related Financial Disclosures (TNFD).

- *Guidance should be applicable across financial instruments as well as to a wide range of financial institutions*. As evidenced by the survey results, financing for the sustainable blue economy operates through a variety of instruments. Guidance to direct financing towards the SBE should therefore be flexible enough to accommodate this variety of financial instruments as well as the range of capital providers.
- *Guidance should be applicable across a broad range of regional circumstances*. The conditions and contexts that the development of different sectors face will vary significantly by the market within which they operate. Some of these will be particularly advanced in comparison to others, both in the maturity of the sector itself as well as the maturity of applicable sustainability regulations and benchmarks. The guidance should be universal in its application, yet able to earmark where geographic/ market-specific distinctions in approach and best practice are relevant for financial institutions to consider.
- *Include financial institutions and other stakeholders in the development and refinement of the guidance*. It is clear from the insights gained through the survey that financial institutions can offer valuable perspectives and data into the state of the SBE market and their understanding of its risks and trends. In order to ensure broad buy-in and adoption of the SBE guidance by financial institutions, it will be crucial to include their perspectives and review of the guidance from the outset to create a resource that is helpful and practical.

Further, "United Nation: The sustainable Blue Economy Finance" principles are the foundational key stone to in rest in the ocean economy world's first global guiding framework finance a sustainable blue economy. Risk aware inclusive transparent, partnering.[2]

It is well established that the ocean is a vital driver of planetary systems, a source of economic activity, livelihoods and food security. The Intergovernmental Panel on Climate Change (IPCC)'s 2019 special report on the ocean and cryosphere in a changing climate states:

- "In addition to their role within the climate system, such as the uptake and redistribution of

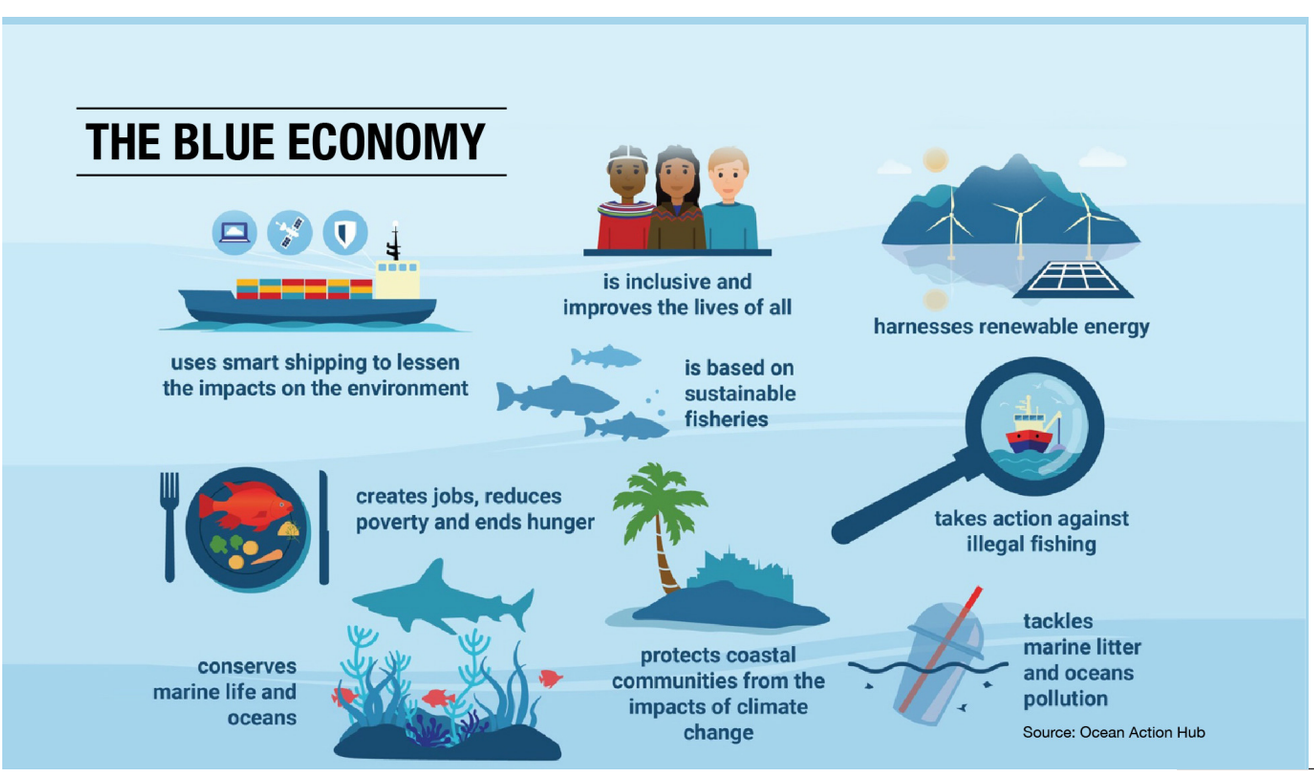
2 UN's Sustainable Blue Finance initative: Mobilising Capital for a sustainable ocean, 2018.

natural and anthropogenic carbon dioxide (CO2) and heat, as well as ecosystem support, services provided to people by the ocean and/or cryosphere include food and water supply, renewable energy, and benefits for health and well-being, cultural values, tourism, trade, and transport. The state of the ocean and cryosphere interacts with each aspect of sustainability reflected in the United Nations Sustainable Development Goals (SDGs)"

However, the health of the oceans is under threat from climate change and human activity with existing financing being largely directed towards unsustainable sectors and activities. Finance for a sustainable ocean remains limited, with SDG 14 (Life Below Water) receiving the least public funding of all the SDGs in 2017 (SDG Financing Lab, 2017). Nevertheless, awareness of the key services and provisions provided by the ocean is increasing, as well as the recognition that continued ocean health decline inhibits prosperity (Friends of Ocean Action, 2020).

What is Sustainable Blue Economy?

The Sustainable Blue Economy Finance Principles define a sustainable blue economy as one that "provides social and economic benefits for current and future generations; restores, protects and maintains diverse, productive and resilient ecosystems; and is based on clean technologies, renewable energy and circular material flows". It is an economy based on circularity,



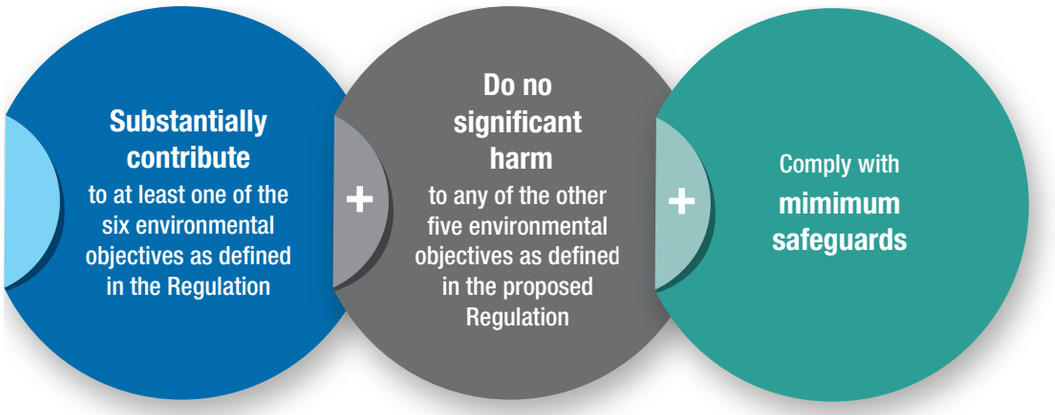


Figure 1: EU taxonomy overview.

From: Taxonomy: Final report of the Technical Expert Group on Sustainable Finance (European Commission, 2020)

collaboration, resilience, opportunity and inter-dependence. Its growth is driven by investments that reduce carbon emissions and pollution, enhance energy efficiency, harness the power of natural capital and the benefits that these ecosystems provide, and halts the loss of biodiversity. By this definition, and for the purposes of this report as well as the guidance to the Principles, the sustainable blue economy excludes non-renewable extractive industries (e.g. offshore oil and gas, and deep-sea mining). However, opportunities to consider how to tackle these industries in the context of a longer-term transition to sustainability may be developed in future.[3]

What do we mean by Finance for the Sustainable Blue Economy?

Financial institutions can play a pivotal role in developing a sustainable blue economy, so it is important that the meaning of finance for the sustainable blue economy is clearly defined. Here, finance for the sustainable blue economy is defined as "financial activity (including investment, insurance, banking and supporting intermediary activities) in, or in support of, the development of a sustainable blue economy, for example through the application of the Sustainable Blue Economy Finance Principles in financial decision-making, ESG frameworks, and reporting." As such, it covers both finance being deployed directly to invest in SBE projects (e.g. into specific projects) as well as financial activity/capital being deployed to support the development of the SBE more broadly (e.g. activity by financial institutions to de-risk, promote or further mainstream investment into the SBE). Whether or not finance is sustainable depends on the activities and decisions made by financial institutions, rather than any assessment of the virtue or value

3 Adopted from Rising Tide: Mapping Ocean Finance for a New Decade UNEP, 2021

of the institution itself—provided it adheres to the SBEFP and the sector-specific guidance when making its decisions. Thus, on these terms, a bond issuance by a large corporation to finance sustainable shipping is as valid a means of finance for the SBE as an impact fund investing in a community-managed fishery, and one

The Sustainable Blue Economy Finance Principles define a sustainable blue economy as one that "provides social and economic benefits for current and future generations; restores, protects and maintains diverse, productive and resilient ecosystems; and is based on clean technologies, renewable energy and circular material flows

BOX 3.1 : The Zero-Pollution Action Plan

The EGD announced that to protect Europe's citizens and ecosystems, the EU needs to move towards a zero pollution ambition, and better prevent and remedy pollution in air, water, soil, and consumer products. To address these interlinked challenges; in 2021 the Commission just adopted a Zero Pollution Action Plan.

This action plan also supports the post-COVID-19 recovery by promoting a more sustainable re-launch of the EU economy, creating job opportunities and reducing social inequalities, as pollution often affects the most vulnerable people most seriously. It seeks synergies with and considers actions and results of related strategies (e.g. pharmaceuticals), policies and evaluations. Marine pollution by excess of nutrients, contaminants, litter and noise is prominent in the action plan.

Specifically, the Zero Pollution Action Plan:

Focuses on measures to strengthen implementation and enforcement, so that public authorities, businesses and citizens can use EU rules on pollution more effectively.

Considers the need to improve the existing health and environment acquits (which will be subject to separate initiatives). To this end it carefully reviews the preparatory work, evaluations and/or impact assessments carried out under dedicated initiatives for pollution of the air, water and marine environment as well as from road transport and industrial emissions, waste and wastewater, and noise. The plan also considers other pollution forms such as soil pollution.

Seeks improvements to the governance of pollution policies, including at the international level and notably via a monitoring and outlook tool using existing (e.g. collected by various EU agencies or reported by Member States) and new (e.g. from EU satellite observation) data sources and models. The Action Plan also addresses the international aspects of the EU's zero pollution ambition such as diplomacy, trade policy and development support.

Drives societal change, amongst others using digital solutions and contributing to a sustainable consumption agenda attentive to pollution impacts.

Table 3.1

EU Blue Economy Established Sectors- Main Indicators, 2018

Indicator	EU Blue Economy, 2018
Turnover	€650 billion
Gross value added	€176 billion
Gross profit	€68 billion
Employment	4.5 million
Net investment in tangible goods	€6.4 billion
Net investment ratio	3.6%
Average annual salary	€24 020

Source: Euro stat (SBS), DCF and Commission Service

is not 'better' or 'more sustainable' than the other.[4]

There is a need for developing sector specific guidance on financing for Sustainable Blue Economy across five key sectors. Maritime transportation; port development Sea food (including fisheries and aqua culture); Coastal and marine Tourism; and Marine renewable energy.

An overview of the current sustainable Blue Economy fiancé landscape includes EU Taxonomy for sustainable activities (2019).

In addition to EU Taxomony, there are other financial institution established at global level, the list is given below:

- Taskforce on Climate-related Financial Disclosures (TCFD);
- Taskforce on Nature-related Financial Disclosures (TNFD);
- Specific Financing Initiatives;
- Ocean Risk and Resilience Action Alliance (ORRAA);
- Coalition for Private Investment in Conservation (CPIC);
- IUCN Blue Natural Capital Finance Facility;
- WTW Global Ecosystem Resilience Facility;
- Capitals Coalition;
- MDB Financing Initiatives;
- Asian Development Bank's Oceans Financing;
- Initiative (OFI) and Healthy Ocean Action Plan;
- World Bank PROBLUE Multi-donor Trust Fund;

4 Adopted from Rising Tide: Mapping Ocean Finance for a New Decade UNEP, 2021

Financing Blue Economy Investment Outlook

Different elements are currently affecting financing in the areas of sustainability, green and the Blue Economy. Firstly, investors need to be able to easily identify which economic activities are sustainable, including those that are ocean related. More clarity on this, with agreements in terms of principles, development of guidelines, taxonomies and best practices could help fill the information gap. The disclosure and reporting of investments in this area may also be vital as it displays the numerous investment opportunities in the Blue Economy. Net investments in tangible goods were estimated at €13.9 billion in 2018, i.e. a 7.7% decrease compared to €15.1 billion in 2009, and -26.4 % compared to 2015 (€19 billion invested). However, recent investor surveys show that interest in sustainable Blue Economy investments is high, and that the global Blue Economy is expected to expand at twice the rate of the mainstream economy by 203014. Secondly, many of the projects in the area of sustainability and Blue Economy are risky or require risk-bearing capacity from investors, as the returns on investments are long for many sectors. The development of a broader range of Blue Economy financial instruments, with appropriate risk sharing mechanisms may contribute to the solution. It is therefore key to have the right institutional framework and financial instruments supporting the projects in this sector, including those that already enjoy higher returns on investment and growth, such as Blue biotechnology or that are resilient in times of crisis (e.g. fisheries and aquaculture). Thirdly, some fragmentation and trade-offs between different economic uses of marine areas and resources create additional risk in this sector. The good use of enabling frameworks such as Maritime Spatial Planning may contribute to reducing this risk by creating predictability, transparency and clearer rules.

The European Union has been at the forefront of efforts to build a financial system that supports sustainable growth. Sustainable finance aims at supporting economic growth, while taking due account of environmental (e.g. climate change mitigation, pollution preventions), social (e.g. inequality, labor relations) and governance (e.g. transparency) considerations when making investment decisions.

At the EU level, sustainable finance has a key role in delivering on the objectives of the EGD as well as in fulfilling the EU's international commitments on climate and sustainability objectives, by channeling public and private investment into the transition to a climate-neutral, environmental, resource-efficient and fair economy. The EU strategy on financing for sustainable growth aims at leading increased longer-term investments into sustainable economic activities and projects. It also helps ensure that investments support a resilient economy and a sustainable recovery from the impacts of the COVID-19 pandemic. As part of the EGD, on January 2020, the European Commission presented the EGD investment plan, which is expected to mobilize at least €1 trillion of sustainable investments over the next decade.

It will enable a framework to facilitate public and private investments needed for the transition to a climate-neutral, green, competitive and inclusive economy.

Reaching the current 2030 climate and energy targets alone require additional investments of approximately €260 billion a year by 2030. The EU is contributing to this investment challenge via the European Fund for Strategic Investments (ESIF) and other initiatives. However, public sector funding alone does not suffice. The entire financial sector has a key role to play by:

- re-directing investments towards more sustainable technologies and businesses;
- financing growth in a sustainable manner over the long term;
- contributing to the creation of a low-carbon, climate resilient and circular economy.

- European Investment Bank's Blue Sustainable Ocean Strategy;[5]

Brief Summary of the Survey Results of the Report (September 2020)[6]

In September 2020 UNEP FI polled members of its network and the wider sustainable finance community to gain insight into the current activity of investors in the blue economy, and their perception of the risks and predictions as to the future development of the five sectors highlighted as part of this study. Of the more than 100 individuals who participated in the survey, 74 represented financial institutions. Majority of participant familiar with Sustainable Blue Economy and they were active in Asia Pacific (19) Europe (20) Africa and Middle East (17), North America (11) Latin America and Caribbean (9). And High sea (3) not active (22); and don't know (9).

The financial institution were applying concessional financing corporate financing, debt conversion derivatives flexible capital (eg. Convertible dept/ equity) green / blue labeled bonds, insurance, private equity project bonds/ finance. And risk mitigation instruments (eg. First loss capital).

Sector wise percentage were Sea food (55%), Ports (43%) Maritime Transportation (35%), Marine Renewable energy (33%), Coastal and marine (33%) Climate resilience (18%) positive environmental impact (16%) are biggest non-financial consideration across sectors apart form (15%) used new technology avoiding negative environmental impacts government support (13%) avoiding negative social impact (7). NGO support etc.

The survey further reveals that fisheries sector would be smaller than today in 2030 (64%) Aquaculture Sector larger in 2030 than today (80%) Sustainability dominates in fisheries to 2030. Reducing environment impact dominates trends in aquaculture to 2030. Marine special planning (MSP) highlighted in the report to achieve sustainability in various sectors of the Blue Economy. The outcomes of the survey show that financial institutions are becoming interested in financing the Blue Economy through new financing instruments; and focusing on environmental impacts.

Section IV

Case Studies of Cooperation in Regional Groupings/ Individual Countries in Blue Economy

As discussed in the section above, sustainable ocean finance is a pre- condition for promoting and implementing the Sustainable blue economy. The Box 3.1 highlights the

5 For details of these institutions see Rising Tide: Mapping Ocean Finance for a New Decade UNEP, 2021 p. 22-29
6 Rising Tide: Mapping Ocean Finance for a New Decade (UNEP, 2021)

initiatives of European Union (EU) for promoting sustainable blue financing to fill the gap in such financing:

The EU is a class example of how the blue economy, earlier known as "Blue Growth ", contributed to the EU Economy. The following table shows the significance of Blue Economy:

On the pattern of EU, other regional groupings have to take the Initiatives. The concept of combined IORA Blue Economy has yet to see the light of the day. The same is true of ASEAN, SAARC and many other such regional groupings. IORA has strongly committed itself to the sustainable Blue Economy through its three Ministerial Conferences on Blue Economy in (2015); (2017) and (2019) in Mauritius, Indonesia and Bangladesh respectively. The focus of the second Ministerial Conference was on creating the Mechanisms for promoting sustainable Blue Economy whereas the focus on Sustainable Financing seems to be missing even in the third Ministerial Conference on Blue Economy.

The reference to IORA's Blue Economy appears in CIOS's Work- report presented in CSO meetings in (2019) and (2020). Except ship- building & repairs and coastal tourism; all other established and emerging sectors such as marine living resources and marine non- living resources, marine renewable energy, ocean energy; desalination; blue bio- economy etc. are in the path of prompt recovery after COVID-19.

Blue Financing in Seychelles

In October 2018, Republic of Seychelles launched the World's first sovereign Blue Bond- a pioneering financial instrument designed to support sustainable marine and fisheries projects. The bond raised US$ 15 Million international investors. It shows the potential of countries to harness capital markets for financing the sustainable use of marine resources. The World Bank provided assistance in searching on three investors: Calvert impact capital, Nureeu and U.S head quartered prudential financial Inc. It combines public and private investment to mobilize resources for empowering local communities and businesses.

- It will help Seychelles in achieving a transition to sustainable fisheries and safeguarding the ocean and sustainably developing the economy in the island. The proceeds from the bond provided support to the expansion of marine protected area;
- Improved governance of priority fisheries and development of Seychelles Blue economy;
- Support through blue grants fund and blue investment fund managed by Seychelles' conservation and climate adaptation trust and the development Bank of Seychelles (DBS) respectively;
- Global environment facility also supported the protection for ocean conservation;

Blue Bond is partially quarantined by US$ million guarantee from the World Bank (IBRD) and further supported by a US $ 5 million concessional loan from the GEF which will partially cover interest payments for the bond.

On 28th October, 2019 with UNDP Seychelles launched a programme of protecting the 40000 of its EEZs, approximately 400,000 KM2 with new instruments of Blue Financing such as Blue Bonds and debt restructuring focused on Seychelles seeking to reduce the vulnerability to climate change focusing on water scarcity and flooding project of more than US$ 6 million focus on eco system based adaptation approach, 7 June, 2021.

Almost US$2.2 million of Seychelles debt was written off in exchange for the country doing more to protect its oceans. The country's debt for the nature swap improved the US conservation group. The nature conservation buying the debt in exchange for a promise to create 13 new marine protected areas

Blue Financing in Mauritius

The Exclusive Economic Zone (EEZ) of Mauritius is approximately 2.3 million Km2 in South West Indian ocean has a reasonable stock of various fish. It has lost 10% of its coastline since the 1960s to erosion and marine spatial planning to very critical and Mauritius hosted IORA's conference on "Indian Ocean Conference on Marine Spatial Planning towards Sustainable use of the Indian Ocean" and "Training Workshop on Ocean observatory Database", 22-23November 2017. Earlier it hosted "Towards COP22 Ocean Economies and Climate Change" in September, 2016.

It is said that Mauritius is key to unlocking Africa's Blue economy. Mauritius has a strong and thriving blue economy but huge investment is required to realize the potential of sectors like fishing and aquaculture port infrastructure, maritime transport ship-building and repairs and marine salt-harvesting in Mauritius. There is a need for the establishment of a regulatory framework to incentivize sustainable financing for the product of sustainable financing and the recipient, such a reduction in the regulatory cost of sustainable banking products has a direct impact on the pricing benefit for a sustainable finance product, which is beneficial for both the stakeholders of sustainable financing. Bank of Mauritius (BOM) is proposing guide for issuance of sustainable bonds in Mauritius (February 3, 2021).

The guide on sustainable bonds provides an overview of the requirements and process for the issuance of sustainable bonds and the listing of these bonds on the stock exchange of Mauritius. Mauritius is on its way to implement the 2030 agenda for sustainable development which requires significant amount of investment, thereby Mauritius

is introducing innovative finance instruments and tools:

- Development of a green finance framework;
- Exploration of the issuance of innovative financial instruments such a green bonds;
- Sustainable bonds universe which include green bonds, blue bonds and climate bonds, social and sustainability bonds;

This shows that Mauritius has taken innovative ways to meet the growing investment requirements for implementing Blue economy in Mauritius as well as championing it (Blue Economy) in Africa by strengthening Blue financing through building sustainable Blue Finance practices into their decision making processes and motivating the financial sector to steer established and emerging ocean industries towards sustainability.

Section V

Conclusions and Policy Implications

From the above narrative, some important points in the Blue Financing are emerging globally, at regional as well as national levels. These are as follows:

- The innovative financing techniques in European Union, Seychelles and Mauritius and elsewhere in other regions and countries indicate that the gap between " Blue Economy " and " Blue Financing " is narrowing down, which is a welcome step in the implementation of Sustainable Blue Economy at global, regional, national and local level.
- The agenda of Sustainable Development as enshrined in the SDGs, in the wake of COVID-19 altered us to change our interaction with Nature. The SDG 14 (LifeBelow Water) has experienced delay in its implementation. We need to take strong blue Initiatives such as understanding the role of International Negotiations for better Ocean Governance; integrating oceans in corporate social responsibility strategies; and blue economy to Blue Finance.
- It is suggested or recommended that under Corporate Social Responsibilities (CSR) at least one per cent for the planet-corporate contributes one percent of their annual sales to Environmental protection.
- The financial Sector needs scientific information to assess the benefitsvis- a- vis risks of blue economy investments. The financial institutions need to build on "blue economy tools" required to build on blue economy tools like "green economy tools" which were developed in the long-run.
- Technological and financial innovations are required in the Blue Economy as it (Blue Economy) is innovative in nature. The links between "green" and

"blue" ecosystems need to be properly understood. More than 80 percent of marine pollution comes from terrestrial sources. The profitability of investing in the blue economy depends on the resilience of marine ecosystems.

- The study is indicative of the fact that much needs to be done in developing a theory of innovative financing; although significant developments are taking place in developing the practices of innovative financing instruments.
- A theoretical and empirical investigation of the efficacy of trade to optimize the use of oceanic natural resources needs to be undertaken. Blue economy is required to be integrated with trade patterns, emerging as a consequence of "new emerging ocean industries".

Policy Implications

The Policy-implication of the study is to integrate blue economy and all of its established and emerging sectors with its growing investment demands and to evolve a policy framework to ensure adequate supply of blue financing so that the gap is filled.Such an attempt requires a comprehensive and collaborative approach through international cooperation and Multilateralism.

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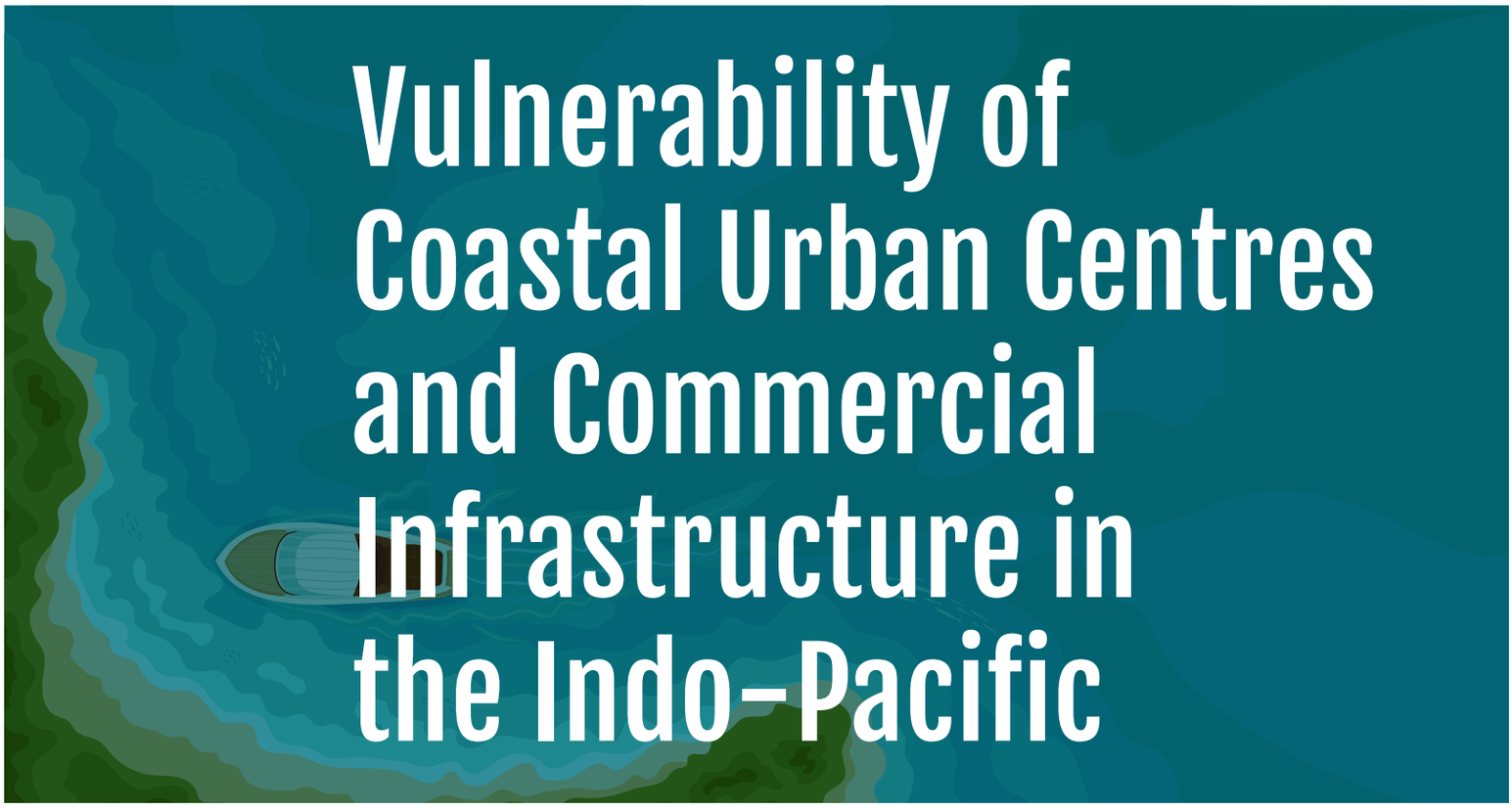
Chapter 5



Vulnerability of Coastal Urban Centres and Commercial Infrastructure in the Indo-Pacific

Prakash Gopal

Introduction

The Indo-Pacific region is arguably the most important strategic frame of reference in the world today. While the precise physical limits of the region remain nebulous, it is a contiguous body of water and combines the Indian and Pacific Oceans. The Indo-Pacific is home to vital sea lines of communication (SLOC) that traverse these waters, fuelling the growth of regional economies.[1] Whilst focusing on the dominant maritime nature of the Indo-Pacific region, it is easy to lose sight of the terrestrial factors that make this maritime space vital. The Indo-Pacific littoral constitutes 44 per cent of the world's area, and home to 65 per cent of global population.[2] Majority of this population is concentrated in urban agglomerates scattered along the coastlines of littoral states.

These urban settlements provide the greatest opportunities for socio-economic growth, however, their proximity to the coast makes them vulnerable to natural disasters. In this context, this chapter seeks to examine the vulnerability of coastal urban centres and commercial infrastructure in the Indo-Pacific region to threats arising out of natural causes such as extreme weather events and sea-level rise. In doing so, the chapter first examine the nature of the coastal features in the region, and assess various threats and vulnerabilities that characterise the sub-regions of the Indi-Pacific. Since the region covers a large and diverse topography, certain key indicative characteristics of some urban centres and economic infrastructure along the Indo-Pacific littoral are examined. This aspect can be easily extended to other areas in the region.

An attempt is made in this chapter to suggest mitigation strategies for risks, using the Sendai Framework for Disaster Risk Reduction (SFDRR) 2030-2015 that can help to evolve policy suggestions at the national and regional levels. It is posited that the nature of such risks extends across state boundaries, and hence their mitigation strategies need to be necessarily based on models that promote international cooperation.

Characteristics of Coastal Areas

There is no universally accepted definition of the coastal zone, with variations based on the context of use. The parameters used to define a coastal zone are therefore different in the contexts of natural vegetation, marine life, and topographical features on land. For the purpose of analysing the interplay between human habitation and the coastal

1 Felix Heiduk and Gudrun Wacker, ***From Asia-Pacific to Indo-Pacific: Significance, Implementation and Challenges***, Swp Research Paper (Berlin: German Institute for International and Security Affairs, 2020), p. 7.
2 Mohammad Masudur Rahman, Chanwahn Kim, and Prabir De, "Indo-Pacific Cooperation: What Do Trade Simulations Indicate?," ***Journal of Economic Structures*** 9, no. 1 (2020): p. 2.

Whilst focusing on the dominant maritime nature of the Indo-Pacific region, it is easy to lose sight of the terrestrial factors that make this maritime space vital.

areas, a coastal zone may be defined as "that part of land most affected by its proximity to the seas, and that part of the ocean most affected by its proximity to land."[3]

Coastal areas are arguably complex environments, lying at the interface of land and water. The earth comprises over 360 million kilometres[2] of water, and nearly 150 million kilometres[2] of land, both of which interact over 1.6 million kilometres of coastlines.[4] Whereas humans live on land, they look to the oceans for sustenance and economic advancement. Natural resources in the sea—that range from fish, coral reefs and mangroves to oil and gas—make access to oceans essential for the human populace. Maritime trade adds another dimension to the importance of oceans to humankind and enablesthe exchange of goods in large quantities, over large distances, and in the most economical manner. Ports, which serve as the terminating points of maritime trade, are also located along the coasts, existing at the hub of an ever-expanding logistic system. Coastal zones are further characterised by rich yet fragile ecosystems that are responsible for much of the unique natural features of the areas.

The interplay of dense human populations, rich natural and mineral resources, and sensitive natural environments create a valuable, yet vulnerable ecosystem. On the attractiveness of coastal areas to human settlement, Martinez et al state:

> Human beings have not been insensitive to the wide array of opportunities provided by the coasts and have been attracted to them, making the coasts the most favoured locations to either live permanently, for leisure, recreational activities, or tourism. The coasts have been centres of human activity for millennia and host the world›s primary ports of commerce.[5]

Coastal areas in the Indo-Pacific are particularly diverse, ranging from tropical to Polar Regions. The large variety of geomorphological features coexists with important ecosystems of mangroves, coral reefs, and sea grass beds. These ecosystems are rich in biodiversity and resources, including fisheries. These factors

3 Don Hinrichsen, ***Coastal Waters of the World: Trends, Threats, and Strategies*** (Washington, D.C.: Island Press, 1998), p. 2.
4 Lauretta Burke et al., ***Coastal Ecosystems*** (Washington, D.C.: World Resources Institute, 2001), p. 8.
5 M. L. Martínez et al., "The Coasts of Our World: Ecological, Economic and Social Importance," ***Ecological Economics*** 63, no. 2 (2007/08/01/ 2007): p. 255.

Coastal areas in the Indo-Pacific are particularly diverse, ranging from tropical to Polar Regions. The large variety of geomorphological features coexists with important ecosystems of mangroves, coral reefs, and sea grass beds.

make the coastal regions attractive for human engagement, with 60 per cent of the region's population living on or near the coast.[6] These areas have also witnessed the largest economic growth, fuelled by migration of people from inland to the coast. This has led to rapid urbanisation along the coasts, with some of the world's largest cities being located in the coastal areas of the Indo-Pacific region.

A significant number of infrastructural facilities are required to support human population, and its economic activities along the coast. These range from strategic facilities like ports, power plants, desalination plants, factories, refineries, and multi-modal transport hubs;to socio-economic facilities such as educational institutions, recreational and sports facilities, health-care facilities, and retail establishments. The smooth functioning of these facilities is key to sustaining the large human populations close to the coast. Their notional value to the coastal states is therefore significantly high, and together with large human population centres, these infrastructure facilities are simultaneously strategic assets and notable vulnerabilities.

Major Coastal Urban Centres in the Indo-Pacific

The Indo-Pacific region is home to nearly two-thirds of the world's population, most of which is concentrated in large urban agglomerates. Of the world's largest 20 cities in 2018, twelve are located in the Indo-Pacific region, out of which nine are located on the coast (See Table 1). The cumulative population of these nine Indo-Pacific urban population centres is nearly 184 million. This by itself would correspond to the eighth most populous country in the world, ahead of Russia (145 million) and Bangladesh (165 million). Whilst not quantified, it may be assumed that

6 Nobuo Mimura and Sombo Yamamura, "Introduction: Scope and Objectives of This Book," in *Asia-Pacific Coasts and Their Management States of Environment*, ed. Nobuo Mimura (Dordrecht: Springer, 2008), p. 1.

The Indo-Pacific region is home to nearly two-thirds of the world's population, most of which is concentrated in large urban agglomerates. Many of the cities in teh region are located on the coast

Table 1: World›s 20 largest cities by population

Rank	City	Country	2020 Population	Coastal/ Inland	Indo-Pacific Region
1	**Tokyo**	Japan	37,393,128	Coastal	Yes
2	**Delhi**	India	30,290,936	Inland	Yes
3	**Shanghai**	China	27,058,480	Coastal	Yes
4	**Sao Paulo**	Brazil	22,043,028	Inland	No
5	**Mexico City**	Mexico	21,782,378	Inland	No
6	**Dhaka**	Bangladesh	21,005,860	Coastal	Yes
7	**Cairo**	Egypt	20,900,604	Inland	No
8	**Beijing**	China	20,462,610	Inland	Yes
9	**Mumbai**	India	20,411,274	Coastal	Yes
10	**Osaka**	Japan	19,165,340	Coastal	Yes
11	**Karachi**	Pakistan	16,093,786	Coastal	Yes
12	**Chongqing**	China	15,872,179	Inland	Yes
13	**Istanbul**	Turkey	15,190,336	Coastal	No
14	**Buenos Aires**	Argentina	15,153,729	Coastal	No
15	**Kolkata**	India	14,850,066	Coastal	Yes
16	**Lagos**	Nigeria	14,368,332	Coastal	No
17	**Kinshasa**	Democratic Republic of Congo	14,342,439	Inland	No
18	**Manila**	Philippines	13,923,452	Coastal	Yes
19	**Tianjin**	China	13,589,078	Coastal	Yes
20	**Rio De Janeiro**	Brazil	13,458,075	Coastal	No

Source: United Nations, World Urbanization Prospects: The 2018 Revision (New York: Department of Economic and Social Affairs, 2019), p.77.

the value of infrastructure required to sustain this large population along the Indo-Pacific coastline would also be fairly significant.

Threats and Risks to Coastal Infrastructure from Natural Events

Coastal Storms and Hurricanes

Storms and hurricanes are terms used to refer to the same weather phenomena. The difference arises in their intensity, as storms with wind speeds in excess of 74 miles per hour are classified as hurricanes.[7] The use of the term hurricanes in more common in the Atlantic and Eastern Pacific Oceans, whereas in the Indian and Western Pacific Ocean rim, the term 'tropical cyclones' is commonly used. A combination of lower geographical elevations and dense populations make coastal urban centres vulnerable to damage from these storms.[8] An approaching tropical cyclone can cause significant damage to cities and towns along the coast. Most of this damage is caused due to storm surge (flooding of coastal areas due to rising sea water), high winds that can topple trees and damage structures, and from shifting sand along the seashore. It is estimated that around 10,000 people die each year due to tropical cyclones around the world.[9] In the period 1998-2017, such storms were second only to earthquakes in causing fatalities, killing around 233,000 people around the world, and affecting over 700 million people.[10] The debilitating effects of these storms are further exacerbated by the near three-fold increase in human population along coastal areas in the last 30 years.[11]

While loss of human life and mass population displacements are the primary effects of such cyclones, they also cause significant economic losses. For instance, Hurricane Katrina, which struck the city of New Orleans in the United States in 2005, is anticipated to have caused losses close to US$ 250 billion.[12] These losses are hard to measure accurately, as the effects occur in multiple orders, and span a large cross-section of infrastructure and human activities. These range from direct damage to houses and public infrastructure, loss of employment, losses in critical infrastructure like energy production, loss of farming income, and health costs associated with a traumatised populace.

7 National Oceanic and Atmospheric Administration (NOAA), "What Is the Difference between a Hurricane and a Typhoon?," U.S. Department of Commerce, updated 26 February 2021, accessed 21 April 2021, https://oceanservice.noaa.gov/facts/cyclone.html.
8 Jejal Reddy Bathi and Himangshu S. Das, "Vulnerability of Coastal Communities from Storm Surge and Flood Disasters," *International journal of environmental research and public health* 13, no. 2 (2016): p. 239.
9 University Corporation for Atmospheric Research, "Hurricane Damage," 2021, accessed 21 April 2021, https://scied.ucar.edu/learning-zone/storms/hurricane-damage.
10 World Health Organisation, "Tropical Cyclones," 2021, accessed 21 April 2021, https://www.who.int/health-topics/tropical-cyclones#tab=tab_1.
11 World Health Organisation, "Tropical Cyclones."
12 Daniel Craig, "Strategic Planning for Disasters – Preventing a Financial Disaster," in *FGFOA Conference* (2017).

These factors are common across regions, as is borne out by the effects of high intensity storms in the Indo-Pacific region as well. For instance, Cyclone Nargis that struck the Myanmar coast in 2008, affected 50 townships and is believed to have caused over 140,000 deaths, most of which were attributed to the 3.6 m storm surge.[13] The economic impact of this cyclone was estimated to be around US$ 4.1 billion, which included loss of over 800,000 homes, and flooding of over 600,000 hectares of farm and forest land.[14] Long-term human costs due to loss of livelihood, and environmental damage causing destruction of species of flora and fauna are difficult to estimate in the aftermath of such storms.

Earthquakes and Tsunamis

For countries located on or close to the seismic belt, minor earthquakes are a relatively frequent and normal occurrence. However, once in a while, a major earthquake can cause untoward destruction of life and property. For coastal cities and townships, the damage caused directly due to earthquakes may often pale in comparison to that caused by an ensuing tsunami. This was evident during the 2004Indian Ocean Tsunami, and more recently in the 2011 earthquake and tsunami off the coast of Japan.

The Boxing Day 2004 earthquake in the deep seas off the Sumatran coast set off a tsunami that ripped through South and South-East Asia, affecting a dozen countries in two continents.[15]The tsunami travelled at speeds of over 800 kilometres/ hour, and struck the coast of Aceh 28 minutes after the earthquake, with waves reaching heights of nearly 25 meters. The western front of the tsunami continued to travel across the Indian Ocean until it made landfall in Thailand, Malaysia, The death toll as a result of this devastating tsunami was placed at between 225,000 and 350,000, as a large number of people were classified as missing.[16]While the immediate economic impact of the tsunami was estimated at around US$ 10 billion, it is not possible to place a figure on long-term economic impacts caused due to destruction of livelihoods, ecological damage, and population displacement.

On March 2011 ,11, an earthquake occurred 130 kilometres off the East coast of Japan. As the Japanese islands experienced the seismic tremors, a tsunami set off radially from the epicentre and soon made landfall on the north-east coast of Japan with

13 Nizar Mohamed, *Learning from Cyclone Nargis: Investing in the Environment for Livelihoods and Disaster Risk Reduction - a Case Study* (Nairobi, Kenya: United Nations Environment Programme, 2009), p. 4.
14 Adelina Kamal et al., *A Humanitarian Call: The Asean Response to Cyclone Nargis* (Jakarta: ASEAN Secretariat, 2010), p. 10.
15 Prema-chandra Athukorala and Budy P. Resosudarmo, "The Indian Ocean Tsunami: Economic Impact, Disaster Management, and Lessons," *Asian Economic Papers* 4, no. 1 (2005): p. 2.
16 Debarati Guha-Sapir and Olivia D'Aoust, "The Frequency and Impact of Natural Disasters," in *The Economic Impacts of Natural Disasters,* ed. Alexandre Borde, Indhira Santos, and Debarati Guha-Sapir (New York ;: Oxford University Press, 2013), p. 12.

wave heights of up to 10m.[17] The waves travelled several kilometres inland before receding, causing widespread damage to human settlements, infrastructural facilities, and to the environment. Over 20,000 people were reportedly killed as a result of the earthquake.[18] While damage to the coast of North Japan was along expected lines in a tsunami scenario, what made this particular disaster even more catastrophic was the damage caused to the Fukushima nuclear power plant located in the town of Okuma. A 14 meters high wave hit the nuclear plant, flooding it and rendering the emergency generators inoperable. This decapitated the cooling system, causing a nuclear meltdown and a series of explosions that damaged structures and cased leakage of radioactive material into the atmosphere.[19]While no deaths were reported as a direct result of the disaster, the long-term effects of exposure to radiation are yet to be analysed. Moreover, this accident caused the evacuation of 150,000 residents from neighbouring towns, with no prospects of returning to their homes for the foreseeable future. Considering the relatively higher density of critical infrastructure along coastal areas, this incident serves as a reminder of the critical vulnerabilities of these facilities to natural disasters.

Sea-level Rise

Sea-level rise due to climate change exacerbates the threat to coastal urban settlements and infrastructure from natural calamities. In the past 15 years, sea levels have risen across most ocean basins around the globe, with some regions experiencing increase in water levels to the magnitude of between 20-15 centimetres.[20] With rise in sea levels, storm surges, which cause the most damage in tropical storms, push further inland, thereby causing significantly more damage. They also cause frequent high-tide floods that may be more disruptive that destructive, but that consume resources for damage control and repair. Higher water levels also causes shoreline erosion, thus rendering coastal dwellings unstable and unsafe.

It is estimated that by the year 2100 sea levels will rise between 67 centimetres2- metres, placing 15 cities globally at high risk of inundation—10 of which are in the Indo-Pacific region.[21] While it is estimated that

17 Dhitinut Ratnapradipa et al., "The 2011 Japanese Earthquake: An Overview of Environmental Health Impacts," *Journal of environmental health* 74, no. 6 (2012): p. 42.
18 CNN Editorial Research, "2011 Japan Earthquake-Tsunami Fast Facts," updated 14 April 2021, accessed 23 April 2021, https://edition.cnn.com/2013/07/17/world/asia/japan-earthquake---tsunami-fast-facts/index.html.
19 "Fukushima Disaster: What Happened at the Nuclear Plant?," BBC News, updated 10 March 2021, accessed 23 April 2021, https://www.bbc.com/news/world-asia-56252695.
20 Rebecca Lindsey, "Climate Change: Global Sea Level," National Oceanic and Atmospheric Administration (NOAA), U.S. Government, updated 25 January 2021, accessed 26 April 2021, https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level#:~:text=In%20urban%20settings%20along%20coastlines,risk%20from%20sea%20level%20rise.
21 "After a Year of Devastating Floods across Asia, This Is How Some of the World's Biggest Countries Are Staying Afloat," World Economic Forum, updated 5 March 2020, accessed 26 April 2021, https://www.weforum.org/agenda/2020/03/asian-cities-urged-to-bolster-defence-against-rising-seas/#:~:text=Many%20of%20Asia's%20rapidly%20expanding,such%20

more than 18 million people have already been forced to migrate from coastal areas in South Asia alone, continuing sea-level rise on predicted scales could see this number increase to 63 million by the year 2050.[22] This figure does not include numbers displaced due to natural disasters. Natural disasters along coastal areas, together with the effects of sea level rise, promise to significantly increase the intensity with which future events may impact human habitations and critical infrastructure along coastal areas.

Mitigation Strategies

The evolving mitigation strategies against natural threats such as extreme weather events are not an easy proposition. Specifically, in the context of determining and reducing impacts of sea level rise on human populations, Oliver-Smith states:

The complexity of the interrelationships between ecological and social systems at multiple levels makes crafting a policy relevant research agenda on the social impacts of sea level rise a challenging task because it requires combining global projections with their local and regional manifestations with local patterns of vulnerability that are socially and economically constructed by local, regional and global processes. The research required on which to base appropriate policies for climate change and sea level rise adaptation must therefore be multi-sited.[23]

While disaster response and recovery measures are indispensable to post-incident recovery, much of the work to reduce human and material costs of natural disasters lies in risk and vulnerability reduction prior to the occurrence. There is also the critical question of capacities –of both the State and other non-governmental stakeholders. Post-incident recovery, rehabilitation, and reconstruction place undoubtedly large demands on a state's resources, in circumstances that may not be conducive to the rapid deployment of such resources. Critical enabling amenities such as electricity and communication networks may not be readily available in the wake of a natural disaster in coastal urban centres. This implies that resources acquired for post-disaster relief need to be able to operate in such an environment, and be self-sufficient to the extent possible. Creating such a resource pool is therefore prohibitively expensive, and is often overlooked in favour of other expenditure that may politically and economically offer greater "return on investment". It is therefore important for states to realise the limitations of a strategy that is more inclined to recovery rather than risk and vulnerability

as%20flooding%20and%20cyclones.&text=Across%20China%2C%20%24348%20billion%20of,level%20rise%2C%20the%20report%20noted.

22 Megan Rowling, "Climate Change Could Create 63 Million Migrants in South Asia by 2050," ***Reuters***, December 19, 2020.

23 Anthony Oliver-Smith, Sea Level Rise and the Vulnerability of Coastal Peoples: Responding to the Local Challenges of Global Climate Change in the 21st Century, Interdisciplinary Security Connections Publication Series of Unu-Ehs (Bonn, Germany: UNU Institute for Environment and Human Security, 2009), p. 10.

reduction, which is not only cost-effective, but is also critical to save lives and material losses.

The SFDRR has evolved over many years of dialogue, exchange of lessons learnt, and expert consultations.[24] It provides a comprehensive and robust template for states template that allows states to develop national strategies of disaster risk mitigation. In that respect it is a framework particularly suited to coastal urban centres and infrastructure in the Indo-Pacific in three distinct ways.

First, the Indo-Pacific comprises of a large number of developing countries, least developed countries, and small island nations, all of whom are particularly vulnerable to the effects of natural and human-induced disasters. The SFDRR recognises the severe limitations that such states may have in their ability to mitigate risks, and states that "there is a need to enhance international cooperation between developed and developing countries and between States and international organizations."[25]The framework also focuses attention on the role of issues such as poverty, inequality, and poor land management in exacerbating effects of disasters—factors which are endemic to most states in the Indo-Pacific region.

Second, the predominant maritime nature of the Indo-Pacific area makes states vulnerable to the effects of climate change and sea-level rise. In this context, the SFDRR states:

Addressing climate change as one of the drivers of disaster risk, while respecting the mandate of the United Nations Framework Convention on Climate Change, represents an opportunity to reduce disaster risk in a meaningful and coherent manner throughout the interrelated intergovernmental processes.[26]

By positing climate change as a key factor in disaster risk management, the framework encourages positive action from Indo-Pacific states to offset its damaging effects.

Third, international cooperation is a key driver of the Indo-Pacific concept with precedents such as the post-tsunami multinational effort in the region in December 2004. On this key aspect, the SFDRR states as its first guiding principle:

Each State has the primary responsibility to prevent and reduce disaster risk, including through international, regional, subregional, trans-boundary and bilateral cooperation. The reduction of disaster risk is a common concern for all States and the extent to which developing countries are able to effectively enhance and implement national disaster risk reduction policies and measures in the context of their respective circumstances and

24 The Sendai Framework (2015-2030) is the successor to the Hyogo framework (2005-2015). Both of these have been based on extensive stakeholder discussions, and analysis of incidents to derive accurate lessons. See ***Sendai Framework for Disaster Risk Reduction 2015-2030***, (Geneva: United Nations Office for Disaster Risk Reduction, 2015), p. 5.
25 *Sendai Framework for Disaster Risk Reduction 2015-2030,* p. 11.
26 *Sendai Framework for Disaster Risk Reduction 2015-2030,* p. 11.

capabilities can be further enhanced through the provision of sustainable international cooperation;[27]

A maritime area such as the Indo-Pacific lends itself particularly well in international cooperation in disaster mitigation and relief, especially in coastal communities where direct access may be available via the sea. This avoids impinging on sensitivities around sovereignty that may otherwise ensue with access provided to agencies of another state over land territory of an affected state.

While recognising the relevance of the SFDRR to disaster risk management and resilience in the Indo-Pacific, it is also important to acknowledge that as a framework it provides only a template, and states need to invest significant effort and resources in turning this into a viable strategy, and then to put that strategy to practice. Such strategies should have tangible and realistic ends, ways, and means for each of the four priorities for action, namely (a) understanding disaster risk; (b) strengthening disaster risk governance to manage disaster risk; (c) investing in disaster risk reduction for resilience; and (d) enhancing preparedness for response.[28]National strategies should also factor in international collaborative lines of effort for each of these priorities, identifying sources of contribution, as well as resources that the state may be able to contribute to mitigate risks and augment recovery efforts in other states.

Fourth, national strategies should identify the disaster risk organisation comprising of lead agency and authority, and other participating agencies with their relationships in the organisation.

With higher population densities and the presence of large number of critical infrastructure facilities, coastal areas are particularly vulnerable to significant damage due to disasters. Despite best efforts at risk and vulnerability reduction, there is likely to be significant damage due to disasters, requiring extensive reconstruction and recovery efforts. The nature of coastal settlements is such that communities are faced with large financial losses, possible loss of habitat, and at least a temporary loss of employment.

Recovery, rehabilitation, and reconstruction after such a disaster, is particularly expensive in these areas, and may not be able to completely offset the damage. For instance, after the Boxing Day tsunami of 2004, the Aceh province in Indonesia received over 7.5$ billion in aid. Despite an extensive multilateral and multi-agency recovery effort, even a decade after the incident many projects did not succeed in rebuilding livelihoods.[29]This has two major implications for states of the Indo-Pacific region.

27 *Sendai Framework for Disaster Risk Reduction 2015-2030*, p. 13.
28 *Sendai Framework for Disaster Risk Reduction 2015-2030*, p. 14.
29 "Aceh Still Suffering a Decade after the Tsunami," Australian National University 2014, accessed 10 June 2021, https://www.anu.edu.au/news/all-news/aceh-still-suffering-a-decade-after-the-tsunami.

First, significant long-term damage post disaster may be prevented by risk and vulnerability measures before an event, with costs and efforts associated with recovery being many times higher than expenditure incurred in mitigation actions.

Second, and importantly, it is vital for governments to involve coastal communities in such endeavours, as they are the most affected stakeholder in this process. A participative, inclusive, and proactive strategy of disaster risk reduction would be more acceptable and consequently, more effective than one that is directive in nature. The recognition of coastal communities as the most affected stakeholder, and their subsequent participation in the process is vital for risk and vulnerability mitigation efforts to be effective.

CONCLUSION

Coastal urban centres in the Indo-Pacific region, and their associated infrastructure networks are highly vulnerable to various disasters. These areas house some of the most densely populated urban agglomerates,and are of significant strategic importance to coastal states. As historically demonstrated, it is not adequate for governments to merely react after a disaster has occurred. A more effective strategy for mitigating effects of disasters is to focus efforts on reducing vulnerabilities and risks before such incidents occur, with allocation of commensurate resources. The SFDRR offers a comprehensive and robust framework that can be used to build an effective disaster risk mitigation strategy. With its proactive approach, the framework is particularly suited to coastal urban areas in the Indo-Pacific region, as they can benefit from the SFDRR's focus on resource allocation, climate change, and international cooperation.

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Chapter 6

Industry 4.0 Technologies and Ocean Data Management

T.V.S. Udaya Bhaskar
and
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Introduction

Oceanography is an interdisciplinary science and integrates fields like geology, biology, chemistry, physics, and engineering for exploring the ocean and is a relatively young field of science. The formal studies relating to oceans began with the H.M.S. Challenger Expedition (1872-1876). During this expedition, data corresponding to ocean temperatures, chemistry, currents, marine life, and seafloor geology were collected. Modern oceanography began during World War II when different countries wanted to learn and understand more about the oceans to gain advantages in communicating and implementing submarine warfare.

At the beginning of this century the amount of ocean data available is quite sparse. This is owing to the difficulty in making these measurements. Temperature is first and fundamental oceanic parameter measured by oceanographers. Buckets thermometers were used initially for measuring the surface temperature of the ocean. This was followed by Mechanical Bathy Thermographs (MBT) which were considered as the first set of instruments used for measuring temperature. Since water temperature varies by different layers (hot at the surface and cold at the bottom) which affect the sonar, resulting in producing inaccurate location results, these bathothermographs were fixed on to the outer hulls of submarines and used effectively during the during World War II.

As operating the MBT is difficult, these were eventually replaced with Expendable Bathy Thermographs (XBT) which was relatively easy to operate and data obtained is more accurate. Though the use of XBT is easy compared to MBTs, the data was available only along selected shipping lanes. This left huge gaps in the data in many part of the global ocean. Also the seas were rough during winter which made the data collection even more difficult. By the late 1950s and 60s, underwater vehicles, known as submersibles, revolutionised oceanographic exploration.

With the advancement in technology and rapid industrialisation, the oceanographic instrumentation became sophisticated measuring many parameters. The limitations of XBTs (measuring temperature alone) were eliminated by using conductivity, temperature and depth (CTD) sensors. Oceanic Research Vessels (ORVs) were built to measure high research quality

With the advancement in technology and rapid industrialisation, the oceanographic instrumentation became sophisticated measuring many parameters

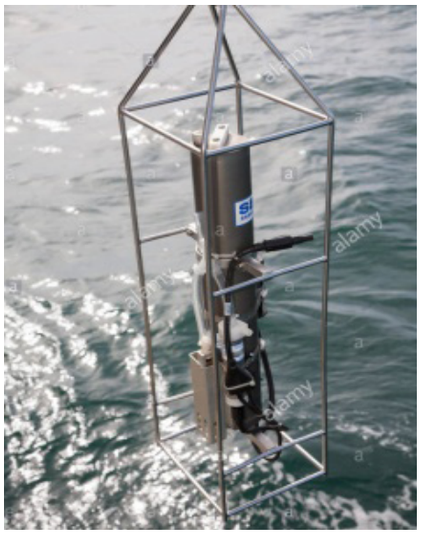
data which is used in enhancing the understanding of the oceans. Figure 1 shows the sample pictures of oceanic instruments used for measuring ocean parameters. However the data sampled using these instruments and ships were still spare as the data is available only along specified shipping routes or those taken during a specific research cruise. Overcoming this needed advancement in technology for autonomous measurement instruments which observe the sea irrespective of the region, season and extreme weather conditions.

This led to the development of Array of Realtime Geostrophic Oceanography (ARGO) profiling floats which performed the tasks of CTD unmanned. These floats once deployed measured the temperature, salinity from surface to the 2000 m depth as long as their battery supports and the mission once set cannot be changed during the course of its life. Initial versions of this technology saw few teething problems with shorter battery life, micro leakage problems, pressure sensor offsets etc. Improvements in instrumentation, communication, and battery life

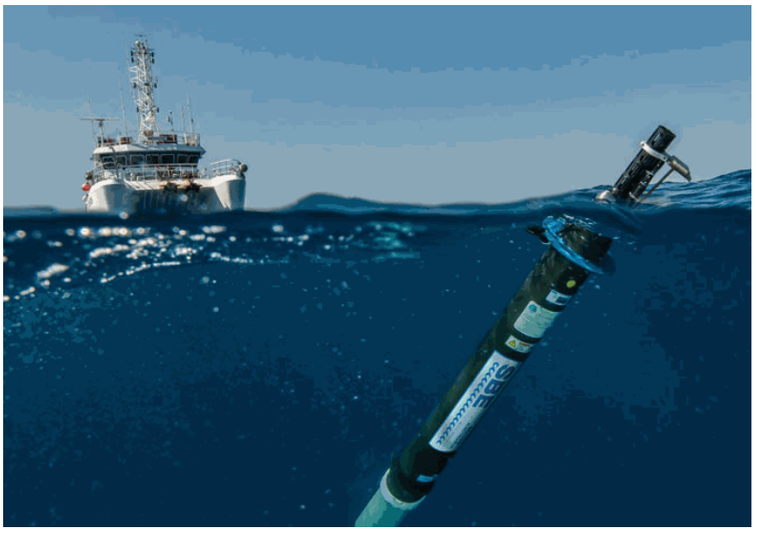
Figure 1: Sample pictures of (a) MBT (b) XBT (c) CTD (d) Argo profiling float.

Mechanical Bathy Thermograph

Expandable Bathy Thermograph



CTD



Argo profiling float

everything led to the development of the renewed Argo floats which revolutionized the way the oceans are measured.

Today the data from Argo floats in the past two decades surpassed all the measurements taken during the past century. The Industrial revolution 3.0 has seen a sea of change in the way the instruments and sensors with high precision being manufactured for use in measuring ocean parameters.

Industry 4.0, also known as the fourth industrial revolution, consists of advance manufacturing and information technologies, to fulfil the customised requirement of different areas of the human being in lesser time. It has enabled oceanographic observational platforms which are supported by wireless connectivity and high precision sensors. The latest set of Argo floats have intelligence built in so that they can change their missions to suit the needs of the users on the land. The floats intelligently measures the data and communicate it to primary or secondary servers based on availability and also check to see if the mission is changed or not and accordingly start to begin it new cycle. Also these under water autonomous robots are equipped with the technology to check if it is going to hit the bottom and change its profiling depth accordingly. Also the floats can communicate host of problems like "end of life" etc. This sea of change in the data collection became possible only due to the developments owing to Industry 4.0.

Today, moored buoys and water column samplers are used to monitor sea surface conditions and water quality factors, coring devices collect sediment samples, sonar helps create maps of the seafloor, and remotely operated vehicles (ROVs) allow us to safely and efficiently explore all parts of the ocean. As ocean exploration increases and technology advances, so does our understanding of the way the ocean functions and supports life on Earth. With safety, cost, and efficiency as top priorities, the manner in which ocean exploration has progressed continues to evolve. We have seen a technological transition from manned submersibles to ROVs. Advances in remote sensing, satellite communication, and data collection, including sampling devices and live video feeds, allow experts from across the globe to connect and share information in real time. The industrial revolution 4.0 has paved the way the instruments are networked; data is shared in real time; vast amount of data managed; intelligent decisions are taken using the data.

Significant benefits of Industry 4.0 technologies for Ocean Data collection

Industry 4.0 technologies have the ability to provide instrumentation solutions to map the ocean data during extreme events. Various benefits of Industry 4.0 technologies, envisaged for oceans are as under:

Table1

Significant technologies of Industry 4.0 useful in oceanographic applications

#	Technology	Use in Oceanography data collection and data management
1.	**Autonomous robot instruments**	As data collection during extreme conditions and dangerous locations is difficult, it would be ideal to build autonomous robotic instruments which can work incessantly and map the oceans which can be used in the forecasting models.Sensors can be scaled up to map high resolution data and battery life can be enhanced to make it work for longer duration. Example instruments include Argo profiling floats that map the ocean during all weather conditions to as deep as 2000 meters.
2.	**Internet of Things**	IoT is can be very helpful in the collection of various ocean parameters. Network of sensors can be deployed to collect information and relay it in real time for making quick decisions. For instance beach water quality can be monitored by network of sensor and the information can be relayed for making quick decision about the water quality and issue warning to general public thereby improving the coastal tourism.
3.	**Cloud computing**	With data norms eased for sharing the data and many agencies wanting the data from ocean in real time/near real time, Cloud computing can be very helpful to study and analyse the state of the oceans in many way. Commonly sharable data can be made available through clouds for users to assimilate them in forecasting models and the outputs can also be shared through cloud for better management of computing resources.
4.	**Big Data**	The heterogeneous data from in situ and remote sensing platforms calls for use of Big data applications in oceanography. It can be highly useful for real time/near real time analysing and forecasting. The oceanic instruments collect data in real-time/near real time from sources around the region of interest. This data subsequently equip the oceanographers and policymakers with the latest information which can be very helpful to make better decisions for minimizing the impact.
5.	**Artificial intelligence**	With the data available from host of sensors spanning decades, AI can be used to predict information at time and regions where the data collection is not possible owing to unforeseen conditions. For instance if any sensors installed at a remote location is found to be malfunctioning/not reporting data, AI techniques can be used with the data collected until then and predictions can be made to a reasonable accuracy.

The Indian National Centre for Ocean Information (INCOIS) is an autonomous body, it has also set up good links with various organisations involved in ocean observational programs, to ensure continuous flow of marine met data into INCOIS database.

- Planning of data collection activities regarding extreme events like cyclones, Tsunamis, high wave etc.;
- Manufacturing of instruments which are resilient to these extreme events and still measure the ocean parameters;
- Use robotic instruments to map the surface/sub-surface data and its structure for use in future studies;
- The digital technologies help oceanographers perform analysis from the remotely sensed data.
- Helps in providing innovations in advance manufacturing and digital technologies for obtaining high quality data which is not possible manually;
- Oceanographic research community can use these technologies to identify unusual and anomalous information and correlate with suitable climate indices;

Some of significant technologies of Industry 4.0 that can be of use in oceanographic data collection and data management are given in the Table 1.

Benefits of Industry 4.0 Technologies for Data Management

The Indian Ocean is among the most data-sparse regions in the world. In addition to the limited availability of observed data, the length and quality of currently available data in digital form are not sufficient to generate reliable climate products. The National Institute of Oceanography (NIO) was set up in 1966 as an outcome of the International Indian Ocean Expedition (IIOE) which acted as the National Oceanographic Data Centre (NODC) till 2004.

The Indian National Centre for Ocean Information (INCOIS) was established as an autonomous body in 1999 under the Ministry of Earth Sciences (MoES), Government of India. Since its inception, INCOIS has been providing ocean data, information and advisory services to society, industry, government and scientific communities through sustained ocean observations (Pattabhi et al., 2018). This is supported by constant improvements using latest techniques by the way of systematic and focused research.

With advancement in industries and manufacturing technologies, a network of ocean observing systems covering both open and coastal oceans(involving in-situ and remote sensing instruments),was established

in the Indian Ocean with the help of various agencies working under MoES. These observing network provides data on various oceanographic and surface meteorological parameters in real-time. INCOIS, is designated as the central repository for marine data in the country. Accordingly it receives data from many ocean observation platforms both in real/near real time as well as in delayed mode (at the end of cruise, after servicing etc.). Apart from these, huge quantities of historical data are also archived.

INCOIS has also set up good links with various organisations involved in ocean observational programs, to ensure continuous flow of marine met data into INCOIS database. Excellent communication network set up at INCOIS ensures reception of data from in-situ platforms like Argo profiling floats, moorings, drifters, tide gauges, tsunami &wave rider buoys and automated weather stations (AWS) mounted on the top of ship etc., in real time. For communication INSAT and ARGOS constellation of satellites are employed.

INCOIS data centre is given the authority to archive all marine met data collected under various national or regional programmes. INCOIS gets the data from a host of sensors and in situ platforms from multitude of sources. Each such data received at INCOIS from different origins and platforms are treated differently for different parameters. Data are primarily processed and assessed for their quality following international standards. For instance, Argo profiling float data was quality assessed following the recommendations of Argo Data Management Team (Wong et al, 2021); data from drifting buoys was quality assessed using Hansen and Poulain, (1996); XBT data was quality checked using CSIRO cookbook, Bailey et al., (1994). The resulting data which is quality flagged is then archived for dissemination to various stake holders and is also used in generation of value added data products. The inventory of metadata is published on the web site for the assistance of users. The National Data Policy (NDSAP, 2012) set forth by the Govt. Of India is strictly followed while making these data available to the general public. Data holding at INCOIS are segregated into two categories viz., open and restricted. Particularly any data within the Exclusive Economic Zone (EEZ) is generally restricted for general users, while it is provided without any restriction to Indian Navy and Defence organizations.

While sharing data with researchers of Indian origin an undertaking is obtained stating that the data will be specifically used for research purpose and not be shared with any third party users. Commercial users are generally charged depending on the parameter and duration of interest. Foreign national requests are processed only after due approval is provided by committee of members formed by Director, INCOIS.

Table 2

Types of data sets archived and served at INCOIS

INCOIS data archives	In situ (CTD, XBT/XCTD, Argo, Wave Rider Buoys etc)	Historical Data sets and Maps
	Remote Sensing (NOAA AVHRR, MODIS , OCM etc)	
	OGCM outputs (MOM, ROMs, HyCOMetc)	

INCOIS data centre also has the responsibility of international data exchange. Argo profiling floats data is shared in near real time by send the data to GTS and Global Data Archival Centres (GDAC). Drifting and moored buoys data are all shared by disseminating the data on to GTS. INCOIS data centre was recognized by the IODE/IOC for hosting mirror site of OBIS (data on marine species locations). As with any data centre all the necessary quality control procedures, standardization, format set by the international community are followed for interoperability and ease of exchange with the user community.

INCOIS data centre is also designated as the National Oceanographic Data Centre by the International Oceanographic Data and Information Exchange (IODE) Programme of Intergovernmental Oceanographic Commission (IOC). This centre serves as the National and Regional Argo Data Centre for the Indian Ocean as part of the International Argo Programme.

Data Holding and Dissemination Mechanisms

Table3 provides information about the types of data sets archived and disseminated to the end users as a part of ocean data and information services from INCOIS. These data sets are classified into three categories namely in situ, Remote Sensing and Ocean Models outputs. Some historical legacy data sets are obtained at the time establishment of INCOIS which are clubbed along with other in situ measurements from ocean observational platforms and used in re-analysis products. Some hardcopy maps available with INCOS are digitized and are used for fisheries applications. Table3shows the data received and archived at INCOIS which includes the data collected during specific scientific programs, routine observation platforms, moving platforms like drifters, Ocean Research Vessels etc, remote sensing and model reanalysis data. The in situ data is available to the users as individual observation records. Both remote sensing and model outputs

Table 3

List of various data holdings archived at INCOIS for dissemination to end users

Type of Data	Parameters
In situ Argo (http://www.incois.gov.in/argo/argo.jsp) Moored buoys (www.odis.incois.gov.in) Drifting buoys (www.odis.incois.gov.in) Tide guages (www.odis.incois.gov.in) Bottom pressure recorders (www.odis.incois.gov.in) XBT observations (www.odis.incois.gov.in) Current meters (www.odis.incois.gov.in) HF Radars (www.odis.incois.gov.in) Automatic Weather Stations (www.odis.incois.gov.in) Wave Rider Buoys (www.odis.incois.gov.in) Wave Height Meter (www.odis.incois.gov.in) CTD (www.odis.incois.gov.in) Coastal Ocean Monitoring and Prediction System (http://www.incois.gov.in/portal/comaps/home.jsp)	Temperature and salinity Air pressure air temperature wind speed and direction water temperature wave height and direction current speed and direction Wave parameters SST and Air Temperature Atmospheric Pressure Sea Surface Currents Sea Level Pollution monitoring along the coast.
Remote Sensing MODIS/Terra and Aqua (las.incois.gov.in) OCM-1&2/Oceansat-2 (las.incois.gov.in) Altimeter/TOPEX TMI/TRMM-TMI (las.incois.gov.in) Quicksat& ASCAT (las.incois.gov.in) SeaWifs	Sea surface temperature Chlorophyll Wave height Sea level Rainfall Wind speed and Wind vector
Ocean Models Simple Oceanographic Data Assimilation (SODA) Joint Environmental Data Analysis Centre (JEDA) National Centre for Environmental Prediction (NCEP) CPC Merged Analysis of Precipitation(CMAP). WW3 analysis products. various parameters from MOM and ROMS models.	Ocean currents Temperature and salinity Depth of 20deg Isotherm Mixed Layer Depth Isothermal Layer Depth Rainfall Wave parameters

are available on regular grids covering the global oceans. Variety of data with multi dimensions in space and time poses a challenge for archival and subsequent retrieval. Quite often, similar parameter from different platforms/sensors needs to be stored together for easy retrieval thereby reducing latency.

Traditionally data are stored, retrieved and disseminated by the means of flat files. But depending on the type of data, different dissemination mechanism is needed to serve the end user. Enhancement in software industry led to many advancement in the way the data are handled and served to the users. Various dissemination mechanisms for the type of data served is listed in table

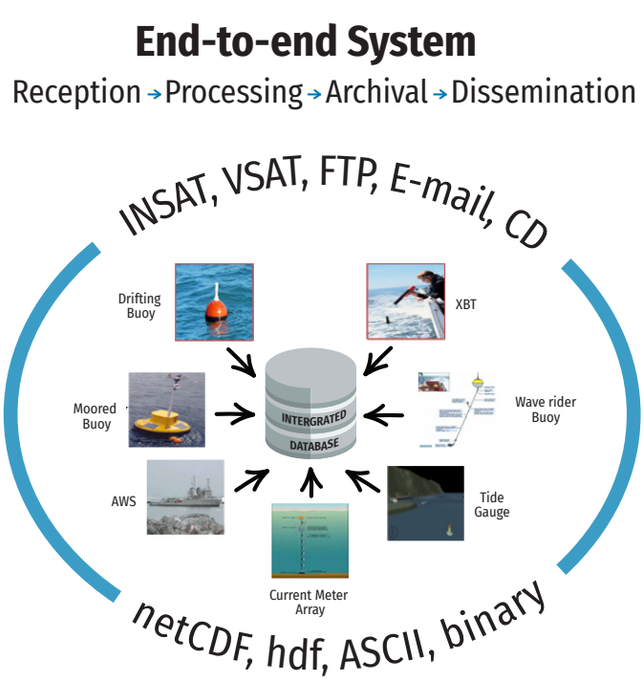


Figure 1
Heterogeneous *insitu* data (Eularian and Lagrangian types) flow from observational platforms into the centralized database.

4. The diversified and heterogeneous nature of the ocean data has caused problems in handling them in a unified way under single window. The advancement in the software industry owing to Industry 4.0 also enabled the dissemination of the data and derived information by INCOIS in many forms. INCOIS developed and employed (i) Ocean Data and Information System (ODIS) a web-GIS based system for serving in situ data. (ii) Live Access Server (LAS) for remote sensing data. (iii) web based data services. (iv) Digital Ocean a web-based integrated tool capable of handling all the above.

Ocean Data and Information System (ODIS)

To deal with heterogeneous type of in situ data sets and to allow easy retrieval and analysis facilities, the Ocean Data and Information System (ODIS) has been set up (Shesu et al., 2013). The ODIS act as a one stop shop for all the in situ data and information with varying parameters from open oceans and coastal regions and delivers them to the users as per the data policies. ODIS is a unified system that is capable of multiple functionalities viz., archiving, visualizing, and sharing heterogeneous data from a single point. Thus the ODIS serves the needs of the user community by delivering data and preliminary information services at lower costs, manpower and time-scales than has been associated with ocean state monitoring and management previously.

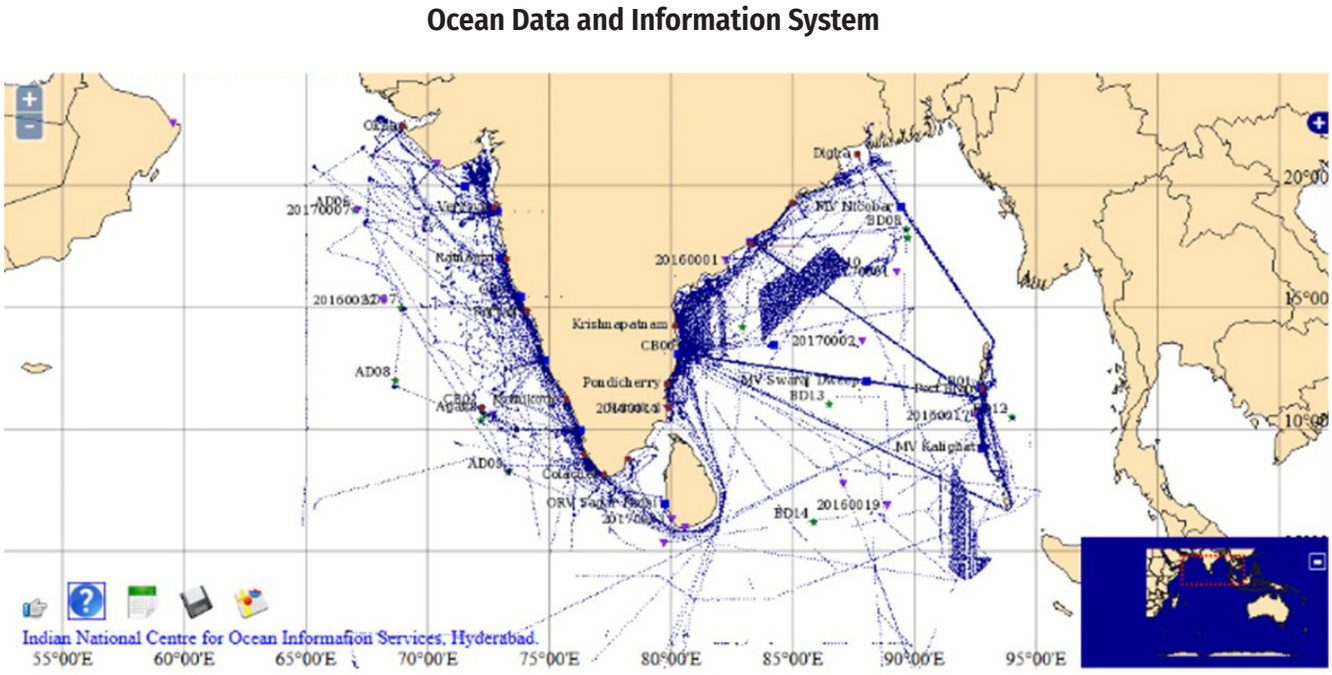


Figure 2 : Ocean Data and Information System (ODIS) set up at INCOIS (shesu et al ., 2013).

Table 4

Methods employed for dissemination of data and value added products by INCOIS

Type of data	Dissemination method	URL for access
In situ	**Ocean data and information system and ERDDAP**	http://odis.incois.gov.in; http://erddap.incois.gov.in/erddap/tabledap/Indian_ARGO_Floats.graph?longitude%2Clatitude%2CCYCLE_NUMBER&time%3E=2017-08-21T00%3A00%3A00Z&time%3C=2017-08-28T00%3A00%3A00Z&longitude%3E=20&longitude%3C=150&latitude%3E=-70&latitude%3C=30&.draw=markers&.marker=5%7C5&.color=0x000000&.colorBar=%7C%7C%7C%7C%7C&.bgColor=0xffccccff
Remote Sensing data	**Web services and Live Accesses Server and ERDDAP**	http://www.incois.gov.in/portal/remotesensing/TERA_display.html ; http://las.incois.gov.in/las/UI.vm#panelHeaderHidden=false;differences=false;autoContour=false;xCATID=AVHRR-AMSR-ID;xDSID=id-5bcbfeb022;varid=sst-id-5bcbfeb022;imageSize=auto;over=xy;compute=Nonetoken;zlo=0;zhi=0;tlo=01-Jun-2002%2000:00;thi=01-Jun-2002%2000:00;catid=AVHRR-AMSR-ID;dsid=id-5bcbfeb022;varid=sst-id-5bcbfeb022;avarcount=0;xlo=20.125;xhi=139.88;ylo=-29.875;yhi=29.88;operation_id=Plot_2D_XY_zoom;view=xy http://erddap.incois.gov.in/erddap/griddap/AMSR2_3Day_Global.graph
Model outputs	**Live Access Server**	http://las.incois.gov.in

Table 5

Details of raw and derived data available on ILAS (las.incois.gov.in)

Product	Availability Period
Objectively Analyzed Argo (10 days & Monthly)	Jan 2002 – Till date
AMSRE (3 day & monthly)	Jun 2002 – Till date
NOAA High resolution SST	Sep 1981 – Till date
NOAA SST (INCOIS ground station)	2008 – Till date
WHOI Air – Sea Fluxes	Jan 1985 – Jul 2010
OCEAN Analysis (MOM –GODAS)	Jan 2003 – Jun 2011
Ocean Color Monitor (OCM1)	Jan 2003 – Apr 2006
Quik Scat Wind products	Aug 1999 – Nov 2009
TMI (3 day and monthly)	Jan 1998 – Till date
ASCAT wind products	Nov 2008 – Till date

Initially, the traditional method of data handling (e.g., flat files) was used. With the passage of time huge inflow of data from various sources was witnessed. With this, the traditional methods of handling data proved to be difficult. Conventional methods have difficulties with comprehensive management, analysis, and application of the dynamic ocean data, owing to the spatial and temporal complexity of the data (ZHAO et al., 2009). Elements of the ODIS set up at INCOIS is shown in Figure 2. ODIS was designed and developed using open access data management and web access tools like MySQL, UMN Map Server and Open Layers (Mapserver Team, 2013). It thus serves as an end-to-end ocean data management system (Shesu et al., 2013).

The basic aim of ODIS to make it one of its kind to ensure delivery of heterogeneous data sets, mainly from all research organizations and university students involved in collection, to the oceanographic community. A sample snapshot of the data from ship based automatic weather stations is shown in Figure 2.

Data Services through Live Access Server (LAS)

As the remote sensing and model data are on regular grids unlike the in situ data which is for a point source, different mechanism is formulated for visualization and dissemination. Remote Sensing and Model data are served using Live Access Server (LAS). Also value added products derived from the in situ observations using

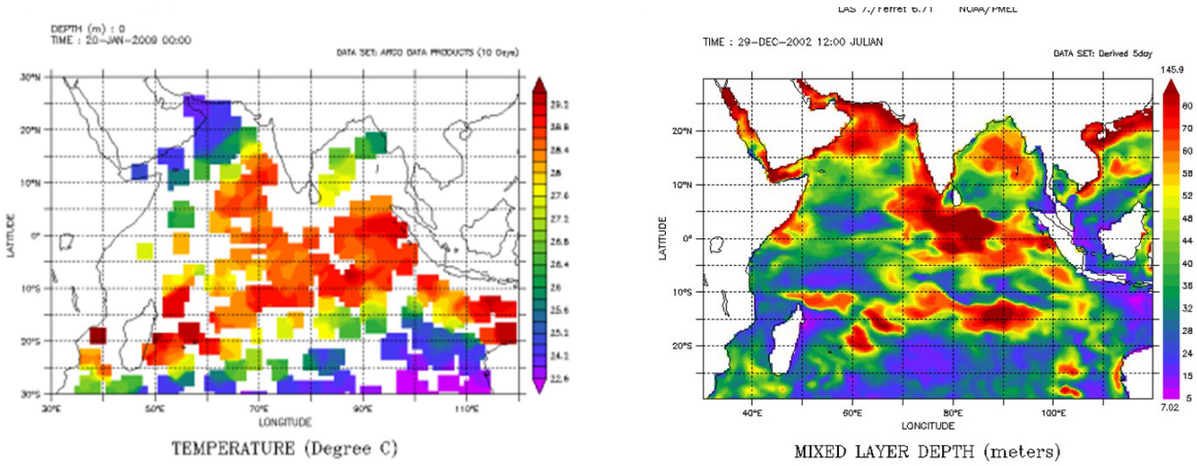


Figure 4 : Snap shot of products on ILAS (a) Sea Surface Temperature from Argo and (b) Mixed Layer Depth derived from MOM-GODAS

objective analysis (gridded product of Argo profile data; (Udaya Bhaskar et. al., 2007) is also made available via the LAS. The in situ data sets are first quality controlled following a three way quality control process, details of which are provided in (Udaya bhaskar et al., 2012), before they are employed in generating value added data sets. The resulting value added products, model generated data sets, remote sensing data are updated regularly as and when the data are available.

Table 6 lists the information about gridded data which is made available through the INCOIS LAS. A sample snapshot of products made available on Live Access Server is given in Figure 4. Live Access Server is designed to provide flexible access to geo-referenced scientific data (Devender et. al., 2013). A LAS which uses the Open-source Project for a Network Data Access Protocol (Open DAP) and Distributed Ocean Data System (DODS) technology allows the user to visualize, download, and even perform the preliminary analysis of data in a graphical user interface. The preliminary analysis include generation of area averages, time series plots pertaining to any desired location, generation of hovmoller plots, scatter plots of different parameters, anomaly plots, multi-parameter view etc.

Web-based Data Services

The advent of internet technology provided the user with easy and

The advent of internet technology provided the user with easy and faster access to the available information with a mouse-click and the Geographical Information System (GIS) provided the capability for storing and managing large amounts of spatial data.

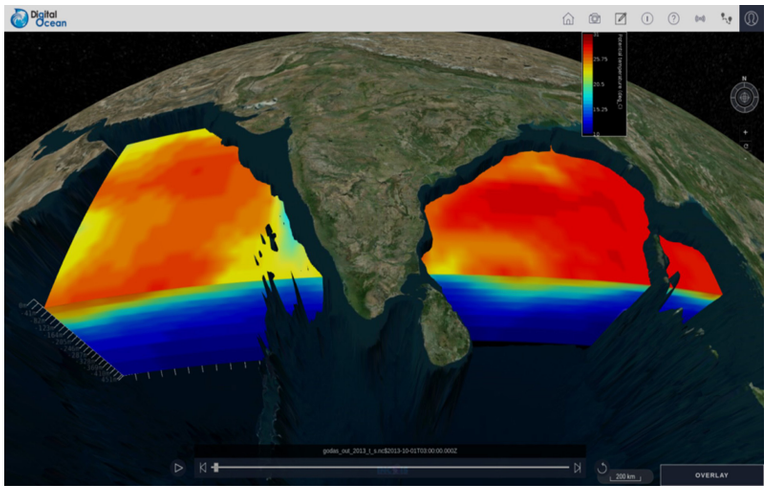


Figure 3 **: 5**D Visualisation of temperature data from the model output

faster access to the available information with a mouse-click and the Geographical Information System (GIS) provided the capability for storing and managing large amounts of spatial data. A Web-GIS system combines the advantages of both internet and GIS technologies, allowing users to access the geospatial information and data via web-browsers without purchasing expensive, proprietary GIS software.

These web-based data services developed at INCOIS are now providing ocean data, information and advisory services using the Web-GIS technologies like Java, Java script, HTML, Arc-View and Arc-Info, UMN mapserver (Rama Rao et al., 2009; Markstorm et al., 2002; Tsou, 2004), enabling the users to query, analyze, visualize and download ocean data, information and advisories for their regions of interest. The system also allows the integration of data from different sources and management.

Digital Ocean

Though the individual means of visualizing, disseminating of heterogeneous data described above are useful there are still growing request for integrating all these together to achieve better results. Also there is ever increasing demand for on the fly visualization, web-based analysis and data products retrieval by many users. As we are living in the digital era, data driven decisions with advanced analytics and visualization features are becoming integral part of all walks of life. In Ocean Sciences, abundant marine meteorological and oceanographic data in real-time from variety of ocean observing systems are fed in to the models to improve the quality of weather and ocean state forecasts. Well organised data in an integrated environment will support the usage and help in better understanding of oceanographic processes. This request led to the development of Digital Ocean which is means for efficiently integrating the heterogeneous ocean data and provide advanced visualization and analysis tools to facilitate the improved understanding of oceans in multi-disciplinary approach. Figure 6 show a sample 3D visualization of model output which might not be possible with previously discussed methods of LAS or other means.

Summary and Conclusions

Industry 4.0 provides solutions to various industries and other related

areas including oceanography and earth sciences. This consists of various manufacturing and digital information technologies to collect, transfer, store, analyse and properly monitor information system. The hardships faced by the scientist in the field of ocean data collection and management was reduced to a greater extend owing the advancement in digital technologies which provide an innovative method for the data collection, management and dissemination. By the application of these I4.0 technologies, scientist are able to observe the oceans remotely from their desks discovering new oceanic features, communicate with the remote instruments perform rapid measurements, use these data in coming up with decisions in real time.

INCOIS, an organization under the Ministry of Earth Sciences (MoES) is identified as the agency for central repository for marine met data in India. Being the nodal agency, it receives oceanographic (marine and met) data in real time/ near real time, as well as in delayed mode (after planned cruises, servicing etc.) from various network. INCOIS has strong inter-organizational links with many agencies who are involved in ocean observational programs. This strong links ensure consistent flow of data (in situ, remote sensing, model outputs) to its center. With the archival of all the data, INCOIS is conferred with the mandate to process the data uniformly, perform advanced quality control check and assign flags, archive it and disseminate it in the form of raw/processed data and data products. The data dissemination is done in accordance with India's national data policy using host of technologies developed under Industry 4.0. Data archived at INCOIS are classified into three categories namely in situ, remote sensing and model outputs.

Various modes of dissemination of data depending on the type of data is employed. ODIS and LAS are chosen to disseminate in situ and data in regular grid format respectively. The problem with ODIS and LAS were overcome by developing Digital Ocean as web-based analysis, on the fly visualization platform which was possible with immense developments in software industry as per the I4.0 standards. INCOIS, through its data management activities, plays a vital role in many areas critical to the study of climate change, marine resources. Its links to international programs ensures that the Indian data is available for global models, thereby strengthening these models and also allows Indian researchers to access these global datasets, in turn strengthening their research outcomes.

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Chapter 7

Trade, Connectivity and Maritime Transport

Prabir De

Introduction

The Indo-Pacific is a multipolar region with geographical coverage in the Indian and the Pacific oceans. India occupies a prominent position in the Indian Ocean in terms of geographical, cultural and civilisational linkages. Indo-Pacific participating countries strongly believe in a region that is free, open and inclusive, and one that is founded upon a cooperative and collaborative rules-based order. At the UNSC High-Level Open Debate on 9 August 2021, Indian Prime Minister Narendra Modi underlined the five principles as a global roadmap of maritime security cooperation.[1]Maritime trade and maritime security go hand in hand. Both are essential components of the Indo-Pacific initiative. At the same time, better efficiency in maritime transport may boost competitiveness and stimulate economic growth in emerging markets in Indo-Pacific.

To strengthen the Indo-Pacific partnership, India has introduced the country's Indo-Pacific vision by announcing the Indo-Pacific Oceans' Initiative (IPOI) in November 2019.[2] Several other nations and regional blocs such as the European Union (EU) and Association of South East Asian Nations (ASEAN) have gradually introduced their respective Indo-Pacific visions and/or work plans with latest being the African nation Kenya. Facilitation of maritime trade and transportation is found to be one of the key pillars in all Indo-Pacific visions.

Indo-Pacific participating countries recognise that maritime connectivity is a prime catalyst for international trade competitiveness and economic growth. For example, the strength of maritime trade acts as a stimulus to the growth of the countries. Better efficiency in maritime transport may boost competitiveness and stimulate economic growth in Indo-Pacific.[3] To strengthen the maritime connectivity in the Indian Ocean, Prime Minister Narendra Modi has envisioned the concept of SAGAR – "Security and Growth for All in the Region".[4] SAGAR in a way signifies India's engagement in the Indian Ocean to ensure peace, stability and prosperity. Therefore, enhanced understanding of the strategic importance of maritime transport for trade and development is important. However, contrary to popular belief, maritime transport occupies a relatively small part of conventional regional integration analysis.

Tariff is no longer the prime barrier to international trade. Non-tariff issues such as missing links in inter-country transportation and variation in domestic regulations have a direct impact on trade in the Indo-Pacific. An inefficient port or shipping line can affect the price of traded products in the same way as high tariff does (De, 2009; Munim and Schramm, 2018).

On the other hand, domestic regulations in the transportation sector also strongly affect the trade

in goods and services. For example, port regulations and stevedoring vary across countries in the Indo-Pacific. While the rise of maritime trade triggers the growth of the countries and vice-versa, variations in trade flows and resource endowments between countries increase maritime costs. Legal and regulatory issues also adversely impact on maritime connectivity in Indo-Pacific.[5] Indo-Pacific countries face many "common" challenges in the maritime transport sector. In the context of the above, this chapter attempts to identify a set of recommendations for enhanced maritime transport cooperation in the Indo-Pacific.

There is a growing consensus in understanding the geographical scope and economic and strategic approaches towards Indo-Pacific. The perspective of Indo-Pacific is to ensure safe and secure maritime space through an inclusive and multilateral approach among participating countries while ascertaining the ASEAN centrality and to support the rules-based international order and regional stability. India's vision for the Indo-Pacific includes securing end-to-end supply chains in the region, no disproportionate dependence on a single country, and ensuring prosperity for all stakeholder nations. Being the centre of gravity of economic growth, Indo-Pacific could drive the world towards sustainable and resilient recovery from the current crisis.

Trade profile

The Indo-Pacific contributes more than half of the world's GDP and population and has huge natural resources and potential for new economic opportunities. Nearly 65 per cent of world trade is from Indo-Pacific participating countries, thus indicating strong interdependence in trade and can potentially strength of economic integration in the region. For instance, Indo-Pacific countries' global exports and imports were about US$ 11.76 trillion (47.43 per cent) and US$ 11.98 trillion (49.27 per cent), respectively, in 2019 (see Appendix 1). Due to the number of bilateral and multilateral free trade agreements (FTAs) among Indo-Pacific countries (about 50 per cent of FTAs signed by Indo-Pacific countries among WTO members), tariffs have come down for most of the products traded, which then has facilitated the rise in trade. The intra-regional merchandise trade in Indo-Pacific stands at 70 per cent (about US$ 7 trillion) in 2019. The most traded merchandise products

Indo-Pacific participating countries recognise that maritime connectivity is a prime catalyst for international trade competitiveness and economic growth. These countries face many "common" challenges in the maritime transport sector.

Table 1

India's Exports to and Imports from Indo-Pacific

Year	Exports to Indo-Pacific	Imports from Indo-Pacific	Share of India's Export to Indo-Pacific in World	Share of India's Import from Indo-Pacific in World
	(US$ Billion)		(%)	
2000	23.61	18.14	55.6	36.1
2010	134.55	191.12	60.4	54.5
2019	198.48	271.59	61.1	56.6

Source: Calculated by authors based on DOTS, IMF Database

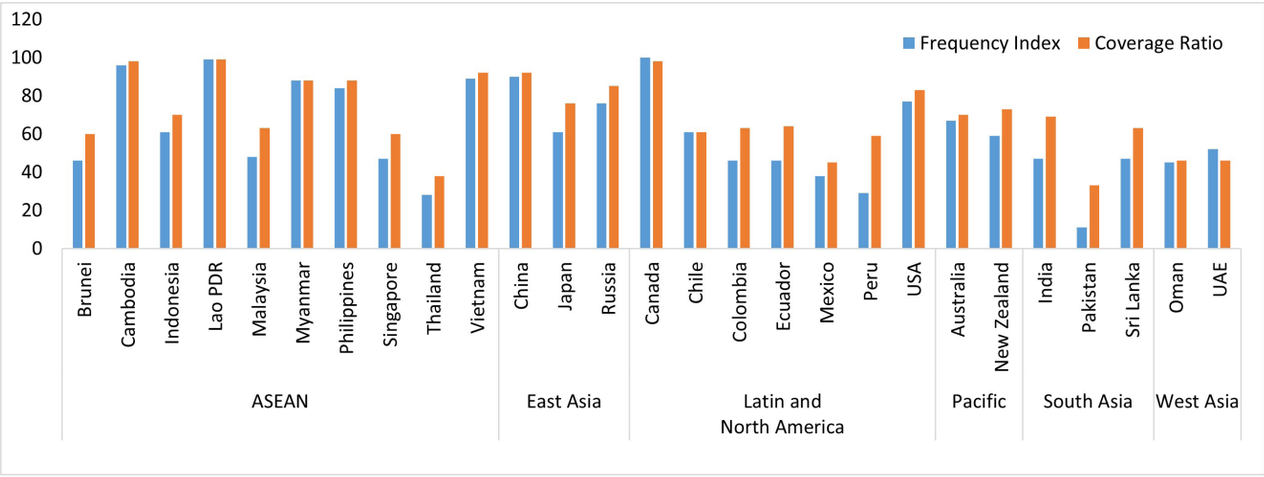
within the Indo-Pacific region include machinery and transport equipment, automobiles, garments, digital and office equipment, mineral fuels, lubricants, chemical and related products. Services are an increasingly important part of the Indo-Pacific region, wherein trade in services plays an important role in integrating Indo-Pacific in the areas of Industry 4.0, tourism, education, transportation, financial services, among others.

The trade liberalisation that started in the early 1990s ushered in three decades of steady reduction in tariffs and regulations. In 2019, India's merchandise export and import with the Indo-Pacific region were about US$ 198 billion and US$ 272 billion, respectively (Table 1). In the same year, about 61 per cent of India's global export and 57 per cent of India global import were conducted with the Indo-Pacific region, thereby showing India's high dependence on the region for international trade purposes. Light manufacturing, textiles and clothing sector are the primary competitive sectors of India.

Services sector has emerged as one of the growth drivers of the Indian economy. Within Indo-Pacific, India is known for its IT prowess and a leading exporter in technology-enabled modern services. India is one of major commercial services providers in the world, having comparative advantages in export of computer and information services and other business services (that include a wide range of information-intensive services). India's export in services such as travel, communication services, and personal, cultural, and related services have been rising, showing further scope of trade exchange in the Indo-Pacific region. However, with newer developments such as scientific invention like Covid19- vaccines, logistics services become pivotal in meeting the growing demand and supply response.

Today, global value chains in Indo-Pacific require greater resilience and efficiencies in the flow of goods between and within countries. Here comes the scope of collaboration with Japan in securing faster and best

Figure 1: High Incidence of NTMs in the Indo-Pacific in 2020



Note: Incidence of NTM is computed based on the Frequency Index (FI), which describes percentage share of number of products exported that are affected by NTMs imposed by importing countries. In other words, FI accounts only for the presence or absence of an NTM and summarises the percentage of products to which one or more NTMs are applied.
Source: Author's own calculation

logistics services, which may trigger new types of growth strategies for the entire region. India has substantial intra-Sectoral level trade in P&Cs with Indo-Pacific in electrical equipment, industrial machines, automobiles, power generating machines and telecommunications. India also has high potential in some of the sectors which are interdependent with the services sector such as ICT, R&D, pharmaceuticals, etc. Besides, there are huge business opportunities for SMEs and Start-ups in the post-Covid19-, particularly, in digital connectivity, e-commerce, cross-border delivery services, logistics business, etc. Indo-Pacific countries have strong interdependence in trade and it is the key strength of economic growth in the region.

It is imperative that the Indo-Pacific countries invest more in post-Covid-19 recovery phase, particularly in health and other physical infrastructures. To enhance the trade and value chains, the Indo-Pacific countries could aim for a regional investment framework. A regional investment framework would facilitate regional coordination as also exploit economies of scale. It will motivate countries for harmonising the investment regime and streamlining and simplifying the procedures for investment applications and approvals (Kumarasamy and De, 2019).

Trade barriers and trade facilitation

Non-tariff measures (NTMs) are one of the key trade barriers in Indo-Pacific - both technical and non-technical measures (such as SPS, TBT, anti-dumping duties, quotas, restriction of movement of professionals and others). This is highly apparent

during the current Covid-19 period, when many countries have notified several NTMs related to the Covid-19 protocols to maintain health, hygienic and quality standards. Figure 1 suggests high incidence of NTMs in Indo-Pacific.

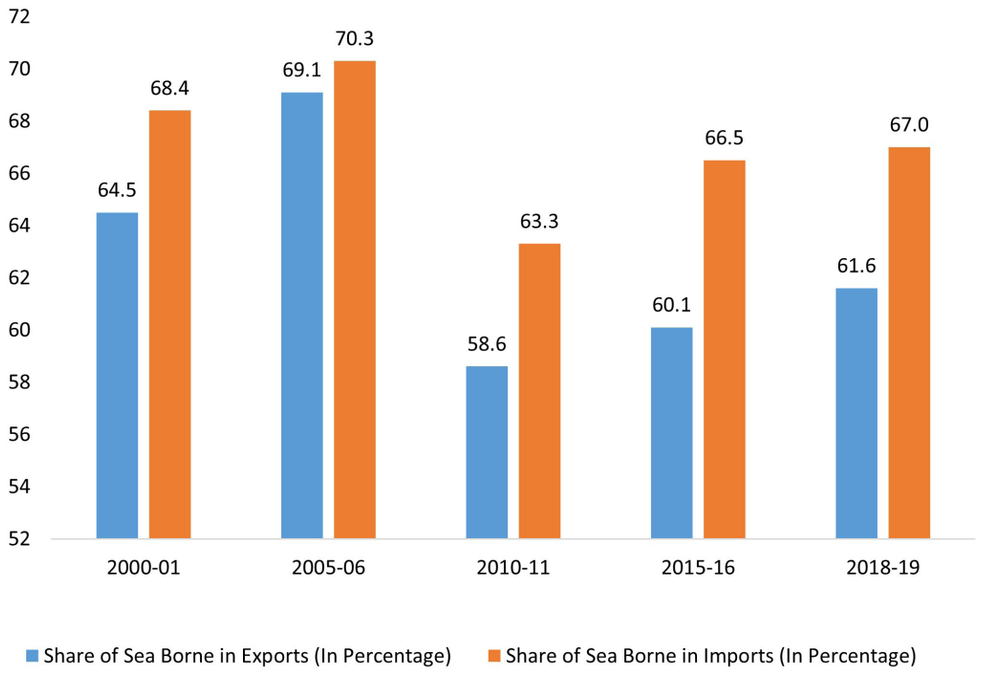
There is now an urgent need for harmonisation or consolidation of trade agreements and facilitation of rules-based favourable and sustainable business and trade environments in order to ease out regulatory bottlenecks and promote regional and global value chain linkages in the Indo-Pacific. Therefore, given the trade interdependencies of the Indo-Pacific countries, strengthening the 7th pillar of the IPOI can entail the needed stimulus to support sustainable growth and prosperity. Here, collaboration for mutual recognition of standards; developing testing facilities for health and food safety; raising people's awareness; and further promoting mutual communication and connectivity with global institutions will bring needed resilience on standards and quality control as well as ease the burden of NTMs.

Major trade facilitation issues today are simplifications of trade procedures, interoperability and synchronisation of digital interfaces, etc. To facilitate digital trade, India has initiated several digital trade facilitation initiatives which have effectively improved the trade facilitation process. At the same time, countries have adopted the paperless / contact-less trade in coping with the ongoing pandemic. Many of the Indo-Pacific countries have introduced Single Window systems.

To facilitate trade in Indo-Pacific, reinforcing the Trade Facilitation Agreement (TFA) of the WTO is the best hope. The TFA aims to improve transparency, increase possibilities to participate in global value chains, and reduce the scope of corruption. It also sets out measures for effective cooperation between customs and other appropriate authorities on trade facilitation and customs compliance issues. As on date, nearly 36 Indo-Pacific countries have ratified the WTO TFA. Globally, the signing of the Customs Convention on the International Transport of Goods under Cover of TIR Carnets (TIR Convention, 1975) is a positive step towards the elimination of some NTBs and simplifying procedures. India is one of the Indo-Pacific countries, which has ratified TIR.

There is now an urgent need for harmonisation or consolidation of trade agreements and facilitation of rules-based favourable and sustainable business and trade environments in order to ease out regulatory bottlenecks and promote regional and global value chain linkages in the Indo-Pacific.

Figure 2: Share of Sea-Borne Trade in Total Foreign Trade in India (%)



Source Author's own calculation based on Basic Ports Statistics, various issues

The Covid-19 outbreak has forced the producers of goods and services to move towards digitalisation of business operations. In particular, digitalising the supply chain would help achieve business resilience against supply chain disruptions amidst Covid-19 outbreak (De, 2021). Besides, the IT-enabled services will make the trade procedures simple, and help firms to avoid delay in export time and reduce trade costs associated with cumbersome administrative procedures. Digital technology in the trade facilitation measures would strengthen the supply chains.

To mitigate the supply shocks and rebound strongly in post-Covid 19, Japan has initiated the Supply Chain Resilience Initiative (SCRI), a trilateral approach to trade, partnering with India and Australia. The SCRI is set to reshape the geographical contour of the cross-border production networks in the region and would help in diversifying the supply risks across nations instead of being dependent on one or few countries (De, 2021). This would create a new wave of industrialisation, where MNCs look for sustainable value chains across the region. Indo-Pacific region can leverage the emerging scenario and support each other to build new and resilient supply chains.

Maritime connectivity

Share of sea-borne trade in country's total trade is high and growing. Sea-borne exports and imports contribute about 62 per cent and 67 per cent

of India's total exports and India's total import, respectively (Figure 2). Access to port and quality of port infrastructure are some important factors contributing to developing country's rise in international trade and to improve a region's connectivity.[6] Studies show the scope for potential strength of economic integration across the Indo-Pacific region, and indicate that the Indo-Pacific could become a powerful bloc if the South and Southeast Asia could be linked through stronger connectivity, particularly developing maritime linkages and improved trade facilitation and other networks that would reduce trade costs, which are a necessary step in order to realise the trade potential of the Indo-Pacific.[7]

While world's best performing ports are in Asia, Asia also leads in construction of new ports and terminals. Identifying these challenges in advance and corresponding mitigating strategies would be the correct step forward in adding further momentum to the Indo-Pacific integration. A way of classifying the challenges of maritime transportation from the supply side is to divide them into five groups: (a) ports, shipping and logistics; (b) regulatory barriers, (c) supply chain; (d) human resource; and (e) investment. Given these challenges, a set of maritime transportation proposals below may strengthen the Indo-Pacific partnership.

Value of direct maritime connectivity

Volume of maritime trade is a crucial building block for greater economic integration in the Indo-Pacific. About 80 percent of global trade by volume and more than 70 per cent by value are managed by sea-bound trade across the world, thereby demonstrating the importance of the maritime sector to international trade. Asia has become the driver of world maritime trade till the recent COVID-19 outbreak.

Table 2: Indo-Pacific Shipping Indicators

Country	Country LSCI	Number of services	Number of country calls	Number of operators	Ship capacity (TEU)	Deployed annual capacity (TEU)	Number of direct calls
Australia	37.23	49	46	28	10,622	70,12,238	37
France	77.43	78	73	33	23,964	2,02,57,192	80
India	57.21	96	89	44	14,000	1,76,39,963	55
Indonesia	34.93	111	106	36	6,910	96,30,971	17
Japan	87.49	203	206	59	23,656	2,04,77,147	47
United States	103.83	198	179	61	23,656	4,20,64,326	104

Data refers to the year 2020

Source: Author's own based on MDS Transmodal, the UK

Sea-bound trade in Asian countries will hold a share of about 50 per cent (i.e. 11.33 billion tonnes) in 2019, followed by Europe, North America and Latin American countries.[8] Therefore, the importance of direct maritime linkages is crucial for Indo-Pacific maritime connectivity. For example, China having the highest number of trading partners with zero transhipment (including its top 15 trading partners), compared to Singapore and Hong Kong, is ranked as the number one maritime connected country in the world.[9] Direct maritime connectivity reduces the costs of transportation and time. Some high impact cooperation areas could be explored are short-sea shipping, cruise shipping, inland waterways, to mention a few.

Reducing disparity in maritime infrastructure

Containerised trade infrastructure including ports and shipping networks is important for participation in regional and global value chains. Indo-Pacific participating countries had a share of 70.5 per cent (572.3 million TEUs in 2019) in global container throughput.[10] East Asia and Southeast Asian countries had covered about 50 percent of container traffic in 2019.[11] China alone contributes over one fourth of the world's total container traffic. Next comes the USA and Singapore. More developed regional economies – such as Singapore, the UAE, Malaysia, Australia and South Africa – have better ports than less developed economies, particularly in Africa. Notwithstanding China's phenomenal rise in containerised trade, the gap between China and the rest of the other Indo-Pacific participating countries is quite high and also growing.

Table 2 clearly highlights the shipping strengths of select Indo-Pacific countries as of 2020. India's strength in shipping is commensurate with its long coastline, making it truly a maritime nation. However, both India and Indonesia require scaling up ship capacity and the number of shipping operators. Indonesia, in particular, requires adding more direct calls which would lead to improving the country's liner shipping connectivity index (LSCI) and corresponding global rank. Therefore, narrowing the maritime infrastructure gap in the Indo-Pacific has high merit and will have lasting and more critical effect on the regional economies.

Deepening liner shipping network

Since trade is largely carried through the ocean, stronger maritime transport cooperation will lead to strengthening the liner shipping networks, both within and between countries in the Indo-Pacific. Liner shipping connectivity improvement, particularly in developing countries and LDCs should be the priority of Indo-Pacific maritime cooperation. In the Indo-Pacific, there is high scope to

Indo-Pacific countries exchange large amounts of data, particularly between North America and Asia. The massive data exchanges are carried through submarine cables across the globe.

improve liner shipping connectivity. Being a maritime zone, an Indo-Pacific-wide regional initiative to develop and improve liner shipping connectivity, involving operators, regulators, and shippers would be extremely beneficial in terms of promoting more liner services, lowering transportation costs, and enhancing connectivity.

At the same time, container ship size has been increasing globally. About 52 per cent of the merchant fleets are under the control of Indo-Pacific countries as of 2020.[12] However, most of the merchant fleets are registered in the small island countries such as Panama, Liberia, Marshall Islands, Hong Kong and Singapore due to the advantage of lower taxes and hassle free registration in these countries. Getting back the business in Indo-Pacific may require setting up a favourable environment for registration of merchant fleets.

Development of port facilities

Seven out of the largest 10 container ports in the world are in China. Some of the major ASEAN ports such as Singapore Port, Port Klang and Tanjung Pelepas in Malaysia, Laem Chabang, Thailand, Ho Chi Minh City Port, Vietnam are within 35 rank globally. The principal port in South Asia is Colombo (ranked 24th in the world). The largest container ports in India are on the west coast (Jawaharlal Nehru Port and Mundra port). Among the deep-sea ports in Asia, only a few are located in the Indian Ocean Region (IOR) and the majority are located in China and South Korea. This also calls for new investments in the port sector in the Indo-Pacific in order to accommodate bigger vessels and also in strengthening backend connectivity with the hinterland.[13] Several Indo-Pacific participating countries are currently building new port facilities and some are either under construction or in the planning stage. India has taken an ambitious port development project called Sagarmala. Sagarmala project offers important lessons on developing new ports which are environment friendly (Green Port), financing models and multi-modal transportation.

Implementing digital maritime programme

Indo-Pacific countries exchange large amounts of data, particularly between North America and Asia. The massive data exchanges are carried through submarine cables across the globe. As of early 2019, there are approximately 378 submarine cables in service around the world.[14] Indo-Pacific region should provide special attention to manage the choke points

such as the Strait of Malacca between Malaysia, Singapore and Indonesia; the Strait of Luzon between Chinese Taipei and the Philippines; and the South China Sea. Greater cooperation among cable operators, content developers, industry associations, private sector, etc. may help designing a regional programme to protect the digital infrastructure, sharing information among service providers and governments, conduct training and capacity building, etc.

Port and shipping services or the maritime transport quality can significantly benefit from digitalization. Digitalization and new developments in Artificial Intelligence, Blockchain, the Internet of things and automation are of increasing relevance to maritime transport. They help optimize existing processes, create new business opportunities and transform supply chains and the geography of trade. Digitalization in maritime transport offers new business opportunities in the Indo-Pacific. Development of information and communication technology will be essential to reach a regional convergence of port community systems. Indo-Pacific countries may convene a global conference on investment opportunities in port sector digitalization.

Table 3: Largest Container Ship Operators, 2021

Rank	Operator	Number of Ships	TEU (000's)	Share (%)
1	Maersk	708	4121.78	16.9
2	Mediterranean shipping corporation (MSC)	589	3920.78	16.1
3	CMAA CGM Group	557	3049.74	12.5
4	COSCO Group	498	3007.41	12.3
5	Hapag-Lloyd	256	1789.39	7.3
6	Ocean Network Express	221	1600.53	6.6
7	Evergreen Line	202	1345.53	5.5
8	HMM Company Ltd	75	752.6	3.1
9	Yang Ming Marine Transport Corporation	89	628.46	2.6
10	Zim	95	409.81	1.7
	Total		**24,571.68**	**100**

Note: based on capacity on offer
Source: Alphaliner.https://alphaliner.axsmarine.com/PublicTop100/

Strengthening competition and supply chain networks

The global market is highly concentrated with a few major players, as shown in Table 3. Top five shipping lines together share a staggering 65 percent of container shipping operations in 2021. The skewed distribution of container ship operators is a matter of concern. Although disproportionate trade across the countries has lead to rise of concentration of container transportation, it may cause several risks: first, generate inefficiency when there is excess capacity; second, rise in shortage of containers and shipping rates, which pose severe threat to supply chain networks; and third, put a halt to product (or services) differentiation. To encourage competition, Indo-Pacific countries may consider regulatory reforms and set up a forum of competition authorities of Indo-Pacific countries. While higher competition may encourage more enterprises joining the business, particularly from developing parts of the Indo-Pacific such as India, this may also promote the supply chain resilience in the region.

Climate change adaptation and sustainability

Indo-Pacific participating countries should collaborate to promote green shipping and development of green ports, including through GHG emission reduction and work to help improve understanding of issues at the interface of maritime transport and the climate change challenges. Special emphasis should be placed on climate change adaptation and the need to enhance the climate-resilience of transport systems. To meet this objective, Indo-Pacific participating countries may organize a policy dialogue to generate new ideas in climate change adaptation of maritime transportation in the Indo-Pacific.

Enhanced trade facilitation for maritime transportation

Indo-Pacific participating countries may undertake Enhanced Trade Facilitation for Maritime Transportation in Indo-Pacific (ETFMT-IP). The ETFMT-IP can aim for, among others, (a) simplification and harmonization of maritime trade procedures; (b) designing and implementing common trading standards; (c) application of digital technology to marine logistics chain; (d) promoting the use of new technologies to facilitate transport and logistics in the region by sharing experience, developing knowledge products, including transport facilitation tools, and undertaking pilot demonstrations; and (e) training and capacity building programmes in the maritime transportation and logistics.

Performance monitoring of Indo-Pacific ports will add immense value in designing an appropriate regional policy for development of ports and shipping. Besides, the ETFMT-IP will lead to integrated port community systems with their respective integrated customs management systems within and between countries. Indo-pacific participating countries can facilitate ETFMT-IP by promoting national collaborative platforms such as single windows, port community systems or national trade facilitation committees. A network of national trade facilitation authorities of Indo-Pacific participating countries could be a good start.

Gains from institutional cooperation

There are several ways to strengthen institutional cooperation. First, in order to move ahead with the enhanced programmes on maritime transportation, Indo-Pacific participating countries may establish an intergovernmental group of experts on maritime transportation to support participating countries in planning and operationalization of international transport and maritime corridors in the Indo-Pacific and beyond. Second, Indo-Pacific participating countries may introduce new academic courses on maritime transportation or maritime economics. India may offer a Masters programme on maritime economics / management at the Indian Maritime University (IMU) in partnership with similar organisations in other Indo-Pacific countries. Third, to cope up with the unfolding challenges in the port sector, Indo-Pacific participating countries may consider organising the first ever Indo-Pacific Ports Conclave in 2022-23.

An Indo-Pacific Forum of ports may be set up which would then facilitate sharing of information, promote training and capacity building programmes and exchange of best practices in post-COVID-19 period. Similarly, a regional maritime fund for promotion of maritime connectivity in the Indo-Pacific will facilitate implementation of regional projects.

Partnering with Japan in maritime connectivity

Japan's connectivity initiatives are well known for quality infrastructure investment.[15] India-Japan collaboration can offer support to the enhanced maritime connectivity, which may help to lower logistic costs and increase trade in the Indo-Pacific region. Japan with its capabilities on ship building with over 1000 shipyards domestically, can offer technological support for ship building. Maritime transportation in India may get the desired technological fillip with Japan's participation in IPOI. India and Japan may join hands to build maritime infrastructure in third countries.

Coordination with regional bodies

For coordinated improvements of maritime connectivity, Indo-Pacific countries can connect with regional programmes having impacts on maritime trade and integration such as the ASEAN (Master Plan of ASEAN Connectivity), BIMSTEC (BIMSTEC Master Plan of Transport Connectivity), the EU (TEN-T), etc.

Need of a regional comprehensive maritime transport policy

In view of scaling up the maritime activities, Indo-Pacific participating countries could aim for a regional policy framework in maritime transport, which will facilitate simplification of maritime trade procedures and reforms, sourcing and sharing best practices, and regional coordination, leading to promote maritime transportation across the region. It may also provide a mechanism for knowledge-sharing and policy dialogue around good practices. Standardized and harmonized data reporting, dissemination and statistical framework is required for regional cooperation in maritime transportation including short sea shipping and/or coastal shipping. In this context, BIMSTEC offers important lessons for regional maritime cooperation. Negotiation of BIMSTEC maritime cooperation agreement, which earlier used to be known as BIMSTEC coastal shipping agreement, has been concluded and all participating countries have agreed to liberalise the cabotage in the region.

Concluding Remarks

The Indo-Pacific region contributes more than half of the world's GDP and population and has huge natural resources and potential for new economic opportunities. Nearly 65 percent of world trade is from Indo-Pacific participating countries, thus indicating strong interdependence in trade and has a potential strength of economic integration in the Indo-Pacific. About 68 per cent of India's sea-borne exports to and about 51 percent India's sea-borne imports are from Indo-Pacific countries, respectively, therefore indicating high dependence on the Indo-Pacific region in trade. Access to port and quality of port infrastructure are some important factors contributing to developing countries' rise in international trade and to improve a region's connectivity. While tariff is no longer the prime barrier to international trade, non-tariff issues such as missing links in inter-country transportation and variation in domestic regulations have a direct impact on trade in the Indo-Pacific. An inefficient port or shipping line can affect the price of traded products in the same way a high tariff does. On the other hand, domestic regulations in the transportation sector also strongly affect the trade in goods and services. In essence, a regional

comprehensive maritime transport policy in Indo-Pacific can add to the economic dynamism in the Indo-Pacific.

Focus should on cooperation other than liberalisation, and allow the IPOI to be "Project-driven". India must strengthen maritime transport linkages with ASEAN, South Asia and Island nations in India Ocean and Pacific. Engaging private sector in IPOI may generate high dividends. Some of the areas where Indian private sector leads in the region are ship building, port development, AEOs, shipping lines, etc. India and Japan partnership can drive the IPOI 7th Pillar, but it requires "anchor" project(s) to start with.

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End Notes

[1] Refer, Indian Prime Minister's speech at PM's remarks at the UNSC High-Level Open Debate on "Enhancing Maritime Security: A Case for International Cooperation", available at https://www.pmindia.gov.in/en/news_updates/pms-remarks-at-the-unsc-high-level-open-debate-on-enhancing-maritime-security-a-case-for-international-cooperation/?comment=disable&tag_term=pmspeech

[2] The IPOI focuses on seven pillars: (i) Maritime Security; (ii) Maritime Ecology; (iii) Maritime Resources; (iv) Capacity Building and Resource Sharing; (v) Disaster Risk Reduction and Management; (vi) Science, Technology and Academic Cooperation; and (viii) Trade, Connectivity and Maritime Transport.

[3] Refer, Indo-Pacific Report 2019 (NMF, 2019).

[4] Refer Prime Minister's speech delivered during his Mauritius visit in March 2015, available at https://www.pmindia.gov.in/en/news_updates/text-of-the-pms-remarks-on-the-commissioning-of-coast-ship-barracuda

[5] Refer, ADB (2019)

[6] Refer, for example, Munim and Schramm (2018)

[7] Refer, Rahman et al. (2020) investigate the potential economic effect of Indo-Pacific regional economic cooperation and compares with the extended CPTPP. Using the Computable General Equilibrium (CGE) modelling, authors have shown that the quadrilateral alliance between the US, Japan, Australia, and India along with South and Southeast Asia would lead to substantial economic gain.

[8] Refer, AIC-RIS (2021)

[9] Refer, Saeed and Cullinane (2021)

[10] Refer, AIC-RIS (2021)

[11] ibid

[12] ibid

[13] In a recent paper, Wignarajaet al. (2021) have argued that success in the new operating environment requires Commonwealth countries to build resilience by improving the quality of seaport infrastructure, logistics and transport networks, enhancing trade openness and trade facilitation, addressing maritime security threats and increasing the environmental sustainability of shipping operations. These are equally valid for Indo-Pacific countries. Also refer, De (2019)

[14] Refer, for example, Indo-Pacific Report (NMF, 2019)

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Appendix 1: Major Indicators of Indo-Pacific, 2019

Indicators	Indo-Pacific	Share in World (%)
Land area (million sq. km)	74.23	58.29
Population (billion)	5.24	68.28
GDP (current US$ trillion)	60.19	68.63
Merchandise exports (US$ trillion)	11.76	47.43
Merchandise imports (US$ trillion)	11.98	49.27
Total merchandise trade (US$ trillion)	23.74	48.27
Intra-regional trade (US$ trillion)	6.81	69.65

Note:ASEAN: Brunei Darussalam, Cambodia, Lao PDR, Myanmar, Malaysia, Indonesia, Singapore, Thailand, Vietnam, Philippines; ***South Asia***: India, Sri Lanka, Pakistan, Bangladesh, Maldives; ***Latin America***: Colombia, Chile, Ecuador, Peru; North America: Canada, Mexico, United States; ***North-East Asia***: China, Japan, South Korea, Russian Federation; ***Pacific***: Australia, New Zealand, Papua New Guinea, Fiji; ***West Asia***: Iran, Islamic Rep., United Arab Emirates, Yemen, Rep., Oman; ***Africa***: Kenya, Somalia, Tanzania, Madagascar, Mozambique, South Africa, Mauritius, Comoros, Seychelles; ***European Union***: France

Source: Calculated based on the World Development Indicators, the World Bank

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