Blue Economy - Opportunities for India

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INTRODUCTION

The global population which is expected to exceed 8 billion by 2030 will require 30% more water, 40% more energy and 50% more food. More than 40% of the world population live within 100km from the coastline, and it continues to be in the uptrend. The Organisation for Economic Cooperation and Development (OECD) estimates the gross value added to global output from the oceans shall be ~ US$ 3.5 trillion in 2030 and shall supporting more than 40 million jobs. Considering the strategic importance of the oceans, the United Nations (UN) has allocated a total global Exclusive Economic Zone (EEZ) of ~137 million km^2, including ~ 12, 11.3,8.5 and 2.3 million km^2 to France, US, Australia and India, respectively. Based on the foundations of the 2012 Rio + 20 UN Conference on sustainable development, the global community announced its commitment on the Sustainable Development Goals (SDG) 2030, in which Goal 14 relates to the sustainable development of the Ocean resources by which the economic activity is in balance with the long-term capacity of the ocean ecosystems, remain resilient and healthy. The importance of sustained utilization of the ocean resources is stressed by the UN declaring 2021-2030 to be the decade of Ocean Science for Sustainable Development.

The pillars essential for transforming the traditional "Ocean and marine economy" to a "Blue" or "Sustainable" economy require appropriate governance in the sustained utilization of the ocean, coastal and marine economies, vision, technology, management, monitoring and time-bound regulatory reforms. The blue economy is thus based on resilient systems, persistent innovation and advances in achieving integrated ecological, economic and social well-being. Hence the fast emerging blue economy paradigm with its components shown in Table 1 requires proper estimation of the size of the opportunity, nature of risks involved, identification of sustainable ocean asset investment, investment framework, and scaling up the capital investments of the blue industries.

Table.1. Components of the Blue Economy

Type of Activity	Ocean Service	Industry
Extraction of non-living resources	Minerals	Seabed Mining
	Energy	Oil and natural gas
		Renewables
	Fresh water	Desalination
Harvesting of living resources	Seafood	Fisheries
		Aquaculture
	Marine biotechnology	Pharmaceuticals, Chemicals
Ocean commerce	Transport and trade	Shipping
		Port infrastructure and services
	Tourism and recreation	Tourism
		Coastal Development

Understanding the strategic importance, different national and global initiatives are underway to develop a future roadmap for blue economy with measurable outcomes and special budgetary provisions. Subsequent to the leadership of the Small Island Developing States (SIDS) and the coastal nations which advocated Blue Economy, the major countries including Australia, Brazil, U.K., U.S., Russia and Norway have developed their National Ocean Policy and established hierarchal institutions at federal and state levels for ensuring progress in the blue growth. With the blue economies of the United States, China and the European Union estimated to be ~US$1.5, 0.1, and 0.5 trillion, respectively, it is expected that blue economy could significantly contribute to India's vision of becoming a US$ 10 trillion economy by 2030.

OPPORTUNITIES FOR INDIA

India with a coastline of 7517 kms and 1208 islands has 13 major ports, 200 notified minor and intermediate ports. The EEZ includes 1.64 million km^2 near the Indian mainland and Lakshadweep, and 0.66 million km^2 in the Andaman and Nicobar Island area. Considering its strategic interest, India is currently seeking to extend its EEZ to 563kms, by which the total EEZ area will equal its land area. India is a key member in the Indian Ocean Rim Association (IORA), an inter-governmental organization comprising of 21 member states and 9 dialogue nations aimed in strengthening regional cooperation and sustainable development within the Indian Ocean region. The IORA blue economy dialogue held in Goa in Aug 2015 passed the Goa declaration stressing the need to identify the thrust areas of the blue economy. During 2018, National Institution of Transforming India (NITI), the Indian Government's apex policy think-tank conducted discussions with all the stakeholders to identify the potential areas of the blue economy which are to be placed on the national strategic focus and to formulate policies for blue growth. Several initiatives have been initiated the Ministry of Environment & Forests and Climate Change (MoEF & CC), Ministry of Earth Sciences (MoES), Ministry of Shipping and other organisations. They include the Deep Ocean Mission, Integrated Coastal Zone Management, Sagarmala, Sagar and Mausam which focuses on the deep ocean resource exploration, marine spatial planning, port development, maritime security and improving livelihood opportunities for coastal communities. In order to synergize the multi-ministry efforts which are engaged in silos, seven working groups are formed by the Government of India (Fig.1) to formulate robust recommendations to capture the huge potential and opportunities in this sector. Thus sustainable, integrated, inclusive and people centric policy for Blue Economy is being evolved by India and the policy statement states that "The blue economy refers to exploring and optimizing the potential of the oceans and seas which are under India's legal jurisdiction for socio-economic development while preserving the health of the oceans".

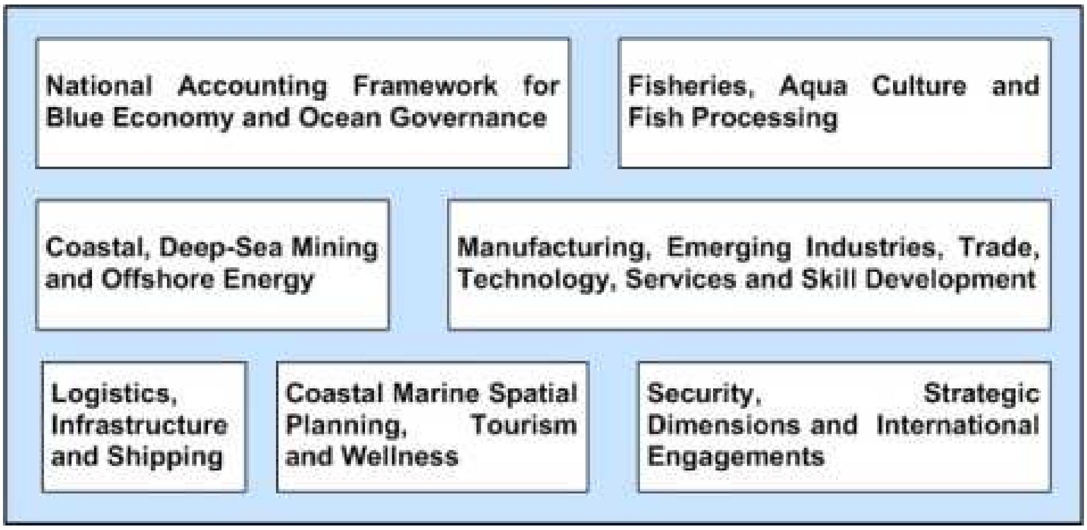

Fig.1. Seven working groups under Indian Government

NON LIVING RESOURCES

Blue Minerals

The developments of the coastal and offshore mineral resources are complimentary for the industrial and economic growth. The coastal placer minerals, such as ilmenite, magnetite, zircon are extensively available on the Kerala, Tamil Nadu, Andhra Pradesh, Orissa and Maharashtra coasts and near shore waters. The Geological Survey of India (GSI), Atomic Mineral Division (AMD) of the Atomic Energy Department and the CSIR-NIO have been involved in exploration and survey of these minerals. The status of the onshore exploration for heavy mineral placers in India is shown in Fig.2. The reserves including ilmenite, rutile, garnet, zircon, kyanite and sillimanite are estimated to be ~ 600, 30, 60, 35, 2 and 4 million tons, worth approximately US $ 120 billion. The deep blue mineral resources include the seafloor polymetallic sulfides around the hydro-thermal vents, cobalt-rich crusts on the seamounts and the polymetallic manganese nodules on the abyssal plains. The polymetallic nodules comprise of manganese, nickel, copper, cobalt, molybdenum, rare earth metals, and traces of elements of commercial interest, including platinum and tellurium. The seafloor sulphides are rich in copper, gold, zinc, lead, barium, and silver. The cobalt-rich crusts contain manganese, iron and a wide array of trace metals including cobalt, copper, nickel, and platinum. About 247, 1.82, 10.47 and 9.5 million tons of manganese, cobalt, nickel and copper are located in waters depths ranging from 5000 to 6000m as polymetallic nodules in the Central Indian Ocean Basin (CIOB), hydrothermal sulphides in the southern Indian Ocean and cobalt crusts in the Afanacy Nikitin sea mount area (Fig.3)

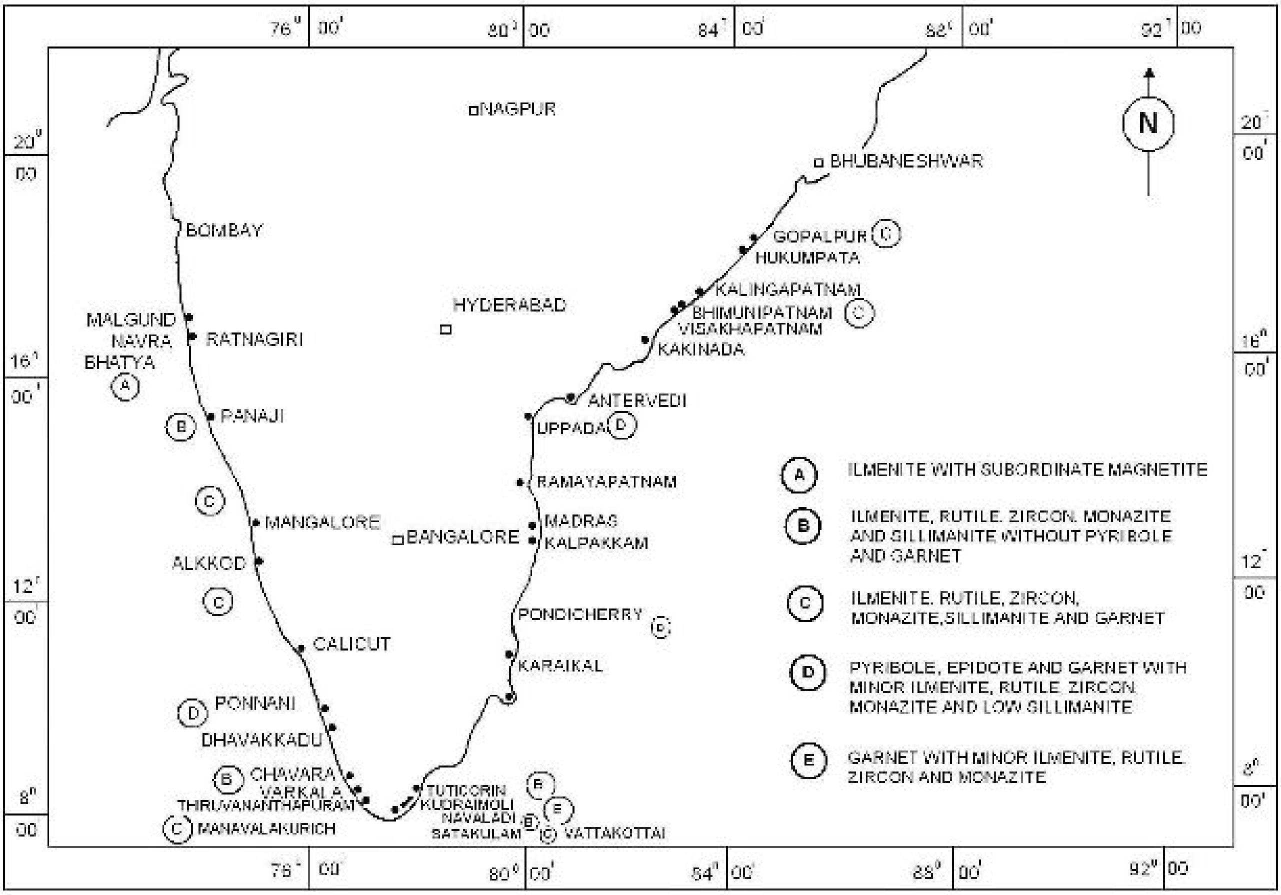

Fig.2. Status of placer deposits exploration in India

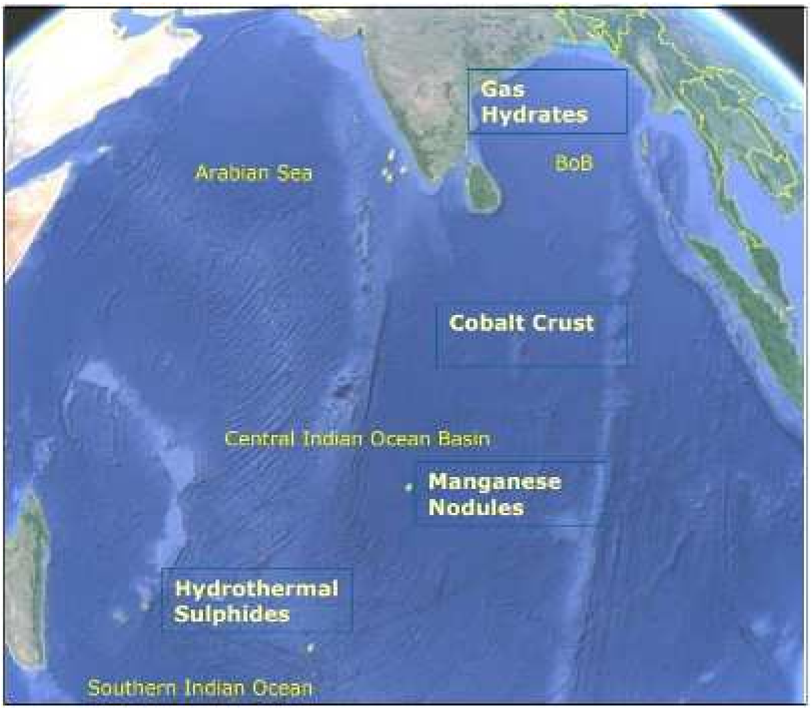

Fig.3. Minerals and energy resources in the Indian Ocean

For carrying out demonstration mining, India has been allocated an area of 75000 km^{2}and 10,000 km^2 in the polymetallic nodule and hydrothermal sulphide sites, respectively. After carrying out field demonstration of a crawler-based mining machine at about 500m water depth, the MoES-NIOT has undertaken the development of a 6000m depth-rated demonstrative polymetallic nodule mining machine. Other associated systems including a 6000m depth-rated electric work-class Remotely Operated Vehicle (ROSUB 6000) and an in-situ deep ocean soil tester which are being used upto 6000m water depths. In order to understand environmental impacts of deep ocean mining and to generate base line data, deep ocean moorings are being developed by NIOT and CSIR-National Institute of Oceanography (NIO). The development of metallurgical processes for extraction of metals is developed by CSIR-Institute for Mineral and Material technology (IMMT) and CSIR-National Metallurgical Laboratory (NML). The development of a battery-powered 6000m depth rated scientific human-occupied submersible with an operational endurance of 12 hours and weighing ~ 20 tons is being undertaken by NIOT.

Blue hydrocarbons

About 26 sedimentary basins in India covering about 3.14 million km^2 host 28 billion tons of conventional hydrocarbons. About 67% of these resources are located offshore. The Mumbai High hosts about 9.2BT, the sedimentary basin with an area of 1.3 million km^2 in the east and west coasts of India spanning from 400m water depth up to the EEZ hosts about 7 BT, and the rest of the resources are concentrated in the Krishna-Godavari (KG), Cauvery and Kerala-Konkan basins. The KG basin hydrocarbon production accounts to ~ 40% of the India's in-house production. In order to foster the natural gas production from deep waters, wells have been established in the KG basin at 2483m water depths. For effective exploitation of the ultra-deep waters, Indian government has planned to invest about US$10 billion in the deep water projects in the KG basin.

About 1684TCM of methane gas are identified to be sequestrated as gas hydrates in the continental settings in 100-300m below the sea floor at water depths ranging between 800-3000m. Considering the strategic importance of the natural gas hydrates, the National Gas Hydrate Program (NGHP) led by the Directorate General of Hydrocarbons (DGH) and supported by Oil and Natural Gas Corporation (ONGC), major oil companies and national scientific organizations including NIOT, the National Geophysical Research Institute (NGRI) and the National Institute of Oceanography (NIO) has performed two detailed drilling expeditions n the Krishna-Godavari (KG), Mahanadi, and Andaman convergent margin and confirmed the presence of large, highly saturated gas hydrate accumulations in the coarse-grained sand-rich depositional systems in the KG basin (Fig.4) .Plans are being discussed for establishing a pilot scale well in the KG basin for long term production capability assessment..

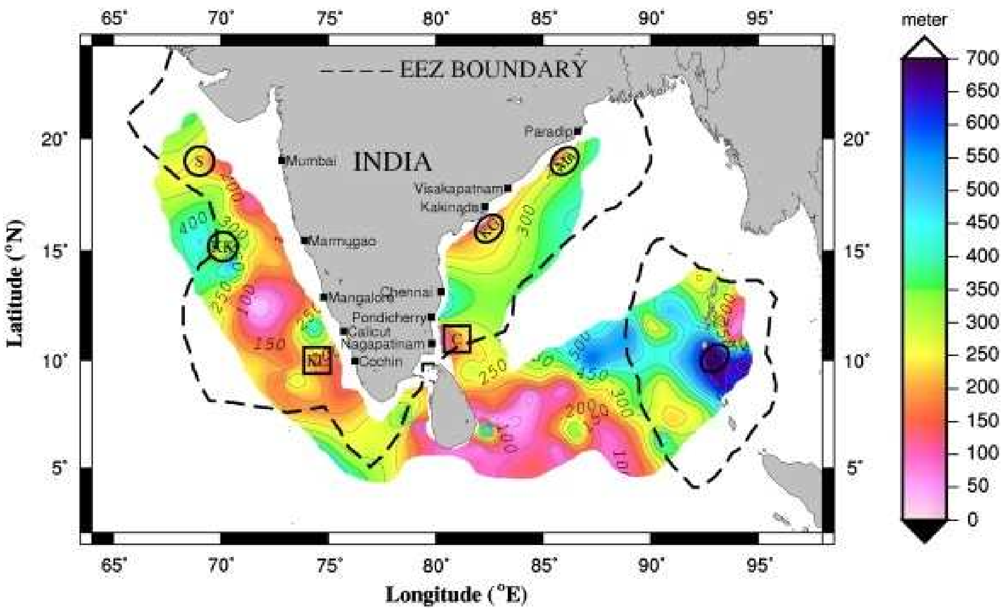

Fig.4. Location of major gas hydrate provinces of India

Renewable Energy

Sustainable marine energy plays a vital role in the economic development and climate adaptation. Offshore regions have tremendous potential to provide renewable energy, viz. offshore wind, waves, ocean currents including tidal currents and thermal energy. About 350GW of offshore wind energy is estimated within the EEZ of India. For fostering the growth of the offshore wind energy, the National Offshore Wind Energy Authority is established for carrying out resource assessment in the EEZ. The offshore wind resource assessment by the MoES-Indian National Center for Ocean Information Systems (INCOIS) based on the long-term satellite wind data (Fig.5) indicates high wind energy potential off-Kanyakumari, Gujarat offshore, Rameshwaram and Jakhau.

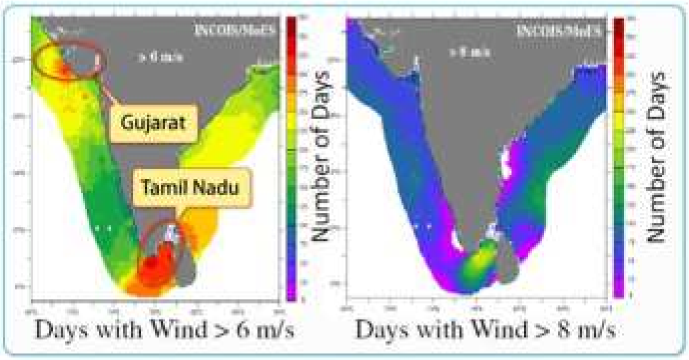

Fig.5. Offshore wind energy resource assessment

For carrying out wind speed, direction, temperature and humidity measurements at 20m elevation from the sea level, LIDAR-based data collection platforms are installed by NIOT and MNRE-National Institute of Wind Energy (NIWE) in the Gulf of Kutch and Gulf of Khambhat. Other ocean energy technologies which are in various stages of development include marine current, wave power and ocean thermal energy conversion (OTEC) face stiff competition from other onshore options. The development on these technologies at NIOT has successfully crossed laboratory stage, improving understanding of complexities involved along the way. Wave energy devices and hydrokinetic turbines have been successfully demonstrated in the open sea by NIOT. Some locations in the Andaman Islands revealed high water current potential and suitable scaled up hydrokinetic turbines are being developed. India being a tropical country has a good potential for Ocean Thermal Energy Conversion (OTEC). The sea water temperatures are observed to be stable and are prevailing continuously throughout the year, making it ideal for a base load energy plant. An OTEC powered desalination system has been taken up by NIOT which will be set up in Lakshadweep islands. India is a member of the International Energy Agency-Ocean Energy Systems (IEA-OES) Group and has taken up activities for accelerating the growth of ocean energy systems in the Asian region.

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Ocean Desalination

Securing adequate quantities of clean water to meet the needs of the growing population is a major challenge. Coastal communities are increasingly turning to the sea to meet their drinking water needs, while in inland there is a tendency for groundwater to become increasingly brackish over time. NIOT has designed and implemented Low Temperature Thermal Desalination (LTTD) plants of 100 m^3/day capacities in the three Islands in the Union Territory of Lakshadweep, where a long cold water is used to draw water from water depth around 300m using a high density polyethylene pipe (Fig.6). The plants which are operating over a decade have proved multiple socio-economic advantages including health of the island community. Efforts are underway for installing LTTD-based desalination plants in six more islands of India. Efforts are also undertaken for realizing combined power and water production.

Fig.6. Desalination plant in Agatti Island of India

LIVING RESOURCES

Seafood- Fisheries, Aquaculture and Pharmaceuticals

Effective and sustained marine bio-prospecting is essential for pursuing human health, offering sustainable supply of high quality food, developing sustainable sources of energy alternates to the conventional hydrocarbons, new industrial products and processes with low greenhouse gas emissions. Hence development of sustainable fisheries and aquaculture is an essential component of the blue economy. The global contributions of the biomass production from marine, aquaculture and inland waters are represented in Fig.7.

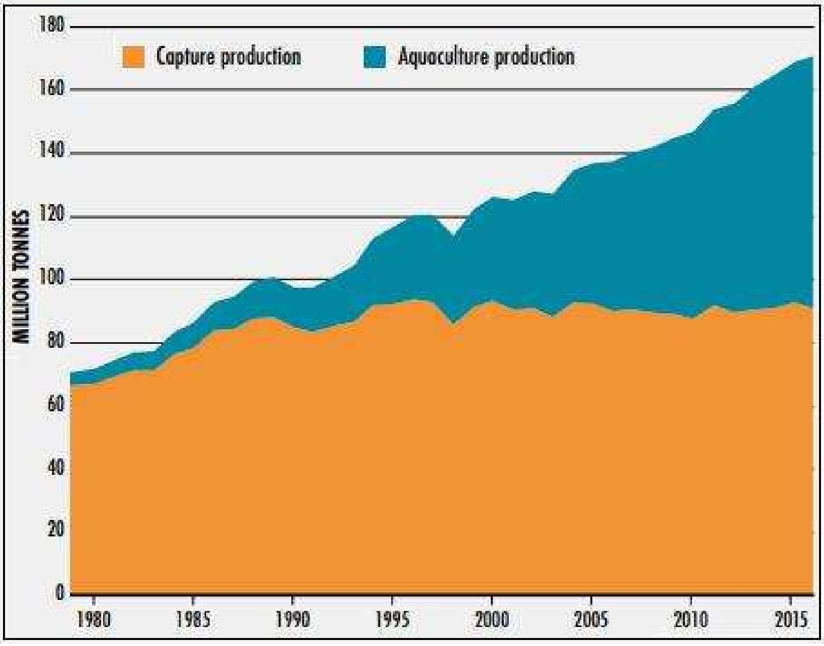

Fig.7. Growth trend of fisheries and aquaculture

With over 2.4 lakh fishing crafts, 6 major fishing harbors, 62 minor fishing harbors, 3432 fishing villages 1511 landing centers and employing 4 million fishing population, India stands 3rd in global fish production. More than 50 different types of fish and shellfish products are exported to 75 countries. The sector contributes 1.1% of the national GDP and creates annual export earnings of about US$ 5 billion. Out of total fish production of 6.4 million tons, marine contributes 3 million tons and production from about 73,000 km^2 of inland water bodies is about 3.4 million tons.

It is identified that potential fish production could be up to 8.4 million tons, a 30% increase from the current production. As a part of motivating deep sea fishing, the integrated development and management of fisheries provides subsidies for conversion of fishing trawlers into deep sea fishing vessels. With the aid of Indian satellite based oceanography,INCOIS provides reliable and timely advisories on the Potential Fishing Zones with specific references to more than 500 fish-landing centers along the Indian coast and also for the algal blooms at near real-time for assessment of primary productivity. Programs are undertaken by MoES- Center for Marine Living Resources and Ecology (CMLRE) to address the biogeochemistry of the eastern Arabian Sea and biological responses including fishery resources in the northern Indian Ocean region through systematic survey. In order to increase the marine finfish production, multi-point moored 9 m diameter open sea cages made of high density polyethylene capable of withstanding turbulent sea states (Fig.8) are developed and demonstrated by NIOT.

Fig.8. Open sea fish cages in Andaman Islands

The Department of Biotechnology (DBT) through various research centres is carrying out activities including fish genomics and transcriptomics, fish and shellfish diseases, immune-stimulants and antimicrobial peptides. Development of bioactive molecules, biomaterials, biosurfactants, DNA bar coding and molecular taxonomy, cell lines and diagnostics were also pursued through adoption of molecular tools and techniques. The marine-microalgae, which are the key for the food, nutritional, cosmetic, pharma and bio-fuel industries, are being studied at NIOT. For fostering the studies on the applications of the deep sea piezophilic micro-organisms in the health and medical sectors, a deep ocean microbial sampling and incubation system capable of bringing the deep-ocean micro bio-resources to the surface and incubating them by maintaining their ambient pressure (Fig.9) is established in NIOT.

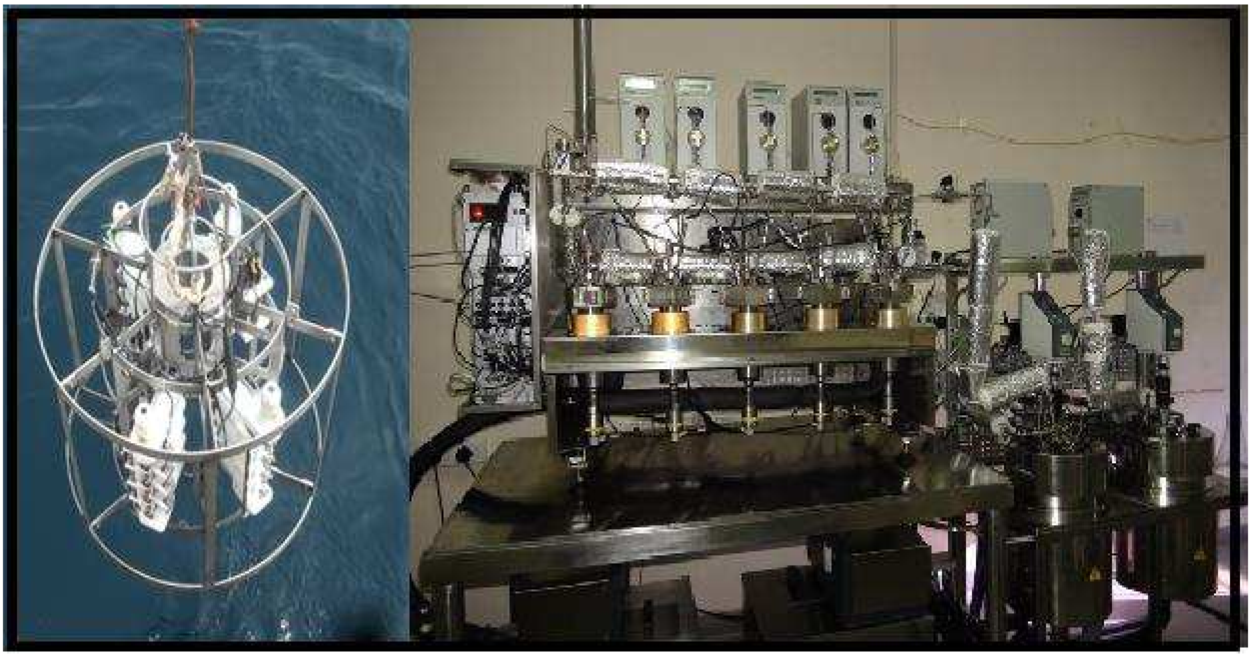

Fig.9. Deep sea sampling and microbial culture facility

OCEAN COMMERCE

Trade and Transport

In India, during 2018, the major ports with a capacity of 1.45 BT handled 0.7 BT and non-major ports handled ~ 0.5 BT. With the total vessel fleet of 1400 with gross registered tonnage (GRT) of ~ 10 million tons, ~ 451 vessels with a capacity of 88% is used for overseas trade and ~ 938 coastal vessels are used for ferrying goods within the country. The inland waterway transport is an economical means of domestic transport. Out of ~ 0.6 million km of navigable waterways in the world, China, Russia, Brazil, Europe, and USA share 18, 16, 8, 7 and 8% .

In India, the contribution of waterways in the domestic transport is <1% compared to China and US which stands at 24% and 6%, respectively. In order to accelerate the ocean commerce and transport, the national maritime development programs worth US$ 11.8 billion are being implemented. Considering the need for efficient, eco-friendly and economical domestic freight services utilizing the coastal and inland waterways, a national perspective plan, Sagarmala, aimed in the port modernisation, effective port connectivity, port-led industrialization is formulated in 2016 by the Ministry of Shipping (Fig.10). Under the Sagarmala Programme, the government has envisioned a total of 189 projects for modernisation of ports involving an investment of US$ 22 billion by the year 2035. The successful realization the program, involving an infrastructure mobilization of US$ 60 billion, aspires to reduce the logistics costs for EXIM and domestic cargo by US$ 6 billion annually, double the share of waterways, boost exports by US$ 110 billion, create 4 million direct jobs, 6 million indirect jobs, and increase the commercial vessel fleet to 1600 by 2025.

Tourism

Tourism is an important source of foreign exchange and is tied to the social, economic, and environmental well-being of many countries. Coastal and ocean-related tourism comes in many forms and includes dive tourism, maritime archaeology, surfing, cruises, ecotourism, and recreational fishing operations. Sustainable tourism can be part of the blue economy, promote conservation and sustainable use of marine environments and species, and generate income for local communities, and maintain and respect local cultures, traditions, and heritage. The United States, Spain and Thailand top the list in tourist count, while France, United States and Spain leads in terms of the number of international visitors. India’s 43% of the coastline with sandy beaches, 11% with rocky land and 31 mangrove areas are potential tourist hubs. In India tourism industry contributed 2% to the total GDP and is projected to reach 6.4% by 2022. In 2017, ~ 10.4 million foreign tourists visited India, mostly coastal places, earning $27 billion. The government has undertaken 17 coastal development projects across the country in the past four years.

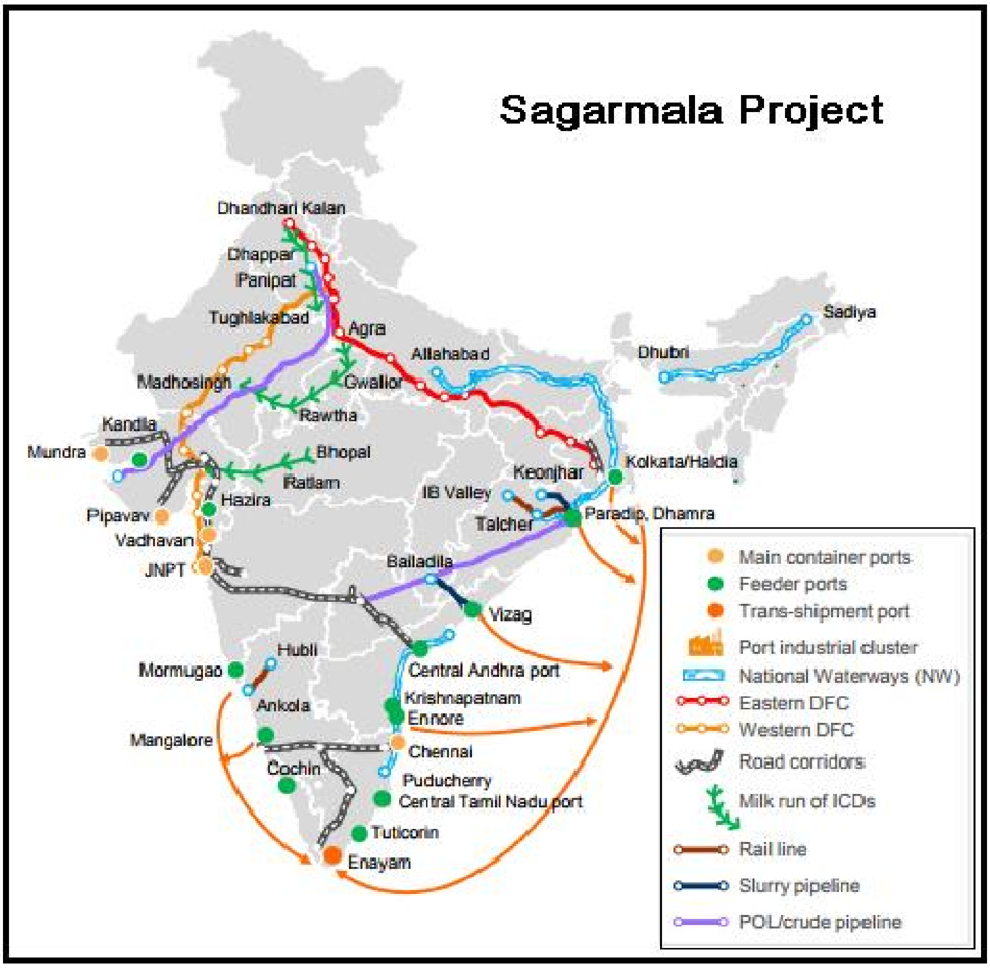

Fig.10. Efficient evacuating network under Sagarmala

CONCLUSION

With its enormous resources, oceans are the ultimate frontier which shall help to transform the economy of the society from scarcity to abundance. With the extended Exclusive Economic Zone, India's Ocean jurisdiction equals to the land area. Hence an integrated approach with long term vision, technology, management, monitoring, and time-bound regulatory reforms are essential for building a sustained blue economy for India. It is beyond doubt that the upcoming blue economy shall serve as a growth catalyst for the robust Indian economy envisioned to reach US$ 10 trillion by 2030.

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About the authors

Dr. M. A. Atmanand, currently the Director of National Institute of Ocean Technology has done pioneering work in the area of deep sea technologies in India. He took his undergraduate degree in Instrumentation & Control from University of Calicut, Master's and doctorate degrees from Indian Institute of Technology, Madras. He led a team of engineers for the design and development of underwater crawler for deep sea operation which was tested at a depth of 5200 m and India's first Remotely Operable Vehicle which was later tested at a depth of 5289m water depth. He has also guided various indigenization programmes for Ocean observation and under water systems. He has published about 100 papers including International Journals, International conferences, National Conference and authored multiple book chapters. He received IEEE Oceanic Engineering presidential award in 2016, National Geoscience award 2010 from Ministry of Mines and the International Society for Offshore and Polar Engineers (ISOPE) Ocean Mining Symposium award in the year 2009. He is an Associate Editor of IEEE Journal of Oceanic Engineering. He is the founder Chair of IEEE Oceanic Engineering Society in India. He has served IEEE Madras Section in various capacities.

Dr. Purnima is a senior scientist heading the Energy and Fresh Water group in the National Institute of Ocean Technology, India. She has coordinated many first– ever projects in ocean energy and desalination. She has a tremendous contribution in the setting up of the first ever ocean thermal gradient based desalination plant at Kavaratti island in the Lakshadweep group in the Arabian Sea which has helped transform the lives of the small island community which had a serious lack of drinking water. For this work she was awarded the Vishwakarma Medal in 2006 by the Indian National Science Academy. This success led to more plants in islands and offshore. She is now attempting to scale up the technology and power such plants using ocean renewable energies. She has a PhD in Civil Engineering from Duke University, USA. She is on many committees of the Indian Government, related to water and renewable energy.

Dr. M V Ramanamurthy Scientist-G is currently Director, National Centre for Coastal Research (NCCR), Ministry of Earth Sciences. He also looks after the groups of Ocean Structures/ Island Desalination, and Coastal and Environmental Engineering at National Institute of Ocean Technology, Chennai His area of specialization include Port and Harbour Structures, Wave Structure Interaction Studies, Offshore and Coastal Hydrodynamics, Coastal Engineering & Measurements and Coastal process modeling including tsunami & storm surge and Integrated Coastal and Marine Area Management. His qualification include B.E (Civil), M.Tech (Planning), CEPT, Ahmadabad, M.Tech and PhD in Ocean Engineering, IITM, Chennai. He started his career in 1991 at Vishakhaptanam Port Trust as a Design Engineer in 1997 at Engineers India Ltd as Senior Engineer, in 1999 at Ministry of Earth Sciences, ICMAM-PD, Scientist-D to Scientist – F and at NIOT from 2009 as Scientist-G. The awards received by him include National Geo Science Award 2010, Ministry of Earth Sciences Award 2006. and American Bureau of Shipping Award 1997 at IIT Madras. His has more than 38 publications in international Journals, 7 in International/National Conferences. He is a member of various national committees of the Indian Government related to CRZ, BIS, Member CPDAC and President Ocean Society India.

Dr. G. A. Ramada*ss* is a Scientist-G in National Institute of Technology (NIOT), Chennai. His research areas include Deep Sea Technology, Underwater Acoustics and Marine Instruments. At NIOT he is the head of the Deep Sea Technology Group. In 2010 he won the National Geoscience award under the Exploration of Oil and Natural Gas category and National meritorious invention Award – 2019 by Government of India for the development and usage of underwater vehicle for deep sea mineral exploration and shallow water biodiversity studies. He led NIOT team during the 34th Indian Scientific Expedition to Antarctica in February- March 2015. Polar Remotely Operated Vehicle (PROVe), developed indigenously at NIOT, was used for exploration in the lake and shelf area of Antarctica during this expedition. A doctorate from Indian Institute of Technology, Madras he handled technology development programmes leading to products and patents. He has been the Chief Scientist of 15 cruises and scientific explorations on-board various research vessels His recent work includes publications in the international journals, international conferences and four international patents.

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Lake Baikal, Siberia, Russia during winter and summer. As an exploration geologist he has participated and led cruise programs in ships namely and published more than 30 research articles in international and national journal apart from five chapters in books and two patents. As a team member, recipient of National Geo-Science Award – 2010 and National meritorious invention Award – 2019 by Government of India for the development and usage of underwater vehicle for deep sea mineral exploration and shallow water biodiversity studies.

K A Gopkumar Kuttikrishnan has been with NIOT since 2013 leading the efforts in developing a deep sea mining system for harvesting polymetallic nodules from depths up to 6000 m. A marine engineering professional, has worked with the Navy in various responsibilities of operations, R&D and perspective planning.

Dr. N. Vedachalam is currently Scientist-F at the National Institute of Technology (NIOT), Ministry of Earth Sciences, Chennai, India. His 24 years of experience covers industrial power, process, offshore, and subsea domains. The technical exposure includes development of multi-megawatt power electronic converters, control systems, and energy storage for the long step out deep-water enhanced hydrocarbon recovery systems; ocean renewable energy systems including ocean thermal energy conversion (OTEC), wave energy systems and subsea grids for tidal energy farms; subsea intervention systems including deep-water work class remotely operated vehicles; and industrial power generation, utilization and boiler control systems. He was the Secretary of IEEE Ocean Engineering Society- India Chapter, Executive Member of Marine Technology Society- India Section and Senior Member-Bureau of Indian Standards. He has about 60 publications in science citation indexed international journals, holds one international and two national patents in the areas of subsea robotics, subsea process and gas hydrates production. He received National meritorious invention Award in 2019 for the development and usage of underwater vehicle for shallow water biodiversity studies.

Dr. G. DHARANI, MSc, M Phil, PhD is currently Scientist-F & Group Head In-Charge of Marine Biotechnology in National Institute of Ocean Technology**,** Chennai, India**,** Email: dhara@niot.res.in. His research interests include Plankton Ecology & Biology and Marine Biotechnology. Since he joined in NIOT in 1998 he has contributed to various projects of NIOT in various capacities. He has about 38 international publications, 63 conference papers, authored 16 book chapters, holds four patents and 200 DNA sequences. He received the Young Scientist Award, for outstanding contribution in the field of Ocean Sciences, Ministry of Earth Sciences, Government of India, Delhi, 2010. Best Paper Award, National Conference on “Biotechnological Approaches to Alternate Energy (BAAE-08) at IIT Chennai, 2008; Best Paper Award, in the International Conference on Recent Advances in Marine Antifouling Technology, NIOT, 2006.