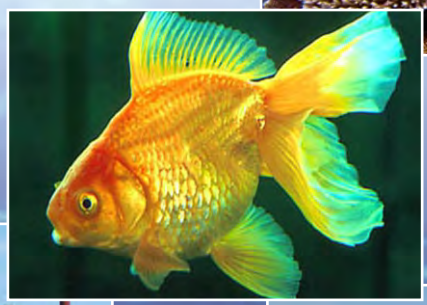
Prospects of Blue Economy in the Indian Ocean



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Preface

Sachin Chaturvedi
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The concept of Blue Economy is emerging as a new narrative on productive and sustainable engagement with the vast development opportunities that oceanic resources offer. The important sectors of Blue Economy are fisheries, sea-minerals including oil & gas, ports & shipping, marine tourism, marine biotechnology, deep-sea mining, and transport & logistics.

It is believed that by undertaking Blue Economy initiative countries would be able to achieve high economic growth and maintain healthy balance between resource use and its renewability. However, there are few attempts to estimate the gains of Blue Economy. This assumes importance in the light of the fact that the world faces the challenge of restoring a healthy balance between the ambition of high economic growth and the goal of environmental sustainability. With the launch of SDGs, concerns are emerging in favour of sustainable use of natural resources especially in the context of growth-centric development models. In fact the oceans and the ocean related activities are viewed as the greatest source of growth in the post-recession period.

In view of the importance of the subject for both national and regional development, RIS, with support from the Ministry of External Affairs, Government of India, organised the First IORA Blue Economy Dialogue at Goa, India in collaboration with the Observer Research Foundation (ORF) during August 17-18, 2015. Eminent experts from the Indian Ocean region contributed to the Dialogue on various facets of blue economy and the scope for regional cooperation among the member states of IORA. The rich deliberations took the shape of 'Goa Declaration' which was released at the end of the Dialogue on 18 August 2015.

I would also like to thank Amb. Shyam Saran, Chairman, RIS; Ms. Sujata Mehta, Secretary (M&ER) and Mr. Charanjeet Singh, Joint Secretary, Ministry of External Affairs for their continued support and engagement with the RIS work programme on Blue Economy. The present Report is a continuation of our ongoing work programme on Blue Economy led by my colleague Prof S. K. Mohanty and his team. The publication of the Report has been coordinated by Mr. Tish Malhotra and Mr. Pradeep Kumar. I am sure the Report would be found useful by policy makers, researchers and by all those interested in the emerging idea of Blue Economy.

New Delhi
October 17, 2015

Prof. Sachin Chaturvedi
Director-General

Prospects of Blue Economy in the Indian Ocean

1. Introduction

Blue economies are gifted with specific resource endowments which could determine their course of development in future. For centuries, marine resources have served the human settlements in many different ways by providing food, energy, biodiversity, recreation and above all, the oceans, the lifelines that have the potential to absorb and regenerate. All the costal nations in the world are dependent on oceans for fishing, minerals, oil & gas, rare earth metals, renewable energy and other living and non-living resources for earning livelihood, achieving holistic growth, empowering native coastal communities and attaining greater social and economic inclusion. In that spirit, the role of blue economy which aims at optimum and sustainable use of oceanic resources for growth and development is critical for the costal nations especially for the small island developing states. Since a large portion of marine resources is believed to have remained untapped or unexplored in different marine zones of the world, there is a widespread conviction that the future source of growth is probably contingent upon the efficient utilization of those rich ocean resources. Its importance is realised prominently after the unprecedented contraction of global output and employment affecting the livelihoods of millions of people in different regions of the world. The European Union considers the vast potential of marine sectors for job creation and revival of economic activity in the member countries in the post-recession period. Moreover, for the small island developing states such as Seychelles and Mauritius the underlying growth triggers are visualised in the success of blue economy. The whole development paradigm in those countries is greatly inspired by the principles of blue economy. Even the biggest economies of the world such as the United States and China recognise the importance of enormous marine resources for economic growth, social development, restoration of environment, and protection and conservation of marine habitat. The contribution of blue economy to the overall economy has been impressive for a number of countries in the recent past with signs of robust performance in the future.

The Blue World

Indian Ocean region covers diverse areas of rich ocean cover spreading over three continents and serves as a major link for trade, investment and technology cooperation between the littoral states. The countries in the Indian Ocean region had very strong civilisational linkages manifested in maritime trade, cultural exchanges, tourism and pilgrimage, diplomatic relations and so on. Indian Ocean is a major sea route for the world connecting India, China, Far East, East Africa, South Asia and the Middle East. Given the vast endowment of oceanic resources, the littoral states representing the Indian Ocean Rim Association (IORA) countries consider the importance of harnessing blue economy for economic and social development in the region. With advancement in exploration technology, deep-sea mining could unleash huge potential for exploration of hydrocarbons, petroleum, natural gas, and rare earth metals. In addition, the demand for ports and shipping services would flourish as seaborne trade grows in the future. The rich flora and fauna attracts a large number of tourists from different parts of the world. With a focussed approach, coastal tourism and other marine services sectors may provide ample opportunities for occupational diversification and inclusive development.

There has been a continuous debate in the academic and policy circles about alternative discourses on development policies particularly after the collapse of dirigisme and greater acceptance of market mechanisms since the mid-1980s in all

important spheres of social and economic life in different communities and societies worldwide. While the brightest minds of the global development community tended to fear further perpetuation of income inequality and social deprivation in the market-led economic systems, they seem to have helplessly endorsed the current development model even though the flip sides of resource-intensive high-energy development strategies are often noticed. In this line of thinking, the costs of high growth are manifested in rapid depletion of living and non-living resource stock, severe environmental degradation, marginalization of rural and landless families, new forms of social discrimination, distorted access to social security provisions such as health and education, increasing dislocation of communities due to racial and religious civil wars, and so on. A new set of terminologies were coined to reorient the conventional development paradigm to be more people-centric and equitable which include 'sustainable development', 'green economy', 'human development', 'inclusive growth', etc. Moreover, greater concerns are voiced in favour of sustainable use of natural resources especially the rebuilding of stocks as resource use is perceived to be irreversible in the context of growth-centric development models. Following that philosophy, the oceans and the ocean-related activities are viewed as the greatest sources of growth in the post-recession period. The concept of 'blue economy' is considered as one of those vintages of development thinking.

Essentially, the principles of blue economy are similar to the kind of economic processes and activities envisaged in the 'marine economy', 'ocean economy', 'coastal economy' among others except the emphasis that it attaches to the optimum use of marine resources. Unlike green economy that propagates prevention of environmental degradation and ecological imbalance, blue economy aims at productive employment of precious oceanic resources in the development process. To a great extent, blue economy largely corresponds to the virtues of the alternative development strategies mentioned above. However, blue economy as such does not appear to be a development model itself rather it could serve as a crucial component of any other mainstream development models. Fisheries, sea-minerals such as oil & gas, ports & shipping, marine tourism, marine biotechnology, deep-sea mining, transport & logistics are some of the important sectors of blue economy. It is believed that by undertaking blue economy initiatives countries would be able to achieve high economic growth and maintain healthy balance between resource use and its renewability. For example, anecdotal estimates suggest that the contribution of blue economy (synonymously used as ocean economy) to gross domestic product for China, Indonesia and the United States is 10 per cent, 20 per cent and 1.8 per cent respectively.

Blue economy initiatives are vital to the growth of the Small Island Developing States (SIDS) as they have long coastlines and substantial jurisdiction over sea resources. SIDSs such as Seychelles and Mauritius who are members of the Indian Ocean Rim Association (IORA) have already introduced measures towards promoting blue economy as part of their

maritime strategy. The conditions for nurturing blue economy are equally conducive in many countries of the world having greater access to oceans. As the IORA member states are located along the coast of the Indian Ocean, the marine resources could be harnessed optimally for the benefit of the people of the region. Member states including Australia, South Africa and India have exhibited keenness to explore opportunities in the blue economy sectors. Among the living resources, Indian Ocean has a rich endowment of fish species contributing to food security, livelihood and foreign exchange earnings. India Ocean is also home for key marine natural resources such as oil & gas, hydrocarbons, thorium, manganese and zinc nodules, rare earth metals and other minerals. In addition, deep-sea mining in the Indian Ocean is feasible due to development of sophisticated exploration technologies in the recent years. By undertaking suitable policy measures the IORA countries may exploit the potential of blue economy for growth and development of their respective economies.

In continuation of the global debate on the role and importance of blue economy for sustainable development, a few international events were held recently in different parts of the Indian Ocean region. In August 2015, the First IORA Blue Economy Dialogue was held in the coastal town of Goa, India by the Ministry of External Affairs, Govt. of India and the two premier New Delhi-based think tanks, the Research and Information System for Developing Countries (RIS) and the Observer Research Foundation (ORF). Experts drawn from diverse fields of blue economy representing the IORA countries and from other parts of the world contributed to the deliberations on different academic and policy perspectives relating to the prospects of blue economy in the Indian Ocean region. The outcome of the deliberations was formally released in the name of 'Goa Declaration' by the conference organisers. This Dialogue was followed by the First IORA Ministerial Blue Economy Conference organised by the IORA Secretariat in Mauritius during 2-3 September 2015 and the 2nd Indian Ocean Dialogue held in Perth, Australia in September 2015. All the three conferences focused on several key areas of blue economy ranging from accounting framework, fisheries & aquaculture, renewable ocean energy, seaports & shipping, seabed exploration & minerals, and mineral services. Besides highlighting the sectoral priorities and policy measures, the need for a comprehensive accounting framework for measuring blue economy was endorsed by the conference participants. In addition, the IORA Women's Economic Empowerment event held in Seychelles highlighted the good practices and solutions related to women's empowerment and entrepreneurship in blue economy in Seychelles. These events seem to have spread adequate awareness among the various stakeholders of blue economy in the Indian Ocean region, and aroused interests among the academics and policy makers for pursuing this subject in future.

Against this backdrop, this Report presents the synthesis of various conceptual and methodological issues relating to blue economy and the importance of this paradigm to the overall

social and economic progress of the IORA countries. Since there exist ambiguities over the coverage of blue economy sectors and data availability, empirical estimates of the size of blue economy and related indicators are avoided here.

2. Definitions of Blue Economy

The concept of blue economy is still at an evolving stage where there is yet to be any comprehensive definition which would be appropriate from the operational point of view. In the literature, blue economy has been used synonymous to 'marine economy', coastal economy', ocean economy', 'green economy' and so on. While the basic tenets and goals of these competing paradigms are more or less similar, there are basic differences in the approaches and treatment of various elements such as resource management, growth objectives, sustainability and social equality. At the United Nations Conference on Sustainable Development held in Rio de Janeiro in 2012, blue economy was viewed as ocean economy that aims at the "improvement of human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. At its core the ocean economy refers to the de-coupling of socio-economic development from environmental degradation. In this regard, efficiency and optimisation of natural marine resources within ecological limits becomes paramount" (UNCTAD, 2014). By that definition, ocean economy can be defined as the economic activity which directly or indirectly uses the sea as an input whereas the coastal economy represents all economic activity which takes place in a specific coastal region (Morrissey et al, 2010).

To understand the 'ocean economy', one has to understand its features as follows. Ocean economy (1) a sub-set of the economy (2) dependent on ocean for inputs to invigorate its production process (3) based on industry and also geographical locations and (4) these industries/activities are located in coastal and non-coastal areas. According to Colgan (2004), "the *ocean economy* is that proportion of the economy which relies on the ocean as an input to the production process or which, by virtue of geographical location, taking place on or under the ocean. It is a function of both industry and geography … While most of the ocean economy (for example, boat building, seafood retailers and many ocean instrumentation, equipment and surveying industries) may be located in non-coastal region".

In terms of volume of activities, the 'costal economy' is larger than 'ocean economy'. The basic features of the coastal economy are: (1) a sub-set of the economy (2) concentration of activities on or around the coastal areas and (3) sum of all activities relating to output, employment and wages in the coastal region. Therefore, Colgan (2004) has defined costal economy as "..... all economic activity in the coastal region, and is thus the sum of employment, wages, and output in the region. Some of the coastal economy is the ocean economy, but the coastal economy incorporates a broader set of economic activities".

The 'marine economy' is a horizontally integrated cluster industries which include sectors meant for a common market for the end products, using common technology or labour force skills, or require similar natural resources

(University of Massachusetts, 2006). This sector comprises of five major sectors including commercial seafood, marine transportation, coastal tourism and recreation, marine science and technology, marine-related construction and infrastructure. The marine economy is a sub-set of the coastal economy.

The Government of Australia in its report titled 'Marine Nation 2025: Marine Science to Support Australia's Blue Economy' defines that "a blue economy is one in which our ocean ecosystems bring economic and social benefits that are efficient, equitable and sustainable" (Govt. of Australia, 2013). In same line of thinking, EIU (2015a) summarises the concept and objectives of blue economy with clarity. It says national ocean development strategies refer blue economy as a guiding principle. And, blue economy is synonymous to "greening of the ocean economy". Extending this further, as per the UN Summit the horizon of blue economy is much wider and inclusive. It has futuristic development implications by visualising certain patterns of production and consumption of ocean resources.

Fishing Activities in Coastal Region

UN in its concept paper is of the view that blue economy conceptualises ocean economy as development spaces. From this perspective, blue economy should break the mould of business-as-usual 'brown' development model where oceans are perceived as a means of free resource extraction and waste dumping without taking into account the costs of the negative externalities. This strand of thinking signals the inherent risks involved in indiscriminate exploitation of marine resources for economic growth. Further, resource accounting should take into cognisance the costs of environmental damage and ecological imbalance caused due to consumption-centric resource use (Pauli, 2010). The European Commission (2012) has defined the concept of blue economy as "all economic activities related to the oceans, seas and coasts. This include the closest direct and indirect supporting activities necessary for the functioning of these economic sectors, which can be located anywhere, including in landlocked countries".

The growing competition among the nations for energy and resources focuses the need for regional cooperation

Courtesy: http://www.dnv.com/binaries/

Key Ocean Activity

Table 1: Taxonomy of Blue Economy Sectors and Activities	
Sector	**Activity**
Fishing	Capture fishery, Aquaculture, seafood processing
Marine Biotechnology	Pharmaceuticals, chemicals, seaweed harvesting, seaweed products, marine derived bio-products
Minerals	Oil and gas, deep-sea mining (exploration of rare earth metals, hydrocarbon,
Marine Renewable Energy	Offshore wind energy production, wave energy production, tidal energy production
Marine manufacturing	Boat manufacturing, sail making, net manufacturing, boat and ship repair, marine instrumentation, aquaculture technology, water construction, marine industrial engineering
Shipping, Port & Maritime Logistics	Ship building and repairing, ship owners and operators, shipping agents and brokers, ship management, liner and port agents, port companies, ship suppliers, container shipping services, stevedores, roll-on roll-off operators, custom clearance, freight forwarders, safety and training
Marine Tourism & Leisure	Sea angling from boats, sea angling from the shore, sailing at sea, boating at sea, water skiing, jet skiing, surfing, sail boarding, sea kayaking, scuba diving, swimming in the sea, bird watching in coastal areas, whale/dolphin watching, visiting coastal natural reserves, trips to the beach, seaside and islands
Marine Construction	Marine construction and engineering
Marine Commerce	Marine financial services, marine legal services, marine insurance, ship finance & related services, charterers, media & publishing
Marine ICT	Marine engineering consultancy, meteorological consultancy, environmental consultancy, hydro-survey consultancy, project management consultancy, ICT solutions, geo-informatics services, yacht design, submarine telecom,
Education and research	Education and training, R&D

Sources: Compiled from Morrissey et al. (2010), EIU (2015a), Govt. of Ireland (2012) and Marine Institute (2005).

to harness the endowments in a more sustainable manner. Adoption of a comprehensive definition of the blue economy is necessary to understand and to act jointly to harness the existing potential of blue economy in the IORA region. However, the blue economy and other related concepts may be comprehensively defined as the following:

As a segment of an economy, *Ocean economy* is dependent on ocean for inputs to run certain production processes in the coastal and non-coastal regions, and these activities are identified by both industry and geographical location.

As a sub-sector of an economy, *Coastal economy* includes all economic activities including the sum of output, employment and wages, taking place on or near coast.

As a sub-set of the economy, *blue economy* covers all ocean related activities including direct and indirect supporting activities required for functioning of these economic sectors, while adjusting to the costs of environmental damage and ecological imbalance caused due to exploitation of ocean resources for consumption. Therefore, the scope of blue economy is much wider and inclusive.

The concept of blue economy is subject to multiple interpretations because of the coverage of activities, geographical locations and sectors. From the available literature, an indicative list of sectors and the activities fall in those sectors are illustrated in Table 1. While some studies classify different sectors of blue economy into traditional and emerging sectors, there is hardly any common position on this view.

In this context, Table 2 presents data on the size of blue economy in select countries. Since the conception and methodology differs across the sources, these numbers are indicative only. Going by the figures shown in Table 2, promoting

Table 2: National Estimates of Blue Economy

Country	Size of Blue Economy			Indicative Employment	
	Year	Output (US$ Billion)	% of GDP	Year	No.
Australia	2004	17.00	3.6	-	-
Canada	2004	15.98	1.5	2006	1,71,365
France	2006	16.69	1.4	2009	4,59,358
New Zealand	2006	2.14	2.0	-	-
United Kingdom	2008	84.27	4.2	2006	5,48,674
United States	2009	138.0	1.2	2010	2,770,000
China	2010	239.09	4.0	2010	9,253,000
Ireland	2007	1.9	1.0	2007	17,000

Sources: Compiled from Colgan and Kildow (2013); Zhao et al. (2013).

Notes: Data for size of blue economy are from Colgan and Kildow (2013). For China and Ireland, value added figures are drawn from Zhao et al (2013). Data on employment are based on Zhao et al (2013).

blue economy is socially desirable as the magnitude of job creation is substantial.

Recent cross-country evidences show that blue economy is emerging as a dynamic component of some economies, thus generating interest for its comprehensive development through formulating national policies, evolving strategies at the national level and arousing debate in the global platform to highlight the importance of the issue and initiative global plan of action to focus on ocean and other related activities.

3. Importance of Blue Economy: Key Economic Issues

There are several good reasons to pursue with the regional agenda of blue economy which is gaining ground in the Indian Ocean region. Several regional economies have linked health of their economies with the health of the planet and have understood that their fates are thoroughly linked with the state of health of the ocean. In this regard, the region's economic and strategic interests are intricately linked to ocean economy as the region is dependent on ocean for critical issues including food security, livelihood security, minerals, energy security, industrial activities and various key services activities. As several Member countries are aspiring to have close economic regional cooperation at the sectoral level, there is clear convergence of interest between these countries to understand the nature of blue economy and to initiate multi-layer cooperation between them in the region. Following Rio+20 conference in 2012, it emerged prominently about the independent development thinking regarding the blue economy without seeing it as a rejoinder to the sustainable development agenda. It becomes a challenge to the member countries to take recourse to immediate policy action in order to take advantage of the opportunities offered by the blue economy. Some of the opportunities provided by the blue economy are briefly discussed below to highlight its relevance.

3.1 Food Security

Blue economy has a major role in securing food security for the people. The fisheries sector including aquaculture and aquatic plants, contributes sizable proteins, fats and calories supply which supports food security situation in a country. Ensuring food security requires improved access to nutritious food of both animal and non-animal origin, reduction of food wastage, low barriers to trade in food and food products, and provision of efficient distribution of food items in food-deficient regions. In addition to the conventional measures of addressing food insecurity, blue economy offers ample opportunities to meet the growing demand for healthy and safe food by enhancing marine fishing. A good number of finfish and shellfish varieties in raw as well as processed forms are used as seafood worldwide. Fishing areas in the Indian Ocean region represent a rich endowment of fishery resources. Persistence in the decline of catch fish has been a major concern for the world economy. However, the biological stocks of many of those species are depleting due to overfishing and illegal, unreported and unregulated (IUU) fishing. Since capture fish landing faces stagnancy the dependence on marine aquaculture (also termed as mariculture) for fish supply has grown significantly in the recent years. Fishing nations in the region

Fish as a Major Source of Food Security

have taken necessary steps to promote aquaculture which helped them meet domestic demand for fish and export to other markets. The contribution of fishery sector to food security can be enhanced by adopting blue economy policies in the regional economies.

In the context of blue economy, higher fish production with lower environmental damage is possible through polyculture, specie diversification, optimal feeds and feeding, prevention of diseases and so on. Moreover, countries embracing blue economy would focus more on developing sophisticated technologies for farming, conservation and processing of species. The role of small-scale aquaculture by the native fishing communities is paramount from the perspective of food security. After meeting the household demand for fish for subsistence, the local fishermen would be able to earn their livelihood by selling surplus fish in the urban markets. Further, by having enabling policies on pricing, certification, labelling and marketing, the fishing sector in the context of blue economy can be more organised and regulated.

3.2 Demand for Protein

Demand for protein can be effectively addressed by the blue economy. For a healthy life, humans need balanced diet comprising of proteins, fats and other essential ingredients.[1] A minimum amount of protein intake is required in that food basket as it helps maintain the average

[1] For feature of balanced diet, see http://www.who.int/mediacentre/factsheets/fs394/en/.

daily calorie requirements in human body. Fish is a crucial source of animal protein even in countries where the daily average per capita fish consumption is low compared to developed fish-consuming nations. Fish in small quantities can have significant nutritional impact as it is a concentrated source of protein and contains essential fatty acids and micronutrients.[2] Fish and fish products are sources of three different types of animal proteins that are vital to human health. Structural proteins comprising of actin, myosin, tropormyosin and actomyosin constitute 70-80 per cent of the total fish protein. In addition, sarcoplasmic proteins such as myoalbumin, globulin and enzymes and connective tissue proteins account for approximately 25-30 per cent and 3 per cent of total fish protein respectively.[3] It is also the most affordable source of animal protein in absence of any alternative sources of protein. Fish contributes more than 50 per cent of total protein supply in SIDSs and many other countries of the world. For some IORA countries such as Indonesia, Bangladesh and Sri Lanka the share of fish in total animal protein is 54 per cent, 56 per cent and 57 per cent respectively (FAO, 2014). In 2010, fish accounted for 19.6 per cent of animal protein intake in the developing countries. In other words, fish and fish products provided 2.9 million people with almost 20 per cent of their intake of animal protein and 4.3 billion people with about 15 per cent of animal protein. As per an estimate, 150g of fish

Courtesy: http://www.nutritionstyle.net/best-fish-to-eat-while-on-a-diet/

Fish as a Source of Protein

[2] FAO (2014).

[3] FAO (http://www.fao.org/fishery/topic/14869/en).

yields about 50-60 per cent of an adult's daily protein requirement. Interesting revelations on food consumption habits in different parts of the world indicate that animal protein is no more considered as a luxury food rather it is increasingly being accepted as an essential part of the regular diet. Moreover, consumers in low-income countries tend to diversify their food basket towards more protein and fat containing food such as meat and fish (Regmi and Meade, 2013).

The statistics mentioned above hint at the importance of adequate and sustained supply of high quality fish in order to meet the average protein requirements. Although increasing fish production has been the underlying policy priority in most countries of the IORA region, the focussed approach to deal with the issues of nutrition and health using marine fishery resources in the blue economy paradigm would enhance the contribution of fish to animal protein supply in the regional economies. Both freshwater farming and mariculture of protein-rich species should be encouraged in the countries promoting blue economy in the region. Focused blue economy policies for aquatic sector would not only promote production, trade and food security situation in the economy but also to address the protein requirements of people in the IORA region.

3.3 Rising Coastal Tourism

Coastal tourism, a major sector of blue economy, presents huge potential for job creation and economic growth. Experiences of littoral countries indicate that costal tourism goes hand in hand with global tourism. In 2015, the world tourism sector is estimated to grow by 3.7 per cent and employ 283,983 people. Tourism activities shrank drastically during 2007-09 due to the global economic recession. However, the sector revived strongly by registering an average growth rate of 3.3 per cent over the period 2010-15. At present, the size of tourism sector is US$7,863.5 billion which accounts for 9.9 per cent of world GDP.[4] Leisure tourism spending constitutes a little more than 50 per cent of the total tourism output. For the IORA region as a whole (except Somalia) the tourism sector in 2015 turns out to be US$670 billion representing 8.5 per cent of world tourism industry. Besides the overall role of the tourism sector, the importance of marine or coastal tourism is relatively higher for a successful blue economy. UNEP (2009) observes that growth of coastal tourism has reached its peak in recent decades. In the EU, this segment is counted in the EU's Blue Growth Strategy as a sector with special potential to foster smart, sustainable and inclusive Europe. It is the biggest maritime sector in terms of gross value added and employment generation.[5] In countries like Ireland, the water-based tourism and leisure industry is quite substantial in terms of value addition and diversification. It is an outcome of a set of concerted policy measures that addresses the potential and the constraints in promoting the marine tourism sector. Sea angling, bird watching, boating at sea, dolphin watching, scuba

[4] Based on data from World Travel and Tourism Council (http://www.wttc.org/datagateway/).

[5] http://ec.europa.eu/maritimeaffairs/policy/coastal_tourism/index_en.htm

Coastal Tourism: Untapped Opportunities

diving, swimming in the sea and other related activities around the sea are some of those emerging segments of coastal tourism.[6] Hotels, motels, water sport, cruise and restaurants are potential segments for expansion and growth in the coastal tourism sector. The flora and fauna spreading over the littoral states of the Indian Ocean provides biggest opportunities for investment in the tourism sector which in turn would contribute to more robust blue economy in the region. At the same time, the adverse effects of expanded tourism activities have to be monitored regularly to optimise welfare effects stemming from the coastal tourism sector.

3.4 Surging of Seaborne Trade

Sea is a cost-effective and carbon-friendly mode of transportation for global trade. About 90 per cent of world trade is conducted through the sea routes. Advances in technology improved efficiency of shipping and contributed to the sustained rise in the world seaborne trade. About 50,000 merchant ships including container ships, bulk carriers, ferries and cruise ships are engaged in international trade.[7] International

6 See Morrissey et al (2010).

7 International Chamber of Shipping (http://www.ics-shipping.org/shipping-facts/shipping-and-world-trade).

Courtesy: http://www.libraworldwide.com/international-shipping-logistics-services/

Seaborne Trade: A Traditional Mode of Commerce

seaborne trade continued to grow at a steady rate over the past few years after a sharp contraction in activities during the global economic recession. In 2009, total cargo handled through sea dropped drastically by 4.5 per cent to 7,858 million ton from 8,229 million ton in the previous year. Since recovery from recession in major economies is fragile, seaborne trade may take time to bounce back in the next few years.[8] As per the latest reported data (2013), the size of seaborne trade is approximately 9,600 million ton. Dry cargo accounts for more than 70 per cent of the total volume of seaborne trade in the world. These include trade in bulk commodities such as iron ore, coal, grain, bauxite, alumina, phosphate rock, containerized trade and general cargo.

Although large part of the growth in trade by sea is explained by rapid industrialisation and liberalization of trade policies in most countries of the world, the main triggers for seaborne trade has come from increasing demand for imports of raw materials, resources, etc by China, India and other Asian economies. In addition, the pace of urbanisation and competitive international ore prices would support growth in the major dry bulk cargo sector. Potential for additional

[8] UNCTAD (2014).

capacity creation and demand for refined petroleum products will be triggered by the increasing requirements in developing Asia and America. Likewise, additional supply capacity in the Asia-Pacific and the United States and new fields in the Caspian region would help LNG shipments to rise in the coming years. Coal trade is also expected to grow in the future. These developments signal a great potential for blue economy to deliver in the Indian Ocean region. More than two-thirds of global seaborne trade are routed through the Indian Ocean. The IORA states are not only the active participants of this flourishing segment of world trade but also the major suppliers of port and shipping services in the region. Some of the IORA countries are major producers, users and exporters of iron ore, coal, steel and grain in the world. As emphasized before, in the blue economy framework, ocean-based activities get relatively higher attention than its absence. The priorities and policy measures towards promoting trade by sea route may be more systematic, target-oriented and futuristic. For example, the demand for imports of resources from Africa would facilitate two-way mutually beneficial trade between China, India, the African countries and others as both the parties would be keen to invest in blue economy sectors.

3.5 Demand for Alternative Sources of Energy

Blue economy could be a major source of clean energy, where large renewable energy is not tapped. Where world economy is aspiring for clean, renewable and affordable energy supply, the blue economy is emerging as a large reservoir of such energy. The ever-increasing demand for energy for the purposes of household and industrial consumption in most parts of the world especially in India, China, Brazil and other emerging markets necessitates alternative sources of energy, most importantly the renewable energy. As per the estimates by the International Energy Agency, in the next 15 years the global primary energy demand would grow by 40 per cent; a substantial chunk of that would come from developing Asia and the Middle East. The renewable energy market is growing in a good number of non-OECD countries which signal the potential of this sector from the perspective of blue economy. Resources under the blue economy initiatives can be suitably employed for development and promotion of renewable energy technologies. For instance, solar PV and wind in India; non-hydro renewables in Brazil, Egypt, Thailand and the Middle East; hydropower in Asian countries and others indicate the achievements in the renewable energy sector.[9]

Ocean renewable energy in the form of wave energy, solar energy, tidal energy, hydroelectric energy would reduce the burden on finite conventional sources of energy production. Renewables account for the net additions to power capacity in many developing countries. In this context, the role of fossil fuel would remain crucial for China, India, Brazil and other developing countries for expansion of the

[9] IEA (2015).

Future Source of Energy

renewable energy sector. The Government of India has set measurable targets for four key sectors of renewable energy such as wind power, solar power, biomass power and small hydro power in its Strategic Plan for New and Renewable Energy Sector 2011-17.[10] Interestingly, the global average cost of energy production for wind and solar PV has fallen considerably in the recent years. Further, with projected fall in the cost of production in the future, renewable energy would meet a lion's share of energy demand in the IORA region. In fact, many littoral countries are dependent on blue economy for the supply of hydrocarbon including India. However, by using the cleaner and environment-friendly ocean energy technologies larger goals of the blue economy paradigm could be achieved.

[10] Govt. of India (2011).

Courtesy: https://www.google.co.in/

Surging Urbanisation in Coastal Areas

3.6 Managing Coastal Urbanisation

In several littoral countries, fast growth of urbanisation along the coast line is the contribution of the blue economy paradigm. However, uncontrolled rise of urbanisation has detrimental impact on the economy. From different perspectives, urbanization should be considered as a positive logical transition for a country along the development path. However, unplanned urbanisation in different parts of the world have caused serious damage to the living habitat, land use pattern, spatial congestion due to migration from rural areas, spread of slums, heath risks arising from poor solid waste management and a variety of governance challenges. As a result, urbanisation invites more negative connotations than positive ones in the contemporary literature for the developing and less developed countries.[11]

However, blue economy policies seem to have more positive propositions in favour of urbanisation. In precise terms, promoting coastal urbanisation by subscribing to the core principles of sustainable, low-carbon and eco-

[11] IOC/UNESCO, IMO, FAO, UNDP (2011) present disturbing facts relating to coastal megacities in the world and the challenges it throws for blue economy.

friendly processes and technologies would eliminate the established fears associated with the business-as-usual approach toward city planning. There is a need to switch from production-led urbanisation to tourism-led urbanisation in which a city would rather serve as a space for consumption and leisure than for production.[12] In the blue economy framework, coastal cities can be viewed as a source of economic dynamism, agglomeration of blue activities, social empowerment of resource-dependent local communities and pollution-free built-in environment.[13] IORA countries must seize the opportunities in the coastal cities by investing in new blue cities or revamping the old coastal cities.

3.7 Improving Ocean Health

With very little dispute, it is a fact that the oceans and the oceanic resources face the risk of extinction and secular depletion due to the rapid industrialisation, unplanned and poorly governed urbanisation, sea encroachments, water pollution, soil degradation, climate change and many other factors. As a result, the quality of marine biodiversity is getting eroded day-by-day without commensurate compensating mechanisms in place. Oceans serve as the biggest sink whereas the importance of its resources for the very sustenance of the mankind is undermined. Greenhouse gases would raise the temperature, chemistry, structure and height of the oceans which in turn would affect the ability of marine organisms to survive, the ability of the populations to persist, the evolution of species and the interaction between species. It may require calibrated policy initiatives representing a mix of identification of vulnerable species, marine protected areas, ecosystem-based management, effective fisheries regulations and so on.[14]

Likewise, other pollutants deteriorate ecological balance and lower the degree of natural and biological resilience to such environmental threats. As envisaged in its principles, blue economy approach would contribute to the process of restoring the ocean health and its precious resources. It is observed that investment in coastal habitat restoration projects stimulates job creation, rebuilds fisheries, revives coastal tourism, raises property values, and improves water quality.[15] This has greater relevance for the IORA countries as the marine space covered under its jurisdiction is quite large for blue economy to show tangible gains. It is likely that countries adopting blue economy would have elaborate schemes for conservation and protection of the living and non-living resources. For fisheries, the role of regional fishery organisations may assume renewed importance in the context of blue economy. Similarly, for non-living seabed resources, the policies, regulations and enforcement mechanism by the

[12] Qian et al (2012) present case studies of tourism –driven urbanisation in Guangdong province in China and document the distinctness of this approach for local socio-economic development.

[13] Beall et al (2008) discuss the multidisciplinary perspective on urbanisation and development. To them, urbanisation in a broader sense serves the purpose of development.

[14] For further details, see Pinsky et al (2013).

[15] See Edwards et al (2013).

Conservation of Marine Habitat

International Seabed Authority and other international maritime organisations can be effectively used once blue economy goals are seriously pursed in the Indian Ocean region.

3.8 Providing Marine Governance

The potential of marine resources for socio-economic development depends on the effectiveness of marine governance both at the national and the global level. It refers to the provisions, regulations and mechanisms surrounding access, management and control of oceans, ocean resources and the ocean-related activities. In many different forms, marine governance is an integral component of a plethora of international and multilateral conventions on sea. In addition, some regional mechanisms such as regional fishery management organisations, regional inter-governmental maritime cooperation organisations and others also cater to various aspects of marine resource governance. Among the international organisations, the UN Convention on Law of the Sea which came into force in 1994 has been viewed as the most comprehensive single piece of legislation with membership of more than 150 countries of the world. In addition, a number of mechanisms in the form of conventions and agreements on fisheries are facilitated by the Food and Agriculture Organisation and other sister UN bodies.

While provisions and mandates of some of those mechanisms, national as well as international, are binding, most of them are advisory in nature, thereby no penalty for violations. Although many of those difficulties would continue to complicate marine governance in countries adopting blue economy, one could hope for a much better and compliant governance regime once measures towards blue economy gather momentum. Moreover, coastal countries may require formalisation of certain regional and global governance and regulatory practices for the success of blue economy in the future.

3.9 Ocean Technologies

Ocean technologies correspond to technologies used for renewable energy production, deep-sea mining, freshwater production from sea, offshore structural components, ocean acoustics, seabed classification, modelling of oceanic processes, ocean electronics, marine biotechnology, aquaculture, coastal and environmental engineering, among others. The potential of those technologies are vast in terms of their future contribution to energy supply, production process, drug development, seabed management, and so on. The development of ocean technologies may get more attention in coastal economies pursing blue economy. In conventional policies for oceans, the nature of resource allocation and the mindset delay the process of implementation, sometimes leading to project closure. Since technology and innovation are key

Offshore Renewable Energy

drivers of blue growth, the countries following blue economy may devote more resources to develop those technologies and institute mechanisms for long-term pursuit of scientific knowledge in those areas. Almost all the IORA countries have shown interest in promoting blue economy in the coming years in a very big way. Since energy demand is growing in most of the IORA countries, the search for innovative technologies for renewable energy production would remain supreme. At the same time, marine biotechnology has better prospects in the IORA region. The need for new formulations and compounds would invite fresh investments into the sector. Blue economy in the IORA region would need ocean technologies, and therefore will undertake necessary steps to develop such technologies in the emerging sectors.

As highlighted above, blue economy encompasses a wide range of sectors that could address key developmental challenges facing the coastal economies. By harnessing blue resources, the issues of poverty, food insecurity, unemployment and ecological imbalance can be effectively tackled. Research and innovations in marine biotechnology, higher access to seabed resources, investment in marine ICT and proper integration of costal tourism and other services could play a crucial role in injecting stimulus for creating additional economic activities in the IORA region.

4. Guiding Principles of Blue Economy

Considering the plethora of issues, the principles and goals of blue economy are quite ambitious. At present, global experience in implementing policy initiatives for blue economy is scant and varied. In order to develop a holistic stand on the definition and measurement of blue economy, it is imperative to highlight the key crucial elements of blue economy at the global as well as the national level. It would help facilitate a systematic effort towards kick-starting blue economy in the Indian Ocean region and building capacity in other countries for suitable replication and adaptation.

4.1 Efficient Utilization of Marine Resources

Optimum and efficient utilization of marine resources is at the core of blue economy which is not so explicitly emphasized in green economy philosophy although ocean economy is solely meant for the use of ocean resources. Basically, blueing of economies would facilitate greater use of untapped marine resources in a much bigger way which, in turn, may raise the contribution of oceans to the overall economy.[16] As claimed by the protagonists of blue economy, the contemporary development strategies focussed more on maximum use of oceanic resources with little concern for renewability and rebuilding. As a result, the economic cost of losses resulting from

[16] "To quote from European Marine Board (2015), ".....every second specimen collected from abyssal waters deeper than 3000m belonged to a previously undescribed species".

depletion of natural and biological stock is believed to have increased significantly. If these losses are factored into national income accounting, the net income from marine resources could be lower. Unlike those approaches, blue economy turns its focus from 'maximum' to 'optimum' use thereby envisages 'sustainable use' corresponding to the long-term stock of resources.

4.2 Exploiting Opportunities in Emerging Marine Industries

Although marine industries have contributions to the economy of the coastal economies even in absence of any specific policies for blue economy, the importance of marine industries is higher in the blue economy framework. Instead of benefiting from the use of available marine resources and technologies, blue economy paradigm may enable fresh investments in R&D and technology development that could help explore new marine resources. This, in turn, would facilitate emergence of new marine industries and expand activities in the economy. Marine biotechnology, marine ICT, tourism and leisure are some of the sunrise blue economy sectors which are considered to have potential for accelerated growth. New drugs are being developed from marine organisms which may be highly useful for certain critical diseases. Further research on marine organisms could shed more light on the opportunities in the biotechnology sector in the future. Telephone cables, gas pipelines, energy corridors and intensive engagement among the regional countries would require greater application of information technology in the coming years. Likewise, blue economy initiatives could diversify the marine services sectors particularly transport and tourism.

4.3 Inclusive and Harmonious Growth with Sustainability Concerns

The concern for sustainability of resources is not new in the development literature. 'Green economy' philosophy is based on the idea of controlling environmental pollution caused in the process of development. Unlike green economy, blue economy blends both the objectives of optimum use and preventing misuse or wasteful use of marine resources.[17] Also, blue economy sounds more appealing compared to green economy as the possibility of expanding production frontier is relatively high in case of the former. In other words, blue economy paradigm not only emphasizes upon the protection and rebuilding of marine resources rather it advocates higher use of precious oceanic resources which perhaps remain underutilized so far. Except maximising economic growth, the weight given to sustainability in the blue economy paradigm has connotations for inclusive growth as well. Following the conventional thinking, the oceans were treated as the greatest sink of all industrial and human wastes. Whatever efforts were directed towards preventing marine pollution and degradation of ocean habitat in the past, those efforts were basically corrective in nature without

[17] For details about opportunities in the blue economy sectors and the desired sustainable practices corresponding to those sectors, see EIU (2015b).

any thinking for switching to alternative development strategies. Blue economy apparently incorporates both these canons of sustainable and inclusive development.

4.4 Creating Legal and Regulatory Institutions

As per the existing international maritime regimes, coastal countries have jurisdiction to fisheries, minerals and other marine resources within their respective Exclusive Economic Zones (EEZs). Resources in the deep-sea are governed in accordance with the provisions of certain international conventions such as the United Nations Convention in the Law of the Sea (UNCLOS), conventions of International Maritime Organization (IMO), International Seabed Authority (ISA) and regional and global institutions of the Food and Agriculture Organization (FAO). Since the guidelines of these conventions are largely advisory in nature, there is enough room for breach of territorial jurisdictions in high seas by any country regardless of its membership to those conventions. As a result, disputes are likely if aggressive maritime strategies are followed by the competing world powers in the Indian Ocean Region. In case of fisheries, dealing with the migratory species is a very contentious issue. There are some regional fisheries management organizations like the Indian Ocean Tuna Commission (IOTC), International Commission for the Conservation of Atlantic Tunas (ICCAT), Western and Central Pacific Fisheries Commission (WCPFC) and so on. Some of those fishing organisations have binding rules and regulations whereas most of those are advisory. Similarly, deep-sea exploration is regulated by the licenses issued by the ISA. Despite ISA regulations, there are instances of violations of areas allotted for deep-sea mining.

As blue economy envisages intensification of activities in and around the oceans, the likelihood of frequent territorial disputes relating to use and misuse of marine resources cannot be undermined. It, therefore, requires either creation or streamlining of the current institutional arrangements governing the access, use and protection of maritime resources.

5. Elements of Blue Economy

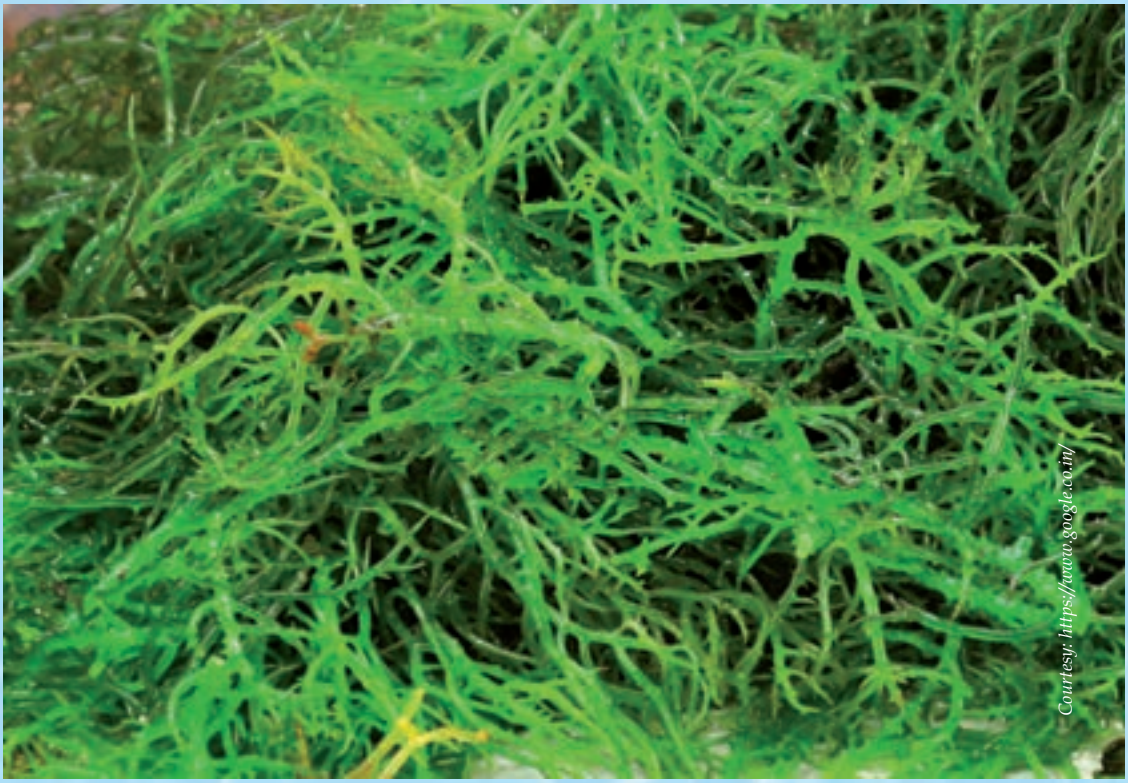
The blue economy paradigm puts emphasis on the term 'blue' which primarily refers to water. In that perspective, the coverage of blue economy can be expanded to all water-bodies and water-related activities over the land and in the seas within the sovereign jurisdiction of a country. Logically, the whole range of activities involving fresh as well as marine water would comprise blue economy for any typical economy. However, this argument does not seem consistent with the position maintained in the current literature. Broadly speaking, there is some agreement over the inclusion of marine sectors and its related activities in the blue economy. None of the studies mentions about inclusion of activities in freshwater as part of blue economy. On the contrary, ocean and ocean-related activities have been the core of blue economy. It is commonly believed that ocean and ocean-related activities are mostly related to maritime trade, fisheries and aquaculture, and a few other activities, but blue economy activities are deeply entrenched into

almost all sectors of an economy. In fact, there is no such major sector which is excluded from the activities of the blue economy.

The structure of the blue economy is very similar to national income, but there are differences in terms of inclusion and exclusion of specific sectors/industries in the estimation process. In terms of industries engaged in production activities, nearly 15 per cent of disaggregated industries is falling under the domain of blue economy. Unlike the national income accounting, blue economy activities are not only determined through the associate industries but by their geographical locations. The bulk of economic activities related to the blue economy takes place in the coastal area. Therefore, accounting system of blue economy is different from that of national income estimation. Different country studies show that the blue economy grows faster than the rest of the economy, thus, the latter has high growth potential in future. The key sub-sectors of the major economic sectors in an economy, exhibiting dynamism of blue economy, are briefly discussed.

5.1 Agriculture

Agriculture is a crucial sector of blue economy for any country in the world. In the context of blue economy, agriculture refers to fisheries and aquaculture. This sector contributes significantly to food, nutrition, livelihood security, job creation and foreign exchange earnings. While overall



Seaweeds: Changing Food Habits

stagnancy was observed in capture fishery for the past few decades, aquaculture witnessed dramatic growth in these years. Fishery is considered as an important traditional sector whereas aquaculture is counted among the emerging sectors of blue economy. However, as mentioned above, the inclusion of inland fishery resources in blue economy remains a debatable issue. Besides fishery, all other aquatic resources including aquatic plants should ideally form part of blue economy. However, in some countries aquatic plants are not covered in blue economy. Moreover, agricultural crops will have to be considered if freshwater is added to the coverage of blue economy. All these issues are quite contentious at present at least from the point of empirical measure of the contribution of the sector to national output.

5.2 Mining

Oceans are a rich treasure of oil, natural gas, minerals including hydrocarbons, rare earth metals, zinc, manganese noodles and other oceanic resources on the seabed. Deep-sea mining is viewed as a potential sector for promotion of blue economy. Most of the studies have considered oceanic minerals and offshore mining as the major blue economy sectors. However, the coverage of mining sector differs from country to country based on the respective national statistical systems. In addition, the distinction between mining in the land and mining in the seas in certain sectors is not known. In that case, the potential and performance of that sector would be underestimated. Exploration of seabed resources requires permission of the International Seabed Authority (ISA). Countries are allowed to do exploration

Offshore Oceanic Resources: Unleashing Potential of Seabed Resources

only in their allocated areas on the seabed. Since the race for deep-sea mining has already begun, international regulations pertaining to the sustainable harnessing of seabed minerals need to be compatible with the changing environment. Once blue economy takes off in most countries of the world, the disputes over access to minerals outside the EEZs may rise in the future.

5.3 Industry

Marine manufacturing, electricity generation from offshore sources, gas and water constitute the industrial sectors of blue economy. Marine manufacturing sector covers a wide range of activities such as boat manufacturing, sail making, net manufacturing, boat and ship repair, marine instrumentation, aquaculture technology, water construction, marine industrial engineering, and so on. This list of activities is exhaustive and encompasses several manufacturing sectors. Since blue economy is evolving in different parts of the world the activities that are emerging in marine manufacturing vary across the countries. For instance, the demand for new ship building would grow as the seaborne trade expands. Likewise, new shipping technologies would require replacement of old ships thereby providing further impetus to ship manufacturing industry. Along with shipping marine industrial engineering sectors would also grow. The industry

Ship Repairing Services: Creating Jobs

would demand technicians and trained marine engineers for manufacturing and repair of ship, machinery, etc.

5.4 Services

While the contribution of services sectors in general is rising for most of the countries of the world, marine services segment exhibit significant potential for growth in the future. In the context of blue economy these sectors assume higher importance. As the magnitude of investment is expected to rise in view of increasing blue economy orientation in the coastal countries, in-depth analysis of the potential and prospects of marine services is important. Major services sectors include ports & shipping, tourism, banking and financial services, transport & logistics, marine commerce, ICT and others. In the tourism sector, leisure cruise, coastal tourism, bird watching, angling, fishing and other related services have huge potential for wage-employment in local areas and foreign exchange earnings. As blue economy policies are implemented fully, the need for project financing, term financing and brokerage services would grow. This, in turn, would require a deep marine banking

Cruise: An Emerging Segment of Coastal Tourism

and financial services sectors. Moreover, the resources needed for financing deep-sea mining projects may be large which can help prosper investment banking. Likewise, other sectors of marine services will also deepen in the future.

6. Accounting Framework for Blue Economy

Any serious policy making for blue economy is possible only when the contribution of that sector to national income is known *a priori*. It requires systematic and replicable methodology for recording of data and measurement of activities in the blue economy sectors. Till date, there is hardly any well-defined measure of the size of blue economy. Moreover, without proper accounting of activities it is difficult to formulate and implement blue economy strategies in national development plans. Further, it would complicate cross-country comparisons of the performance of blue economy sectors in different parts of the world.[18] Although some anecdotal estimates of the size of blue economy are available for a few countries including the United States, China, Indonesia and others, there is no clarity over the techniques employed for those computations.

The difficulty in measurement of blue economy is because of ambiguities over the definitional issues. The coverage of sectors and sub-sectors of blue economy cannot be properly articulated as per the existing international economic classifications such as ISIC, CPC, HS, SITC and others. These classifications fail to categorise the land- and ocean-based activities. Even the System of National Accounts (NAS), the most comprehensive accounting framework for measurement of gross domestic product, does not provide any clear picture of the coverage of blue economy activities. In the current version, identification of codes for production and trade in the blue economy sectors is seemingly incomplete and cumbersome. In absence of clear distinction between the ocean economy and blue economy, record and analysis of data for policy making following any of the existing classifications would be misleading and grossly underestimate the potential of blue economy in a country.

Blue economy typically involves numerous types of coastal activities ranging from fishing to tourism. However, there is no such system of reporting of those activities. As a result, any reference to the magnitude of coastal activities in a country or a region is not flawless. Given the difficulty of tracing coastal activities, there has to be suitable coding and tracking system for the coastal activities. For example, the United States uses postal ZIP codes for tracking coastal activities in the country. Innovations of that sort would be necessary for systematic record of activities/services in blue economy sectors. Emerging activities in agriculture, biodiversity and biotechnology areas are not included in ISIC classifications. Besides manufacturing, services such as research and development (R&D) in marine

[18] EIU (2015a).

biotechnology, marine ICT and others are not clearly defined in the existing classification systems. In addition, the role of government particularly with respect to naval and other defence services is not property identified in those statistical systems. The present classification system does not cover high-valued minerals including thorium, hydrocarbons, etc. These sectors are quite substantial as those involve heavy investments in explorations at deep-sea, regular investment in R&D and technology upgradation and services relating to mining, technology development and other services.

Keeping in mind the above mentioned complications in defining and measuring blue economy, the proposed accounting framework should be viewed from the perspective of its coverage, utility and transparency in objective identification of production, trade and services relating to different segments of blue economy. In addition to output, this framework should cover other important macroeconomic data such as value added, employment, capital formation, foreign investment flows, etc. As the concept of blue economy is evolving, the process of developing a robust and credible accounting framework would be in the interests of all the coastal countries embracing maritime economy.

Given the inherent difficulties in classifying blue economy activities, NAS is not appropriate for analysis of blue economy. Although data from NAS would be a great source of understanding of the pattern of blue economy in country, it cannot be relied upon entirely for any meaningful policy making exercises. As tried in a few countries, field surveys on activities in blue economy sectors could provide some lead in formulating methodologies for data collection, compilation and development of suitable statistical framework for measurement of blue economy at national and global levels. As mentioned above, tracking coastal activities by using postal codes (e.g. US & Indonesia) may also be attempted.

7. Blue Economy: Taxonomy of Sectors

Blue economy constitutes a number of economic sectors that are directly or indirectly linked to oceans and ocean-related activities. In the literature those are broadly classified as traditional and emerging sectors without any strict distinction between the two (see Table 1). The importance and relevance of different sectors of blue economy are discussed below.

7.1 Fisheries and Aquaculture

Fishery is a vital oceanic resource that forms the core of blue economy. Besides wild catch, there has been phenomenal growth in fish farming worldwide. While dependence on aquaculture is growing over time due to increasing demand for fish and fish products, people in many parts of the world view aquaculture as a sector for gainful employment and self-enterprise. All the member countries of IORA are well-endowed with fisheries and aquatic plants which could be harnessed for the growth of blue economy. Following the principles of blue economy, the problems of overfishing, IUU fishing, fishing in high and open seas, etc are expected to be regulated even though the focus would still be on the optimum use of fishery stock in the

region. In other words, blue economy may warrant a significant departure from the conventional fishing practices and regulations in the IORA countries. In addition, this may necessitate changes in the legal and institutional structures for enabling a smooth realization of blue economy goals.

Blue economy orientation is likely to emphasize more on the optimum use of fisheries. Of the new areas that assume higher importance in blue economy, the most crucial component is the possibility of value addition through fish processing. Unilaterally, some countries such as China, Thailand and others are promoting the processed fish industry in order to benefit from the surge in demand from the US and EU. Since capture fisheries face the problem of overfishing and low fertility in most fishing areas of the world, the challenges of food security can be addressed through sustained aquaculture production. In the blue economy paradigm, both raw and processed sectors in aquaculture would require greater application of modern technology. It is therefore necessary to establish suitable mechanisms for technology transfer in fisheries among the IORA countries.

Pricing of fish and fish products is a contentious aspect of fisheries in the context of blue economy. In absence of comparable global database on fish prices, it is hard to estimate the contribution of fisheries to national output and the nature of pricing. Data availability on fish prices would help in determination and stabilization of market prices in fish markets in the IORA region and in other parts of the world. In addition, cross-country database on prices would be useful for determination of fair

Marine Aquaculture: Serving Growing Demand for Fish

and remunerative prices for fish products.

It is widely believed that a significant part of the potential of blue economy is not tapped yet. If that is true, then the fisheries and aquaculture sectors would get boost in the coming years. It would necessitate sizeable investment and higher market access beyond the national borders. IORA countries should open up their fisheries sectors and institute necessary reforms that would unlock market opportunities in the region. In that light, the fishing nations in IORA should negotiate for higher market access in each others' markets and undertake necessary measures aimed at developing region-wide standards for processing, certification, labelling and marketing of fish products in the region and in the world.

Although some forms of regional arrangements (e.g. Fisheries Support Unit) for fisheries and aquaculture exist among the IORA countries, it is imperative to examine the additional tiers of cooperation in fisheries within the blue economy framework. A number of questions need to be answered particularly the appropriate format of cooperation, the types of policy measures and the degree of enforceability in event of violation of those policies. Further, the limits of fisheries and aquaculture sectors for commercial exploitation are well-known to the fishing nations as well as the regional and global fishery bodies responsible for the regulation and governance of fishery resources in the world. In that light, what kinds of preventive and regulatory measures those could be considered for effective implementation of blue economy strategies in the region? Most importantly, what would be the modalities for transfer of technology and sharing of production and trade data in fish processing sectors?

7.2 Ports and Shipping

With expansion of seaborne trade in the recent years, port development assumes importance in the Indian Ocean region. There has been sustained rise in world container throughput over the past few years. At the same time, the demand for large vessels and increasing use of dry-bulk cargo puts emphasis on concerted efforts towards capacity expansion and modernisation of ports. In a regional context, ports should be treated as shared infrastructure which would lower transaction costs and facilitate smoother flows of goods in the region. Further, there are many countries such as Hong Kong, the United Arab Emirates, Tanzania, etc whose port facilities are primarily meant for transit facilities and services to other countries trading through those routes.

In the blue economy framework, countries may tend to develop their own ports and focus on long-distance shipping thereby affecting the services of the transit ports. However, a protagonist view favours capacity expansion in the sense that more ports may intensify seaborne trade and services across the region with insignificant effects on the businesses of the transit ports. This remains controversial at this juncture because of the complex interplay of competing sectors and forces in the blue economy model. For instance, the major seaports in the European Union are in competition with each other due to concentration of cargo handling in select ports such as Rotterdam, Antwerp and Hamburg whereas some ports grapple

Ports and Services: A Flourishing Blue Economy Sector

with excess capacity. Optimum use of these connected seaports would minimise trade distortions and promote regional trade in the EU. Likewise, the Indian Ocean rim countries must take cognisance of these conflicts while implementing blue economy measures in their economies. Ports would become the nerves for numerous blue economy activities and services in shipping and ancillary sectors. Besides ports, shipping in general may get renewed focus in the region due to blue economy orientation. Investment opportunities in ship building may grow as the demand for new varieties of ships catering to traditional shipping, ferry, small cruise and other forms of marine tourism is likely to grow in the future.

Blue economy covers a number of traditional as well as non-traditional sectors including deep-sea exploration of minerals including hydrocarbons, thorium, etc, oil & gas production, marine biotechnology, bunkering, petroleum storage, marine ICT, water-based tourism and leisure, shipping & maritime transport, marine construction and engineering, renewable ocean energy, boat building, cruise, and other marine services. With advancement in exploration technology, the feasibility of exploitation of seabed resources and sea mining is seemingly high. Countries in the region may freeze this opportunity by investing in development of these technologies. Rare earth metals that are used for a number of high-tech products and other technologies are important for the promotion of blue economy in the region. IORA countries may enhance cooperation in mining and use of these precious resources for promotion of blue economy and overall development in their economies. Similarly, the region has a

rich treasure of coal reserves; a vital blue resource that has immense contribution to development in the region.

7.3 Deep-Sea Oceanic Resources

Advancement in exploration technology has enabled the coastal nations to examine the feasibility of exploiting the seabed resources. Research suggests that there is vast unexplored stock of minerals on the seabed such as hydrocarbons, oil & natural gas, manganese noodles, cobalt, rare earth metals, among others. Since the current pace of resource extraction from landmass is alarming in most countries of the world, the demand for minerals can be met by exploration of deep-sea minerals. However, it is highly dependent on sophisticated technology and requires continuous investment in R&D. It is believed that the potential for exploration of seabed resources in the Indian Ocean is yet to be fully exploited. Some of the Indian Ocean countries including India, Australia, Indonesia and others have made significant investments in developing technology and conducting feasibility studies. Since mining beyond the continental shelf is within the jurisdiction of the costal nations, the rights for exploration of seabed resources need to be earned from the International Seabed Authority (ISA).

Further, in a regional context like the IORA, the issues of technology transfer

Deep-Sea Mining Technology

and sharing of best practices can also be explored. Australia has a very strong offshore resources sector which could be harnessed for the country as well as for the prosperity of the nation. India has also made significant headway in technology development for deep-sea exploration. Although deep-sea mining opens up opportunities for additional sources of resources, it inflicts costs to the society in terms of adverse effects on the marine environment. Before designing the mining system, proper geological, meteorological and biological assessments should be done. Based on an experiment by India, certain environmental parameters are suggested for minimizing the impact of deep-sea mining which include minimizing sediment penetration, separation of noodles from associated sediments near the seafloor, lifting of minimum possible sediment to the surface, discharge tailings below oxygen minimum zone, treat tailings before discharging and constructive use of unwanted material after extraction of metals.[19]

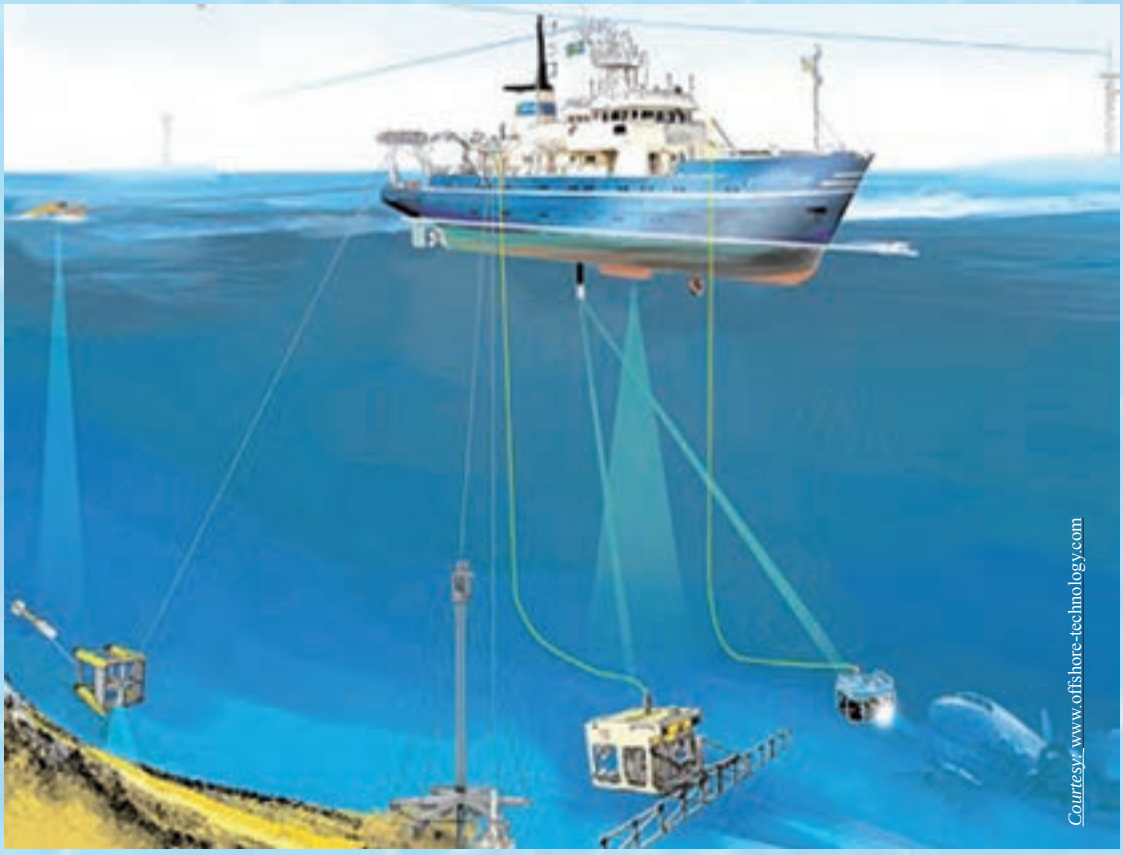
7.4 Marine Biotechnology

Marine biotechnology is an emerging sector of blue economy as its applications spread into many fields of social and economic life. The living organisms, microalgae, sponge and other biological species in the oceans are rich sources of medicine. By setting suitable culture conditions, new compounds and molecules can be developed for drug development. In fact, the successful formulations derived from the marine biological resources encourage further R&D and investment in bioprospecting and biosynthesis. Besides discovery of new drugs, marine biotechnology has much wider applications in tissue culture, aquaculture, manufacturing of medical devices, among others. Marine biotechnology also helps in introduction of new species and improving understanding of molecular and physiological basis for reproduction. Cells of horsecrab could be useful in detecting early infection in human as well as traces of pyrogens in biotechnological products. Similarly, protein and enzymes derived from marine organisms are of great use to food and pharmaceutical industries. Biopolymers is a useful product with a range of uses such as biodegradable plastics to food additives, pharmaceutical and medical polymers, wound dressing, bio-adhesives, dental biomaterials, tissue regeneration and 3D tissue culture scaffolds. As this sector is a knowledge-intensive sector, public support for marine science education and research may be necessary in order to inspire greater applications of innovations in marine biotechnology. Since capture fish production is declining worldwide, the need for upscaling of aquaculture production is of utmost importance. At the same time, farming of species should be compatible with the environmental standards. Polyculture and other similar innovations in fishing should be preferred to conventional farming systems in marine aquaculture. There may be numerous other applications of marine derived technologies and biological processes.

[19] Sharma (2015).

7.5 Marine Services

Like fishery and manufacturing, marine services sectors show symptoms of growth and diversification. Marine services include a whole range of activities including costal tourism, ports & shipping services, marine baking, insurance and financial services, transportation & logistics, and others. With surge in blue economy activities, the associated services activities would also multiply. Looking at the strategic position of the Indian Ocean region, the marine services sectors in the IORA countries are expected to assume depth in the future. Interestingly, services trade of the IORA countries have grown dramatically over the period 1997-2014. It might have propelled ports, shipping and transportation services during this period. As regards shipping services, many shipping lines pass through the Indian Ocean region. The current volume of shipping services in the region indicates that the potential for those services is fully exhausted. Indian Ocean region constitutes 11.2 per cent of shipping in DWT terms, Dead Weight tonnage and 9.9 per cent in terms of real nationality. Singapore, India and UAE have one per cent share in the shipping services. In addition, the ships of many nations including India are old. For India, about 43 per cent of its ships are 20 years old. The Government of India has introduced



Marine ICT: Wider Applications in Blue Economy

certain policy initiatives to promote this sector. India now allows its shipping companies to acquire ships abroad and flag them in other nations.

Besides shipping services, there is enormous potential for port services such as transhipments, stevedoring, bunker services, etc in the Indian Ocean region. The region has world's top container ports including Singapore and Dubai. The container throughput of the top ten IORA nations is 18 per cent of the world. Although ports in the region are capable of handling many services, the standards of these ports are far below the global standards. Port infrastructure, offshore infrastructure and very large floating structures (VLFS) can be developed for entertainment services. Ship repairing and ship breaking is a crucial segment of port services. Since SIDS countries lack capacity in many segments of port services, regional cooperation should be encouraged in training centres, dredging activities, ship repairs, dry docking and transhipment facilities.

Tourism is a flourishing sector in services. Among the IORA countries, Thailand leads the region followed by Malaysia and Singapore. Visa problems are often blamed for the low tourist arrivals to the most of the destinations in the Indian Ocean region. India has introduced e-Visa to facilitate cross-border tourist movements. India has extended this facility to 13 other member states of IORA whereas 11 IORA states have done for India. Likewise, other marine services have vast potential for job creation and economic diversification in the region.

8. Ocean Energy

8.1 Relevance of Renewable Ocean Energy

Global demand for energy continues to rise with prosperity in the emerging and developing economies particularly in China, India, Brazil, South Africa, Japan and Korea. At the same time, the severity of environmental degradation and climate change associated with conventional sources of energy in the form of increased CO2 emission, acidification in oceans, etc. is greatly acknowledged by the high-energy consuming nations. In the blue economy paradigm, the tolerance level for higher emissions will no longer be acceptable to the countries adopting it in their development models. Since demand for energy would remain high in the growing economies in the future, the reliance on alternative non-conventional renewable sources of energy would remain high. Oceans are a vast source of energy particularly for the renewable energy. As per an estimate, electricity generation from oceans could range from 20,000 terawatts to 80,000 terawatts per year which is equivalent to 100 to 400 per cent of the current global demand for energy. Further, sea can produce 250 billion barrels (oil equivalent) of energy every day. Ocean energy could be classified based on the different sources such as tides, tidal currents, solar, waves, salinity gradient and thermal gradient.

Renewable energy is advantageous than non-renewable energy in mainly three aspects. Renewable energy provides energy security, climate change mitigation and provides wider access to resources

for energy production for a nation. In addition, it also provides job opportunities in the sector. Renewable sources of energy such as solar and wind have been harnessed worldwide and to some extent reached a level of saturation in countries like the United Kingdom, Denmark and other European countries. In comparison, marine renewable resources have the potential to contribute to the global energy market (Dubois, *et al.*, 2008), even though they are more than 15-20 years younger than wind energy in terms of installed capacity (Mueller, 2008). Moreover, volatility in prices of raw materials for conventional sources of energy has been an obstacle in achieving current and future energy requirements of developing nations, particularly in the IORA region. This further enhances the exigencies to bring forward the scope of blue energies.

Indian Ocean rim countries have already taken measures to exploit the renewable energy resources for meeting the growing energy demand in the region. The Indian Ocean Renewable Energy Ministerial Forum held in January 2014 launched several initiatives to explore renewable energy resources in the Indian Ocean region. Like other countries along the Rim, India considers renewable ocean energy as an important source of energy that could supplement the rising energy requirements in the country. The recent policy initiatives by the government such as generation-based Incentives (GBI), tax holidays, 100 per cent FDI in renewable energy sector and so on could prove effective in promoting energy production in the renewable ocean energy sector. In its Strategic Plan for the period 2011-17, the Government of India emphasizes this sector as a key component of energy supply in the country and aims at increasing its contribution to total installed power generation capacity of the country from 16 per cent to 18 per cent by 2022. Besides augmenting domestic sources of renewable energy sector in which the ocean energy is a crucial component, India gives importance to fostering international cooperation in the new and renewable energy sectors.

8.2 SDGs in the context of Blue Economy

The earnest solution of energy security is not a matter of serendipity, but a more practical outlook is the need of the hour. The recent Sustainable Development Goals (SDGs) have raised the need for affordable, reliable, sustainable and modern energy requirement for all by the year 2030, defined in SDG-7. It aims at increasing the share of renewable energy in the total energy basket of the world. In addition, SDG-14, aims at sustainable use of oceans, seas and marine resources, especially for Small Island Developing States (SIDS) and Least Developed Countries (LDCs). Both these goals can be accomplished together while answering the untapped potential of Offshore Renewable Energy. Ocean-based renewable energy have the potential to enhance the efficiency of harvesting non-conventional resources, reduce the carbon emissions and would also minimize the use of land for power generation.

8.3 Potential, Current State and Demand Pattern of Renewable Energy

Wave Energy

Power drawn from waves occurs when wind blows across the sea surface and water act as carrier for the energy by using wave energy converters. The quantity of energy generated varies with height and the time gap between successive peaks. Energy drawn from waves is considered to be the most promising energy as it is less variable in comparison to other sources of energy like wind and solar. Generally, western coast of the continents and extreme latitude are the places where best wave energy is found. There are many different technologies presented globally to capture energy from waves, a couple of them are presented below:

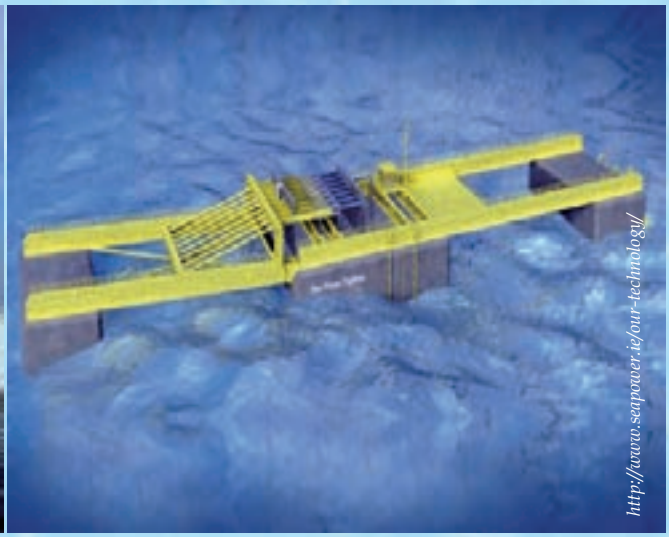
ATTENUATOR- the floating device (Attenuator) oriented parallel to the wave direction and hence traps energy from the relative motion of the two arms. The most well-known example of this kind of technology is **Pelamis**, where there is long series of cylindrical floating devices connected to each other with hinges and anchored to the seabed.

POINT ABSORBER- These devices does not restrict capturing wave energy unidirectional, however it traps energy from all the possible directions. One such device is called the Aquabuoy developed by Finavera. According to an estimate, there are more than 100 different patented proposals for this energy and many of them have shown economically viable electricity generation. Wave energy is the least mature energy in renewables. Globally, there is no consensus over any design for wave energy technology as it is still in testing phase. Even though with less development in wave energy technology, it has higher potential than tidal energy, hence there is expectation of further development in this technology in future.

Table 3: Theoretical Wave Net Power Resources Globally and Regionally

Region	Wave Energy (GW)
Western and Northern Europe	290
Mediterranean Sea and Atlantic Archipelagos	148
North America and Greenland	245
Central America	171
South America	526
Africa	422
Asia	547
Australia, New Zealand and Pacific Islands	637
Total	2986

Source: Mørk et al (2010).



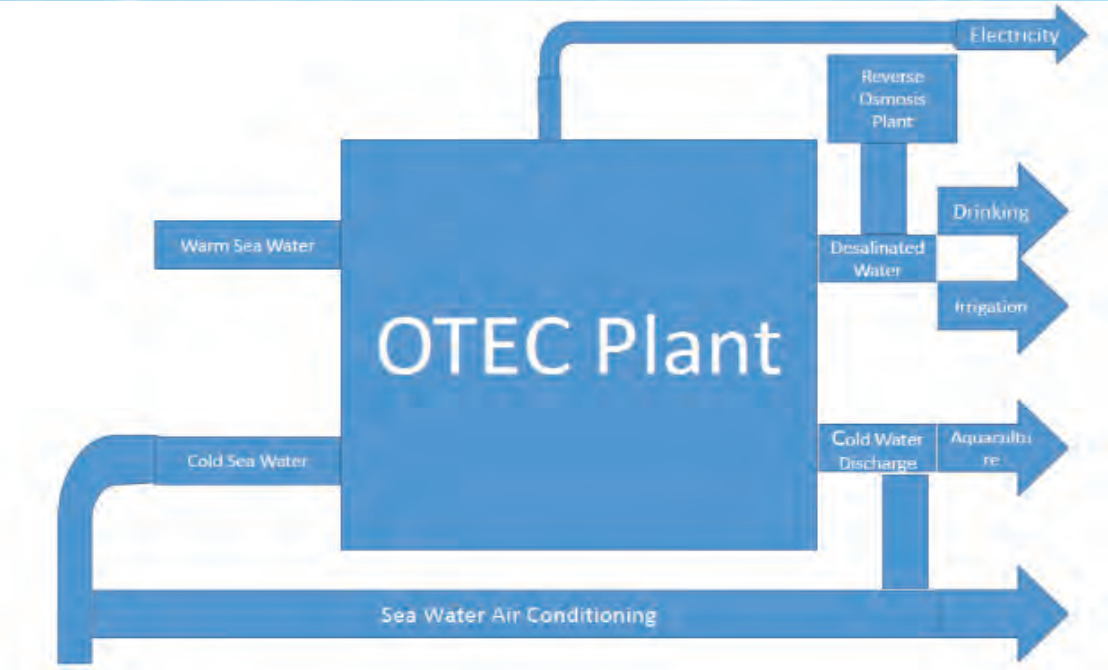
Variants of Wave Energy Technology

Ocean Thermal Energy

The difference between the temperature of warm and cold sea water at around 800-1000 meters depth is used to run heat engine and hence produces electricity. This technology needs an environment where the thermal gradient between the surface and depth is at least 22 degree Celsius, which makes it only viable in tropical seas. The difference in temperature is

A Traditional Source of Offshore Energy: How about Its Cost-Effectiveness

Presentation of Multi-functionality of OTEC Plant



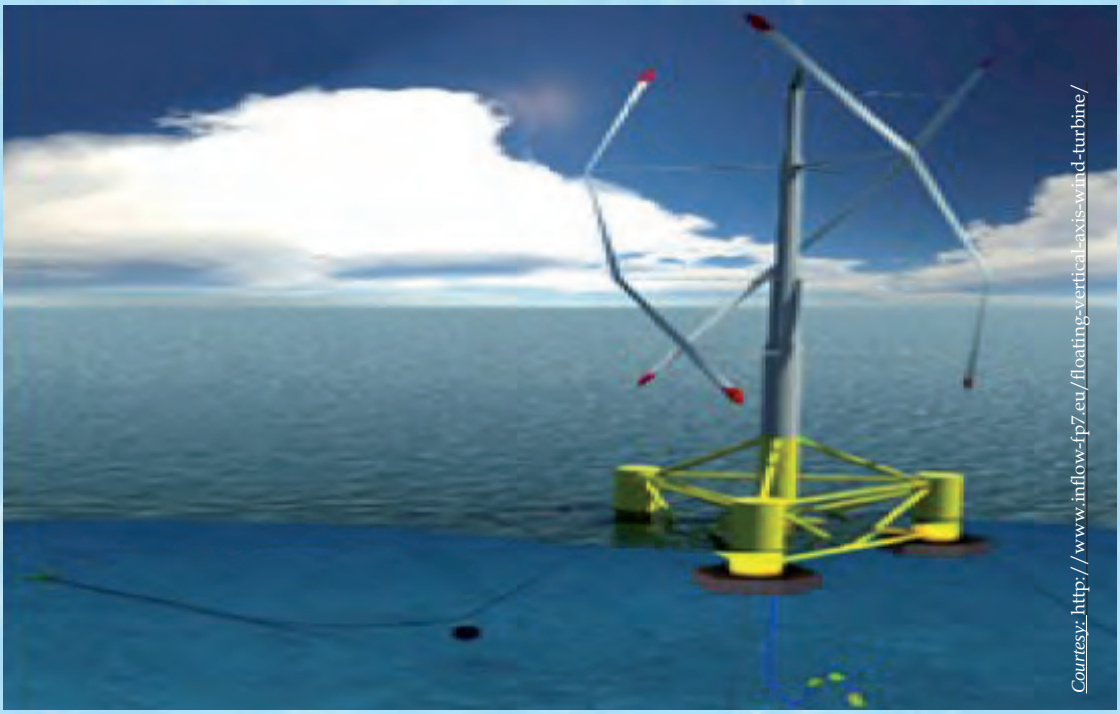
***Source**: Ocean Thermal Energy Conversion Technology Brief, IRENA*

converted into electrical power through turbines. On one hand, vapors from the warm sea water are used as working fluid to drive the turbine, on the other hand, cold water is used to condense the vapor. This difference in vapor pressure drives the turbine, hence produces energy. The resource can be utilized in either side of the equator (latitude 0 to 30 degrees). The capacity factor of OTEC is in between 90-95% which is among the highest in all power generation technologies in both renewable and non-renewable sector.

There are three schemes in OTEC energy production: open cycle, closed cycle, kallna cycle and hybrid system (a mix of open and closed cycle). Open cycle OTEC uses seawater as working fluid whereas closed cycle OTEC uses ammonia as working fluid and the kallna cycle uses both fluids. Ocean thermal energy can also be used for seawater air conditioning (Nihous, 2007), seawater district cooling or aquaculture purpose. Moreover, OTEC plants can also produce fresh water with the desalination technologies. According to a study, around 2.28 million litres of desalinated water can be obtained each day per megawatt of power generated by a hybrid OTEC system (Magesh, 2010).

Offshore Wind Energy

It is an indirect form of solar energy, resulted due to unequal heating of various parts of Earth thereby replacing warmer air by cooler air and hence causing wind. It is estimated that around 1-2% of solar radiation is converted into wind. With the growing concern of land acquisition, noise pollution, visual impact problems and many other problems with onshore wind energy, the vital role of offshore energy has been recognized.



Offshore Wind Energy: On Its Path to Cost Convergence

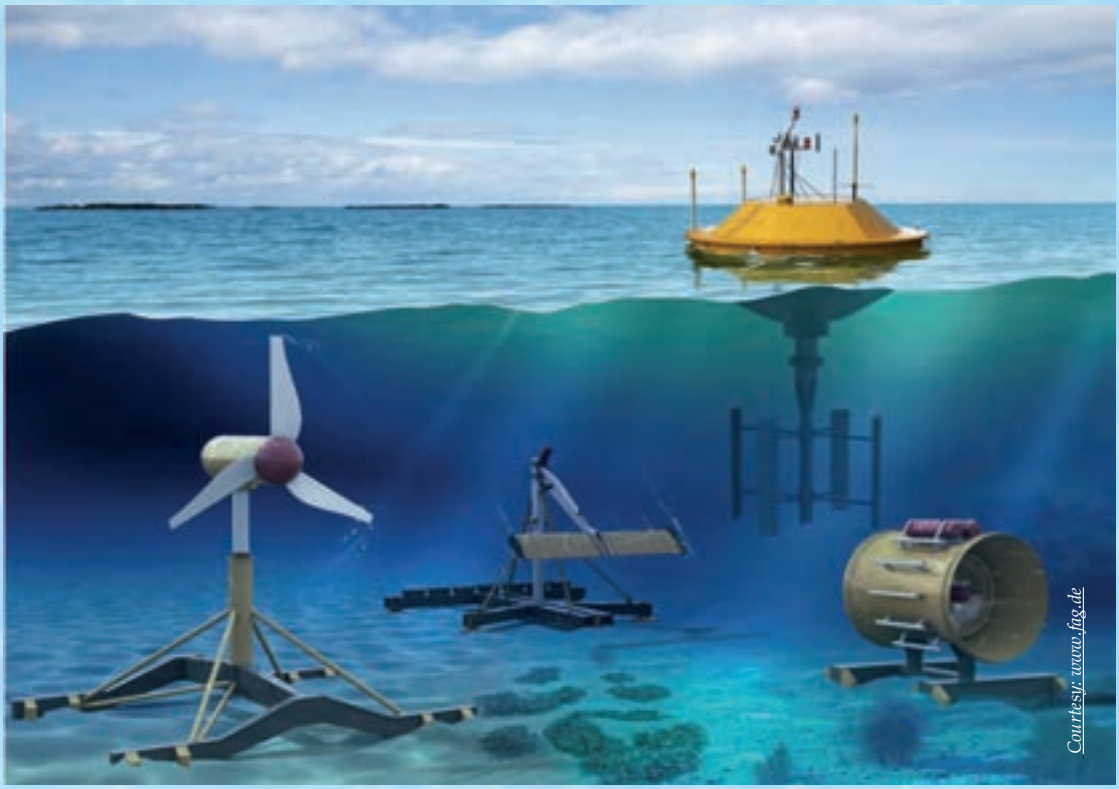
Table 4: Different Turbines and Required Water Depth Level for Offshore Wind Energy

Turbine	Water depth level (in meters)
Monopile	Up to 30
Gravity Base Structure	20-80
Tripod Pile Structure	20-80
Tripod suction caisson structures	20-80
Conventional steel jacket structures	20-80
Floating Wind Turbine	Deep water

Siemens and Vestas accounted for turbine supplies of 90% of offshore wind power, while Dong Energy, Vattenfall and E. on were the leading offshore operators as of 2010. The most developed technology in offshore wind energy is installed on either gravity foundation or sited on monopolies.

There are other turbines used at different water depth levels to harness wind energy from the oceans. The following table provides a gist of different turbines and their required water depth level. Improvement in technologies such as 'Smart Turbine Blades', use of material like carbon fibre, direct-drive generator technology would expand the harnessing of offshore wind energy (Sun, *et al.*, 2012).

The total annual installation for 2014 globally has reached to 8,759 MW, wherein 91% can be found in European waters. Offshore wind power installations represented 12.6% of the annual EU wind energy market in 2014 (GWEC). The UK has the largest offshore wind capacity



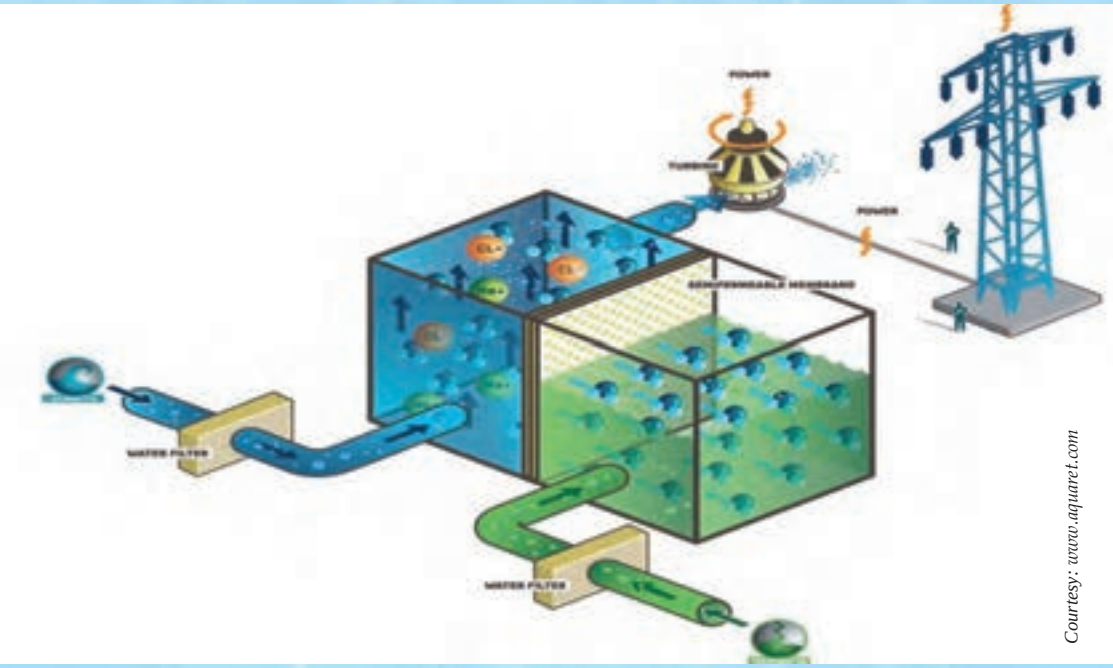
Tidal Energy: Highly Predictable Source of Offshore Energy

in Europe accounting for over 55% of all installations. Danish Government has also included target of achieving 1500 MW of energy from offshore wind in the new energy agreement for the period 2012-2020. The new competitors in this sector are the United States and China. A report by National Renewable Laboratory estimates that wind energy generation of 54GW in the United States would generate economic activities worth $200 billion with 43,000 jobs in manufacturing, construction, maintenance and operations.

Tidal Energy

Tidal cycles are caused by rise and fall of the tides occurring every 12 hours due to gravitational force of the moon. Water flowing in and out of estuaries carries energy and the amount of energy extractable depends on the area intercepted and speed of flowing stream. Tidal range can be forecasted with a high level of accuracy and is highly predictable when compared to wave, solar and wind energy. The current in tidal flows is constant over the water depth, hence it makes tidal energy to be a greatest opportunity to harness energy. There are mainly two methods for generating energy from tidal: Tidal Barrages and Tidal Stream Turbines.

Variation in tides ranges from 4.5m to 12.4m; however, to harness tidal energy economically at least 7m high tide is required to head start the turbine. The cost efficiency of tidal power plant depends on the 'Gibrat' ratio, which is the ratio of the length of the barrage (in meters) to annual energy production in kWh. The



Saline Power: Fusion of Fresh and Salt Water

smaller the ratio the better the site is for harnessing energy. The harvestable tidal energy resource is estimated at 1 terawatts (TW) globally. Extensive plans exist for tidal barrage projects in India, Korea, the Philippines and Russia adding up to around 115 gigawatts (GW). The sites such as Severn Estuary between Southwest England and South Wales are examples of favorable sites which could provide 12 GW (approximately 10% electricity need of the country) of energy. Several sites in the Bay of Fundy, Cook Inlet in Alaska, and the White Sea in Russia have been found to have the potential to generate large amounts of electricity.

Salinity Power

Saline Power is the energy created from salt concentration between fresh and salt water places where the river flows into the ocean (river mouths). The energy density from saline gradient can be measured as osmotic pressure between two saline solutions. The global estimation of the saline gradient energy is 3.1 TW[20], where Asia has the highest potential, followed by South America and North America. The projected cost for standalone installation for the year 2020 ranges from EUR 0.09/kWh to EUR 0.28/kWh for producing energy from saline gradient (IRENA).

Reversed electro dialysis (RED) and pressure-retarded osmosis (PRO) is among the two technologies identified for converting power. PRO is often called osmotic power. The first 5 kW PRO pilot power plant was commissioned in Norway in 2009. PRO creates power by utilizing the difference in the pressure of salt water and fresh water. Seawater is pumped into a pressure exchanger

[20] http://salinitygradientpower.eu/wp-content/uploads/2011/08/workshop-report-EUSEW.pdf

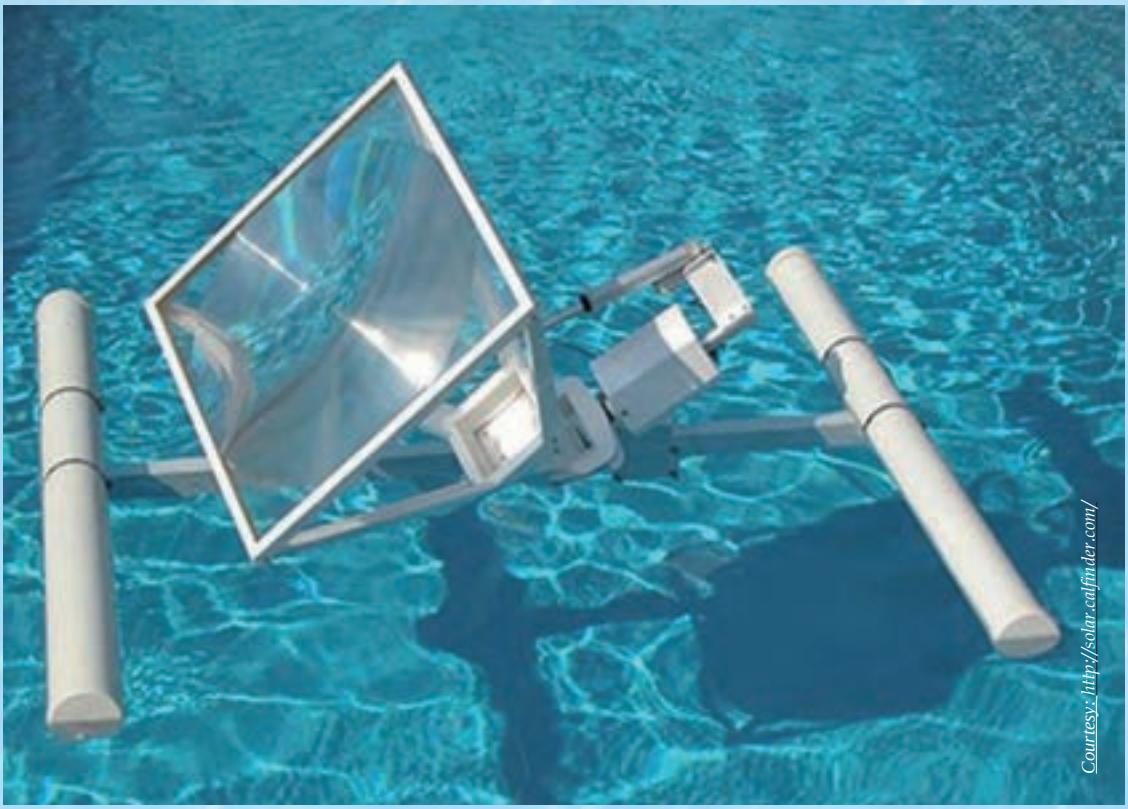
Table 5: Potential of Salinity Gradient Energy	
Region	Saline Power (GW)
Europe	241
Africa	307
Asia	1015
North America	479
South America	969
Australia (including Oceania)	147
World	3158

Source: *Stenzel (2012).*

and freshwater flows through a semi-permeable membrane towards the sea water, which increases the pressure within the chamber, followed by spinning the turbine and hence generating electricity. On the other hand, in RED, ions (salt) are transported through the membrane, which essentially creates a salt battery. This method is described by Weinstein and Leitz as "an array of alternating anion and cation exchange membranes can be used to generate electric power from the free energy of river and sea water." However, the global potential in the salinity energy as shown in Table 5 has been large and substantial energy potential from this source has been identified in Asia and Latin America.

Offshore Solar Energy

Solar energy can be tapped directly by Photovoltaic (PV) cells or indirectly by concentrating solar power. PV cells produce direct current electricity by releasing the electrons when they are exposed to sun, which can be stored or transferred into the grid with an inverter.



Solar Panel: A Source of Clean Energy

On the other hand, concentration solar power (CSP) requires a large flat area to heat a liquid substance which is then used to drive an electric generator. This method generates alternating current (AC) which can be easily distributed into the grids. The use of offshore solar power plants would increase the resource power for countries like Europe, where landscape for CSP is scare (Diendorfer, *et al.*, 2014).

Offshore solar power plants offer two technical advantages. Firstly, the implementation of vertical axis to track sun heat is easy which not only simplifies the requirement of CSP but also avoids shading between collector rows. Secondly, the cooling water needed for solar plants is available easily which would increase the efficiency in thermodynamic cycle (Diendorfer, *et al.*, 2014). In addition to this, offshore solar power plants reduce water requirement for cleaning up the panels due to concentration of dust, especially in desert areas. According to an estimate, dust on solar panels can reduce their efficiency by about 3 per cent. Though the usage of water depends on technology, weather and climatic conditions of the site where the solar panel has been established, yet according to an estimate approximately 20 gallons of water is used by solar plants per megawatt hour. These advantages lead to cost reduction as compared to onshore solar power plants and offset the extra cost incurred for offshore power plants. The performance of offshore solar plant depends basically on solar irradiation and

Floating Structure for Solar Energy Production

the status of the sea which includes wave and wind motion and their variability.

Japan's largest solar power plant, Kagoshima Nanatsujima, is an offshore technology, generating 70 MW of energy in Kagoshima City which is expected to supply electricity to approximately 22,000 average households. This would help in achieving country's solar PV target of 28 GW by 20202 and 53 GW by 2030. Another example of offshore solar PV is SUNdy- a floating offshore field concept of more than 50 MW of energy developed by DNV KEMA, which has total of 4,200 solar panels in the water ranging from 20-100 m in depth and around 5 miles away from shore[21] in Singapore.

Sun being the primary source of energy provides a great amount of potential for electricity generation. India being a tropical country becomes an abundant source of solar energy with 260-300 clear sunny days, capable of producing 5,000 GW[22] of energy. India's export of Solar PV cell was at US$207.21 million and that of import is at US$ 539 million in 2013-14 (Apr-Dec). The increasing trend of export of PV cells has fallen after 2010-11 largely due to increase in capacity building by China[23]. Enhancing the technology in offshore solar energy would further increase the trade in this area and also raises the scope of collaboration in exploring the untapped solar energy from the oceans.

Offshore solar power has got high potential which can be a major source of energy for the IORA countries, particularly those which are close to the equatorial region as mentioned in literature. In terms of cost of production of solar energy, it is competitive. There are variations in costs among different variants of technologies. When each of these PV technologies is blended with other sources of energy such as wave, fossil oil, etc., production capacity of solar energy plant increases significantly (Trapani and Millar, 2013). It is shown that the discounted costs of electricity from two different types of PV solar technologies, namely, poly-crystalline PV and a-Si PV, are €10.06 cents/kWh and €14.52 cents/kWh respectively in Malta. As shown in the Table 6, the cost of panels for poly-crystalline PV is significantly higher than that of a-Si PV. The technological improvement in solar power panel has led to fusion of solar energy with gas turbine and steam turbines technologies. In comparison high wave energy, offshore solar power has similar infrastructural and installation coast. Empirical evidences show that PV integration with a-Si PV technology can lead to reduction in cost which can also be generalised for other island countries. With the increase in the efficiency and reduction in cost, this integration also provides benefits in the form of reduction in carbon di-oxide emissions to the extent of about 25 per cent annually for a 250MW plant. Pooling of regional resources can benefit member

[21] http://www.dnv.com/binaries/Leaflet%20SUNdy%20DEF_tcm4-529461.pdf

[22] http://www.ireda.gov.in/forms/contentpage.aspx?lid=833

[23] http://www.greensummit.in/greensummit_2015/pdf/India-Renewable-Energy-Status-Report-2014.pdf

Table 6: Capital Expenditure and O&M Costs for the Floating PV Arrays		
	Pontoon-based (poly-crystalline Si)	Flexible system (a-Si)
	Million (£/MW)	Million (£/MW)
Panels	1.4012	0.7759
Pontoon	0.1582	--
Moorings[a]	0.2072	0.2072
Installation	0.5386	0.5386
Grid connection	0.1657	0.1657
Project management	0.0828	0.0828
Total CAPEX	2.5537	1.7702
Annuitized CAPEX	0.2601	0.1803
Annual O&M	0.002	0.0014
Discounted cost of Electricity ($ cents/KWh)	10.063	14.521

***Source**: Trapani and Millar (2013).*

***Note**: [a] Also due to the thin film mooring experiencing less force, since it is not designed to withstand the impact of the waves. It is expected that the mooring cost would be less than for a pontoon based system.*

countries in developing technologies for solar PV and blending them with other sources of energy.

8.4 Cost of Ocean Renewable Energy

The argument of cost effectiveness of marine renewable energy is a major concerned. The cost of energy generation from non-renewable resources such as coal plant and natural gas plant is around 3 cents per kWh, which is way less than that of ocean renewable energy. However, the cost reduces considerably over time due to advancement in technologies and economies of scale (Pelc and Fujita, 2002). Table 7 provides assessment of cost of producing electricity in United Kingdom in 2002 and the projected future cost in 2020. It is evident that though the ocean-based energy resources are expensive in the current years but in the long-run the cost is converging.

Among the ocean sources of energies, Tidal Barrage is expensive as compared to wave and wind energy. Though tidal energy is one of the oldest forms of energy, which can be dated back to 787 A.D. in Spain, France and British coast regions and the technology is also developed, is the most expensive form of marine energy. The main driver of high cost of tidal energy is the capital cost as the construction period of tidal plant is around 10 years.

The estimated cost of OTEC large scale plant ranges from USD 5,000-15,000 per kilowatt and that of the small scale

Table 7: Average Cost of Marine Renewable Energy in UK		
Technology	**Current Cost (US Cents/kWh)**	**Projected future Cost beyond 2020 (US Cents/kWh)**
Wind Energy:		
Onshore	3 - 5	2 – 3
Offshore	6 - 10	2 – 5
Marine Energy:		
Tidal Barrage	12	12
Tidal Stream	8 - 15	8 – 15
Wave	8 - 20	5 – 7

***Source**: Assessment of Technological Options to Address Climate Change: A Report for the Prime Minister's Strategy Unit, ICCEPT.*

OTEC plant is USD 16,400-35,400/kW[24]. Despite a vast resource availability and knowledge for the technology, the cost of installation and operations makes it commercially difficult to operate anywhere globally. The largest OTEC plant generating 1 MW of electricity is located in Hawaii. There are a number of more plants that has been set up or in stage of setting up in countries like China, Japan, India and South Korea. However, further exploration of technology and more experience and standardization of design of OTEC plant would bring down the cost of the tapping energy in the near future.

8.5 Importance of Ocean Renewable Energy in SIDS

The Small Island Developing States (SIDS) felt disconnected with the concept of Green Economy as it does not give justice to the ecosystem they are associated to, which lead to the concept of Blue Economy in Rio+20. Though the Blue Economy concept was initiated due to SIDS, it is relevant to other coastal states and countries. The SIDSs are characterized as dependent countries on imported petroleum products in the world (Dornan, 2015). Hence, renewable energy can help to mitigate vulnerability to oil price volatility and the dependence on fossil fuels. Climate change mitigation, energy security and access drive the deployment of renewable energy in SIDSs. The most reliable source for SIDSs is energy from OTEC as it can provide fresh drinking water while harnessing electricity for domestic purpose and economic activities. It is also a vital source of energy for SIDSs, even though it has a limited contribution worldwide (Pelc and Fujita, 2002). However, absence of economies of scale, appropriate regulatory

[24] http://www.irena.org/DocumentDownloads/Publications/Ocean_Thermal_Energy_V4_web.pdf

arrangement, lesser technical skills act as an obstacle in development of renewable energy in those countries.

In order to compensate these obstacles, required initiatives need to be taken to share the existing technologies to assist developing an environment conducive to renewable energy deployment in SIDSs. Countries like Mauritius and Seychelles have set their target of renewable energy at 35% (for the year 2025) and 15% (for 2030) respectively, which do have some experience in installation and generation of electricity from renewable resources. Hence, such countries can take a lead role and support other countries especially African SIDSs to achieve further development in ocean energy sources.

8.6 Importance and Status of Ocean Renewable Energy for IORA

The potential of different marine renewable energy varies for different countries. For Comoros, OTEC is very high, where a single plant (10MW) can cover the current electricity consumption (Hammar et al, 2012). Whereas for Mauritius a large potential for wind power, wave, solar and OTEC can provide ample energy as the first two sources peak in southern monsoon and the rest in northern monsoon. Offshore wave farm has been proposed on South Coast of Mauritius having power density of 41.5kW/m, which would also not interfere with the tourism sector as there are no reefs and lagoons at the stretch. Potential for wind and wave energy for Seychelles is quite high during northern monsoon. On the other hand, energy production from OTEC is not much of use due to small population of the country and large investment in technology. However, their concern is to get the access of these energies from turbine to shore at an affordable and efficient cost.

According to an estimate, the offshore wind energy (750 GW) in China has more potential than the land-based sources (253 GW). In order to tap this potential, two offshore wind projects have been started and will be completed in 2015 as Donghai Bridge project and Lingang wind farm in Shanghai. In addition, National Energy Administration has announced 1GW offshore wind farm project in eastern Jiangsu Province. These initiative would try to achieve the target, by Chinese Renewable Energy Industries Association, of 30GW installed offshore wind power by 2020.

The recent First IORA Blue Economy Conference focused on four sectors of Blue economy, out of which Renewable Ocean Energy was one. It recognizes the importance of Blue Economy in reducing the cost of energy and providing collaboration in mitigating and adapting the impact of climate change. The already installed and economically feasible applications of wave, offshore wind and tidal can be shared between the member countries of IORA, which would not only provide the access to such technologies to the countries which are deprived, rather by gaining the knowledge of basic technology, those countries can further make an initiative to enhance the technology.

8.7 Factors Affecting Growth of Renewable Energy

The study of Mani and Dhingra (2013) has listed five factors which would affect the growth of offshore wind energy sector in India out of which, government support, fiscal and quota based and enabling R&D ecosystem contributes more than 90% of the effect. The study findings reveal that fiscal and quota-based incentives such as feed-in-tariff, accelerated depreciation, generation based incentives and renewable energy certificates have 33.6% impact on the growth of offshore wind energy in India. Similarly, government support like single window clearance system, long term policies for sustainability effects 32% and active R&D in the offshore wind energy sector has 25.3% impact on the growth. While significant progress has been achieved in exploring renewable energy resources, the sector faces the challenge of cost reduction and improving the reliability and performance of the system.

Technology Status: Challenges and Opportunities

The first and foremost challenge with the renewable energy is that they are variable in nature. In case of wave energy, direction of wave and period varies quite frequently. Similarly for offshore wind energy, wind speed is a variable factor which leads to variation in production of electricity and transmission volume to the grid. However, with development in the technology in Offshore Wind power plants, especially in Europe, many offshore wind farms have raised the trend in renewable sector. Though, the turbine structure of offshore power plant is similar to that of onshore plant, yet there are further modifications needed like protection from corrosion, high grade exterior paint, built in services cranes, etc. A new design for wind turbine with vertical axis has been recently gained importance, which rotates regardless of the wind direction. It is estimated that vertical axis may perform better than the horizontal axis wind turbine and hence provide larger amount of energy at a simple structure, relatively low level of gravity and low maintenance cost.

Nova Research projects (2009) undertaken by a UK-based consortium of Wind Power Limited and many more companies, examined the efficiency of 5 MW or 10 MW offshore vertical axis turbine. Another Vertiwind project by French oil and gas engineering company Technip and wind power startup Nenuphar has developed an offshore floating plant with vertical axis turbine. A research group at Shanghai University has recently developed a novel vertical axis wind turbine, where the turbine is surrounded with several flat plates. This type of design achieves an efficient energy utilization and have a stable structure in comparison with other vertical axis turbine (Sun, *et al.*, 2012).

Another problem is the affordability of these resources. At present the cost of ocean renewable energy is quite high as compared with other sources. Though initially, the cost of a particular technology in high, with passage of time and experience in manufacturing and with growth in operations, the cost gets reduced and the technology becomes more

cost-effective. It is also widely known that the cost of transmission of energy from offshore is high, as there is a need of connecting transmission lines to the grid. This questions the feasibility of operating the offshore power plant at a high cost.

Environment Impact

The fact that energy generation is a vital element in an economy's growth and development is something that cannot be denied. It is also important to increase the supply of power keeping in mind the environmental degradation such as increase in CO2 emission, which therefore raises the need of developing renewable energy sources. However, these blue energies (offshore renewable sources of energy) have some environmental impact on the ecosystem. In case of OTEC, releasing of toxics like ammonia, chlorine, entailment of small organisms have a negative impact on marine life. Moreover, the concentration of nutrients and dissolved gases can be minimized at the depth of 50m or above. Cold water released in the process of generating electricity would also release greenhouse gasses like CO2. However, the emissions are way too low in comparison to fossil fuel power plants.

In case of small scale wave energy power plant the impact is minimal, however, large scale plants lead to harming ocean ecosystem especially the species which inhabit near the coast. For tidal energy plants, apart from affecting the marine environment and recreational activities, they also pose threats of altering the salinity and hydrology of the estuaries where they are sited. Tidal energy technologies do have a negative impact on the tidal flows, however, the impact depends on the geography of the site where it is located. According a study, there is a negligible effect on the local tides due to La Rance barrage in France whereas it is estimated that the local tides have decreased by 15cm in Bay of Fundy in North America.

Table 8: Potential for Ocean Renewable Energy in India

Source of Energy	India's Potential (GW)
Offshore Wind	1
Tidal	12.4
Wave	40
Salinity Gradient	54.8
Ocean Thermal Energy Conversion	180

***Sources**: Das (1986); AFD and IREDA (2014).*

In case of offshore wind energy, apart from noise and visual impact which are unlikely the issue, disturbance in fisheries and seabed communities have been a major concern. Offshore wind farms have potential to kill migratory birds. All of the above provides evidence that there could be a potential danger in installing these power plants. However, a proper impact analysis is needed to quantify the gains and losses from ocean energy and then concluding the overall effect.

Offshore Renewable Energy in India

India with total installed capacity of 23GW (as on 31 March, 2015) is ranked the fifth largest in the world with respect to onshore wind energy. The total potential for wind power generation in the country

as on the end of 2014 is 69.6%[25] of the total estimate of renewable energy at 147.615 GW. In addition to its onshore energy, a long coastline of 7,500 km (including island territories), emerges as an enormous source of offshore wind as well, which is yet to develop. With the announcement of draft offshore wind power policy, Govt. of India has suggested potential of 1GW of offshore energy along the coastline of Rameshwaram and Kanyakumari in Tamil Nadu (MNRE)[26].

According to a study by IREDA, there are only three locations in India with largest concentration of tidal energies – Gulf of *Khambhat*, Gulf of *Kutchh* and *Sunderbans* region. A plant of 3.65 megawatt capacity has been established at *Durga Duani* creeks in *Sunderbans* Delta. The other plant of 50 megawatt capacity will be developed by the London-based company Atlantis Resources Corporation in partnership with Gujarat Power Corporation. The potential estimates for tidal energy is around 12.4GW with technological advancement at the locations identified in the study on tidal and wave energy in India by IREDA[27]. In India, the power potential from saline gradient 54.8GW, out of which 72.8% is pertaining to rivers discharging in Bay of Bengal and the rest to Arabian Sea (Das and Ramaraju, 1986). According to MNRE estimates, the total OTEC potential installed capacity in India is 180GW.

The total potential for wave energy in India assessed by MNRE is around 40 GW along the 6,000 km long India's coastline. India's western coastline has higher potential as compared to the eastern coastline due to the presence of strong waves during the south-west monsoon and due to presence of strong wind and effect of refraction, the maximum power is attained at the southern tip on the peninsular- *Kanyakumari* and *koondakulam*. In addition, a pilot project on wave energy of 150 kilowatt capacity has been set up in Thiruvananthapuram in Kerala. In the same area, an ocean current power plant is also in operation. A lot of experiments in that project are being carried out by the National Institute of Ocean Technology, Chennai. India is also a pioneer in ocean energy research. On an average, 200 patents are filed every year in the area of ocean technology mostly in the fields of tidal and wave energy.

9. Technology-Driven Emerging Sectors

Certain sectors of blue economy are highly technology-driven including deep-sea mining, marine biotechnology, deep-sea fishing, cruise industry, marine pharmaceuticals and marine instrumentation. The performance of those sectors depends on continuous R&D and catching up with the market expectations in terms of advanced technological applications. Despite considerable progress in scientific understanding of the technologies required for those sectors, there is serious lack of implementation of such technologies into various products

[25] www.inwea.org

[26] Energy Statistics 2015, MOSPI

[27] http://www.ireda.gov.in/writereaddata/AFD_Final%20Report_Study_on_Tidal_and_Waves_Energy.pdf

Deep-Sea Exploration: Technology-Driven Marine Manufacturing

and processes. In the context of blue economy, it is therefore imperative to examine the pace of technology acquisition and application with respect to blue economy sectors in the costal nations with particular reference to the Indian Ocean region.

9.1 Offshore & Deep-Sea Oceanic Resources

Exploration of seabed minerals is viewed as an emerging sector of blue economy in the Indian Ocean region. Despite significant advancement in mining technology, commercial deep-sea mining has not picked up so strongly in any part of the world. It is believed that the current advancement in exploration technology for offshore and deep-sea minerals could make it a reality soon. Among the seabed resources, the most precious metals are cobalt, nickel, manganese, iron, copper, lead, zinc, gold, silver, titanium, thorium and other rare earth metals. The current low-scale of commercial seabed mining could be primarily attributed to three factors. Firstly, the stock of metals and minerals available on land is not completely exhausted. Although the knowledge of sophisticated mining technology is known to the investors, high risks involved in deep-sea mining discourage them as long as land-based resources meet the demand. Secondly, the countries need to get licence from the International Seabed Authority (ISA) for exploration rights. Thirdly, the size of investments is relatively large for these kinds of ventures as uncertainty level is usually high. There are also less numbers of ISA contractors who can be engaged in deep-sea explorations. The number of

Rare Earth Metals on Seabed: Still Unexplored

contractors with ISA has increased in the last five years. In addition, the economic viability of deep-sea mining is also questionable given the current pace of technology development and investment trends.

In addition to the economic incentives, the business of seabed mining requires consistent and transparent legal framework. The UN Convention on the Law of the Sea that entered into force in 1994 by 166 countries provides an elaborate legal framework for the rights and obligations of member countries with respect to access, use and reclamation of ocean space and marine resources in territorial waters and high seas. The Convention defines the ocean space under the jurisdiction of a sovereign nation that could be classified into territorial sea, contiguous zone, exclusive economic zone (EEZ), continental shelf and the high seas. Of those, EEZ is highly relevant for the purposes of exploring and exploiting ocean resources. Similarly, the area covered under continental shelf is crucial for seabed explorations. The Convention delineates the intricacies of defining outer limits and the enabling provisions for its approval by the ISA. The important part of the Convention is that the sovereign right over resources of the continental shelf are the inherent and exclusive rights of the state. No other state can exploit those resources thereby minimising inter-country conflicts. Beyond continental shelf are the high seas or the international area of the sea. This part of the oceans is the common heritage of the mankind. From the property rights perspective, high seas could be considered as a common property for the present as well as the future generations. In this part of the seas,

resources are common for all but that does not necessarily imply complete freedom of use by the nations in and around the oceans. A number of conventions on sea and ocean resources encourage the nations to adhere to and promote the sustainable use of marine resources both for industrial and non-industrial uses. For a successful blue economy, spatial clarity over the oceanic zones and the limits to be exercised by a country in expressing sovereign rights over the ocean resources as envisaged in different conventions is vital if not a pre-condition itself.

Indian Ocean is endowed with oil & gas, hydrocarbons, rare earth metals and other minerals. In particular, the Central and South Western parts of the Indian Ocean are rich in copper, lead, zinc and other minerals. In the blue economy paradigm, there could be more emphasis on harnessing this unexploited rich endowment of precious seabed resources. Since the experience on deep-sea mining is scant and its economic viability is doubtful, the Indian Ocean rim countries may end up in undertaking selective experimentations. Investment into deep-sea mining is growing in the recent years. Looking back, the procedure for commercial investments followed a gradual step with the provision for preparatory investments as laid out in the UN Convention. Before 1st January 1983, the requirement was that the states or the entities sponsored by a state must have expended US$ 3 million in the exploration of polymetallic nodules out of which US$ 10 million should have been expended for survey, location and sampling. India, Japan, France and the former Soviet Union were the four state entities which were recognised as pioneer investors. There were four other corporate entities but none of those were party to the convention. After the Convention came into force in 1994, the scheme of pioneer investors were dropped. All the countries are considered to be the contractors with the ISA.

In terms of its mandate, the ISA has developed regulations for prospecting and exploration of polymetallic nodules, polymetallic sulphides and cobalt-rich ferromanganese crusts. For polymetallic nodules, India, Japan, Korea, France, Russia and China were the pioneer investors with those the ISA enter into contracts after the UN Convention came into effect. Besides transparent regulations, technology development is key to deep-sea mining in the Indian Ocean region. Technology development may be required at different stages which involves resource estimation and mine site identification, mining technology, processing technology and environmental impact assessment. The technologies prevalent for commercial mining of the ocean floor are: (1) the continuous line bucket system and (2) the hydraulic suction system. Although the command over technology development for deep-sea mining is more sophisticated in some countries, India is at par with France, Japan, China, Korea and others in mining and processing technology. India has officially recognized deep-sea mining as a future frontier that was outlined in a policy paper by the National Security Council in 2012. Indian mining capability and efforts got a fillip when it acquired the deep-sea exploration ship *Samudra Ratnakar* from South Korea.

As per an estimate, the total mass of nodules in the area allocated to India in the Indian Ocean region is approximately 380 million metric tonnes. The vessel *Samudra Ratnakar* alone would not be sufficient to extract minerals. It would require specialist onboard equipment operators to reach the minerals at the bottom of the sea. In this regard, India is considering a proposal of cooperation with Japan under the larger ambit of the strategic dialogue framework as well as acquisition of more deep-sea exploration vessels. As part of the Indo-Japanese strategic collaboration signed in 2014 the Ministry of Earth Sciences, India and the Japanese Agency for marine Earth Science and Technology have reached an understanding for joint collaborative work in the field of ocean earth sciences,

9.2 Deep-Sea Fishing

Fishing is a major sector for most blue economies of the world. It provides essential food and nutrients that humans need for leading a healthy life. Fishing within the EEZs is the right of the costal nations. However, there are increasing cases of fishing in the high/deep seas in most fishing areas of the world including the Indian Ocean. High profits attract commercial fishers to explore deep-sea fishing which often to illegal, unregulated and unreported fishing. Besides these issues, deep-sea fishing requires access to certain fishing technologies

Commercial Fishing in High Seas: Good or Bad

Illegal Fishing in High Seas: Threat to Blue Economy

particularly fishing gear, seine, vessel quality, and processing. While native fishing communities rely on artisanal subsistence fishing in most of the coastal nations, foreign commercial fishing firms mostly from the EU, Japan and the United States invest heavily in vessel technology and monitoring, control and surveillance mechanisms. Given these challenges, countries are concerned about the competition in the high seas for large-scale fishing. Since no such international binding convention address the issues of deep-sea fishing, the evolution of regional fishery management institutions is considered as a healthy trend.

Whether to promote deep-sea fishing or not, it remains unresolved till some global legal and regulatory regime develop a framework for exploitation and regulation of these fishery resources. As blue economy propagates optimum use of resources, the unreported cases of fish catch in high seas is a loss to the coastal countries. In order to maximise gains from deep-sea fishing, the Indian Ocean countries should formulate suitable incentives for not resorting to race to the bottom competition and encourage mutually reinforcing fishing obligations in deep seas at least in conformity with the UN Convention on the Law of the Sea.

9.3 Emerging Cruise Sector

Cruise sector has witnessed tremendous diversification in the recent years in many port cities of the world. International cruise, in particular, is a growing segment in the cruise industry. Global passenger cruise industry continued to expand steadily even during the recession period 2007-09. In addition, there is enormous potential in the roll-on roll-off (RORO) sector. Modern cruise products is quite diversified now with intelligent

packaging of vacation desires, on-board amenities, shore side activities, food and other comfort segments. In addition, the passenger cruise industry is undergoing a structural transformation as the cruise companies are investing in new vessel designs and trip planning corresponding to the various demographic targets and vacation patterns (Pallis, 2015). This industry has better prospects in the future as coastal tourism will have spillover effects on cruise business. With acceleration in cruise business, the port-cities would benefit from expansion of activities in terms of more employment in cruise companies, food and logistics supply, supporting land-based transport, and so on. Further, a host of other activities may increase along the cruise chain. Luxury cruise may be more profitable as the tourist arrivals from the advanced countries to attractive destinations in different parts of the world increase. As mentioned above, a systematic packaging of tour length, comfort preferences, on-board facilities, food preferences and related facilities would help the cruise industry to deepen in the future. RORO is an emerging segment in the ports sector having bearings for the shipping and cruise industry in general. Indian Ocean region covers a vast ocean space surrounded by a large number of countries, cultures and civilizational diversity. The IORA countries should examine the areas of regional cooperation for promoting this industry in the region.

9.4 Marine Biotechnology

Of the few emerging sectors, marine biotechnology is one of the promising sectors of blue economy. As per an estimate, the global market for marine biotechnology products and processes is

Marine Bioprospecting: Source of New Drug Development

Sponges: Source of Bioactive Substances

estimated at EUR 2.8 billion in 2010 with cumulative annual growth rate of 4 to 5 per cent. The oceans are home to numerous living organisms which have potential for developing new drugs, producing diagnostic devices for monitoring health and providing new techniques to monitor, assess, restore, protect and manage marine ecosystems. Marine organisms grow in a much better environment for biosynthesis compared to terrestrial organisms. The future prospects of marine biotechnology industry depend on the search for new and improved products. Bioprospecting and bioscreening can be used for identifying organisms for this purpose. Microorganisms, plants or animals may be cultured for production of bioactive molecules and substances. In a broader sense, marine biotechnology addresses key societal challenges in five different sectors including food, energy, health, environment, and industrial products and processes. By improving and optimising culture conditions for microorganisms higher number of bioactive molecules can be developed. Besides new drug discovery, metabolites produced by marine bacteria and invertebrates have facilitated formulation of several pharmaceutical products. These include anti-inflammatory agents such as pseudopterosins, topsentins, scytonemin, manoalide, anti-cancer agents such as bryostatins, discodermolide, eleutherobin and sarcodictyin, and antibiotics such as marinone.[28]

Revolution in marine biotechnology has led to introduction of new species and better understanding of the molecular and physiological basis for reproduction.[29] The circulating cells of horsecrab, a living

[28] Marine Board (2001).

[29] Marine Board-ESF (2010).

fossil, could be useful in detecting early infection in human as well as traces of pyrogens in biotechnological products. Horsecrab also contains certain molecules, lectins, are important for defence reactions. Microorganisms are used for developing a good number of sophisticated medical devices, biosensors, diagnostic devices for medicine and environmental monitoring. The ability to decode genome properties is a great innovation in modern bioscience. Marine biotechnology has a variety of applications in aquaculture. In view of overfishing, rational enhancement of fish populations by stocking and mariculture may alleviate constraints in fish production. Certain breeding and hatchery production of alevins can also be tried. Populations of some fish species such as salmon, sea trout, turbot, mussels, etc have been enhanced successfully in the past. Polyculture, specie diversification, optimal feeds and feeding, prevention of diseases etc can also help arrest the decaying of species due to overfishing and restore the degraded biological stock of many species.

As mentioned above, it has got much wider applications in energy production, industrial products and processes, medicine and environmental health. Biofuels can be produced from microalgae. Similarly, protein and enzymes derived from marine organisms are of great use to food and pharmaceutical industries. Biopolymers is a useful product with a range of uses such as biodegradable plastics to food additives, pharmaceutical and medical polymers, wound dressing, bio-adhesives, dental biomaterials, tissue regeneration and 3D tissue culture scaffolds. Although the uses and applications of marine biotechnology are manifold, the current pace of exploitation of these resources is believed to be very low. Over the period 1967-1999, more than ten thousand compounds were isolated. One of the reasons for this sluggish pace is the non-availability of specimens. Due to the complex structure of the molecules, the weight of active compound in those molecules is less. For clinical trials and marketing of drugs several kilograms of those compounds are required. Further, in the process of purification the compound may get transformed as inactive.

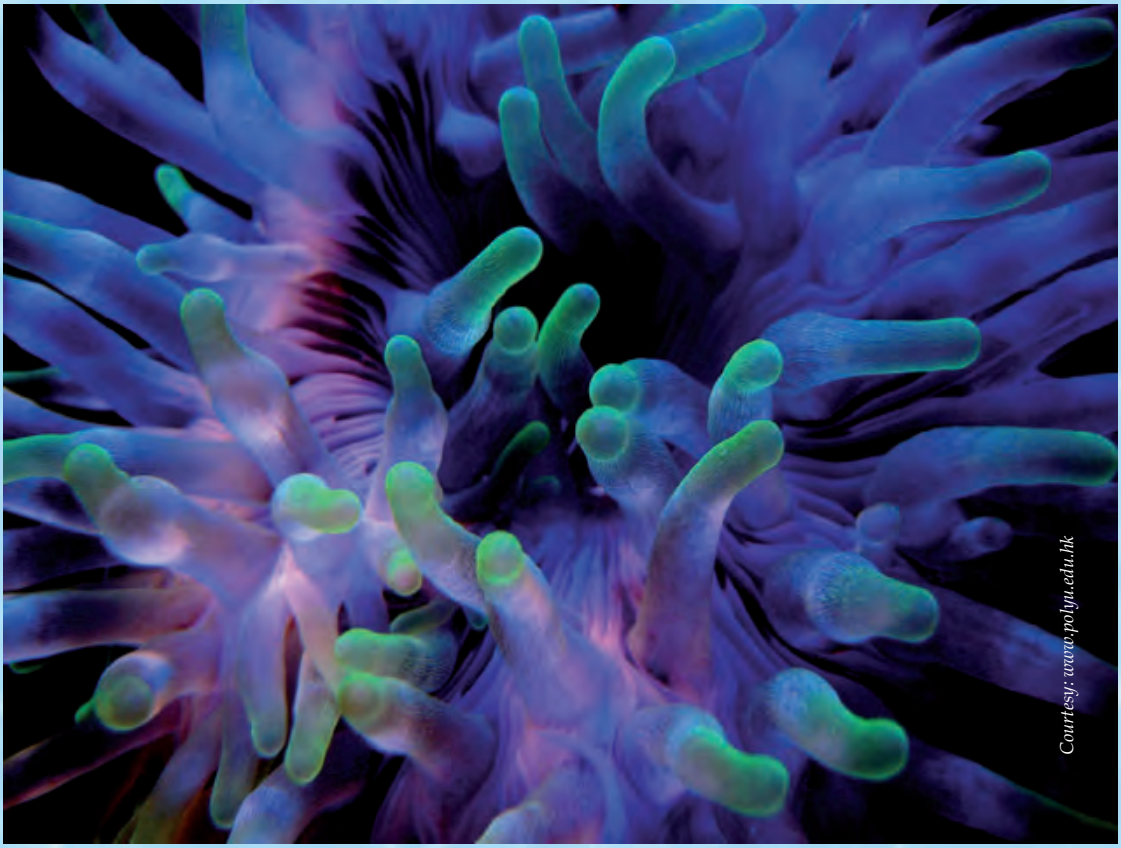
Irrespective of all these difficulties, the progress on various frontiers of marine biotechnology is really commendable. In Europe, a long-term strategic vision has been visualized.[30] In India, the National Institute of Oceanography and other institutions are working for the scientific exploitation of marine organisms and development of marine biotechnology sector. However, the marine biotechnology sector in general faces a number of challenges in the form of problems in getting secure access to marine resources, absence of solid intellectual property regime, availability of quality marine resources, lack of suitable technology with respect to screening of active compounds and de-replication, preventing repeated

[30] See Marine Board-ESF (2010) for details on the objectives, framework and plans and programmes of the vision statement.

rediscovery and structural costs of drug discovery from natural products.

9.5 Marine Derived Pharmaceuticals

Pharmaceutical products using marine resources have established their strong market base in the world economy and it is expected to grow exponentially in the future. The availability of large marine-based resources provides the basis for potential industrial development where several industries ranging from cosmetics to pharmaceuticals are expected to come up in future. The marine bio-products are instrumental in producing several hundreds of compounds which are supporting drug development in different part of the world including the IORA states. The marine environment is conducive for providing platform to both biological and chemical diversity. As the marine environment is a source of chemical compounds, it has potential to spur industrial development in divergent sectors including those of pharmaceuticals, cosmetics, nutritional supplements, molecular probes, enzymes, fine chemicals, agrichemicals, etc. among others. The market has witnessed considerable level of drug developments so far, but a few species are used for this purpose including those of sponge, microalgae, jellyfish, red algae, seaweeds etc. which are common dietary constituents. These drugs have application in a wide range of diseases



Novel Anti-Cancer Agents

from cancer to AIDS. These drugs are having proven record of curing several such critical diseases.

These bio-products are mostly available in shallow water. Therefore, it is rather convenient to have access to these bio-products in a sustainable manner. On the contrary, the possibility of bio-products sourced from deep water has been very low, and hence, no need for using high-tech exploration technology to obtain such bio-resources from the high sea. Though nature has provided limited habitat space for the pharmacy-related marine species to dwell in the shallow water but not in the deep sea, still they are not fully exploited.

Potential of these marine derived pharmaceutical products in terms of market value has been running into multi-billion dollars through patents (BioScience, 1996). Many of those products are available in the market and several of them are at the trial stage. However, the marine derived pharmaceutical products have large market potential to grow along with food and additives, but the challenges that the industry is facing have been enormous which are like to compound in the coming years with the proliferation of 21st century high quality FTAs in the world economy.

Marine biotechnology plays a vital role in development of new products in pharmaceutical industry (Saravanan and Debnath, 2013). Marine derived pharmaceuticals are the resultant of biotechnological application to marine sources which then could be used for curing life-threatening illnesses and potential health benefits like including antioxidant, anticancer, antiviral, anticoagulant, antidiabetic, anti-allergy, anti-inflammatory, antihypertensive, antibacterial, and radio protective activities. They are high-value ingredients as they are the have a unique metabolic abilities (Martins, et al, 2014). *Tethya crypta* (marine sponge) was among the first marine organism which was commercialized for the producing drugs against HIV and Herpes. According to an estimate, around 10-15% of the marine natural products are under clinical trials in the areas of cancer and other diseases (Gopal et al, 2008). There are various forms in which these compounds are used like pills, tablets, syrups, medicated oils, fermented liquids, powders, decoctions etc.

Marine Patents

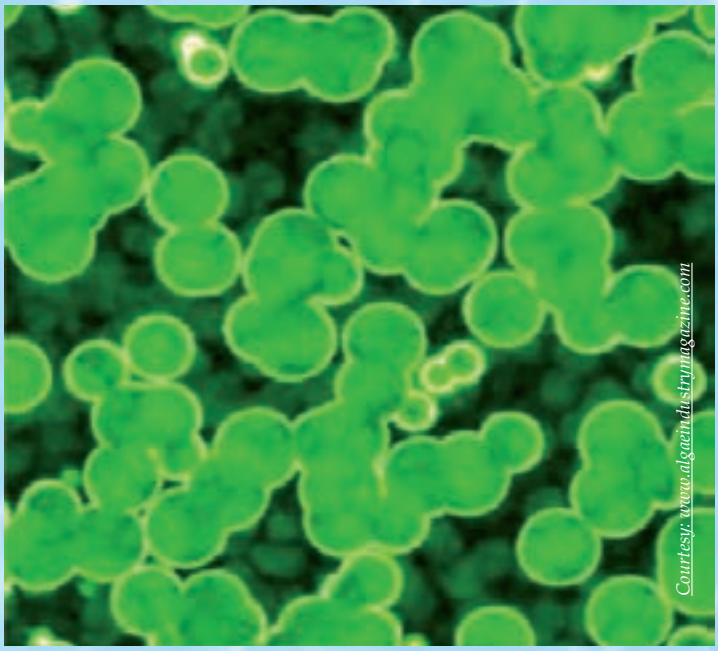
The basis for applications of marine biotechnology in pharmaceuticals is the knowledge of genetics and developments in genetics and genetic engineering. Thus pharmacology and human needs constitutes 55 per cent of the applications of gene of marine organisms patented (Saravanan and Debnath, 2013). As per the Indian Patent Office, seaweeds and snails are the most valuable products from the sea. Corals, sponges and blue green algae are gaining potential research targets. According to Table 9, it is observed that out of the total 677 international claims between 1991 and 2009 of marine gene patents, 90 per cent of the total are constituted by the listed 10 countries, where the top three countries: USA, Germany and Japan holds 70 per cent share. India comes at 11th place in the list with total number of marine organism patent claims of eight. Patent claims for

Table 9: Top 10 International Claims of Marine Gene patents During 1991-2009	
Country	**Marine Organism Patent Claims**
USA	199
Germany	149
Japan	128
France	34
United Kingdom	33
Denmark	24
Belgium	17
Netherland	13
Switzerland	11
Norway	9

Source: *Saravanan and Debnath (2013).*

marine organism is highest in India as compared with 3 in Rice (oryza) and 1 in Maize (zea) out of the total of 12 (Arnaud-Haond, Arrieta and Duarte, 2011).

Generally, pharmacognosy is regarded with terrestrial environment.



Microalgae: Sustainable Source of Drug Development

However, marine pharmacology can be dated back to the 1950s where drugs like Ara-C (an anti-cancer drug) and Ara-A (an antiviral drug) were developed and are still in use (Murti and Agrawal, 2010). Many studies have shown that sponges and marine animals to be the largest source of pharmaceutical products. Among other marine organisms, fungi has become a vital and rich source for medical and pharmaceuticals benefits.

Table 10 lists down various drugs available from ocean with their therapeutic categories. The drugs range from antibacterial to antimalarial and further to bone grafting category. Antiviral agents like Didemnin B is characterised as useful for antitumor activities. Other drugs like Avarone and Avarol have potential to cross the blood-brain barrier. Various marine derived pharmaceuticals ingredients like secondary metabolites, bioactive peptides, sulfated polysaccharides, sterols are beneficial in various health-related activities as they have properties like reducing cholesterol, antioxidant, antidiabetic, radio-protective, anti-Alzheimer's disease and various others (Kim, 2012).

Research areas

Ocean resources as major frontier of medical research has been accepted by pharmaceutical industries worldwide (Thakur, Thakur and Muller, 2005). The leading position for drug development from sea is taken up by PharmaMAR in Spain and USA, whereas AquaPharma Biodiversity Ltd. in United Kingdom is working in discovery of novel pharmaceuticals products from the ocean (Saravanan and Debnath, 2013). Nereus

Table 10: Different Drugs with their Therapeutic Categories		
S. No.	**Therapeutic Category**	**Drugs**
1	Analgesic	PrialtTM
2	Anticancer	Squalimine, KRN 7000, Eleutherobin E7389,
		Discodermolide, Dictyostatin 1, Apratoxin
		Bryostatins 1 And 2, Isodolastatin H
		Salinosporamide A, Dolastatin H, Niphatesine D
		Auripyrone A and B, Clavepictine A and B
		Amphidinolides G and H, Lejimalides A-D
		Sporiolides A and B, Spongiostatin 4,
		Cephalostatin 1, Sorbicillactone A and B
3	Anti-inflammatory	Topsentin, Sesterterpene, palaulol
		Sesquiterpene furan, Tsitsixenicin A
		5α-pregna-1,20-dien-3-one, Tsitsixenicin B
4	Antimalarial	Manzamine A, Axisonitrile 3, Kalihinol A
5	Antimicrobial	Cephalosporins, Istamycin, Speradine A
		Modiolides A and B, Seragakinone A
		2S-acetamido-3s-acetoxy- 5E
6	Antiviral	Ara A, Didemnin B Rietone, Avarol and Avarone
7	Antiparasitic	α-Kainic acid
8	Bone grafting	Orthopedic implants
9	Molecular probe	Okadaic acid
10	Enzyme	Polyketide synthase
11	Ca^{2+}-ATPase and histone	Speradine A
	deacetylase ihibitor	

***Source**: Murti and Agrawal (2010)*

Pharmaceutical in USA is recognised with a strong R&D program in this field. While in India, institutions like National Institute of Oceanography (NIO) in Goa, Bose Institute in Kolkata, Regional Research Laboratory (RRL) in Bhubaneswar, Central Drug Research Institute (CDRI) in Lucknow and Central Institute of Fisheries Education (CIFE) in Mumbai have been engaged in investigation of the lifesaving drugs from oceans and examining their importance and further ways of tapping these products. Growth in Indian marine biotechnology industry is indicated with increasing patenting trends (Saravanan and Debnath, 2013).

Challenges in development of Marine-derived Pharmaceuticals

Martins et al (2014) analyse the hindrances in development and discovery of marine bio-actives and group them into three categories. First is the accessibility of the ocean and its components. Taxonomy of different marine species is still

unidentified. Collecting samples for research by scuba diving is not feasible for water depth of more than 30m; moreover, it often ruins the sample and the ecosystem. It is estimated that around 30-35 per cent of marine habitats have been destroyed due to anthropogenic and pharmaceuticals interventions (Saravanan and Debnath, 2013). For collecting samples, higher and sophisticated machines, such as manned submersibles, are used which provide the knowledge of the habitat a particular marine organism is living in. However, these equipments are quite expensive and very few research laboratories have access to them. In addition, conventions like Nagoya Protocol provides an unclear framework on the extent of access to biodiversity different regions have.

The next issue in development of marine derived pharmaceuticals is the issue of sustainability of the specie. The variability in environmental conditions makes it difficult to get the same sample again with the same properties. The treat to marine ecosystem is observable as there is an average increase in sea surface by 0.4 degree centigrade since the 1950s (Saravanan and Debnath, 2013). Although techniques like mariculture and aquaculture have been used to artificially maintain the same environment, yet the issue of uniqueness of the specie remains intact. Knowledge of taxonomy of marine products is important for marketing, but the nature and quantity of products required in the market is more important. The awareness of technology used in the process of extracting the resources from the ocean and its cost with respect to processing and technology development is a major concern for the industries.

10. Country Experiences on Performance of Blue Economy

In addition to the global understanding of various aspects of blue economy, it would be useful to understand the country dynamics with regard to the performance of blue economy. Since the concept and measurement of blue economy differs from country to country, the justification for studying country experiences makes more sense for policy making. The performances of a few blue economies are presented below.

10.1 Australia

Australia is one of those countries that consider the importance of blue economy for addressing the major development gaps such as poverty, food security, sustainable livelihoods and conservation. For Australia, in blue economy ocean ecosystems can bring social and economic benefits that are efficient, equitable and sustainable.[31] Over the past few years, the Government of Australia has implemented several initiatives that delineate comprehensive measures towards maximising the use of ocean resources by promoting scientific, technological and other innovations, and establishing necessary mechanisms for regional cooperation among the neighbouring countries. In the United Nations Conference on Sustainable

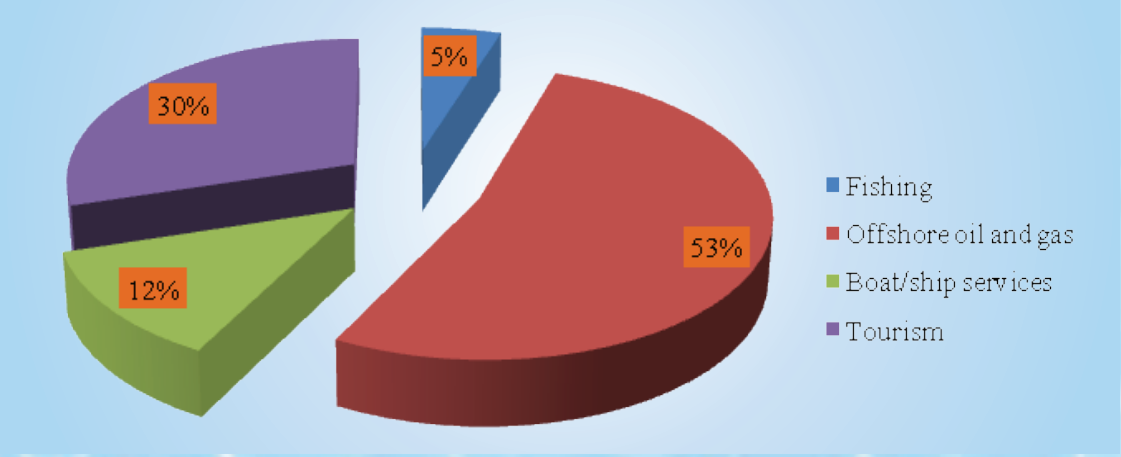
[31] Govt. of Australia (www.environment.gov.au/rio) accessed on October 12, 2015.

Development held in June 2012 in Rio de Janerio, Brazil (called as Rio+20), Australia came up with a clear vision to create a blue economy with ambitious goals. However, this is not the first time for the Government to announce its intentions towards blue economy in the country. Substantial efforts were devoted in the 2000s for promoting marine science in the country which ultimately culminated in the form of a strategic National Framework for Marine Research and Innovation in 2009.[32] In addition, a number of studies have been conducted to assess and examine the progress made since 2009 in different critical areas of marine science, research, and innovation that are expected to raise competitiveness of the marine industries and contribute to the success of blue economy in Australia.

Profile of Blue Economy

Australia has the third largest marine jurisdiction of 13.86 million square km, much larger than its land territory. Blue economy covering wild fisheries, aquaculture, offshore oil and gas, shipping, tourism, marine biotechnology and other contributes significantly to the Australian economy. In 2011-12, the size of Australian economy was estimated at $47 billion which is believed to have doubled since 2002-03. It is projected to grow reach $100 billion by 2025 driven by opportunities in renewable energy, offshore oil and gas, and aquaculture. Australia's blue economy is dominated by two sectors, namely offshore oil & gas and tourism. Offshore oil and gas industry grew account for more than 50 per cent of the total output of blue economy in Australia. Tourism and shipping services constitutes the rest 40 per cent of blue economy in the country (Fig.1). During 2004-07, blue economy sectors as a whole attained double-digit growth reflected in substantial increase in sectoral output from $29 billion in 2004-05 to $41 billion in 2007-08. This dynamism

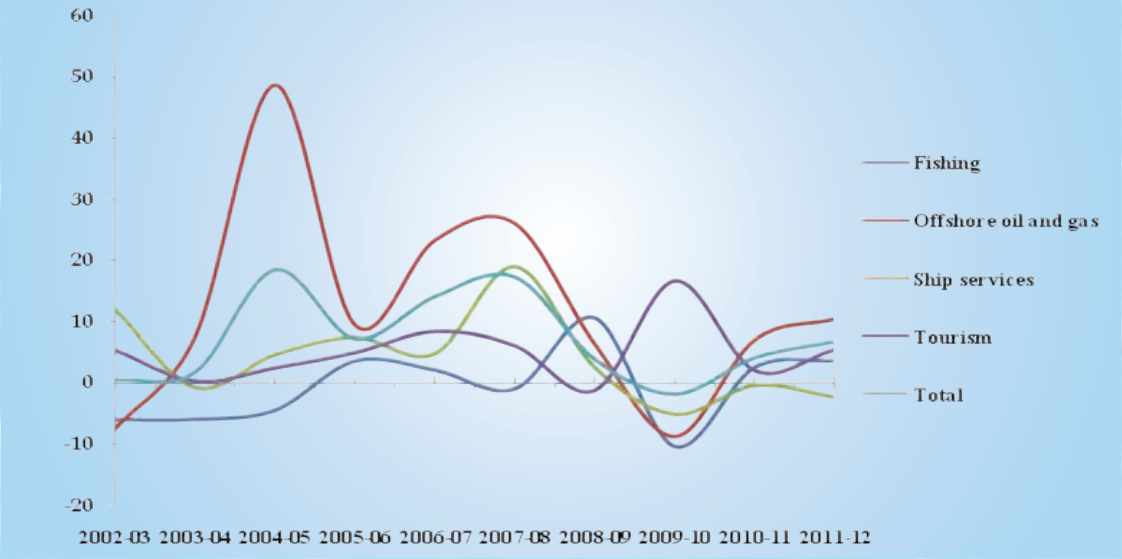
Fig 1. Size of Blue Economy in Australia, 2011-12



***Source**: Based on data from Govt. of Australia-AIMS (2014).*

[32] Govt. of Australia (2013).

Fig 2. Performance of Blue Economy Sectors in Australia (Growth, %)



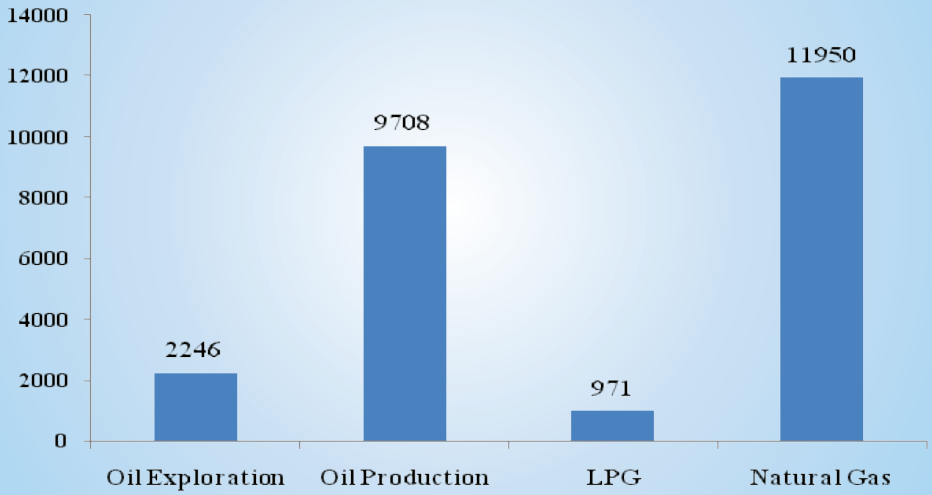
***Source**: Based on data from Govt. of Australia-AIMS (2014).*

in blue economy was the outcome of the extraordinarily high growth in the offshore oil & gas industries followed by boat & ship services and tourism (Fig. 2). Surprisingly, fishing sector grew by an unusually high rate in 2008-09 whereas other leading sectors of the blue economy registered sharp cut in activities.

In terms of composition of output, blue economy in Australia has undergone a structural change in the 2000s. The contribution of fishing continued to decline over time and has become stagnant even though steady growth in mariculture is observed. Likewise, the output of tourism and ship services witnessed regular contraction in the past decade. On the other hand, the share of offshore oil and gas industries in blue economy has gone up remarkably from 33.4 per cent in 2002-03 to roughly 53 per cent in 2011-12.

All the four sub-sectors of offshore oil and gas industry show tremendous potential for growth in blue economy in Australia. Despite cyclical fluctuations, these sectors expanded considerably over the past decade. Natural gas is the biggest contributor in this sector followed by oil production and oil exploration. Half of the total output in offshore oil & gas comes from natural gas (Fig. 3). Moreover, the potential of the offshore oil & gas sector is not fully exploited. Certain developments in terms of identification of new fields and exploration facilities indicate unleashing of vast reserve of oil and gas resources in the near future. Expansion of hydrocarbon extraction facilities offshore North-Western Australia and gas processing facilities in both North-western Australia and the coast of central Queensland are some potential sources of fresh production. Besides these economic

Fig 3. Offshore Oil & Gas Sector in Australia, 2011-12 (A$ Million)



***Source**: Based on data from Govt. of Australia-AIMS (2014).*

sectors the potential of ecosystem services including climate regulation, nutrient cycling, etc in Australia is enormous. Since most of those services are not easily quantifiable, it is believed that the contribution of ecosystem services could be up to $25 billion. This massive potential in ecosystem services, if harnessed, could trigger sustained growth in Australian blue economy.

Further, the dynamism in blue economy in Australia is rooted in host of other sources. Booming resource sectors invites higher investments in sea transport and bulk commodity ports. Ports and shipping channels are being developed in close proximity to the Great Barrier Reef which would facilitate increasing seaborne trade. The gap between fish production and consumption is widening day-by-day. It signals win-win situation for the domestic fish farms and the exporting countries in the region. More than the supply gaps, there is a greater demand for safe and high-quality processed food in the country. The strong growth in local and global demand for premium seafood especially from Asia, suitable on-shore and off-shore marine aquaculture production sites, advances in environmental engineering, aquaculture breeding etc would fuel the growth in the seafood industry. In general, fishery is Australia is mostly of high-value species that are primarily for export purposes. In addition, the scope of recreational and indigenous customary fishing has increased substantially in the recent years.

Policy and Programmes

The intentions and policy priorities of the Australian government with respect to blue economy are clear and futuristic. The basic premise of the marine policy is to identify the untapped marine resources, addressing data gaps and measurement difficulties, investing in marine research

facilities for capacity building and knowledge creation, and integrating the unexplored avenues for maximising activities in blue economy. As mentioned above, the National Framework for Marine Research and Innovation highlights the critical areas of marine science that offer opportunities for experimentation and investments. The Framework envisages schemes for improving the quality of marine science research; creations of marine infrastructure in terms of observe technologies, observe vessels, etc; reorganisation of existing institutions for marine research for better coordination and effective execution. In order to build a strong blue economy, the National Marine Science Plan 2015-2025 identifies a number of policy initiatives for future investments which include (1) National Blue Economy Innovation Fund, (2) National Marine Research Infrastructure, (3) National Marine Baselines and Monitoring Program, (4) National Integrated Marine Experimental Facility, (5) National Ocean Modelling Program, and (6) Marine Science Capability Development Fund.[33]

Three other major initiatives for blue economy are marine biological plans, the Coral Triangle Initiative and Arafura and Timor Seas Ecosystem Action. Under marine biological plans, efforts are made towards conservation of biodiversity and sustainable use of oceans by industry. A number of marine protected areas are meant to restore the biological stock of fish species and maintain ecological balance. The Coral Triangle Initiative is a partnership between Indonesia, Malaysia, Papua New Guinea, the Philippines, Solomon Islands, and Timor Leste. Australia is one of the development partners along with the United States, Asian Development Bank, WWF, the Nature Conservancy and Conservation International. This initiative aims at enhancing food security and sustainable livelihoods through conservation of marine biodiversity. Australia has allocated $3.5 billion to support this initiative. The Arafura and Timor Seas Ecosystem Action focuses on developing a framework for integrated, sustainable and ecosystem-based management and use of the living coastal and marine resources of the Arafura and Timor seas.

10.2 Mauritius

Mauritius is one of those leading SIDSs whose efforts towards promoting blue economy is resonated loudly among the coastal economies. The major goals of blue economy and the policy initiatives that are to be undertaken in the medium- and long-term are clearly spelled out in a document on ocean economy released by the Government of Mauritius in 2013. In addition, Mauritius has actively pushed its interests in blue economy in the IORA regional policy forums. At national level, the Ministry of Ocean Economy, Marine Resources, Fisheries, Shipping and Outer Island has identified a number of potential areas for investment in blue economy along with necessary fiscal, regulatory and legal frameworks. The maritime zone of Mauritius spreads over

[33] Govt. of Australia, National Marine Science Plan 2015-2025.

2.3 million square km with exclusive economic zone of 1.96 million square km and continental shelf of 396,000 square km. Based on data and facts; it is observed that blue economy is the backbone of the economy of Mauritius. The contribution of fisheries, tourism, ocean minerals and marine services to GDP is substantial and registered impressive growth in the recent years. With effective implementation of the Ocean economy policies and the SIDS policies for sustainable development, Mauritius may unleash significant potential for growth, expansion and social progress.

Profile of Blue Economy

The output of blue economy was estimated at MUR 32.5 billion in 2012 which account for 10.8 per cent of gross domestic product. Three sectors i.e. coastal tourism and marine leisure, seaport-related activities, and seafood-related activities constitute about 90 per cent of blue economy in Mauritius. In terms of sectoral share, coastal hotels and marine leisure is the largest sector explaining 60.1 per cent of blue economy output followed by seaport-related activities (18 per cent), fisheries & seafood processing (13.2 per cent) and others (8.7 per cent). Forecasts suggest enormous potential for growth in most of these blue economy sectors. The vast reserve of hydrocarbon would provide stimulus to the future growth blue economy in Mauritius. New discovery of hydrocarbons and mineral deposits would attract substantial investment in the coming years. The granitic nature of the Seychelles Islands and the discovery of a thick sedimentary sequence in the Seychelles plateau have attracted oil companies in the region to prospect and invest in the region. With regard to fisheries, new sites have been identified for fisheries and aquaculture. Fisheries sector witnessed significant expansion with doubling of export volume over the period 2005-12 and remarkable increase in the canning capacity. The Recycling of tuna by-products into production of fishmeal and fish oil is a growing industry. It would help create additional employment and livelihood for the fishing-dependent communities in the country. Fishing in Mauritius covers island-based artisanal fisheries, fish aggregating devices, offshore demersal of fishery of the banks of the Mascarene Plateau and the Chagos Archipelago and the tuna fishery in the Western Indian Ocean. New fishing vessels can be employed for harvesting of healthy tuna stock in the South West Indian Ocean. Transhipment activities at the ports such as cutting, filleting, loining and packaging are likely to increase in the near future. Emphasis is also on in-lagoon aquaculture and farming of high-value and niche products such as seaweed, oyster, oyster pearl, crabs, sea-urchins and other shellfish.[34]

Deep Ocean Water Application (DOWA) projects will provide sea water air conditioning to industrial and commercial users, reduce the dependence on fossil fuels, and create downstream business activities for high-end aquaculture,

[34] http://www.investmauritius.com/investment-opportunities/ocean-economy.aspx.

seaweed and algal culture, cosmetics and pharmaceuticals, agrochemicals, water bottling, thalassotherapy and others. Among the merging sectors, marine biotechnology offers better growth prospects. Mapping and stock-taking of seabed would develop better understanding for living organisms and hydrocarbon & mineral resources. A rich stock of living organisms within the EEZs may contribute to development of new compounds and formulations. Among the seaport-related activities, business opportunities exist in container transhipment, cruise travelling, port services and bunkering. Further, Mauritius can also benefits from the emergence of a plethora of dynamic port-related industries including seafood hub, cruise tourism, freeport, logistics and transhipment.

Services sectors are key pillars of blue economy in Mauritius. Marine ICT presents a variety of services which are not yet explored. The applications of ICT in marine sector may include ecosystem and wave modelling tools, fish habitat monitoring, sustainable fishing resources management systems, and trade and maritime transport-related data. Tourism is a dominant sector of blue economy with great potential for occupational diversification in the future. With higher tourist arrivals, the coastal hotels and restaurants will grow in and around the coastal town and tourist infrastructure. A host of activities relating to leisure tourism including sea angling, boating, excursions, scuba diving, towing, kite surfing and kayaking will flourish with the higher investments and creative designs. In shipping, there are opportunities in ship registration, ship leasing, ship insurance, ship management and ship repairs Although marine banking and financial services at present is less significant in its contribution to blue economy, the potential for those services may widen as the policies for blue economy become effective.

Policy and Programmes

Mauritius has a grand vision for its blue economy spanning over the period up to 2025. A comprehensive Roadmap for ocean economy released in 2013 lists out several priority areas of policy action with ambitious targets. The short-term objectives of the Roadmap focus on developing a major hub in the region for petroleum products, container transhipment and port services; developing the country as seafood processing hub; and consolidation of tourism sector through diversification of tourism products, cruise tourism and sea sport. Along with the short-term objectives, the Roadmap mentions a few medium- and long-term objectives also. Medium-term objectives emphasize upon three aspects:- sustained production of renewable energy from oceans, capitalising on services sectors, and optimal utilisation of living organisms. The long-term objectives visualizes dramatic expansion of blue economy by 2015 with a clear focus on enhancing the sectoral contribution to 20 per cent, developing the country as a Centre of Excellence for Ocean knowledge, better understanding of living and non-living resources, and promoting ecologically clean and safe EEZ.

The policies and programmes for blue economy in Mauritius are centred on seven clusters. Those include seabed

exploration for hydrocarbon and minerals, fishing, seafood processing and aquaculture, deep ocean water applications, marine services, seaport-related activities, marine renewable energy and ocean knowledge.[35] For each of these clusters, a detailed scheme of policy execution has been envisioned. The scheme includes a regulatory and legal framework for sustainable development, international and regional cooperation, business development and promotion strategies, research and innovation, investment issues and incentives. In addition, an advisory council has been proposed for each cluster. A number of other institutions/mechanisms like Ocean Centre of Excellence, Ocean Business Park, National Public Private Taskforce, Skill Development Programme, and Ocean Economy Indicator with specific aims have also been proposed.

10.3 China

Profile of Blue Economy

China, the fastest growing economy in the world, is home to rich endowment of blue resources which could help sustain its high growth spell in the future. China has a vast coastline of 32, 000 km including continental shelves and exclusive economic zones. It has marine oil reserves of 24 billion tons and natural gas reserves of 1.6 billion cubic meters (Zhao et al, 2013). In 2010, Ocean economy in China constituting the ocean industries accounted for 4.03 per cent of GDP and employed 9.25 million individuals. In terms of gross value added, marine sectors such as coastal tourism, marine transport and communications and fishery are the top three contributors to blue economy in the country. The combined output of three sectors constitutes roughly 74 per cent of the size of blue economy. Among the rest sectors, the contribution of offshore oil and gas, shipbuilding, marine engineering building and marine chemical industries is substantial. Although coastal tourism almost two-third of the country ocean economy, marine fishery is the biggest employment generating sectors of blue economy in China (Table 11). Since China is a populous country, it is health sign that blue economy offers wage employment to a sizeable fraction of domestic workforce.

Besides fishery, the other marine industries that have strong potential for job creation include coastal tourism, marine communications & transportation and marine engineering building. As observed, all the sectors of blue economy have registered steady growth during 2001-10 with particular mention of the top three sectors which have grown at a relatively higher rate.

Policy and Programmes

As the demand for resources and energy is expected to grow due to rapid industrialisation and urbanisation, the Government of China emphasizes on marine resources and the oceans to supplement its land resources. Above

[35] See Govt. of Mauritius (2013) for the sectoral projections at three time horizons: baseline (2013), short-term (2015), medium-term (2020) and long-term (2025).

Table 11: Output and Employment in Chinese: Blue Economy Sectors (2010)		
Sectors	**Gross Value Added (US$ Billion)**	**Employment (10000 Persons)**
Coastal Tourism	78.3	124.4
Marine Communications and Transportation Industry	55.9	80.7
Marine Fishery	42.1	553.2
Offshore Oil and Gas Industry	19.2	19.7
Shipbuilding industry	17.9	32.7
Marine Engineering Building Industry	12.9	61.5
Marine Chemical Industry	9.1	25.6
Marine Biomedicine Industry	1.2	1.0
Marine Salt Industry	0.9	23.8
Ocean Mining Industry	0.7	1.6
Marine Electric Power Industry	0.6	1.1
Seawater Utilization Industry	0.1	-
Total	239.1	925.3

***Source**: Zhao et al (2013).*

all, there is a greater realization of the importance of oceans for economic growth and ecological sustainability. For the first time, the Chinese government launched the China Ocean Agenda 21 in 1996 with the objective to formulate a comprehensive strategy for sustainable development of marine resources, safeguard state's marine rights and interests, and protect marine ecosystems (Zhao et al, 2013). One can say that the adoption of this agenda was the beginning of blue economy in China. Likewise, the State Council published a document titled 'An Outline of the Planning of National Marine Economy Development' in 2003 setting some ambitious targets of gross value added fro ocean economy reaching 4 per cent of GDP by 2005 and 5 per cent of GDP by 2010. Interestingly, ocean economy expanded dramatically in the following years with remarkable improvement in the value of marine economy activities (Zhao et al, 2013; Zhao, 2013).

Another motivation for embracing blue economy in China is the ever-increasing cases of environmental pollution and destruction of ecological biodiversity. Environmental damage in the form of nutrient pollution; metal pollution; concentration of mercury, cadmium and petroleum compounds; overexploited fisheries; loss of biodiversity and other sources of pollution would not only reduce the resilience of marine ecosystems but also impair the future access to finite ocean resources. It is believed that environmental considerations along with economic priorities were the prime drivers for promoting blue economy in China (Conathan and Moore, 2015).

At policy level, blue economy assumed significance in the 12th five-year plan for national and social development, 2011-15 which for the first time devoted emphasis to the development of ocean economy. The major objective of the Plan was to optimise the structure of blue economy through the development of marine industries. As per the Plan, this can be achieved by (a) integrated marine management, (b) coordination between marine environmental protection and land-based pollution control, (c) controlling excessive development of offshore resources, (d) strengthening management of marine reclamation activities, and (e) protection and restoration of marine ecosystems. The Plan envisioned the crucial role that the two strategically important marine industries such as seawater desalination and marine bio-medicine would play for the growth of blue economy in the country. Separate five-year plans were issued for these two sectors in 2012 and 2013 respectively. As per the plan targets, water desalinization target were fixed at 2.2 million cubic meters per day by 2015.

11. Policy Recommendations

Based on thediscussion of issues on various aspects of blue economy and country experiences in the previous sections, the Report highlights the following policy recommendations:-

- IORA should evolve a consistent definition to formulate appropriate policies for developing blue economy in the region.

- A suitable accounting framework for measuring the contribution of blue economy to the overall economy of the IORA countries needs to be devised. An appropriate institutional mechanism may be evolved at the regional level to formulate and examine the size of blue economy in different member countries.

- For sustained eco-friendly aquaculture in the region, fish farming techniques involving specie diversification and polyculture should be encouraged. The regional efforts should be to focus on regional technology sharing and capacity building programmes to empower SMEs in the region.

- Suitable preservation technologies, disease prevention and necessary promotional measures are necessary to enhance the protein contribution of fish and fish products in the IORA region. Country level programmes may be evolved to develop pisciculture using best practices in the region.

- Proper urban planning and efficient packaging of tourism-related activities could be useful for promoting coastal tourism in the region.Stand-alone country-specific tourism packages may not be sustainable. Therefore, regional tourism development package covering both eco-tourism and monumental tourism should be encouraged.

- Coastal urbanisation by using sustainable, low-carbon and eco-friendly processes and technologies may augment the contribution of blue economy especially in marine

services. Regional guidelines may be evolved with a focus on low-carbon and eco-friendly technologies for coastal urbanisation.

- Technology development and regional cooperation among the member states in sharing of expertise in building energy infrastructure is important for raising production of renewable energy in the region. Regional initiatives may be made to harness regional energy potential to augment production and absorption of clean energy in the region.

- Sustainable use of living organisms can lead to discovery of new drugs in the IORA region. Efforts towards regional collaboration may be evolved to develop "Regional Products" in the pharmaceutical sector.

- IORA countries should explore the possibility of establishing national and regional funds for research and innovation in marine biotechnology.

- IORA countries may undertake targeted policy measures in ship building, port modernisation, design of cruise vessels and related areas to promote shipping and cruise industry in the region.

- Regional mechanism should be evolved to foster technology transfer for deep-sea exploration and management of resources.

- IUU fishing is a concern for the regional economies in the Indian Ocean. Necessary measures to control IUU fishing in the deep sea through institutional mechanism may be evolved.

- IORA countries may consider to formulate medium-term strategy for blue economy and integrate such policies with their overall economic policy programmes.

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Annexure-1

GOA DECLARATION

The First IORA Blue Economy Dialogue was held in Goa, India on 17-18, August 2015. The dialogue deliberated key aspects of Blue Economy that included an accounting framework; fisheries & aquaculture; renewable ocean energy; ports, shipping and manufacturing services; and sea-bed explorations and minerals. Major highlights of the Dialogue included:

Accounting Framework

- Blue Economy paradigm envisages a development strategy aimed at economic growth, environmental sustainability, that focuses on poverty alleviation, job-creation and social equity.

- That a global consensus on a precise definition of Blue Economy is still emerging. This pertains to a framework that accounts for Blue Economy covering ocean economy, coastal economy, and marine economy besides the governmental sectors.

- An appropriate sectoral classification for accounting framework is critical in estimating the size of the Blue Economy. Besides inclusion of sectors, their geographical locations are significant in identifying Blue Economy activities. A suitable sectoral classification should therefore be identified to account for the Blue Economies of the IORA Member states and the region as a whole.

- That some IORA countries have legislated upon National Ocean Acts. It facilitates federal budgeting for the development of Blue Economy activities. It may be recognised that there is diversity of budgetary practices in different Member countries which should be considered suitably in the accounting framework. These initiatives could encourage Member countries to adopt a focussed approach towards promoting Blue Economy.

- Given the asymmetry that exists among the Member countries with regard to Blue Economy accounting norms, a commonly agreed regional approach, including constituting a regional agency, would help in this regard.

- Setting up of a task-force to work out the definitional issues and measures to estimate Blue Economies of the Member states and the region as whole.

Fisheries and Aquaculture

- It is recognised that fisheries and aquaculture are the drivers of Blue Economy in the region. It provides food, nutrition and employment opportunities to the people in the region.

- Overfishing, illegal, unreported and unregulated (IUU) fishing, bycatches and fishing in the high seas remain key challenges to the fisheries and aquaculture in the region.

- Region's fishery sector is also subjected to market-access constraints on account of Non-Tariff Barriers (NTBs), Sanitary and Phyto-sanitary (SPS), and Technical Barriers to Trade (TBT) in the developed and emerging countries markets.

- That fisheries exports have remained at sub-optimum levels on account of recessionary pressures of the world economy causing the terms of the trade to deteriorate further, especially, for the low-income countries.

- Sustainable exploitation of fishery resources can be enhanced with enforcement of precautionary instruments such as catch quota, marine protected areas, constant monitoring, etc among others. Implementation of such policies can ensure sustainability of fish production and consumption in the region. The region is also facing pressing issues like subsidies, license fees, generation of revenues for RFMOs, breach on international and regional conventions, etc where regional regulatory mechanism may be warranted.

- Fish processing industry in the Member countries may be promoted for higher value creation, better remuneration to fish farmers and enriching nutrition content.

- For effective governance of fisheries, a regional institutional mechanism may be evolved to enforce commonly agreed principles on individual Member countries.

Renewable Ocean Energy

- Renewable ocean energy generated from wind, solar, tidal and other sources could play an important role in supplementing growing energy demand in the region.

- Harnessing renewable energy resources requires substantial investment and capacity building. Some Member countries are better off than others in attracting resources to the renewable energy sectors.

- Member countries may set up industrial clusters specific to ocean energy to promote inter-industry learning so as to co-evolve the production chain and technology for cost minimization and promoting indigenization.
- Joint collaboration between domestic and foreign firms may enhance efforts for technology development, resource assessment and choice of appropriate technologies.

- There is a need to develop off-shore environmental governance system to minimise conflicts and competition between different sectors.

Ports, Shipping and Other Manufacturing Services

- Ports, shipping, marine biotechnology, multi-specie aquaculture etc are some of the emerging Blue Economy sectors in the region.

- The Member countries can develop their shipping services by acquiring new ships to replace ageing ships; building port infrastructure including setting up of large floating structures which can be used for transhipment or entertainment activities, developing mega hub ports, etc. There is potential to promote ship repairing services in different Member countries to serve the need of such services in the Indian Ocean.

- Coastal tourism can be promoted by acquisition of cruise liners having an intra-country cruise liner sea circuit, sharing management best practices; setting up of an Indian Ocean Sea tourism Board, etc.

- Indian Ocean region is rich in biodiversity with a number of biological hotspots including coral reefs. The chance of finding novel molecules with high therapeutic potential is very high.

- Marine organisms in the Indian Ocean could be used for development of pharmaceuticals. Several drugs have already been tested and marketed using ocean resources. This sector may bepromoted for commercialization of drugs with private sector participation.

Sea-bed Exploration and Minerals

- Sea-bed minerals such as hydrocarbon, polymetallic nodules, ferromanganese crusts, hydrothermal sulphides, rare earth metals etc are important to the region.

- A comprehensive Ocean policy for exploration of minerals as well as energy sources may facilitate regional cooperation in the region.

- Sharing of technology may be initiated to fill technology gaps and exchange of expertise for exploration in the deep sea.

- Regional Economic Communities (RECs) which involve IORA Member states also need to be sensitized through institutional dialogue.

- Spatial clarity is necessary in order for countries around the Indian Ocean to understand and enforce their rights and obligations.

- Development of sea-bed resources should be taken up in tandem with environmental guidelines issued by international agencies such as IMO, ISA, etc.

- There should be a dialogue within IORA to develop consensus on the above mentioned issues.

Goa, India **21 August 2015**

Annexure-2

Mauritius Declaration on Blue Economy

Declaration

Declaration of the Indian Ocean Rim Association on enhancing Blue Economy Cooperation for Sustainable Development in the Indian Ocean Region

Mauritius

2 – 3 September 2015

WE, the Ministers and representatives of the Member States of the Indian Ocean Rim Association (hereinafter referred to as "IORA"), Australia, Bangladesh, Comoros, India, Indonesia, Kenya, Madagascar, Mauritius, Mozambique, Sultanate of Oman, Seychelles, Singapore, South Africa, Sri Lanka, Tanzania, Thailand and United Arab Emirates attended the First IORA Ministerial Blue Economy Conference in Mauritius on 2 – 3 September 2015;

- RECOGNISING the importance of the Blue Economy vis-a-vis :
  - o **Fisheries and Aquaculture** to ensure food security and contribute to poverty alleviation and sustainable livelihoods;
  - o **Renewable Ocean Energy** to reduce the cost of energy and to mitigate and adapt to the impact of climate change;
  - o **Seaport and Shipping** to promote trade, investment and maritime connectivity in the Indian Ocean Rim region; and,
  - o **Offshore Hydrocarbons** and Seabed Minerals to foster new business opportunities and attract investment in the Indian Ocean;

- **RECOGNISING** the need of Member States and Dialogue Partners to promote proper management of marine resources and enhance capacity building in developing countries, Small Island Developing States (SIDS) and Least Developed Countries (LDCs);

- **REAFFIRMING** IORA's role to promote collaboration and cooperation in the Blue Economy for balanced economic development among IORA Member States and Dialogue Partners;

- **ENCOURAGING** IORA Member States and Dialogue Partners to enhance capacity for the protection of coastal areas, marine environment and resources to ensure sustainable development in the Indian Ocean Rim region;

- **RECALLING** the Rio +20 United Nations Conference on Sustainable Development held in Rio de Janeiro, Brazil on 20 - 22 June 2012, that integrates social, economic and environmental goals and objectives for decision-making;

- **RECALLING** the IORA Perth Principles for peaceful, productive and sustainable use of the Indian Ocean and its resources agreed by IORA Ministers in Perth, Australia on 1 November 2013; and the IORA Economic Declaration adopted by IORA Ministers in Perth on 9 October 2014 which recognized the blue economy is emerging as a common source of growth, innovation and job creation for the Indian Ocean Region;

- **RECALLING** the establishment of the Blue Economy Core Group and the conduct of the preparatory workshops for the First IORA Ministerial Blue Economy Conference (BEC) including: (i) The IORA Blue Economy Core Group Workshop on "Promoting Fisheries & Aquaculture and Maritime Safety & Security Cooperation in Indian Ocean Region" that was held in Durban, South Africa, on 4 - 5 May 2015; (ii) The Indian Ocean Region Workshop on "Exploration and Development of Seabed Minerals and Hydrocarbons: Current Capability and Emerging Science Needs" that took place in Bali, Indonesia from 26 - 27 July 2015 and (iii) the IORA Dialogue on the Blue Economy in Goa, India on 17-18 August, 2015;

- **RECALLING** the Third International Conference on Financing for Development that was held in Addis Ababa, Ethiopia, from 13-16 July 2015 that holistically looked at financing for development across three dimensions and addressed the way in which inclusive growth and sustainable development can be achieved to address issues including sustainable energy; climate change; disaster risk reduction; oceans and seas; food security and nutrition; sustainable transportation; gender equality and women's empowerment; and, biodiversity;

- **RECOGNISING** the importance of the proposed Sustainable Development Goals (SDGs) for the Blue Economy, especially for the conservation and sustainable use of the oceans, seas and marine resources for development;

- **RECALLING** IORA's commitment to develop a common vision in making the Blue Economy an engine for sustainable development and sound environmental management in the Indian Ocean Region;

- **RECONFIRMING** IORA's belief in promoting an innovative and sustainable Blue Economy in the Indian Ocean Region;

- **COMMITTING** to an optimization of the populations' benefit from the economic activity of the ocean;

- **REITTERATING** the importance of IORA's cooperation and engagement with Dialogue Partners, relevant international and regional organizations, the private sector, and civil society in delivering Blue Economy objectives;

HEREBY DECLARE AS FOLLOWS:

That the Member States of IORA will be guided by the following principles in our shared goal to foster the sustainable development of the Blue Economy in the Indian Ocean Region:

- The Blue Economy paradigm is founded on the ecosystem approach, including science-based conservation of marine resources and ecosystems, as a means to realise sustainable development;

- IORA's priority sectors of the Blue Economy, including: Fisheries and Aquaculture; Renewable Ocean Energy; Seaports and Shipping; and Offshore Hydrocarbons and Seabed Minerals that should be developed in an environmentally sound manner for the socio-economic benefit of the population;

- Sustainable use of marine resources of the Indian Ocean should be carried out according to international law including UNCLOS and the Convention on Biological Diversity;

- Member States are also encouraged to consider formulating measures for the development of the Blue Economy in a sustainable manner;

- Cooperation by IORA Member States on data collection and development of environmental baselines could ensure a strong foundation for informed decision making and policy development;

- IORA Member States shall promote sustainable fisheries including combating Illegal Unreported and Unregulated (IUU) fishing;

- The role of the IORA Blue Economy Core Group that will focus on: Fisheries and Aquaculture; Renewable Ocean Energy; Seaports and Shipping; and Offshore Hydrocarbons and Seabed Minerals; to promote the Blue Economy as a driver for sustainable development; research and development; investment, technology transfer and capacity building should be encouraged so as to explore the full potential of the oceans and to ensure sustainable development in the Indian Ocean Rim region;

- IORA Member States should attach higher importance on the sustainable development of the Blue Economy and be encouraged to strengthen networking, the exchange of experiences and best practices in relation to the development of the Blue Economy in the Indian Ocean Rim region;

- Member States and Dialogue Partners should be encouraged to facilitate and allocate the availability of sufficient funding from all sources to promote mutual cooperation and technology transfer with regards to the sustainable development of the Blue Economy in the Indian Ocean Rim Region;

- The sustainable development of the IORA priority sectors of the Blue Economy in the Indian Ocean Region would contribute to: food security; poverty alleviation; the mitigation of and resilience to the impacts of climate change; enhanced trade and investment; enhanced maritime connectivity; economic diversification; job creation and socio- economic growth;

- The empowerment of women and facilitation of micro, small and medium enterprises to participate in the development of the Blue Economy is essential to equitable and sustainable economic growth;

- Improving research, networking, and promoting researchers' exchange programmes among the Member States and Dialogue Partners is vital to ensure sustained development in the region: taking advantage of the upcoming UNESCO Indian Ocean Expedition II (IOEII) as endorsed by the 2014 Perth Communique;

- The need to involve Public-Private Partnership to enhance productivity and marketing efforts in different sectors of the Blue Economy;

- The need to set-up or revise existing regional regulatory frameworks and governance with regard to development of the Blue Economy in the region, drawing upon existing case studies and experience where it exists;

- The participation of Multilateral Organisations can make a valuable contribution to the sustainable development of the Blue Economy;

- Blue Economy development in Member States would create a conducive business environment and attract foreign investment to boost growth;

- Member States and Dialogue Partners should promote capacity building for the development of professional skills for the sustainable development and sound environmental management of different sectors in the Blue Economy.

- **ADOPTED** by the Blue Economy Ministers and Senior Officials of the Member States of the Indian Ocean Rim Association on 03 September 2015 in Mauritius.

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