Integrating climate change and Blue Economy in fisheries research and education in India

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Introduction

Fisheries, the fastest food producing sector in the country plays a pivotal role in ensuring food and nutritional security of the growing population, employment generation, enhanced income and foreign exchange earnings. The fisheries resources, resource users and the environment have contributed in tandem to the sustained fish production and fishers welfare through technology upgradation and augmented capital investment in the sector. The sector had been growing at an impressive rate of 6.65 per cent in marine sector and f 26.07 per cent in inland sector. The country has earned more than 5.78 billion US dollars foreign exchange (i.e., Rs.37, 871 crores) in 2016-17 through, exports of fish and fishery products. The present fish production is 9.3 million tonnes with a contribution of 3.93 million tonnes from marine sector and 5.46 million tonnes from inland sector. The fisheries contribution to GDP is 81400 crores contributing to around 0.82 per cent of the total GDP. The sector contributes around 7.3 per cent of the agriculture GDP. In terms of resources the country possesses a huge resource profile with an Exclusive Economic Zone of 2.02 million square km and a coastline of 8129 kms. In order to address the food security concerns of the country it is important to harness its fisheries resources.

The food security concerns in bridging the demand and supply of food fish depend upon the performance of the capture and culture sector. Among these the marine capture sector is grappled with numerous policy hurdles in the value chain extending from resources to the consumption sector (Table I)

Table 1 Policy hurdles in Marine capture fisheries

Resource ↓	Harvest ↓	Post-harvest ↓	Resource Users ↓	Consumption ↓
Over exploitation of fishery resources Targeted fishing common property, access to which is free and open deep-sea waters remain untapped Lack of enforceable property rights regime	Over capitalization and excess fleet capacity Increase in number of multiday fishing boats Harvesting capacity of fishing fleets exceeds the estimated biological sustainability of most commercial fishing stocks Large amounts of by catch along with landings	Trade impediments and infrastructure development Post-harvest losses (both qualitative and quantitative) due to improper handling, packaging, transportation and storage Importance of Post-harvest technology needs to be more realized among various stakeholders in order to make more nutritive food items from raw commodities by proper processing and fortification	Marginalization and inter sectoral disparities Debt trap and lack of institutional credit Mobility/ Migration towards alternate livelihood opportunities Less returns to the farmers due to post harvest loses Addressing issues related to safety at sea for fishers both in terms of policy and support is minimal	Rise in prices and less market research Noncompliance with food safety guidelines Value addition is to be encouraged to meet the increasing food demand Protocols for sanitation, hygiene and quality control is not strictly followed

Climate Change

Climate change emerged as the new grappling problem which is affecting the resources, resource users and the environment at multidimensional levels. Climate Change is a serious global environmental concern. Global Warming is a specific example of the broader term "Climate Change" and refers to the observed increase in the average temperature of the air near earth's surface and oceans in recent decades. "It is estimated that a sea level rise by 3.5 to 34.6 inches between 1990 and 2100 would result in saline coastal groundwater, endangering wetlands, and inundating valuable land and coastal communities," said the report submitted to the U.N. Framework Convention on Climate Change (UNFCC).Its effect particularly on developing countries is adverse as their capacity and resources to deal with the

challenge is limited. So far as India is considered, the country is highly vulnerable to climate change because of high physical exposure to climate related disasters (65% is drought prone, 12% is flood prone, 8% susceptible to cyclones) and also the Indian economy and population depends on climate sensitive sectors like agriculture, forests, tourism and fisheries.

Climate change is modifying the distribution of marine and freshwater species. In general, warm-water species are being displaced towards the poles and are experiencing changes in the size and productivity of their habitats. In a warmed world, ecosystem productivity is likely to be reduced in most tropical and subtropical oceans, seas and lakes and increased in high latitudes. Increased temperatures will also affect fish physiological processes; resulting in both positive and negative effects on fisheries and aquaculture systems depending on the region and latitude. Climate change is already affecting the seasonality of particular biological processes, altering marine and freshwater food webs, with unpredictable consequences for fish production. Increased risks of species invasions and spreading of vector-borne diseases provide additional concerns. Differential warming between land and oceans and between polar and tropical regions will affect the intensity, frequency and seasonality of climate patterns (e.g. El Niño) and extreme weather events (e.g. floods, droughts and storms). These events will impact the stability of related marine and freshwater resources. Sea level rise, glacier melting, ocean acidification and changes in precipitation, groundwater and river flows will significantly affect coral reefs, wetlands, rivers, lakes and estuaries; requiring adaptive measures to exploit opportunities and minimise impacts on fisheries and aquaculture systems.

There is compelling evidence that climate change is the greatest and widest-ranging market failure ever seen, and there is a large chance of a global average temperature rise exceeding 2°C by the end of this century. It has also been established in various scientific studies that any such warming of the planet will lead to increased natural calamities such as floods and cyclones, declined crop yields and ecological degradation. A large increase in global temperatures correlates with an average 5% loss in global GDP, with poor countries suffering costs in excess of 10% of GDP.

Climate change, more particularly harsher weather conditions, will have impact on the quality, productivity, output and viability of fish and aquaculture enterprises, thereby affecting fishing community. The small-scale fishers may be faced with greater uncertainty as availability, access, stability and use of aquatic food and supplies would diminish and work opportunities would dwindle. Aquaculture development opportunities will increase in particular in tropical and sub-tropical regions. The climate change in warmer regions offers new opportunities as production in warmer regions will increase because of better growth rates, a longer growing season and the availability of new fish farming areas where it was once too cold.

The impacts of climate change and its potential outcomes in fisheries is given below in Table II.

Table II Impacts of climate change and its potential outcome

Type of changes	Climatic variable	Impacts	Potential outcomes for fisheries
Physical environment	Ocean acidification	Negative effects on calciferous animals, including slowed rates of coral growth	Declines in production
	Warming of upper ocean layers	Poleward shifts in plankton and fished species	Changes in production and availability of fished species
		Changes in timing of phytoplankton blooms Changing zooplankton composition	Potential mismatch between prey (plankton) and predator (fished species) and declines in production
	Sea level rise	Loss of coastal habitats. Saline intrusion into freshwater habitats	Reduced production of coastal marine and freshwater systems and related fisheries
Fish stocks	Higher water temperatures	Changes in physiology and sex ratios of fished species Altered timing of spawning, migrations, and/or peak abundance	Changes in timing and levels of productivity across marine and freshwater systems
		Increased invasive species, diseases and algal blooms	Reduced production of target species in marine and fresh water systems
	Changes in ocean currents	Effects on fish recruitment	Changes in abundance of juvenile fish and therefore production in marine and fresh water
Ecosystems	Reduced water flows & increased droughts	Changes in lake water levels Changes in dry water flows in rivers	Reduced lake productivity Reduced river productivity
	Increased frequency of ENSO events	Changes in timing and latitude of upwelling	Changes in pelagic fisheries distribution
	Higher water temperatures	Increased frequency and severity of coral bleaching event	Reduced coral reef fisheries productivity

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

A conceptual framework encompassing the different indicators components fitting the vulnerability assessment using sensitivity, adaptive capacity and exposure was developed to arrive at socio ecological vulnerability. Shyam *et al.,* 2014 constructed the vulnerability indices using parameter, attribute, resilient indicator and score (PARS) methodology, a conceptual framework developed for assessing the climate change vulnerability of coastal livelihoods (Fig.1).

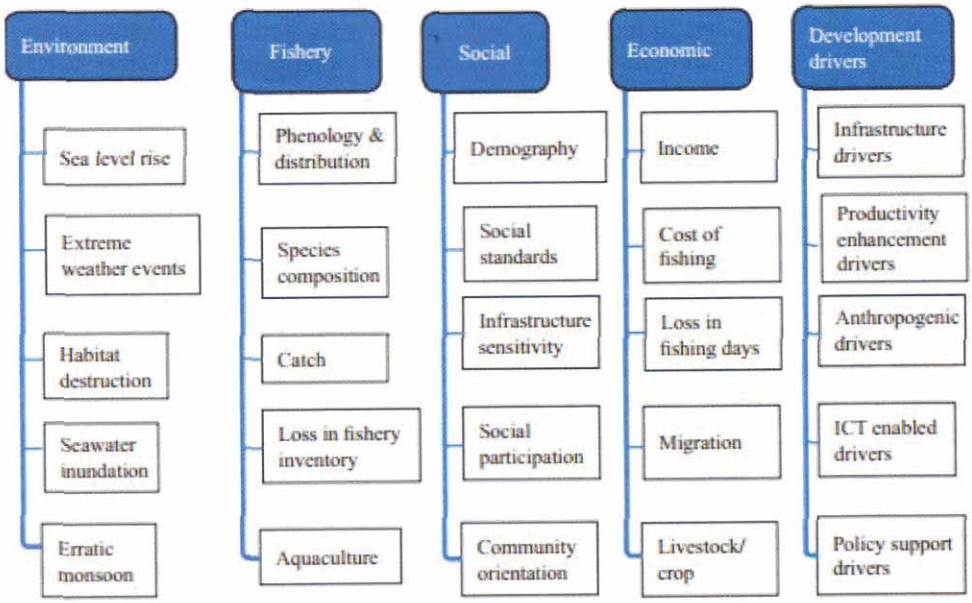

Fig.1 Parameter and attributes used in PARS methodology frame work (Shyam *et al*, 2014)

Along Kerala, two major fishing villages namely Elamkunnapuzha of Ernakulam district and Poonthura of Thiruvananthapuram district in the south west hotspots of India was selected under GULLS project to assess the overall vulnerability of fishery based livelihood due to the impact of climate variation. Findings of this research draw that efforts to reduce livelihood vulnerability in coastal fishing communities should be multidimensional so as to simultaneously tackle exposure, sensitivity, and adaptive capacity. The study advocates the need for a bottom up approach in developing location specific plans to ensure the livelihood of the fishers and the sustainable development of the fisheries sector in the climate change regime with the proactive participation of the fishers.

Even though climate change and its impact on fisheries has become priority in natural resources usage, the level of awareness and adaptation and mitigation plans of the coastal fisheries dependent community has not been taken into account. This is reflected in the results of climate change study conducted in the coast of Kerala as part of GULLS study which reported that 75.07 per cent of the fishers knew about climate change but only 67.35 per cent of the fishers were aware. The fishers were more concerned with erratic monsoon and loss in fishing days as climate change impacts. The major sources of climate change knowledge were media, information exchange between family members, friends and village administration guidelines. The indigenous technical knowledge related to climate change was available across the

fisher households but weren't tapped enough for the adaptation process. There exists various alternative avocations but adequate knowledge and skill upgradation is required. The level of community involvement is minimal and the fishers foresee improved awareness and training programmes for the future. The level of governmental support isn't noteworthy for climate change awareness and adaptation options.

A strategy was conceptualised for planning and implementing village level adaption and mitigation plan through sensitizing and improving the resilience of community towards climate change and initiating a multi stakeholders platform for developing a climate knowledge and information systems; CReVAMP' – "Climate Resilient Village Adaptation and Mitigation Plan" which is facilitated using multi stakeholder governance model by bringing different stakeholders together to participate in the dialogue, decision making, and knowledge sharing and there by instigate knowledge generation process within the community during the course of the process which is directed to create village information system within the community, enable green fishing practices and prepare adaptation and mitigation plan for a community which would in turn helps in community empowerment, thus enabling in building resilient community /Climate Change Informed Fisher Community (CCIF) and they are expected to influence the society and government in decision making and actions related to climate change mitigation and would eventually be able to influence the policy making process.

Carbon emissions: Incentives in climate change

Increased carbon dioxide emission is one of the most important factors causing climate at a faster rate than expected. Climate scientists have observed that CO2 concentrations in the atmosphere have been increasing significantly over the past century, compared to the pre-industrial era level of about 280 parts per million (ppm) globally. In 2016, the average concentration of CO_2 was 403 ppm, 40% higher than in the mid-1800s, with an average growth of 2 ppm/year in the last ten years.

In 2015, the world emitted a total of 32.3 giga ton CO_2, of which China was responsible for 9 gigaton, USA 5 gigaton, and India 2 giga ton CO_2. Over two-thirds of global emissions for 2015 originated from just ten countries, with the shares of China (28%), the United States (15%), and India (6%) far surpassing those of all others. Even though the per capita carbon dioxide emission of India is low, it rose by 394% during 1971-2015 with 0.32 tonnes CO_2 per capita in 1971 to 1.58 tonnes CO_2 per capita.

Considering ocean to be a major carbon sink- this study attempts to create a blue carbon economy based on fishes caught in Indian waters. The carbon emissions based on life cycle assessment; the differential carbon emissions across the chain

during pre-harvest, harvest and post-harvest were analysed.The result of Carbon emission study under GULLS project revealed that the contribution of different sectors to carbon emission is given below in Table 3

Table III Carbon emission in Indian marine fisheries sector

Sector	Carbon Emissions per ton of fish caught				Total
	Pre harvest #	Harvest	Post-Harvest	Consumption	
Traditional	0.090	0.000	0.0002	0.110	0.110
Motorised	0.330	1.020	0.0020	0.110	1.460
Mechanised	0.210	1.420	0.5000	0.110	2.240

The climate change impacts necessitate the global coordination in reducing carbon emission and results revealed that the carbon emission in the marine fishing operations across different sectors is low compared to other countries. Setting emission standards, green fishing guidelines, low carbon emission provides possible trade-offs and major incentives for Indian fishing operations in the competitive global fish trade.

Blue economy

'Blue economy' has emerged as a commonly acceptable development paradigm which has effectively blended economic growth with sustainable development. The blue economy has an estimated asset value of $24 trillion with annual dividends to humanity ranged between $4-500 billion. Blue economy generally refers to the sustainable use and preservation of the oceans in order to ensure the continued survival of the earth.The main aim of blue economy is to shift from "scarcity to abundance". The concept have become an integral part for oceanic development strategies of the international organizations and both developed and developing countries also many coastal countries like Small Island Developing States(SIDS) are relying on the concept for the economic growth and conservation of the marine resources. FAO is also promoting blue economy for promoting sustainable growth, to ensure food security and poverty alleviation.The newly set up Blue Economy Strategic Thought Forum India, under the auspices of the National Maritime Foundation, has already envisagedthe multiple ways in which the blue economy will influence human activities. It defines the blue economy as "marine-based economic development that leads to improved human wellbeing and social equity, while significantly reducing environmental risks and ecological scarcities".

There is greater scope for the development of the Indian fishery sector especially through technological novelties, infrastructure projects, research & development options with established academic institutions and effective governance

in solving issues such as pollution, illegal trade and sea-bed mining. Blue economy opens up new opportunities for the new generation entrepreneurs, researchers and academicians. Combined with the Blue Economy inspiring entrepreneurs, researchers and academicians has to change the economic framework through bottom-up shifts in business, research and educational models as this provides hope and inspiration. It is estimated that blue economy can provide immense employment opportunities in the near future because now most of the people are relying on renewable sources and so most of them are employed in this sector rather than on oil and gas industries, also the investment on renewable energy sources like solar, wind etc. have far exceeded than that of the new fossil fuels power plants. Even though several grant steps and movements have taken place like green movements in order to attain sustainability still we need to find solutions to the rising global issues and we require new and better economic models.

The important sectors which are likely to be impacted and benefitted by the effect of blue economy are especially the employment sector, transport sector, energy sector The major opportunities of blue economy in different sectors is listed in Fig. 2 given below.

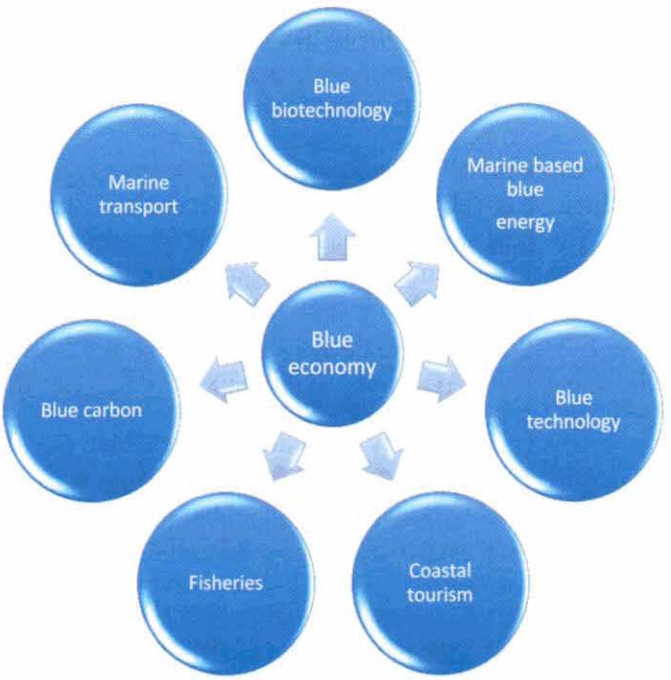

Fig. 2. Major avenues within blue economy

Maritime transport

Shipping is considered as the most eco-friendly, efficient and effective means of transportation. International shipping is considered to be the major tool for

sustainable development. Greening of this sector is possible and can be achieved by effective management and planning techniques. Shipping is also subjected to be major worldwide and officially binding CO2 regulations for an entire economic or industrial sector. More than 80 percent of global trade by volume and 70 percent of trade by value is mostly being carried by sea and ports. The developing and the coastal countries need to focus and improve on their facilities and capacity for trade. Even though there are many challenges the maritime trade is set fair for economic development and benefits while decreasing the effects and also enhancing the blue employment openings in the near future. Even though shipping is considered to be the most carbon efficient means of transportation still it emits considerable amount of greenhouse gases, oil pills and also other means of pollution (Spadling, 2016).

According to the international maritime organization they estimated that CO_2 emissions from shipping are about 3 per cent of the global human caused emissions. In the cruise ships we could find immense improvement in the usage of fuels, propulsion system, wastewater management, solid waste handling and emissions. There is greater opportunity to make the shipping much cleaner and eco-friendly. Another area for likely improvement is the end of life of ships. Ship breaking is the considered as the practice of recycling iron copper and other components from the ruined ships. Unfortunately, as practiced in certain countries, it is poorly regulated industry with chronic labour abuses and minimal environmental mitigation.

Fisheries

More than 350 million jobs are provided by the marine fisheries across the globe, and among them 90 per cent of them are living in developing countries (UNCTAD 2012). The implementation of integrated, ecosystem approach and the removal of fisheries subsidies that initiates overexploitation bid the prospect of restoring key stocks and increasing catches. The execution of good management methods increase the sustainable catches, reduce the energy utilization and costs as well as enhance food security. Exploring green fishing with minimal carbon emission while fishing and standardized post-harvest technologies would provide huge incentives for the subsistence fishers in realizing remunerative prices and income.

Coastal tourism

The international tourist arrival rose to 4 per cent despite the global economic crisis in 2012 and constituted 9 per cent of global GDP (UNWTO 2013). It also provides greater job opportunities and supported 9 per cent of global jobs in 2012.Global tourism mostly focused on marine and coastal environment. The tourism consumer, however, is motivating the change of the sector with a 20 per cent annual progress rate in ecotourism. Blue Economy approach where ecosystem services are properly valued and combined into development planning will further spread this transition, guiding tourism development and promoting lower impact activities, such as ecotourism and nature-based tourism, where the natural capital is maintained as an integral part of the process.

Coastal tourism is the most prominent and developing market across the globe but it is less sustainable. Sustainable tourism is the effective way through which we can mitigate climate change, alleviate poverty as well as helps to support the local economy. Spending more on green tourism can cut the cost and augment the value of ecosystem. Especially the private sector must be trained and should capitalize more on greening practices in order to attain sustainability (Kathijotes, 2012). For sustainable tourism, cross sectorial consultation and Integrated Coastal Zone Management (ICZM) are essential. Government investment and policies can clamp on private sector activities on sustainable tourism. There is immense potential for blue economy to flourish with right actions as the coastal districts of Kerala attained 81.5 per cent of overall tourists (both domestic and foreign) in 2014.

Marine based blue energy

It is important to reduce the fossil fuel energy and also use renewable energy like solar, wind, OTEC, wave and tidal energy, bio fuel from marine algae and sea grasses. It can be observed that marine energies are having the potential to enhance the efficiency of energy resources, and also to reduce the greenhouse gas emissions. These include: Wind-driven marine waves; Gravitation induced marine tidal (tidal-range barrage); Tidal stream (marine currents); Marine salinity gradients; and Thermal gradients between warm surface water and deep (>1000 m) cold water (also called ocean thermal energy conversion, OTEC). While considering the exploitation of any resources like oil gas and other mining and mineral resources it should be carries out in an environment friendly manner as well their economic returns must be utilized for the capacity and well- being of the coastal communities in order to achieve sustainable development.

Blue biotechnology

The capacity of the marine organisms in the underwater world has yet to be studied and explored in order to provide inputs to the blue economy. The anti-viral drugs were obtained from nucleosides isolated from Caribbean sponges. Other companies developed from small soft-bodied marine animals the first drug of marine origin to fight cancer. Exploration of the sea biodiversity is now helping us understand for example how organisms that can withstand extremes of temperature and pressure and grow without light could be used to develop new (Spadling, 2016) Industrial enzymes or pharmaceuticals. At the same time, concerns about the land-use impact and the thirst for water of terrestrial crops grown for bio fuel are driving efforts to explore the use of algae as a source of bio fuels, along with high added value chemicals and bioactive compounds. Switching to blue economy can improve the potential of marine based economy and also can reduce the ocean degradation and environmental consequences.

Remediation and restoration

Ecosystem services and restoration of the ecosystem services are considered as the major important business to make money. The large scale coastal and marine

restoration projects can create better employment opportunities and can improve the coastal livelihoods. Effective management, operation and monitoring of these could benefit the people and could provide better job openings as well.

Blue carbon

A new mode of business is being formed were to sell credits for carbon storage and sequestration in coastal and ocean living biomass. There were huge concern regarding the commodification of the ocean, but other benefits such as improving the productivity in coastal areas and protecting the habitats could reduce its effects. Generally blue carbon is the amount of carbon captured by the oceans and the coastal ecosystem. The carbon captured by living organisms in oceans is stored in the form of biomass and sediments from mangroves, salt marshes, sea grasses and potentially algae. There is a lot of carbon which is released in to the atmosphere oceans and coast provides immense benefit to store and capture this carbon and thereby help to reduce the climate change. Sea grasses, mangroves, and salt marshes along our coast "capture and hold" carbon, acting as something called a carbon sink (Spadling, 2016).

These coastal systems, though much smaller in size than the planet's forests, sequester this carbon at a much faster rate, and can continue to do so for millions of years. The bigger picture of blue carbon is one of coastal habitat conservation. When these systems are damaged, an enormous amount of carbon is emitted back into the atmosphere, where it can then contribute to climate change. So protecting and restoring coastal habitats is a good way to reduce climate change. When we protect the carbon in coastal systems, we protect healthy coastal environments that provide many other benefits to people, such as recreational opportunities, storm protection, and nursery habitat for commercial and recreational fisheries.

Blue technology

The blue technology sector comprises of providers of infrastructure, including manufacturers of sensors, instruments, and platforms; those building, deploying, and operating observing systems; providers of the data infrastructure that bring about and connects ocean data; organizations that develop and sustain data management systems, software tools and models; environmental safety and marine robotics; and desalination.

India have to focus on blue economy mainly because if the country have more innovative and sustainable approach, it would offer better livelihood security for the fisher communities as well as food security for the citizens. The presence of polymetallic nodules such as iron, manganese and zinc along with the untapped oil and natural gas reserves promise a sufficient constituent for foreign exchange earnings. Sea borne trade, port led development, offshore infrastructure can bring sustainable port and shipping regime and Trans loading mechanism can reduce the marine pollution. When considering as green oriented effort, blue economy generally provides more employment, no pollution and no waste. Marine industries like boats

and ship building and also sea product processing unit and marine biotechnology can join the blue agenda. The benefits of Blue economy and its Indian potential is furnished in Table 4

Table 4. Blue Economy: What it holds for India?

Blue economy parameters	**Indian Potential**	**Benefits that can be achieved through blue economy**
1.Blue energy		
(i) Tidal power	12.4 GW	Green, predictable, renewable, long life spans, effective at low speeds
(ii) OTEC	180 GW	Continuous , pollution free, clean energy
(iii)Offshore wind	1 GW	Create jobs, no pollution, provide domestic energy source, no water consumption
(iv)Wave energy	40 GW	Green, reliable, enormous energy potential, area efficient
2. Blue biotechnology		Improved productivity in aquaculture, new pharmaceuticals, new industrial enzymes
3. Blue carbon	Nearly 26 % of CO_2 can be captured by oceans	Bio energy, reduces carbon emissions to atmosphere
4. Coastal tourism	Account 5 per cent job	Economic support for hotels, transportation services, entertainment venues and attractions government spending on related infrastructure, plus the domestic spending of Indians employed in the tourism sector.
5. Fisheries	Incentives with premium prices for green fishing	Improves food security, sophisticated technologies for fish farming, conservation and processing of species, fisheries sector will be more organised by enabling policies on pricing, certification, labelling and marketing.
6.Maritime transport	Added employment, Augmented income , Better terms of trade	Job creation, Reduced GHG , Better trade

Even though blue economy has immense opportunities it faces technological, operational, site specific and societal challenges. This is where fisheries education and research comes into the picture. The prospects of the blue economy created by carbon emission incentives and climate change has to be synergised by the educational and research efforts. Our research and educational institutions should transform itself to cater to the umpteen opportunities provided by the blue economy in terms of developing newer educational curriculum and streamlining to meet the challenges.

Skilled and knowledgeable human resources are going to determine the future course of action in the direction of blue economy. Generating competent professional human resources will be one of the critical inputs in driving the engine of sustainable fisheries and aquaculture. Uniform, relevant and updated curriculum should be developed integrating the concepts of blue economy and changing climate and its impact on fisheries. Institutions will be required to handle maritime security operations, that is, the coordination of law enforcement operations, the sharing of best practices, the organization of training and capacity building, as well as information sharing and maritime domain awareness

Reorienting fisheries education and research in line with the concept of blue economy would require infrastructure development and new regulatory mechanisms. Premier institutes should be encouraged to set up global education centres in collaboration with suitable overseas partners. Interdisciplinary and high quality research to back up the policies should be given focus. The successful integration of blue economy in to our educational and research framework is definitely going to bring new prospects into the fisheries sector and to the fishing community.

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