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Azadi Ka Amrit Mahotsav

Indian Maritime

SAGARMALA

PERFECTION IAS

परिshram TEST SERIES

FOR BPSC 67 MAINS

SCHEDULE

Date	Day	Test	Paper
15 Oct. 2022	Saturday	Test 1 (Sectional Test)	GS-I
22 Oct. 2022	Saturday	Test 2 (Sectional Test)	GS-II
05. Nov. 2022	Saturday	Test 3 (Sectional Test)	GS-I
13 Nov. 2022	Sunday	Test 4 (Sectional Test)	GS-II
19 Nov. 2022	Saturday	Test 5 (Sectional Test)	GS-I
20 Nov. 2022	Sunday	Test 6 (Sectional Test)	GS-II
26 Nov. 2022	Saturday	Test 7 (Sectional Test)	GS-I
27 Nov. 2022	Sunday	Test 8 (Sectional Test)	GS-II
03 Dec. 2022	Saturday	Test 9 (Full Length Test)	GS-I
04 Dec. 2022	Sunday	Test 10 (Full Length Test)	GS-II
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Rig Veda

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IN THIS ISSUE

REGULARS

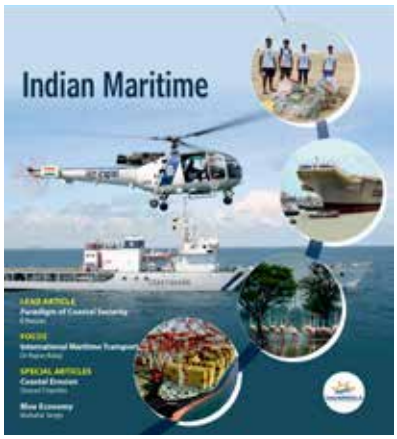
UPCOMING ISSUE: ARCHITECTURE

Number of pages: 56

Details of the Sales Outlets of the Publications Division on Page 33

YOJANA is published in Assamese, Bengali, English, Gujarati, Hindi, Kannada, Malayalam, Marathi, Odia, Punjabi, Tamil, Telugu, and Urdu.

Looking Seaward



India has a vast coastline stretched over 7000 kilometres having over 1000 offshore islands that bring bountiful resources and opportunities. It provides long stretch of shores that has been a habitat of varied coastal communities as well as vegetation. It also opens contours of communication and businesses with the outside world. Safeguarding these waters from external threats and protecting India's maritime interests is of great importance, particularly in the geopolitical and security situation that prevails in the Indian Ocean region. The country's maritime interests encompass the maintenance of the territorial integrity of India against seaward challenges and threats as well as the protection of its maritime trade and people engaged with it. The safety and unhindered continuity of maritime trade, through a wide network of ships is also a primary national concern as it directly impacts our economy.

With the focus on promoting the blue economy, port-led development plans, growth in coastal shipping, trade protocol routes, cruise tourism, and the Sagarmala Project for port-led development, oceanic traffic is expected to increase further. The Sagarmala Project intends to achieve the broad objectives of enhancing the capacity of major and non-major ports and modernising them to make them efficient, thereby enabling them to become drivers of port-led economic development, optimising the use of existing and future transport assets and developing new linkages for transport, setting up of logistics hubs, and establishment of industries and manufacturing centres to be served by ports in Exim and domestic trade. In addition to strengthening port and evacuation infrastructure, it also aims at simplifying procedures used at ports for cargo movement and promotes the usage of electronic channels for information exchange leading to quick, efficient, hassle-free, and seamless cargo movement. These may translate into an increased likelihood of maritime challenges in the proximity of the Indian Coast. The country's maritime sector plays a crucial role in its overall trade and growth, with 95% of the country's trade volume and 65% of the trade value being undertaken through maritime transport.

With the objective of propelling India to the forefront of the Global Maritime Sector, Maritime India Vision 2030 was formulated as a blueprint to ensure coordinated and accelerated growth of India's maritime sector in the next decade. Key themes which are identified to be essential for India to secure its place at the forefront of the Global Maritime Sector include developing best-in-class Port infrastructure, logistics efficiency and cost competitiveness, use of technology and innovation, enhancing global stature and maritime cooperation, leading the world in safe, sustainable, and green maritime sector, and enhancing cargo and passenger movement through inland waterways. This issue discusses how through these initiatives, India is exploring unchartered waters and aiming to realise the potential of its maritime sector to the fullest. ❑

Paradigm of Coastal Security

B Ranjan

The security of the coastline in India was in existence in the rudimentary form before the 1993 Mumbai blasts, wherein, it was established that the explosives used were smuggled through the sea route. It was then that the need for a Coastal Security mechanism emerged. The impetus for an institutionalised framework was accorded by the Group of Ministers Recommendations after the Kargil War. However, the coastal security construct, framework and mechanism took a paradigm shift after the 26/11 Mumbai terror attacks. Almost after a decade of implementation of measures, have we transformed our coastal security system? The article will dwell upon the challenges and actions initiated by the Indian Coast Guard in coordination and cooperation with all stakeholders towards achieving the desired level of security.

Oceans are vast, covering 363 million square kilometres, equivalent to approximately 72% of the Earth's surface. More than 600 million people, equal to around 10% of the world's population, live in coastal areas that are 10 meters above the sea level, and nearly 2.4 billion people, about 40 % of the world's population, the live within 100 km of the coast. In the Indian context, three out of four metro cities are located on the coast. About 14.2% of the population in India lives in coastal districts. Around 95% of India's trade by volume and 68% by value is conducted through these waters, with priority being accorded to port-led development plans in recent years.

The offshore development areas are critical for securing India's energy needs, and we have one of the largest fishing fleets globally. In sum, oceans are the lifeline of global prosperity and pertinent for our fortune too. India, with a coastline of 7516 km along the mainland and island territories, occupies a significant position in the maritime economics of the world trade overseeing the busiest of the international shipping lanes. There are nine Coastal States, four Union Territories and 1295 islands spread along the coast of India, including the Andaman & Nicobar Islands in the east and Lakshadweep Islands in the west. The coastal areas host major commercial cities, and significant strategic and vital installations of Defence, Atomic Energy, Petroleum, and private ventures besides 12 major ports and more than 239 non-major ports, thus increasing the coastline's vulnerability.

To gauge the enormity of Area of Responsibility (AoR) and the challenges therein, we need to have an antithetical view of the nation facing the Indian Ocean. The geostrategic location of the Indian peninsula poses typical oceanic challenges owing to proximity to major international shipping lanes, inimical

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neighborhood-sponsored cross-border terrorism, transnational maritime crimes like narcotics and weapon trafficking, human trafficking etc., and dense fishing traffic around the Indian cape. More than 1,00,000 ships are estimated to transit close to our shores annually. With the focus on promoting the blue economy, port-led development plans, growth in coastal shipping, trade protocol routes, cruise tourism, and the Sagarmala project, oceanic traffic is expected to increase further. These may translate into an increased likelihood of maritime incidents and challenges in the proximity of the Indian Coast.

The geostrategic location of the Indian peninsula poses typical oceanic challenges owing to proximity to major international shipping lanes, inimical neighborhood-sponsored cross-border terrorism, transnational maritime crimes and dense fishing traffic around the Indian cape.

The use of sea route by terrorists during the attacks of 26/11 highlighted the vulnerabilities of our coastline and its security. As the ocean itself is a bounty of nature, the sphere of activities in the nautical environment is vast. Thus, several agencies, which include Indian Coast Guard, Indian Navy, Coastal Security Police, Customs, Fisheries, Port Authorities, Intelligence Agencies, and other Central and State Departments, are the stakeholders in ocean governance.

The multi-agency concept mandates cooperation, coordination, and institutionalised domain control of the respective agency to achieve foolproof security by optimum utilisation of limited resources. Thus, came the concept of a tiered mechanism for surveillance in-depth, wherein the Indian Coast Guard is additionally responsible for coastal security in territorial waters, including areas to be patrolled by Coastal Police, and the Director General Indian Coast Guard is designated as Commander Coastal Command with responsibility for overall coordination between Central and State agencies in all matters relating to Coastal Security.

For effective coordination amongst all stakeholders involved in coastal security, Standard Operating Procedures (SOPs) for Coastal Security were promulgated by the Indian Coast Guard in consultation with all stakeholders. To ensure a high degree of preparedness for responding to an immediate threat and to streamline the response to more significant threat perception, Coastal Security Exercise 'Sagar Kavach' is conducted bi-annually for each coastal state. Additionally, the Government of India initiated a focus on the infrastructure and assets of the Indian Coast Guard and all concerned agencies to enhance their capabilities for surveillance and patrol at sea. More than 200 Coastal Police Stations along with patrol boats have been established in the coastal States, including Island territories, for surveillance of shallow waters. Further, measures such as coastal mapping, strengthening of security at non-major ports, setting up of State Maritime Boards by coastal States, and biometric identity cards for fishermen have also been implemented. These initiatives have been coordinated by ICG for over a decade and have given desirable results.

The integration of technology with surveillance methodology has been achieved by establishing Coastal Surveillance Network (CSN) for seaward electronic surveillance up to 25 NM from the coast under which 46 remote radar stations have been established, and 38 Radar Stations, 04 Mobile Surveillance Systems and 13 Radar Stations under VTMS connectivity are being established for providing near gap-free surveillance.

Joint Coastal Patrol (JCP) by Indian Coast Guard and Coastal Police has been instituted across all coastal States and Union Territories wherein the Coastal Police Personnel are embarked onboard Coast Guard ships, and deployment is undertaken in coordination with electronic surveillance measures for optimum exploitation of resources. The surveillance of 1382 islands is maintained during routine sorties by Indian Coast Guard ships and aircraft.

The apex level monitoring and review of the implementation of measures for enhancing the effectiveness of the Coastal Security Framework are done by the National Committee on Strengthening of Maritime and Coastal Security against threats from the sea (NCSMCS), Multi-

Agency Maritime Security Group (MAMSG) under NSA. The improved information sharing along with better inter-agency coordination and synergy is the hallmark of the revised mechanism. The security agencies are solemn and alert in responding to any maritime security incidents. The persistent and systematic efforts and resolve in getting all other agencies to work in a coordinated manner through the regular conduct of state-wise, inter-agency coastal security exercises 'Sagar Kavach', has been instrumental in this.

Whilst the measures have been implemented and the mechanism established, the question again emerges as to 'Have we done enough to prevent an intrusion and secure our coastline'? The answer lies in measures initiated for surveillance in the depth of oceans as the threat to the coastline emanates in deeper waters much beyond the coastline. The ocean is hence, to be quantified in terms of volume rather than length of coastline.

Coastal security is the maintenance of "Law and Order" close to the coast, and a subset of ocean governance for maintaining good order at sea. Coastal security as seen can be summarised into effective law enforcement measures implemented at sea duly coordinated by the Indian Coast Guard, which, over the years, has grown into a force to reckon with and earned the appellation as 'Sentinels of Seas', executing the role of maritime law enforcement, ocean peacekeeping, anti-smuggling, Maritime Search and Rescue.

To secure 7516.60 km of coastline, which is equivalent to 1/3rd of land borders, 2.01 million square km of Indian Exclusive Economic Zone (EEZ), which is equal to approximately 61% of the landmass of India, is to be maintained under constant surveillance by ships, aircraft, and electronic surveillance measures. On average, 45-50 Indian Coast Guard ships and 10-12 aircraft are deployed daily for surveillance of EEZ of India. The Indian Coast Guard ships and aircraft provide the essential deterrence and ensure the security of maritime zones of India, thereby protecting the national maritime interests in such zones.

The critical issues as challenges for coastal security and, in turn, safety for vessels ranging from small country craft to Ultra Large Crude carriers are primarily embedded in the legal regime of United Nations Conventions for Laws of the Seas (UNCLOS) and its adoption under various other applicable national acts and the rules thereof. Secondly, in the execution of the authority by various stakeholders, responsible for coastal security, the creation of a proper follow-up system towards the accountability as a regular update of actions. Finally, the implementation support along with efficient communication.

The multi-stakeholder concept which emerged post 26/11 for coastal security steered through Chief Secretaries of the respective coastal states and supervised by the MHA, GoI through Border Management Division under the monitoring of the Cabinet Secretary through NCSMCS provides an optimal approach to ensure time-bound implementation of all tasks and a high level of coordination among numerous stakeholders.

The Coastal Security Construct of the present day has successfully built synergy and coordination, which in the current security environment is very much required and must be continued. In one line, coastal security is the maintenance of "Law and Order" close to the coast, and a subset of ocean governance for maintaining good order at sea.

Coastal security as seen can be summarised into effective law enforcement measures implemented at sea 24X7X365 duly coordinated by the Indian Coast Guard, which, over the years, has grown into a force to reckon with and earned the appellation as 'Sentinels of Seas', executing the role of maritime law enforcement, ocean peacekeeping, anti-smuggling, Maritime Search and Rescue and many other tasks, to be rightly called as the 'Saviours'. Over the past four decades, the service has evolved as a multi-mission formidable force performing diverse and concurrent operations to protect the maritime interests of our Nation. ❑

International Maritime Transport

Dr Rajoo Balaji

How inappropriate to call this planet Earth, when it's quite clearly Ocean.
– Arthur C. Clarke

Considering the planet's surface (about 510 million sq km), about seven-tenths of it are oceans and seas (360 million sq km); the rivers are thus a bonus. Much before than the discovery of the Mundus Novus (New World) by Amerigo Vespucci, mankind had traversed the seas. Today, transportation is ubiquitous globally, but water transport, especially through the oceans and seas has been a major contributor to the planet's progress. As industrialisation and international trade expanded, countries increasingly invested in seaports, airports, produced storage, and large ocean-going ships. Though trade had flourished through the ages, maritime transport matured in technology and tonnage only after the World War-II, especially in the last three decades of the 20th century. Solids, liquids and liquefied gases are carried on purpose-built vessels and trade volumes have multiplied manifolds catering to global consumerism. Trade barriers diminished with globalisation, advancing marine engineering technologies and containerisation. And remarkably, computerisation changed the ways and conduct of international trade and transport.

The terms 'maritime transport' and 'merchant marine' can be considered synonymous but they include many other elements in their sense. The ships, seafarers, ports, shore personnel etc., belong here. With the container concept and liner trade gaining favour, the multimodal sector also joins the spokes of the maritime transport wheel. This article captures the present complexion of global maritime transport and also tries to see the India's progress in this international climate.

Status and Challenges

A major disruption in the sector was caused by the pandemic pause. Prior to and during these periods, decarbonisation had been the major challenge. Shipping costs, fuel costs, freight and logistics costs had increased and were yet to find firm levels. The Drewry World Container Index (composite), an indicator of the container spot rates had climbed 5 to 6 times since end-2020 and breached USD10000 (in 2021). Currently, it is hovering below USD8000 (for a 40' container).[1] Economies in

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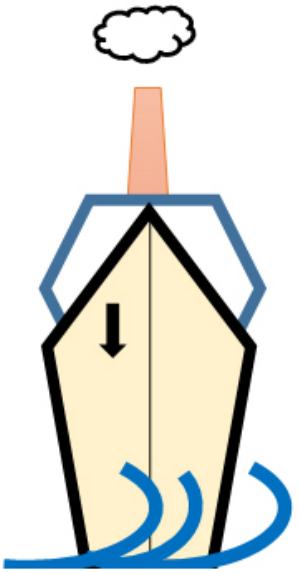
transition have been the most affected. But if cargo loaded during this phase is considered, developing countries especially in Asia continue to be on top.

Table 1 indicates a few significant figures related to shipping. Referring to tonnage addition (as a factor for growth) fall since 2010 (>11%) and at the beginning of 2021, the fleet size increase was just over 3%.[2] Fleet size and hence the tonnage addition may be expected to remain or increase but within the single-digit range. It may be reasoned that the costs of ships have risen and post-pandemic, ship owners would prefer to use the existing tonnage (though aged) and amortise and/or optimise. Ship costs have risen due to additional equipment/retrofits resulting from regulatory requirements on ballast water, emissions and energy efficiencies.



During the lockdown and the low trade movement periods of 2020, the new ship deliveries shrank further but the order books have been active since 2021. However, the order book trends have been dull. This could be a hangover following the excess capacity situation. China, South Korea and Japan remain the leading shipbuilding nations.

Table 1: Global Merchant Shipping
(UNCTAD Report 2021)

Global seaborne volumes	10.6 billion tonnes
World Container Traffic	813.5 million TEUs
World Number of Vessels (Commercial vessels >100grt)	99800 (2,134,639,907 dwt)

(TEU: Twenty Equivalent Unit; dwt: Dead Weight Tonnage; grt: Gross Registered Tonnage)

Another trend for analysis is the size of vessels. While large vessel rationale fits well for liquid/gas petroleum tankers, large container ship (>10000 TEUs) construction started in the start of the 21st century. This preference to large container carrying capacity may be attributed to the companies sighting economies of scale[3] and emboldened by advancing technologies.

Given the experience of the ship, 'Ever Given' (20000TEU), which grounded and caused the blockage of the Suez Canal in March 2021, this trend might slow down. About 10% of the world's shipping transits through this waterway. Suez Canal Authority (SCA) has reported the highest ever earnings of USD7 billion for 2021. (SCA increased the rates from 10-15% in September 2022). The gravity of such risks entailing high salvage/insurance costs has caused a relook at this of big builds.

While large petroleum tankers can be tied to buoy moorings well away from the ports (eliminating the need for large berthing facilities inside the port), large container ships require deeper ports and larger berths. However, large vessels have been traversing other waterways (Panama Canal was widened particularly to accommodate broader, large vessels).

Crew care will be a crucial area on the human resources front. Timely wages (and lesser abandonments), vaccinations, free and preferential passage (seafarer as an essential worker), timely reliefs, short/shore leaves and mental health etc., will be in the fleet managers' perspectives. A challenge in perpetuity that maritime transport faces is the regulatory maze due to multiple regulations. The greatest challenge will however be the efforts towards decarbonisation.[3] The drivers will be the technologies which prove to be reliable and realisable.

Impact of Modern Technology

In shipbuilding, preference for light-weight components, superior hull coatings, energy efficient main and auxiliary machinery, condition monitoring, predictive maintenance regimes etc., will continue to improve.

Machine learning, AI and Blockchain will proliferate. Intelligent data applications such as sensing container (Twenty Equivalent Unit or TEU) loads, guiding the cranes towards empty spaces/slots, sensing container securing tensions are already in vogue. Electric cargo handling equipment, high stacker forklifts etc., are already crawling in many modern ports. E-documents, paperless smart technologies for swifter truck movement, digital tracking of containers etc., are changing the business processes in shipping. In the current context, the major point of inflexion is undoubtedly the pandemic.

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Post-Pandemic Trade Climate

While most of the analyses predict good growth in the post-pandemic periods, the effect of uncertainties centring around Covid-19, transport costs, supply chain disruption, globalisation patterns and port congestion[2] persist. Of these, though the Covid-19 infections have shown

diminishing trends, there are other threats (monkeypox), which may slow down the progress. The other factors have prevailed in higher magnitudes.

Geopolitical factors of the Russia-Ukraine conflict and the China-Taiwan tensions also add up to the diminishing growth. The components of these influencing trends are tabulated with exemplar inputs in Table 2 along with few drivers. The major drivers for maritime transportation as per Organisation for Economic Co-operation and Development (OECD) are depicted in Figure 1. The factors are analytically arranged by combining the components from the UNCTAD Report and the OECD drivers. From the Indian perspective, the opportunities for development can be seen under these and targets may be pursued.

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Opportunities for Improvement

Globalisation is the process by which businesses or other organisations develop international influence or start operating on an international scale. This is now well embedded in India's growth plans. The Chabahar port (Iran), the management of petroleum requirements under changing geopolitical scenarios, trade equations with China along with persisting border tensions, the opening up of inland waterways etc., all stand as evidence. However, following are some challenges that still remain.

Structure favourable tax regimes and incentivising shipping: India is placed 35th amongst 46 countries in the PRIME (Protectionism in Maritime Economies) index, implying a high level of protectionism.[5] Economists advise that countries may lessen incentives and shun protectionism so that shipbuilding and operations become competitive and efficacy improves. On the other hand, there are recommendations that Governments 'recover a larger share of infrastructure costs via fees and charges.'[1] Looking at India's progressive context, there ought to be a balanced approach and any prevalent dichotomous policies need to be addressed.

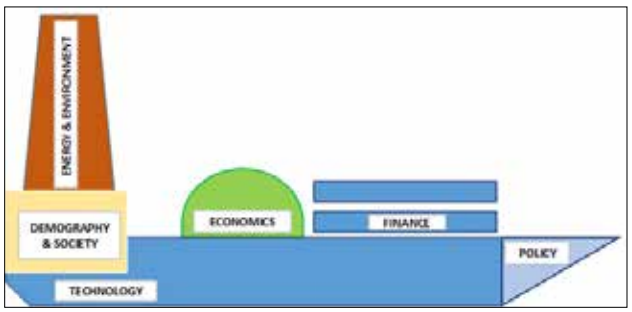

Figure 1: Drivers of Maritime Transport

Low tonnage and dependence on foreign vessels for overseas trade: This is largely attributed to the poor vessel turnaround (supposedly improved to 27 hours at present) and ageing Indian fleet (average age 20 years and above). This causes a bleed of foreign exchange also.

Another factor affecting this is the port calling costs in India, which had generally been higher by 3 to 5 times the costs in neighbouring ports, and high logistics costs. Improved hinterland connectivity, easing port congestion and investment in infrastructure etc., can help with in fighting these challenges.

Lack of focussed attention on core and areas of concern: These include ship building/repair/recycling; container manufacturing etc. India has about 32 yards with the capacity to build ships but the major share of shipbuilding is held by the public sector yards.[4]

On the ship repair front, India is yet to exploit its proximity advantage (geographic location on the international trade routes). The southern Vizhinjam port initiative is worth a mention which is seen as a strategic hub project, given its location along the east-west ship routes and its natural depths of 20m to accommodate large vessels. But the project faces local resistance, financing issues, etc.

On the recycling front, while the global market is between USD10-12 billion, India's share is around USD100 million only. India reportedly cornered about 29% of the global tonnage that was sold for recycling.[2]

Another area of concern is the lack of funding. While European shipping finance models are being considered, shortfalls in allocations to crucial heads such as Indian Maritime University (IMU), Inland Waterways etc., must be made good.[6]

Development delays in Ports Sector (Inland waterways, Sagarmala projects etc.): The integration of inland waterways with ocean transport would pave way for reducing congestion and costs. The connectivity with the country's corners (NER) and neighbours (BIMSTEC/ Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation Members) may be swiftly enhanced.

Manpower: India has the right mix of the young populace (skilled and ready to be skilled), a long coastline, land for development (warehouses, hubs, freight stations) and scope for infrastructure improvement. Presently, India has 12 major ports, 200 minor ports spotting 7157 km of coastline.[6] Though India stays in the top seafarer supplying

Table 2: Maritime Transport: Current Trends

(ITF 2022; UNCTAD 2021; Fitch Solutions 2021; Bank 2010)

Factor/Sector	What to look for/Trends	Recent/On-going Experience
Globalisation/ Policy	Increase in e-commerce; Multi-polarity of trade flows; US efforts to build self-reliant supply chains (reduce dependency on China); Needs-driven political alignments; Regulations on freight; Legislative measures; Cabotage; Demurrage; Tax incentives	Increase in container traffic; Retailers chartering own ships; Construction of specialised ports (LNG, Container etc.); PPP; Landlord models
Supply chain/ other Technologies	Identifying Risks; Other trends (resilient supply chain): Integrated shipping networks/supply chains; Nearshoring; dual sourcing; Increased inventory of critical stock; Caution against cybersecurity; Logistics parks etc.	Chip shortages; Disruptions due to pandemic etc.; Just-in-time (JIT) business and logistics solutions; Digitalisation of ports/terminals; Intermodal hubs; Increase in warehousing; Door-to-door deliveries; Integrated rail-roads; Cargo consolidation; pack-repack distribution
Port/ Demography	Congestion; container shortage; Sourcing of raw materials close to manufacturing hubs; Real estate for port development	Modernisation; Greening; China influencing import/export trends
Energy Transition/ Environment	Emission controls; Alternated fuel usage; Technological solutions; Carbon pricing	Ship design/operations aligned to emission control; High freight costs; Lower ship speeds
Finance	RoI; Tax reforms	High operational costs
Economics/ Geopolitical Conflicts	Consumption; Slow down patterns; Import/ export needs of developing countries; Conflicts-in-perpetuity patterns	Trade opportunities; Asset Destruction; Disruptions (e.g., Suez Canal blockage); Stranding of seafarers/crew repatriation issues

PPP: Public-Private Partnership; RoI: Return on Investment; LNG: Liquified Natural Gas

nations, lesser attraction to sea career amongst youth has dented the quantity and the quality of the workforce. This is a matter of concern.

Maritime India Vision 2030 (MIV 2030)

Many of the discussed factors are addressed in some fashion in the Vision Document of MIV 2030. Figure 2 summarises the significant initiatives. In addition, National Logistics Portal and non-core asset monetisation also are among the initiatives. The Indian Ports Bill, (currently another draft is in circulation for inputs again) is one developmental initiative. This is expected to redefine the Centre-State model for better transparency and to foster growth. The latest announcement of the National Logistics Policy to be implemented through a comprehensive plan is expected to bring the logistics costs down among many other intended benefits.[7]

Conclusion

Interestingly, the curve dip reflecting the economic downturn of 2018-19 can be matched with the data curves for 2008-2009. In agreement with the cyclic nature of shipping, the checkbox can be ticked off and the upswing may well be anticipated.

Maritime transport will be a major mode of trade across the globe, especially considering the volumes. For sustainable development, three major factors namely, geopolitics, environment and technology will have to be kept in the scheme of things.

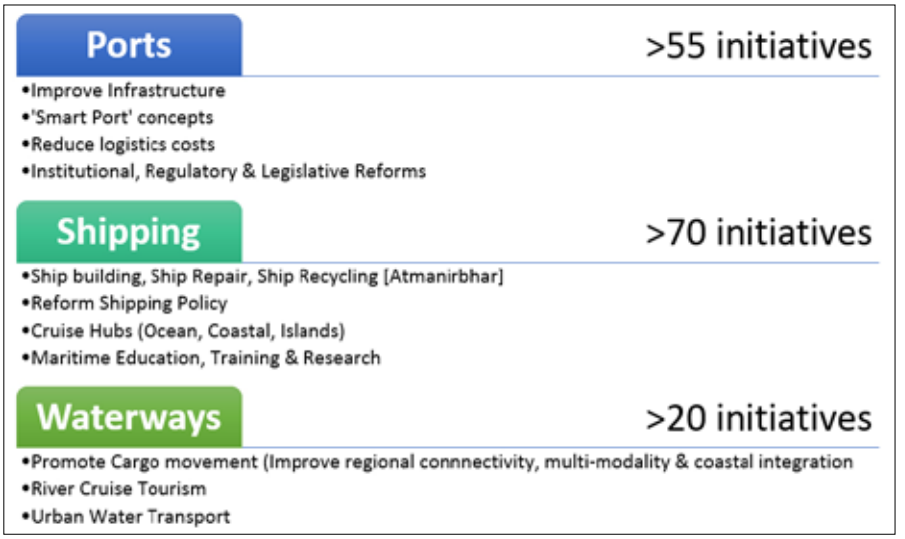

Figure 2: MIV 2030 Initiatives

And lastly, the impression that the pandemic has taught us to be prepared, will always be an understatement. The term, 'future proofing' will always have currency. Risk prediction/ management, management of stocks and inventory etc., will be part of all planning processes. And as always, Maritime Transport will be the means that will matter. ❑

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SPECIAL ARTICLE

Coastal Erosion

Sharad Chandra
R P S Verma
Ashish Kumar

Coastal Erosion is wearing away and redistributing solid elements of the shoreline as well as sediment, normally by such natural forces as waves, tidal and littoral currents, and deflation. The causes of erosion are either natural or man-made. Sometimes, it is a combination of both, natural and man-made factors. While the former is a relentless process that is often impossible to resist, the latter is often due to ill-planned activities and can certainly be contained, or even reversed.

Coastal areas are given vital importance in recent years, due to the increasing human population and accelerated developmental activities near coasts. The developmental activities have put tremendous pressure on the fragile coastal environment and about 20% of the Indian population resides in the coastal area. Many thickly populated and industrialised cities like Mumbai, Chennai, Kolkata, Kochi, and Visakhapatnam are located along/near the coastal regions.

Some of the general problems along the Indian coast which require engineering interventions include silting up of entrance channels, closing of river mouths, flooding during a storm surge, sand bar formation near mouths of inlets, rivers, and estuaries, and erosion of the coast. While all the problems need to be addressed, coastal erosion is a major concern.

A coastline is a complex series of interlinked physical systems in which both offshore and onshore processes are involved. Coastal Erosion is one of these physical processes, wearing away and redistributing solid elements of the shoreline as well as sediment, normally by such natural forces as waves, tidal and littoral currents, and deflation. Erosion occurs when the material being removed, for deposition elsewhere, exceeds the rate of supply finally resulting in the landward shifting of the shoreline.

The coastal sediments, together with those arising from inland erosion and transported seaward by rivers, are redistributed along the coast, providing material for dunes, beaches, marshes, and reefs. The sand can be moved to another beach, to the deeper ocean bottom, into an ocean trench, or onto the landside of a dune. The removal of the sand from the sand-sharing system results in permanent changes in beach shape and structure.

Waves are the main cause of coastal erosion. Wave takes birth in the mid-ocean and moves towards the coast. Waves bring an enormous amount of energy to the coast that is dissipated through wave breaking, generation of currents, water level changes, and movement of sediment, turbulence, and heat. Wave energy is the result of three factors: the speed of the wind blowing over the surface of the sea, the length of fetch (i.e., the distance of sea over which the wind has been blowing), and the length of time that the wind has been blowing for. Incident waves vary spatially and temporally, with their properties changing with movement over the bottom. Waves are the major factor in determining the geometry and composition of the

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beaches. The action of waves dictates the processes of removal and addition of material/sediment on the coast.

Sometimes, the coastal sediment returns to the visible part of the coast by accretion. The two processes of accretion and erosion play a major role in defining coastal geography. The shoreline changes induced by coastal erosion and accretion are natural processes that take place over a range of time scales. With respect to temporal scale, these processes may occur in response to both small-scale events, such as storms, regular wave action, tides, and winds, and large-scale events such as glaciation or orogenic cycles, or tectonic activities that cause coastal land subsidence or emergence.

The removal of dune vegetation and mangroves due to man interventions causes exposure of the low-energy shorelines to the increased energy and reduced sediment stability. This further promotes erosion of coastal zone.

History of Coastal Erosion in India

Kerala is the state which is worst affected by coastal erosion in India. In the original assessment in the 1960s, about 57% of the coastline was identified as vulnerable. Although the erosion of the coastal land has been experienced in the State for a long time and records show anti-erosion works having been constructed even in the nineteenth century. An assessment made in the late 1980s indicated that almost 85% length of Kerala's coastline was in the grip of erosion. Later, it was found that Karnataka and Maharashtra were also affected badly by sea erosion. The problem in other states was found to be in patches/coastal pockets depending on various factors. The first anti-sea erosion measure in Puducherry was initiated by the French in the early 1920s when a 1.75 km long retaining wall was constructed along the urban coastline in Puducherry.

Groynes, a rigid hydraulic structure built perpendicularly from an ocean shore (in coastal engineering) or a river bank

Causes of Coastal Erosion

The shoreline or coastline, the boundary between land and sea, keeps changing its shape and position continuously due to dynamic environmental conditions. Various developmental projects are made in coastal areas, placing great pressure on them, and leading to diverse coastal hazards like soil erosion, seawater intrusion, coral bleaching, shoreline change, etc.

The causes of erosion are either natural or man-made. Sometimes, it is a combination of both natural and man-made factors. While the former is a relentless process that is often impossible to resist, the latter is often due to ill-planned activities and can certainly be contained, or even reversed. The effects of climate change, sea-level rise and other long-term causes of erosion are still unaccounted for.

Natural Causes

Natural factors influencing coastal erosion are waves, winds, tides, near-shore currents, storms, sea level rise, etc. The combined action of different processes on the coastline like waves and tides maintains the stability of the shoreline. If for any reason, the sediment supply to a section of beach is reduced due to littoral drift/sea level rise or constant impact of waves, it can cause severe erosion.

Another important factor here is an increasing gradient in transport rate in the direction of the net transport, e.g. consider the gradient in the wave conditions due to certain relief features or bathymetric conditions. Also, the natural variation in the supply of sediments to the coastline from the river can affect the erosion of the coastline.

Another major factor promoting coastal erosion is the sea level rise. An increasing sea level will promote shoreline setbacks. This setback is higher in the littoral coasts, consisting of finer sediments, as compared to coasts consisting of coarser sediments.

Another factor is the phenomenon of subsidence. Subsidence is a regional phenomenon that lowers the surface area in a specific region. It impacts the coastline in a way similar to sea level rise, however, the rate may vary as per the factor causing this subsidence.

Also, catastrophic events like severe storms, tidal surges, and cyclones cause the sea level to rise to abnormal heights and cause severe erosion. The sudden and furious

Table 1: Findings of the Shoreline Change Atlas of Indian Coast prepared based on satellite imageries of timeframe of 2004-06 and 2014-16

State	Erosion Area (in ha)	Erosion Length (in km)	Accretion area (in ha)	Accretion Length (in km)	Stable Length (in km)	Total Length (in km)
Gujarat, Daman & Diu	313.6	109.76	207.75	49.18	1051.44	1210.4
Maharashtra	104.75	75.16	209.94	60.27	588.64	724.07
Goa	28.78	21.7	13.6	7.13	116.73	145.56
Karnataka	72.05	40.19	111.39	47.74	230.86	318.78
Kerala	285.02	137.33	303.3	121.13	327.17	585.63
Tamil Nadu and Puducherry	358.35	128.88	470.68	188.6	531.57	849.07
Andhra Pradesh	795.67	188.95	807.88	208.15	413.33	810.4
Odisha	831.35	143.6	753.5	98.77	208.19	450.53
West Bengal	393.67	56.3	141.18	33.9	67.24	157.45
Lakshadweep Islands	16.59	11.65	18.4	13.15	115.84	140.66
Andaman-Nicobar Islands	480.08	230.77	1004.01	256.31	1669.7	2156.79
Total	3679.91	1144.29	4041.63	1084.33	5320.71	7549.34

rush of water causes the bars to move seawards. The high surge also causes an offshore movement of sand due to non-equilibrium in the profile.

Man-induced erosion

Most of the human-induced erosion is due to human interventions in the natural transportation process as well as in the sediment load of the rivers. Human activity may be enumerated as Coastal defence structures, river regulation works, dredging aggregate extraction/ sand mining, oil/gas exploration (in the form of long-term subsidence), and ports/harbours that impact sediment transport.

Coastal activities can also directly or indirectly result in beach erosion. The following are some examples:

- Building houses via land reclamation or within sand dune areas has a long-term impact on coastal processes and sediment stability.
- Harbours, meant to provide safe mooring and navigation for the calling vessels, often have shore-perpendicular/inclined solid quays and breakwaters, which obstruct the long-shore transport of sand and cause accretion on the up-drift side, and erosion down drift.
- Sand removal above replenishable quantities from the coast upsets the longshore sand transport budget and can result in erosion down drift.
- Groynes and jetties and other structures on the coast/ shoreline interfere with long-shore sand transport and can result in erosion when these are ill-designed. Groynes protect a part of the shoreline by blocking littoral transport through the accumulation of the littoral sediments on the upstream side of the groynes. This causes a deficit in the littoral drift budget and this has negative consequences on the downstream as the erosion problem shifts to the downstream area.
- Structures like seawalls, bulkheads, breakwaters, etc. have side effects in terms of erosion of adjacent areas. The protective structures like sea walls lead to enhanced erosion at the end of the structure generating scouring at the toe of the seawall and shortening the beach face.
- The mining of sand/gravel along beaches and in the surf zone will cause erosion by depleting the shore of its sediment resources.

The phenomenon of Climate Change has recently emerged as an important determinant in the coastal environment. The phenomenon of Climate Change is not new to the scientific and research community. An overwhelming scientific and research consensus maintains that climate change is real.

- The maintenance dredging of harbours, navigational channels, and tidal inlets causes loss of sand from the littoral zone and the sand is dumped into the deep sea. This disturbs the dynamic sediment equilibrium of the coast and promotes erosion to re-establish the equilibrium.
- Coral mining and other means of spoiling the protective coral reefs will also cause coastal erosion and beach degradation. The production of carbonate sand stops due to the killing

of the corals and the protective function of the reef disappears.

- Vegetation is important for maintaining/improving the sediment slope stability and consolidating the sediments by trapping the sediments. The removal of dune vegetation and mangroves due to man interventions causes exposure of the low-energy shorelines to the increased energy and reduced sediment stability. This further promotes erosion of coastal zone.

Coral mining and other means of spoiling the protective coral reefs will also cause coastal erosion and beach degradation. The production of carbonate sand stops due to the killing of the corals and the protective function of the reef disappears.

In most cases, coastal erosion would be attributed to the cumulative effect of both natural and human-induced factors.

The phenomenon of Climate Change has recently emerged as an important determinant in the coastal environment. The phenomenon of Climate Change is not new to the scientific and research community. An overwhelming scientific and research consensus maintains that climate change is real.

Coasts are sensitive to sea level rise, changes in the frequency and intensity of storms, increases in precipitation, and warmer ocean temperatures. In addition, rising atmospheric concentrations of carbon dioxide (CO2) are causing the oceans to absorb more of the gas and become more acidic. This rising acidity can have significant impacts on coastal and marine ecosystems. The low-lying areas along the coast are likely to be prone to salinisation due to seawater intrusion (surface and ground).

Damage due to coastal erosion

Coastal Protection Measures

Coastal protection measures moderate the long-term average erosion rate of shoreline change from natural or man-made causes. Reduced erosion means a wider buffer zone between the land and the sea. Nature not only erodes but also protects. Protection of the coastline from erosion is provided by nature in the form of a stable beach, capable of dissipating incident wave energy. Such beaches are not available at all places along the coast. Nature's coastal protection is also demonstrated at the headlands, reefs, shores, dunes, etc.

Protection works to prevent erosion should be on a long-term basis and must be planned to suit the particular site conditions on the basis of thorough field investigation and available data which require observations over an extended period of time. However, where urgent steps are imperative to stem the onslaught of erosion and to prevent serious damages immediately, short-term measures will become necessary relying on the design and performance of the structures existing elsewhere.

The measures to control erosion include non-structural and structural or their combination. These solutions have at least two hydraulic functions to control waves and littoral sediment transport (*Kawata, 1989*); in applying the solutions, their underlying principles should be well-understood, otherwise, they will fail. A combination of hard and soft options has become more popular recently for optimum results because they have weaknesses when used singularly. Many schemes have failed and resulted in environmental and socio-economic problems owing to improper design, construction, and maintenance, and were often only implemented locally in specific places or at regional or jurisdictional boundaries, rather than at system boundaries that reflect natural processes (*Kamphuis, 2002*). Brief description of these measures is given below:

Non-structural measures

The Non-structural measures aim at the dissipation of the wave energy by mirroring the natural forces and maintaining the natural topography of the coast. These measures are also called soft solutions. Some of these are:

- Artificial nourishment of beaches
- Coastal vegetation such as mangrove and palm plantation
- Sand bypassing at tidal inlets
- Dune reconstruction/rehabilitation

Before opting for the hard structures, non-structural measures like adaptation to natural coastal processes (by using large setback distances, relocating vital structures, etc.) and moderation of coastal erosion (by stabilising coastal slopes, tripping the waves, etc.) should be used.

These measures have limitations. While artificial nourishment of beaches is complicated and costly, mangrove plantation is possible only in marshy land and in semi-tropical or tropical conditions. Some of these measures are:

Structural Measures

The structural measures, also known as the hard structural/engineering measures use physical structures constructed near the coast to prevent or restrict water from reaching the potential damage areas. These solutions influence the coastal processes to stop/reduce the rate of

coastal erosion.

The structural measures used for coastal erosion prevention include seawalls, revetment, off-shore breakwaters, groins/groynes/spurs, offshore reefs, and artificial headland.

Out of the above measures, seawall is popular and generally used in almost all maritime States in varying proportions. Brief description of the above structural measures is given in subsequent sections:

Combination of beach nourishment and groynes/ artificial headlands promotes the trapping of the downdrift movement of the sediment, thus reducing downdrift erosion. This also reduces the frequency of re-nourishment.

Combination of the Structural and Non-Structural Measures

It has already been stated that using a combination of structural and non-structural measures helps in providing better efficacy and efficiency. The combination gives synergetic outcomes and provides an environmentally and economically acceptable coastal protection system. The hard solutions offer a wide variety of disadvantages like causing erosion and unnecessary accretion at various points, being expensive, and also, at times, spoiling the economic value of the site by making it look less beautiful. In terms of the soft solutions, it may be noted that these are not quick-fix solutions and they take time to be effective and these are effective only in a medium to long-term perspective.

In view of aforesaid aspects and also to optimise the long-term positive impact of soft solutions, many combinations of soft and hard solutions can be selected. These combinations act as interim hard structures and some of the common approaches of combinations are:

- combining beach nourishment with artificial headlands/groynes
- Revegetation with temporary offshore breakwaters/ artificial reefs is commonly used.

Using a combination of beach nourishment and groynes/artificial headlands promotes the trapping of the downdrift movement of the sediment, thus reducing downdrift erosion. This also reduces the frequency of re-nourishment.

We realise that coastal erosion is an extensive and multi-dimensional problem for a vast country like ours. Efforts are being made to counter the menace of coastal erosion and to protect our coasts, using both the traditional approaches (using hard structures like a seawall, etc) and also using the new, innovative soft measures like dune rehabilitation.

The protection works are prioritised, planned, and designed as per the graveness and extent of the problem. This also helps in deciding the resource input needed for executing a particular solution. In view of this, it is of immense importance to accurately gauge the extent and graveness of coastal erosion as a problem.

All the maritime States/UTs are facing a problem of coastal erosion in varying magnitude. The latest national-level data in this regard is obtained from the Shoreline Change Atlas of the Indian Coast.

Shoreline Change Atlas of Indian Coast

Coastal Protection and Development Advisory Committee (CPDAC) constituted by the Department of Water Resources, River Development & Ganga Rejuvenation (Govt of India) recommended the need for preparation of a Coastal Atlas showing information related to coastal erosion derived from satellite data and protection measures undertaken by all maritime states of India. Accordingly, at the behest of Coastal Management Directorate, Central Water Commission (CWC), Department of Water Resources, River Development & Ganga Rejuvenation, Government of India, New Delhi, a project entitled, "Shoreline Change Atlas of the Indian Coast", was initiated by Space Applications Centre (ISRO), Ahmedabad, in collaboration with Central Water Commission. SAC and CWC worked jointly to bring out a shoreline change atlas for the time frame 1989-91 and 2004-06 in 2014.

CWC requested SAC to update the Shoreline change atlas using recent satellite data and SAC has completed the first updation based upon data from 2014-16. This Atlas comprises shoreline change maps prepared using satellite data for 2004-06 and 2014-16 time-frame on a 1:25,000 scale for the entire country. The maps show eroding, stable and accreting coasts along with the status of coastal protection measures taken up by maritime States/UTs.

Results of the Shoreline Change Atlas of Indian Coast

The shoreline is delineated from LISS-IV images of 2014-16 time frames at 1:25,000 scale and shoreline change is estimated. Atlas depicts shorelines classified as eroding, accreting and stable coast and the coastal protection works present. Around 15% of the 7549 km coastline has eroded, 14% of the coast has accreted, and the remaining of the coast remained stable w.r.t 2004-06. The area under accretion is higher than the area under erosion with a net gain of 362 ha of land. The shoreline along the eastern Indian peninsula is observed to be more dynamic and along the west coast, the shoreline changes are more along the Kerala and Karnataka coast. ❑

Marine Plastics Pollution

R Venkatesan
Yazhini Sivaram

Every year, humans produce 300 million tonnes of plastic waste including 11 million tonnes of plastic waste that eventually wind up in the ocean. In fact, by 2050, there could be more plastics than fish in the ocean. Most plastics never disappear instead, it becomes smaller, with particles being swallowed by fish and eventually consumed by Humans in their food and tap water (United Nations, 2022).

Marine Plastics pollution is a global menace. There is a need for regular and standardised monitoring of marine litter to understand long-term changes in marine litter pollution and for the successful development and implementation of mitigation strategies. This article discusses coastal clean-up and marine plastics survey in the Indian context with a focus on the Tamil Nadu coast and the way forward.

Land-based sources

Jambeck et al. (2015) estimated the global amount of plastic waste that entered the ocean in 2010 from coastal populations living within 50 km of the coastline (Lebreton and Andrady, 2019). Based on a fixed percentage of mismanaged plastic waste entering the oceans (15% for the low-range estimates and 40% for the high-range estimates), they estimated that between 4.8 and 12.7×10^6 t

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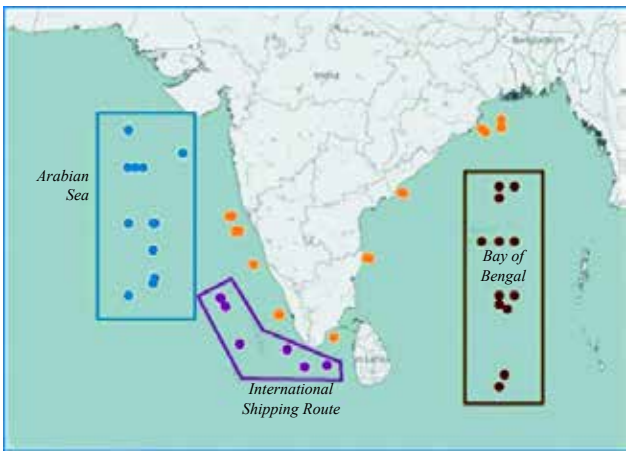


Sampling locations in Northern Indian Ocean for assessment of marine plastics

of plastic entered the global oceans.

Ocean-based sources

Plastic waste can also enter the ocean directly from ocean-based sources such as the fishing industry, commercial and recreational shipping, and offshore platforms. In 1988, the International Convention for the Prevention of Pollution from Ships (MARPOL) prohibited waste dumping from vessels (Pattiaratchi et al., 2022)

Marine Plastics Survey in India

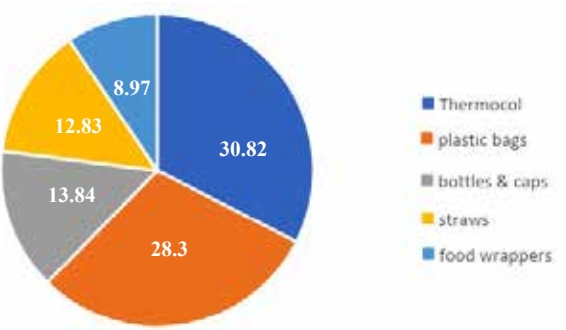
Under the Coastal Ocean Monitoring and Prediction System (COMAPS) programme (one of the longest systematic ocean data collections for 3 decades), by ICMAM-PD now the National Centre for Ocean Research of the Ministry of Earth Sciences, accumulation of marine debris was reported along the coast of Great Nicobar Island, Andaman. This accumulation might have been due to surface ocean currents prevailing leading to the transportation of solid waste dumped by passing ships/fishing vessels (Dharani et al, 2003). This is the first Indian scientific publication on marine debris and subsequently, many more research papers have been published now. It is reported that 8% of the total solid waste produced is plastic waste and the top three cities that contribute most to pollution are Delhi, Kolkata, and Ahmedabad (Bhattacharya et al., 2018). Plastic production in India increased by 39.7% and now stands at 9.46 million tonnes of plastic waste per year when five years ago it was 5.7 million tonnes per year (Sivaram et al., 2022). However only 15% of the plastic waste produced is recycled in India and the rest is sent to landfills, incinerators, or dumped into the oceans and rivers. 0.6 million tonnes of plastic waste end up in oceans from India alone via rivers, surface run-off etc. (Sivaram et al., 2022). Rivers contribute to about 67% of the total marine plastic debris in the world (Lebreton et al., 2017). The Ganges originates from Western Himalayas and flows through four countries and discharges in the Bay of Bengal. The Ganges discharges about 105000 tonnes of plastic waste into the Bay of Bengal every year (Lechthaler et al., 2021).

Accumulation of marine debris was reported along the coast of Great Nicobar Island, Andaman. This accumulation might have been due to surface ocean currents prevailing leading to the transportation of solid waste dumped by passing ships/fishing vessels.

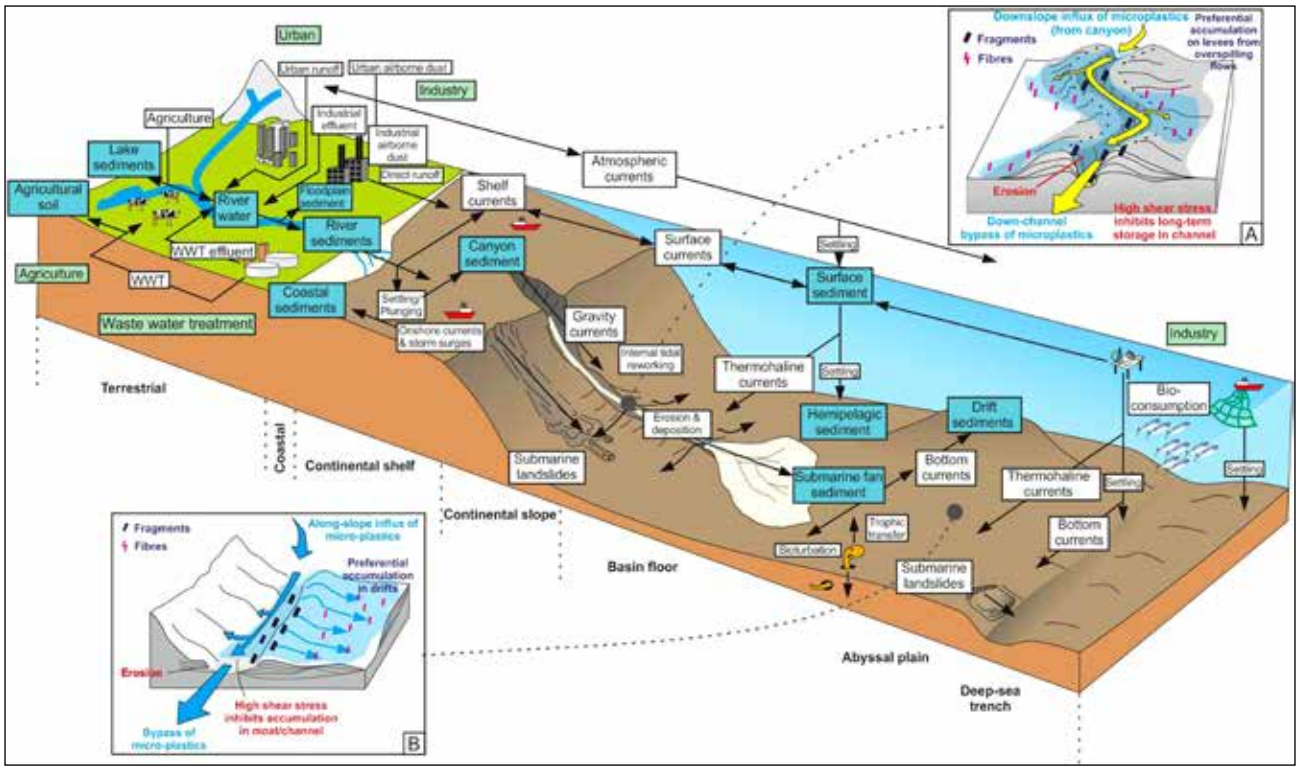
Tamil Nadu Coast

Tamil Nadu has a long coastline but stands second in plastic production in India and the plastic waste reaching through rivers and land run-off and ghost gear dumped cause serious problems to the flora and fauna as well as the livelihood of the fishing communities along the coast (Sivaram et al., 2022). The Government of Tamil Nadu banned the usage of thin plastic (polymers of thickness below 40 microns). Despite such laws passed, Chennai is the major cause of plastic production in Tamil Nadu as it produces about 898700 tonnes of plastic waste per year of which 57000 tonnes per year are disposed into the ocean. The major contributors to the discharge of plastic into the ocean are the Adyar and the Cooum rivers (Sivaram et al., 2022), which running through the heart of the city accounting for 81% and 19% of total riverine discharge from Chennai, respectively. Thermocol (30.82%), plastic bags (28.30%), bottles & caps (13.84%), straws (12.83%), and food wrappers (8.97%) comprise the majority of macroplastic debris. Comparing these estimates with data collected from about five years ago, there seems to be 71.67% increase in plastic discharge into ocean from Chennai alone (Mallapur, 2014; The Pioneer, 2013). This alarming increase could be due to the increased usage of disposable plastics like masks, covid protection kits, and home deliveries (Plastic used for packaging is the major contributor to plastic waste).

Sea-based waste must also be taken into consideration. The fishing boats of Tamil Nadu can be



Major microplastic debris discharged by rivers in Chennai (Ref Lechthaler et al., 2021).



Settlement and transport of plastics in the midwater column of the ocean through various governing factors (Source : Kane & Clare, 2019)

classified as traditional (catamaram, dug-out canoes, plank-built canoes, masula boats, dhinghi, outrigger canoes, built-up boats) and mechanised (hand line boats, pole and line fishing vessel, trolling vessel, dol netter, gill netter, Stern trawlers) (Sivaram et al., 2022) and the major fishing gear types include gillnets, hook and line, shore seines and boat seines (FAO, 1983). No reliable sources are available to calculate the estimated ALDFG along Tamil Nadu coast.

Biodiversity - Gulf of Mannar Biosphere

The Gulf of Mannar is an important biodiversity hotspot as it supports numerous marine ecosystems and provides a sense of economic security for Tamil Nadu due to its fisheries resources. It is situated in Tamil Nadu and extends from Rameswaram to Kanyakumari. Horst-Graben structure, the prevalence of monsoon, two courses of drift in water currents, Cenozoic sedimentary functions and riverine processes make the Gulf of Mannar biosphere ideal for a lot of marine biota and stable marine ecosystems. Anthropogenic influences on the environment leading to pollution and climate change are the major causes of biodiversity degradation worldwide, ALDFG, untreated sewage and solid wastes from domestic and industrial sources (Edward et al., 2020).

The Gulf of Mannar is an important biodiversity hotspot as it supports numerous marine ecosystems and provides a sense of economic security for Tamil Nadu due to its fisheries resources. Anthropogenic influences on the environment leading to pollution and climate change are the major causes of biodiversity degradation worldwide.

Abandoned, Lost, or Discarded Fishing Gear (ALDFG)

Abandoned, Lost, or Discarded Fishing Gear (ALDFG) is a serious problem worldwide as there is a lack of data. Most of these wastes are due to shipping or fishing accidents, bad weather, etc., and while most of the lost gears are retrieved by the fishers, the little that remains causes serious problems to the marine ecosystems. A lot of species are killed by these wastes, and since they do not decompose easily, they keep killing various organisms throughout their lifetime. About 20% of all the plastic debris in the oceans is from ALDFG according to UNEP. Globally, it is estimated that about 640000 tonnes of ghost gears are disposed into the oceans every year (Sivaram et al., 2022).

India has 174000 units of fishing gear in operation, of which 154008 units are gillnets / driftnets and 7285 units are traps while the remaining is fishing lines (Thomas et al., 2019). Of these, 15276 tonnes of gillnets are

lost from India per year (FAO, 2020).

Microplastics

Plastics are made from non-renewable resources such as crude oil and hence they are hard to decompose as the polymers are bonded through covalent bonds, a strong bonding force. Microplastic is about 5mm in diameter and is always disposed into the environment through anthropogenic sources (Sivaram et al., 2022). They are particularly hard to locate, track and study as they are smaller than what the naked eye can see. Another major issue with microplastics is that they show a high affinity to other toxicants, making them more dangerous to the organisms ingesting them. The majority of the plastic debris (~94%) in the oceans disintegrates into microplastic while the remaining 6% remains as microplastic (Sivaram et al., 2022). This makes it important to study microplastic and their dynamics.

Microplastics show a high affinity to other toxicants, making them more dangerous to the organisms ingesting them. Calculating the amount of microplastic entering the ocean can be challenging as they are small and the rate at which plastics degrade is unknown. Large discharge causes harm to the natural ecosystems and inevitably affects humans too.

Calculating the amount of microplastic entering the ocean can be challenging as they are small and the rate at which plastics degrade is unknown. Nevertheless, the abundance of microplastic from Chennai is found to be +/- 184 microplastic/kg of sediments (Satish et al., 2019) and about 0.33 particles/l of water from Adyar river (Sivaram et al., 2022). Adyar river discharges about 11.6 trillion microplastic particles into the Bay of Bengal per year (Lechthaler et al., 2021). Such a large discharge causes harm to the natural ecosystems and inevitably affects humans too. Microplastic abundance was studied, and it was found that the polymers PE contributes to 46.7%, PP to 46.7% and PS to 6.7% of all the microplastic (Fig.2) About 64 % are fibres, 22% films, 12% fragments and 2% pellets and 44% of them were black, 30.4% red, 14.2% white (Lechthaler at al., 2021). These are the types of microplastic discovered in the natural ecosystem so far.

Under the Marine Plastics survey programme of NCCR, the distribution of microplastics was studied in Coastal locations in the Bay of Bengal (BoB) and Arabian Sea (AS) in particular along the International shipping routes. This study showed microplastics are observed in almost all the sampled sites in the Open Ocean in the 100m mid-water column in all seasons. Compared to other transects, more microplastics were observed during pre-monsoon in BoB and post-monsoon in AS. The coastal locations in post-monsoon show three times concentration lesser than AS. Some samples had no plastics at a few locations in the Arabian sea and in the Bay of Bengal. The most dominant type of microplastics found in the water column is microfiber/lines. The major types of polymers identified in the study are Polypropylene (PP), High-Density Polyethylene (HDPE), Low-Density Polyethylene (LDPE), and Poly(amide-6) (Nylon). Further, extensive sampling is needed to understand the vertical movement of the microplastics.

One of the main plastics, polyethylene terephthalate (PET), is found in clothes and when these clothes are washed small plastics known as microplastics are released. Biodegradation offers a method to remove and prevent a build-up of microplastics (and potentially a new recycling method). Biodegradation is a process by which enzymes break up a polymer (e.g., PET) back into its original monomer form. Global research is focused on the use of plastic-degrading enzymes is a promising future prospect in managing and recycling robust plastics such as PET.

Swachh Sagar, Surakshit Sagar

Commemorating the 75th year of India's independence, a coastal cleanup drive was carried out at 75 beaches across the country for 75 days over 7500 km long coastline. This unique first-ever national campaign culminated on "International Coastal Clean-up Day" on 17 September 2022. This drive was aimed to remove 1,500 tonnes of garbage from the sea coast which will be a huge relief to marine life and the people staying in coastal areas.

Discussion

Many industries employ plastic in various products due to its nature and ease of production. They have certainly helped us enhance the efficiency of products, leading to a constant demand for them. While the petrochemical sector is regarded as the backbone of plastic production, it is also considered a yardstick for measuring global economic growth, wherein plastic processing and production are of vital importance. It is expected that in the current financial year (2018) exports would cross 8 billion USD with increased growth of 9.5% in the first half of FY 2018 as compared to the past year. It is also envisaged that exports are expected to double in the next five years, owing to the growing domestic production. However, at a matching rate, the volume of plastic waste has also grown over the years, not just in India, but globally. The major challenge, however, is the segregation and re-aggregation of plastic waste streams such as packaging waste, including laminated plastic.

The biodiversity of India is unique, and steps must be taken to ensure its safety. Millions of people's livelihood depends on the biodiversity of India so care must be taken to protect and boost environmental health. Plastic pollution is a concerning issue as consumption and discharge have increased but no steps have been taken by India to study, monitor, and reduce plastic usage. While the petrochemical sector is regarded as the backbone of plastic production, it is also considered a yardstick for measuring global economic growth, wherein plastic processing and production are of vital importance. However, the volume of plastic waste has also grown over the years. Microplastics add to the harmful effects caused by plastic. These make it necessary to find ways to reduce the usage of plastic because India needs diverse ecosystems to thrive. ❑

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SPECIAL ARTICLE

Blue Economy

Mahabir Singh

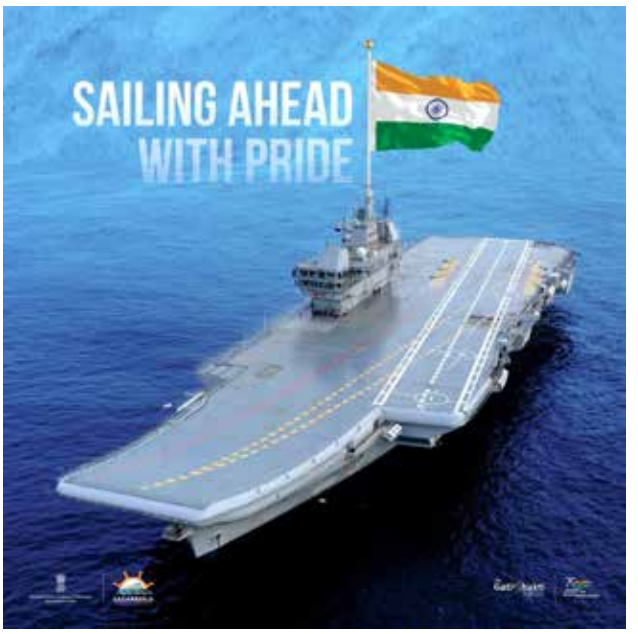
With its geographic and geostrategic position in and critical dependence on the Indian Ocean, India has been leading the Blue Economy discourse at the highest level of the Government, with a greater focus on the Indian Ocean region. The Indian Ocean's Blue Economy has become a global economic corridor. It is the world's third-largest body of water, covering 68.5 million square km and rich in oil and mineral resources, and countries around the ocean's periphery are home to about one-third of humanity.

One-third of planet earth is land and the remaining two-thirds is water. Mankind has habitually exploited nature to serve its own ends. As the human population is rapidly increasing, the available land remains the same which has led to immense pressure on its resources. The population growth and resultant consumption of natural resources have exceeded the regenerative capacities of natural systems. The human pattern and practices of using land have irreparably diminished natural resources. The ocean is one of Earth's most valuable natural resources. Mankind exploits the ocean to meet his energy, food, recreational, military, and other needs. Oceans are used for transportation-both travel and shipping. Today around 80% of world trade is seaborne. As the volume of global trade increases, predictions are that global commercial vessel traffic is expected to double or treble in the next 20 years.

Among the world's oceanic divisions, the Indian Ocean is the third largest, covering an area of more than 70 million sq km that includes extensive Exclusive Economic Zones (EEZ) of different countries and large "High Seas". The economic and sustainable development issues in the Indian Ocean rim are particularly challenging since a majority of littorals are developing countries. These countries are home to one-third of the world's population that rely extensively on marine resources for livelihood and food security. The sheer size of this population subjects the Indian Ocean's resources to pressures from pollution, habitat degradation, and over-exploitation. As the population of the region is projected to increase significantly in the coming decades its impact on food security and the economy from marine resources would become more substantial.

Maritime Governance and Blue Economy

With its geographic and geostrategic position in and critical dependence on the Indian Ocean, India has been leading the Blue Economy discourse at the highest level of the Government, with a greater focus on the Indian Ocean region. The essence of this approach was spelled out by Government for seeking "Security And Growth for All in



Mahabir Singh, Commandant is JD (Air Staff), Indian Coast Guard. Email: proicg@rediffmail.com

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the Region" (SAGAR). The Indian Ocean is vital to the economies, security, and livelihoods of its littoral states. India is focussing on overall maritime governance including economies based on marine resources assured, advancing the blue economy through sustainable management and utilisation of the ocean's resources, food security, and livelihoods for achieving Sustainable Development Goals (SDG). The current governance framework of marine resource management in the Indian Ocean explores the challenges in Blue Economy development to ensure sustainable development in the region. Maritime security is essential to ensure a holistic approach toward the governance, use, and maintenance of Oceans.

Concept of Blue Economy

The Blue Economy encompasses a wide range of economic activities pertaining to the sustainable development of resources and assets in the oceans, related rivers, water bodies, and coastal regions – in a manner that ensures equity, inclusion, innovation, and modern technology. Subtly distinguishable from the "Ocean Economy" in terms of nuance and emphasis, the Blue Economy is a newer and more contemporary term, popular with Small Island Developing States (SIDS) as well as international organisations, media, experts, and governments in a growing number of countries. The Blue Economy is viewed as an integral element of Sustainable Development Goals.

Why focus on Blue Economy?

It would, as Indian Ocean Rim Association (IORA) points out, "contribute to food security, poverty alleviation, the mitigation of and resilience to the impacts of climate change, enhanced trade and investment, enhanced maritime connectivity, enhanced diversification, job creation, and socio-economic growth." From the business perspective, Blue Economy requires innovative and dynamic business models, forming business connections between India and

other relevant countries, especially those located in the Indian Ocean region. It may be underlined that the theatre of the development of the Blue Economy, from India's prism, will be the waters surrounding it, i.e. the Indian Ocean. Hence the countries situated in our immediate and extended neighbourhood would receive our focal attention. India's population is estimated to rise to 1.7 billion in 2050. The Blue Economy may offer a partial path toward food security and millions of jobs to the unemployed.

Overview of India's Blue Economy

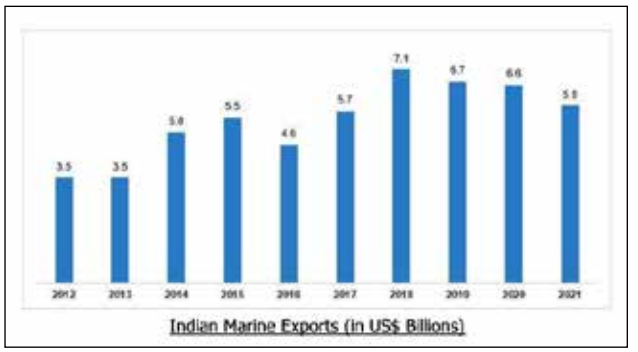
The Blue Economy of India is a subdivision of the national economy that includes the complete ocean resources system as well as human-made economic infrastructure in the country's legal jurisdiction marine, maritime, and onshore coastal zones. India's Blue Economy concept is multi-faceted and plays an important role in the country's economic growth because of its enormous maritime interests. It accounts for roughly 4% of the GDP and is estimated to increase once the mechanism is improved. The sector has stood strong despite the challenges caused by the Covid-19 pandemic and has recorded exports worth US$ 7.2 billion between April 2021- February 2022.

Ocean resources, physical infrastructure for maritime economic development, marine amenities, and coastal management services are all part of the plan to ensure economic growth and sustainability, as well as national security. Fisheries and minerals are the two most viable components of the blue economy in India. The two mineral deposits of commercial significance to developers in the Indian Ocean are polymetallic nodules and polymetallic huge sulphides. Polymetallic nodules, which are golf-to-tennis-ball-sized nodules containing nickel, cobalt, iron, and manganese that grow over millions of years on the seafloor, are often discovered at 4-5 kms in water depth. In 1987, India was granted exclusive rights to explore polymetallic nodules in the Central Indian Ocean Basin. It has explored four million square miles and established two mine locations since then.

The coastal economy sustains over 4 million fishermen and coastal towns. India is the second largest fish-producing nation in the world and has a fleet of 2,50,000 fishing boats. India has a remarkable marine position with 7,517 kilometers of coastline. Nine of India's states have access to the coastline. India comprises 200 ports of which 12 are major ports that handled 541.76 million tones in FY 2021, the highest being Mormugao Port, located in Goa, which handled 62.6% of the total traffic. Shipbuilding and shipping are also important aspects of the blue economy in India. The modal share of coastal shipping has the potential to increase to 33% by 2035, up from roughly 6% presently. Most of the country's oil and gas are supplied by sea, leading to making the Indian Ocean region critical to India's economic growth. This reliance is expected to increase dramatically by 2025.

India's Blue Economy concept is multi-faceted and plays an important role in the country's economic growth because of its enormous maritime interests. India's Blue Economy accounts for roughly 4% of the GDP and is estimated to increase once the mechanism is improved.

The Indian Ocean's Blue Economy has become a global economic corridor. It is the world's third-largest body of water, covering 68.5 million square km and rich in oil and mineral resources, and countries around the ocean's periphery are home to about one-third of humanity. India has significant diplomatic interests in the Indo-Pacific, as well as international commitments in the region under the UNCLOS, such as Search and Rescue, seabed mining, and



Indian Marine Exports (in US$ Billions)

counter-piracy.

There have been efforts to boost the fisheries sector of India in order to harness its full capacity.

The Blue Revolution: Integrated Development and Management of Fisheries

Centrally Sponsored Scheme (CSS) was established in 2015-16 with a five-year budget of Rs. 3,000 crores (US$ 384.3 million). The 'Fisheries and Aquaculture Infrastructure Development Fund' (FIDF) was established in 2018-19 with a fund size of Rs. 7,522.48 crores (963.5 million) to provide concessional credit to state/UT governments, their entities, and the private sector to fill significant gaps in the fisheries infrastructure. The Government of India launched the Pradhan Mantri Matsya Sampada Yojana (PMMSY), in May 2020, with the highest investment of Rs. 20,050 crore (US$ 2.5 billion) to bring about a Blue Revolution through sustainable and responsible development of the country's fisheries sector.

Maritime Security Strategy

India's maritime security strategy focuses on all aspects of the challenges including the ocean economy that are affecting the health and the future of oceans and countries. As it combines the traditional and non-traditional security paradigms of maritime security, it provides a cohesive definition that is apt to address prevalent challenges such as environmental degradation, ocean trade security, migration, climate change, energy security, drug trafficking, and piracy among other non-traditional challenges.

Climate change, environmental degradation, access to resources and expanding sea lanes, and the evolving international ocean regime highlight the need to focus on maritime security. With nations committed to fulfilling the Sustainable Development Goals (SDGs) towards Blue Economy, the role of oceans in this is significant. Addressing the strategic, environmental, and ocean ecosystem challenges is one of the greatest challenges for India and the world.

Maritime security is an enabler of the Blue Economy, for example through safeguarding navigation routes, providing important oceanographic data to marine industries, and protecting rights over valuable marine resources and activities within claimed zones of maritime jurisdiction. The non-traditional security threats have effects on the military and also on strategy, policy, operations, training, capacity building, and environmental protection. The security issues have also seen a transition as maritime security moved from military and traditional issues to non-traditional security threats. Today, minerals are the significant drivers of economic development. India and China are the most active nations in the Indian Ocean region. China is already exploring minerals at the South-West Indian Ocean border. Therefore, there are huge opportunities but uncertainty still looms over mineral exploration with the possibility of large-scale pollution. There is a need to conduct further research to understand the impacts of deep-sea mining on the ocean ecosystem and ecology.

Unregulated and illegal fishing is another aspect that endangers the ocean ecology and while checks and balances have been established to address illegal, unreported, and unregulated fishing (IUU), the current international law regime still lacks rigid barriers and stringent mechanisms to address the rising problem.

Indian Coast Guard (ICG): A Maritime Blue Economy Enabler

With the Indian Coast Guard playing a far bigger role in averting major pollution incidents, anti-poaching, and Search & Rescue, its importance as an essential actor in non-traditional security is well established. The role of Indian Maritime Forces and the definition of maritime security have changed especially in the Indian context, highlighting the myriad challenges and opportunities of the current maritime global order that would be faced by India in the coming decades while pursuing a Blue Economy.

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As India is all set to achieve the goals of the Blue Economy, the role of ICG becomes very crucial. The duties of ICG as enshrined are in consonance with the Blue economy vision of the Government. Indian Coast Guard is one of the major maritime law enforcement agencies in the Indian Ocean Region. India focuses on the development of sectors viz. fisheries, shipping, port, and maritime logistics, marine coastal tourism and leisure,

conventional minerals exploration and production, and marine construction activities. Other emerging sectors are renewable ocean energy including offshore wind, tidal, and wave energy, offshore extraction of oil and gas in deep-sea and other extreme locations, seabed mining for metals and minerals, marine aquaculture, marine biotechnology, ocean monitoring, control and surveillance, and education and research which can be harnessed to our advantage.

India has a 7517 km coastline, 1197 islands, and an Exclusive Economic Zone (EEZ) spanning 2.01 million sq km, which is expected to go up to almost 3 million sq km after the delimitation of the continental shelf. India is strategically located between two important choke points namely the Strait of Hormuz and the Strait of Malacca, through which most of the trade in commercial shipping moves in the Indian Ocean. These straits and rim of the Indian Ocean are laced with a large number of countries from four continents-Asia, Africa, Australia, and Antarctica. It is a large mass of water that has deep-lying resources and dense traffic. The traffic of hazardous and noxious substances for industrial and energy purposes is constantly increasing. Many of the nations in the rim have political problems and regional stability is therefore only transitory. Piracy and other transnational crimes are rampant and ongoing almost daily. Such crimes support militant activism and homemade insurgencies. Considering the future of the exploitation of ocean resources in the IOR, the Indian Coast Guard will have a major role to play.

Indian Coast Guard is the nation's premier maritime agency, the sea has taught generations of ICG men and women to be vigilant and devoted to duty. The Lifesavers, as they are known to many Indians, never fail to live up to their motto and heritage. They provide a broad array of services to protect people and the maritime environment. The future will bring an increased demand for these and other services that can only be dimly perceived today. The Indian Coast Guard has been carrying out duties such as oil spill response, helping mariners in distress at sea, warning vessels during bad weather, offering assistance during scientific experiments, and augmenting the national defence resources. These duties coupled with other challenges would be the focus area of various enablers of the Blue Economy.

Conclusion

In pursuit of the SDGs of Blue Economy, revolutions in maritime transportation and information systems, growth of ports and shipping, mineral research and exploitation, emerging threats to the marine environment, and changing national security concerns will shape the course of the Nation. More than ever, India will call upon the Coast Guard to protect lives and serve the national interests on the high seas, along the Nation's maritime borders and coasts. Mindful of these responsibilities, the ICG has charted its course and embarked on an ambitious plan to renew assets and increase capabilities, by matching its high-performing people with modern equipment and technologies, the Indian Coast Guard will remain always ready to meet the challenges ahead. ❑

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INS Vikrant: India's First Indigenous Aircraft Carrier

India made a historical milestone as it commissioned its first-ever Indigenous Aircraft Carrier (IAC)— Vikrant. Designed by the Indian Navy's in-house Warship Design Bureau (WDB) and built by Cochin Shipyard Limited, a Public Sector Shipyard under the Ministry of Ports, Shipping & Waterways, Vikrant has been built with state-of-the-art automation features and is the largest ship ever built in the maritime history of India.

The 262 meters long and 15-story high INS Vikrant, with a flight deck comparable to two football fields with an angled sky jump, is quite an engineering and ship-building marvel. INS Vikrant is more than five times the size of any warship ever built in the country. India now joins a select group of countries like the US, Russia, China, France, and the UK that can indigenously design, build and integrate an aircraft carrier.

INS Vikrant has been built with state-of-the-art automation features and is the largest ship ever built in the maritime history of India.

The Indigenous Aircraft Carrier is named after her illustrious predecessor, India's first Aircraft Carrier which had played a vital role in the 1971 war. It has a large number of indigenous equipment and machinery, involving major industrial houses in the country as well as over 100 MSMEs. With the commissioning of Vikrant, India will have two operational Aircraft Carriers, which will bolster the maritime security of the nation.

Every part of INS Vikrant has its own merits, a strength, a development journey of its own. It is a symbol of indigenous potential, indigenous resources, and indigenous skills. The steel installed in its airbase is also indigenous, developed by DRDO scientists.

INS VIKRANT

- Made using indigenous equipment and machinery
- Machinery supplied by India's major industrial houses as well as over 100 MSMEs
- Largest ship ever built in the maritime history of India
- Houses state-of-the-art automation features

The Indian Navy's present force level comprises about 150 ships and submarines. There are presently more than 50 ships and submarines under construction. India's preferred choice of inducting ships has been through the indigenous route. Over the years, the Indian Navy has taken a conscious decision to encourage other shipyards, including private yards, to enter the specialised field of warship construction. The indigenous warships construction has come a long way since the commissioning of INS Nilgiri in 1972. There are not many countries in the world that have capability to produce such a wide variety of warships ranging from Fast Attack Craft to Aircraft Carrier. However, few ships are being inducted from abroad also to bridge the gap in the capabilities envisaged in the Master Plan of Navy. ❑

Source: PIB

Sailing Through the History

Aircraft carriers are extremely strong and have powerful weapons. Their military capabilities, which include carrier-borne aircraft, have completely changed the marine domain. An aircraft carrier offers a wide range of strategic benefits. It offers incredibly flexible operational options. Surveillance, air defence, airborne early warning, protection of Sea Lines of Communication (SLOC), and anti-submarine warfare are some of its principal functions.

For India, the carrier battlegroup, with its inherent combat elements and firepower, becomes a key capability to establish effective air dominance and efficient sea control.

History of Aircraft Carriers in India

Right from its Independence, India was well aware of the need for aircraft carriers to establish itself as a blue water navy. Since the sixties, the Indian Navy has had the unique distinction of operating all variants of aircraft launch and recovery systems.

INS Vikrant (R11)- India's First Aircraft Carrier

The INS Vikrant was launched on September 22, 1945 as Hercules. However, its construction was stalled and was completed when India purchased it from Britain in 1957. On March 04, 1961 it was commissioned as Vikrant in its first avatar. It was placed under the command of Captain Pritam Singh Mahindroo. On March 05, 1961, Vikrant sailed from Belfast for Portsmouth and Portland to carry out sea trials, and on October 06, 1961, Vikrant finally sailed for India. It entered Bombay on November 03, 1961.

The 19,500-tonne Carrier, INS Vikrant was the first ever carrier for an Asian country and remained so for a long time. Soon after its commissioning, the INS Vikrant saw action during the Goa Liberation Operation in 1961.

It played a crucial role in the 1971 war with its aircrafts decimating the enemy. The Sea Hawks and Alizés pounded the enemy targets over Chittagong, Cox's Bazar, Khulna

INS Vikrant

and Mongla. Heavy damage was inflicted on the ships and harbour installations. The runways at the first two places were rendered inoperable, and along with other units of the fleet, Vikrant ensured a total blockade off East Pakistan. The INS Vikrant helped in preventing reinforcement of Pakistani forces from the sea, leading to the birth of Bangladesh.

The INS Vikrant emerged in a new avatar as a Vertical/ Short Take Off and Land (V/STOL) carrier in 1984, with the brand new, state-of-the-art aircraft Sea Harrier. Its new capability inspired the induction of INS Vikramaditya, and the plans of its reincarnation. After serving for 36 years, it was decommissioned from active service on 31 January 1997.[1]

INS Viraat- Over 30 Years of Service to the Nation

INS Viraat was originally commissioned by the British Royal Navy as HMS Hermes on November 18, 1959. It served the Royal Navy in three different avatars- 1959-1970: as the Strike Carrier, 1970-1980- as a Commando Anti-Submarine Warfare Carrier, and 1980 onwards it was a V/STOL Carrier, for which it underwent major structural modifications. This included a 12-degree ramp designed to optimally launch Sea Harrier Operations.

In 1982, Hermes saw action in the Falklands under the command of Captain Middleton where she distinguished herself as the Flagship of the Royal Navy in the campaign to regain Falklands and South Georgia from Argentina.

The 74-day war in hostile weather saw the Sea Harriers undertake 2376 sorties and shoot down 20 enemy aircrafts with the loss of two Sea Harriers to enemy ground fire.

The Indian Navy, in need of a second aircraft carrier, acquired the HMS Hermes on April 24, 1986. INS Viraat was finally commissioned by the Indian Navy on 12 May 1987. After acing a set of tests and trials, on July 23, 1987 it sailed from Plymouth to India, reaching the Indian waters on 21 August 1987. It was 227 metres long and 49 metres wide and had a full load displacement of 28,700 tons.

INS Viraat's first major operation was **'Operation Jupiter'** in July 1989 as part of Peace Keeping Operations in Sri Lanka, following the breakdown of the Indo-Sri Lankan Accord of 1986. On July 27, 1989, the ship flew 76 helicopter sorties off Kochi to board more than 350 soldiers and more than 35 tonnes of supplies for the 7 Garhwal Rifles. The INS Viraat and its task group continued to be stationed out in the field for the next two weeks, using the opportunity to train soldiers, proving the Viraat's operational adaptability.

It also played a pivotal role in **Operation Parakram**, which was carried out in the wake of the 2001 terrorist attack on the Indian Parliament. By establishing a blockade against Pakistan during the 1999 Kargil War, the INS Viraat also played a crucial part in **Operation Vijay**. The ship has additionally taken part in a number of foreign joint exercises, including **Malabar** (with the US Navy), **Varuna** (with the French Navy), and **Naseem-Al-Bahr** (with the Oman Navy), as well as being a crucial component of every year's

INS Viraat

Theatre Level Operational Exercise (TROPEX). The ship's last operational deployment was in February 2016 when it took part in the International Fleet Review (IFR-2016) at Visakhapatnam.

The INS Viraat has played a pivotal role in spearheading India's maritime resurgence. Since 1987, the ship's deck launched 22,034 hours of flying, it spent 2,250 days at sea sailing over 5.8 lakh Nautical Miles. It was decommissioned from service on March 06, 2017.

INS Vikramaditya- Indian Navy's Biggest Ship

Russia's refurbished Admiral Gorshkov was commissioned into the Indian Navy as INS Vikramaditya at Severodvinsk, Russia on November 16, 2013. It is a state-of-the-art ship, capable of operating a versatile range of high-performance aircrafts, such as the MiG 29K fighters, KM 31 AEW helicopters, multi-role Seakings and utility Chetaks. The ship is over 285 meters long and 60 meters wide, making it the biggest ship in the Indian Navy. Her 23 decks scale a height of 60 meters.

With over 1,600 personnel on board, INS Vikramaditya is literally a 'Floating City'. With a capacity of over 8,000 tonnes of Low Sulphur High-Speed Diesel (LSHSD), she is capable of operations up to a range of over 7,000 nautical miles or 13000 kms. The ship has the ability to carry over 30 aircrafts, comprising an assortment of MiG 29K/Sea Harrier, Kamov 31, Kamov 28, Sea King, ALH-Dhruv and Chetak helicopters. The MiG 29K swing role fighter is the main offensive platform and provides a quantum jump for the Indian Navy's maritime strike capability. These fourth-generation air superiority fighters provide a significant fillip for the Indian Navy with a range of over 700 nm and an array of weapons including anti-ship missiles, Beyond Visual Range air-to-air missiles, guided bombs and rockets.

INS Vikramaditya

The ship is equipped with state-of-the-art launch and recovery systems along with aids to enable smooth and efficient operation of ship-borne aircraft. Major systems include the LUNA Landing system for MiGs, DAPS Landing system for Sea Harriers and Flight deck lighting systems.

INS Vikrant (IAC-1): The Self-Reliant Rebirth

The 262-metre-long carrier has a full displacement of close to 45,000 tonnes which is much larger and advanced than her predecessor. The ship is powered by four Gas Turbines totaling 88 *MW* power and has a maximum speed of 28 Knots. Built at an overall cost of close to Rs. 20,000 crores, the project has been progressed in three Phases of contract between MoD and CSL. It has an overall indigenous content of 76%.

INS Vikrant (IAC-1)

Vikrant has been built with a high degree of automation for machinery operation, ship navigation, and survivability, and has been designed to accommodate an assortment of fixed- wing and rotary aircraft. The ship would be capable of operating air wing consisting of 30 aircraft comprising of MiG-29K fighter jets, Kamov-31, MH-60R multi-role helicopters, in addition to indigenously manufactured Advanced Light Helicopters (ALH) and Light Combat Aircraft (LCA) (Navy). Using a novel aircraft operation mode known as STOBAR (Short Take-Off but Arrested Landing), the IAC is equipped with a ski-jump for launching aircraft, and a set of 'arrester wires' for their recovery onboard. ❑

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New Ensign of Indian Navy

The new Navy flag was unveiled by the Prime Minister Narendra Modi in September 2022. Resonant to the ongoing national endeavour to move away from the colonial past, a need was felt to transition to a new design that drew inspiration from our history. The White Ensign identified nationwide with the Navy, now comprises of two main constituents - the National Flag in the upper left canton, and a Navy Blue - Gold octagon at the centre of the fly side (away from the staff). The Octagon is with twin golden octagonal borders encompassing the golden National Emblem (Lion Capital of Ashoka– underscribed with 'Satyamev Jayate' in blue Devnagri script) resting atop an anchor; and superimposed on a shield. Below the shield, within the octagon, in a golden bordered ribbon, on a Navy Blue background, is inscribed the motto of the Indian Navy 'Sam No Varunah' in golden Devnagri script. The design encompassed within the octagon has been taken from the Indian Naval crest, wherein the fouled anchor, which is also associated with the colonial legacy, has been replaced with a clear anchor underscoring the steadfastness of the Indian Navy. ❑

- Inspired by the seal of Chhatrapati Shivaji Maharaj
- Befitting the rich Indian maritime heritage
- Octagonal shape represents Indian Navy's multi-directional reach.

Source: PIB

Port-led Development

Sagarmala is the flagship programme of the Ministry of Shipping to promote port-led development in the country through harnessing India's 7,500 km long coastline, 14,500 km of potentially navigable waterways and strategic location on key international maritime trade routes. The main vision of the Sagarmala Programme is to reduce logistics cost for international and domestic trade with minimal infrastructure investment.

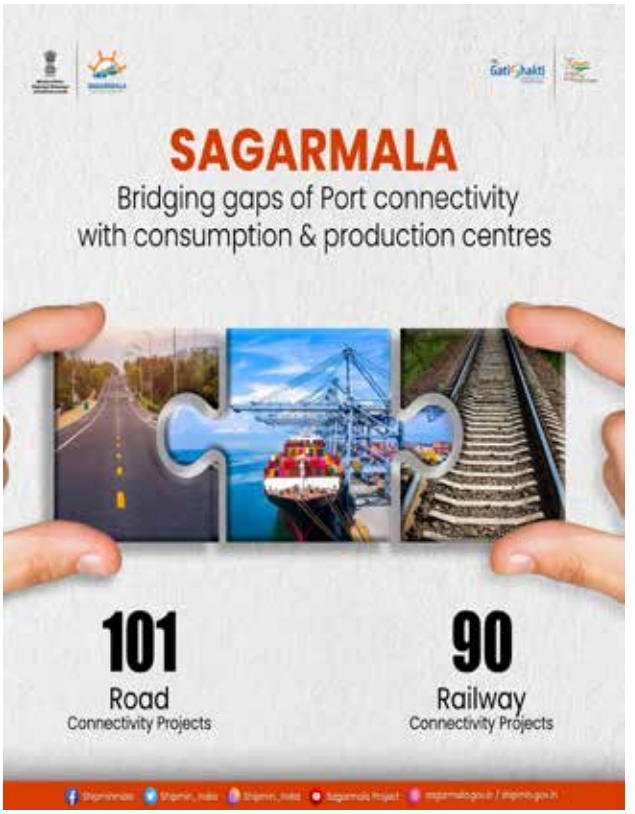
The prime objective of the Sagarmala Project is to promote port-led direct and indirect development and to provide infrastructure to transport goods to and from ports quickly, efficiently and cost-effectively. Therefore, the Sagarmala Project aims to develop access to new development regions with intermodal solutions and promotion of the optimum modal split, enhanced connectivity with main economic centres and beyond through expansion of rail, inland water, coastal and road services.

The Sagarmala initiative addresses challenges by focusing on three pillars of development, namely-

i. Supporting and enabling Port-led Development through appropriate policy and institutional interventions and providing for an institutional framework for ensuring inter-agency and ministries/departments/states' collaboration for integrated development,

ii. Port Infrastructure Enhancement, including modernisation and setting up of new ports, and

iii. Efficient Evacuation to and from hinterland.



The Sagarmala Project intends to achieve the broad objectives of enhancing the capacity of major and non-major ports and modernising them to make them efficient, thereby enabling them to become drivers of port-led economic development, optimising the use of existing and future transport assets and developing new lines/linkages for transport (including roads, rail, inland waterways and coastal routes), setting up of logistics hubs, and establishment of industries and manufacturing centres to be served by ports in EXIM and domestic trade. In addition to strengthening port and evacuation infrastructure, it also aims at simplifying procedures used at ports for cargo movement and promotes usage of electronic channels for information exchange leading to quick, efficient, hassle-free, and seamless cargo movement.

Under Sagarmala Programme, an integrated approach is being adopted for improvement in quality of life with a focus on skill building and training, upgrading of technology in traditional professions, focused, and time-bound action plan for improving physical and social infrastructure in collaboration with the coastal states. The main features of the Coastal Community Development plan include Skill development, Coastal tourism, Development of fishing harbours, and R&D in the Port and Maritime Sector.

Under Sagarmala Programme, an integrated approach is being adopted for improvement in quality of life with a focus on skill building and training, upgrading of technology in traditional professions, focused, and time-bound action plan for improving physical and social infrastructure in collaboration with the coastal states. The main features of the Coastal Community Development plan include Skill development, Coastal tourism, Development of fishing harbours, and R&D in the Port and Maritime Sector.

To ensure technology-based skill development, the Ministry of Shipping has set up Centre of Excellence in Maritime & Shipbuilding (CEMS) with two campuses at Vizag and Mumbai that are operational since February 2019. The centres provide skilled manpower in the Maritime and ship building sector.

Sagarmala Programme in coordination with related Central Ministries and State Governments aims to fund capacity building, infrastructure, and social development projects related to value addition in fisheries, aquaculture and cold chain development. As part of the coastal community development component of the Sagarmala Programme, Ministry is part-funding fishing harbour projects in convergence with Department of Animal Husbandry and Dairying (DADF). In addition, in-principle approval has been given for development of deep sea fishing vessels and fish processing centers in convergence with DADF.

For promoting tourism in maritime states under Sagarmala, projects have been identified in convergence with the Ministry of Tourism and tourism development departments of maritime state governments. Key coastal tourism projects include:

- Development of Coastal Circuits under Swadesh Darshan Scheme of Ministry of Tourism
- Development of infrastructure for promoting Cruise tourism
- Development of lighthouses
- National Maritime Heritage Museum Complex at Lothal
- Underwater viewing gallery and restaurant at Beyt Dwarka

Sagarmala has conducted skill gap studies for 21 coastal districts in India. Skill Development programmes in these 21 districts is being undertaken in convergence with DDU GKY programme of the Ministry of Rural Development. ❑

Source: www.sagarmala.gov.in

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Indian Coastal Community and Climate Change

Asir Ramesh. D
Amali Infantina. J
Priya. P

The coastal areas of India experience tropical climates and have diverse geological, geomorphologic, and ecological setups. The coastline has undergone physical changes throughout its geological past. The Indian coast is endowed with a wide range of biotic and abiotic resources which provide many demanding products that are essentially required for the welfare of human development. Important economic generation activities in the coastal areas include fishing, salt production, agriculture, aquaculture, animal husbandry, energy, tourism, and small-scale and major industries. Climate change parameters such as Sea Level Rise (SLR), increase in Sea Surface Temperature (SST), Shoreline Change (SLC), and Hazards such as floods, cyclones, tsunamis, storm surges, erosion, and drought are influencing the livelihoods of coastal communities. This article discusses the coastal climate change parameters and their impacts on coastal communities.

Most of India's coastal regions are low-lying and densely populated, with nearly 250 million people living within 50 km of the coast. The country has a total of 1382 offshore islands, comprising 514 Islands along the mainland coast and 868 Islands in the island territories (Andaman & Nicobar and Lakshadweep). Among the 1382 offshore islands, 346 islands are inhabited (Bhuvan Database, 2008). As per the Census data of 2011, there are 486 census towns along the coast of India, accounting for a population of 41.7 million constituting 20.7% of the total coastal population. Of the 486 towns, 36 are classified as Class-I towns that have a population of > 100,000 persons. The coastal areas of India experience tropical climates and have diverse geological, geomorphologic, and ecological setups.

India's coast is vulnerable to exponential developmental activities coupled with climate change impacts. Climate change refers to long-term shifts in temperatures and weather patterns. The likely scenarios of climate change and associated variability pose the greatest risk to the socio-economic and environmental functioning of coastal regions. The coastal communities, for their livelihoods, face enormous challenges from natural calamities triggered by climate change parameters. Important coastal economic generation activities such as fishing, salt production, agriculture, aquaculture, animal husbandry, and other major and minor coastal industries have been affected by climate change. The coastal communities such as fishermen, salt workers, farmers, and industrialists have been directly or

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indirectly affected by climate change.

The National Environment Policy (2006) has indicated that in the future, sea level rise due to climate change may have major adverse impacts on the coastal environment. Considering the climate change impacts on the coastal communities, The Coastal Zone Management Guidelines of India (Alias M S. Swaminathan Report, 2005) emphasise strengthening the coping capacity of coastal communities to face the challenge of sea-level rise caused by climate change, as well as the more frequent occurrence of tsunamis and cyclones to protect the life and livelihoods (MoEF, 2005). In view of the recommendations and global climate change scenarios for the coastal areas of India, the Ministry of Environment, Forests and Climate Change (MoEF&CC) has demarcated the Hazard Line which is a hundred years return interval of dangers by natural events such as cyclones, tsunamis, floods, storms, waves, and shoreline changes, and sea level rise due to global warming. The Coastal Regulation Zone Notification (2019) under Environment Protection Act (1986) implemented by MoEF&CC directs to clear the developmental projects in the coastal areas after considering the disaster risks including climate change risks such as SLR and other natural disasters. This article describes the climate change indicators in the coastal areas such as Sea Level Rise (SLR), an increase in Sea Surface Temperature (SST), Shoreline Change (SLC), Hazards such as floods, cyclones, and drought that impact coastal communities and mitigation measures for sustainable development and protection along the coast of India.

The coastal communities, for their livelihoods, face enormous challenges from natural calamities triggered by climate change parameters. Important coastal economic generation activities such as fishing, salt production, agriculture, aquaculture, animal husbandry, and other major and minor coastal industries have been affected by climate change.

Sea Level Rise (SLR)

Globally, the rate of sea-level rise is about 4.5 mm per year. It is projected that SLR risks 10% of the coastal population living in the low-lying coastal region within 10-m elevation of Mean Sea Level (MSL) (McGranahan et al. 2007). SLR is a major impact on coastal regions that cause a combination of risks in retreat, submersion, erosion, and increased vulnerability to extreme marine events (Nicholls and Cazenave 2010). It is one of the primary factors to drive the historical shoreline changes and wave climate changes that engulf land masses with the economically potential physical infrastructures significant to the coastal communities, environmental features, and potential land masses (Passerietal. 2015; Westlund et al. 2007). Coastal communities and other stakeholders are impacted by loss of land, erosion, flooding, and saltwater intrusion in coastal aquifers. This leads to the squeezing of settlements, reduction of common property lands, inland movement of coastal habitats, and submergence of construction, roads, buildings, and other infrastructures in the coastal areas.

SLR is a predicted consequence of climate change however, regional variations due to local subsidence, tectonic upliftment and ocean currents similar to the *El Niño* shall differentiate the rate of local level SLR. The consequences of SLR cause changes in livelihood dependency, ecosystem degradation, reduction in potable water, an increase in hazards, and health ailments, a rise in homelessness and poverty, involuntary migrations, loss of employment, and an increase in debt. It also increases conflicts, criminal cases, delinquencies, and inequality and pave way for human right violations among the coastal communities.

To protect the life and livelihoods of coastal communities, MoEF&CC through the Survey of India and the National Centre for Sustainable Coastal Management (NCSCM) has prepared the Hazard Line (HL) map. The HL is demarcated taking into consideration of possible tides, waves (water level fluctuation), sea level rise, and coastline modifications in the coastal areas of India. The HL is a 100 yrs return interval of dangers by natural events such as cyclones, floods, storms, waves and shoreline changes, and sea level rise due to global climate change. The hazard line has been suggested as a tool for the disaster management plan for the coastal environment, including planning of adaptive and mitigation measures to reduce the vulnerability of the coastal communities and ensuring sustainable livelihood (CRZ 2019).

Increased Sea Surface Temperature (SST)

Sea surface temperature (SST) is the water temperature close to the ocean's surface. As greenhouse gases trap energy from the sun, the oceans absorb heat, resulting in an increase in SST. Changes in ocean temperatures and currents increase SST and lead to alterations in climate patterns around the world. SST affects fish migrations, fish physiology, fish breeding, fish recruitment, and habitat loss. An increase in SST enhances ocean acidification, salinity, and longshore current patterns that influence the primary production and fish stock in the sea (Abowei 2010; Vivekanandan & Krishnakumar 2010). Due to changes in the SST, several species have disappeared or migrated to other regions. Comparing the annual and seasonal fishery data indicated that the distribution and diversity of fish groups in the coastal areas of India are depleting, missing, and replenishing Ambilikumar et al. 2016; NCSCM., 2019). Some economically important fishery groups including lobsters and crabs have declined in many fish landing centers of India which were once abundant. Resilient species have

adapted to the change in SST but those vulnerable have migrated to cooler waters or have declining populations. However, there is no site-specific time series data for stock assessment for fishery biomass, biodiversity, and distribution studies in India's coastal region. Changes in the distribution and diversity of fish groups are also related to climate change parameters, especially with increased SST. Change of SST not only affects fish stock and biomass but also influences cyclogenesis (development or strengthening of cyclonic circulation in the atmosphere), as the warm waters could transform tropical disturbances into cyclones. Tropical disturbances normally become cyclones if the SST is more than 26°C. As the SST increases, the saturation vapor pressure increases. The water vapor associated with the latent heat of water increases the frequency and intensifies cyclones in coastal areas that affect coastal communities' lives and livelihoods in India.

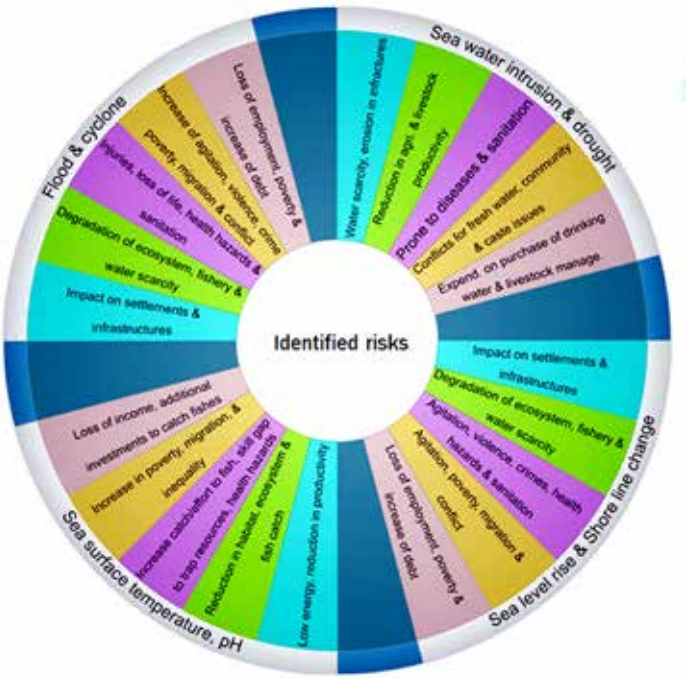

Fig. 1. Climate change risks on livelihoods of the coastal communities

Shoreline Change (SLC)

The wave energy closer to the shore leads to an increase in shoreline changes in soft rocks and beaches (Jenkins et al., 2008). Shorelines at different temporal scales from 1970 were studied by NCSCM to estimate the shoreline trends in the coastal stretches of India. Based on the results of trend analysis, the coastal stretches of India have been classified as stable, accreting, low erosion, medium erosion, and high erosion coasts (NCSCM, 2013). Accordingly, the high erosion (HER) site is where the erosion is higher than -5m/yr, and medium erosion (MER) is between -2m/yr. and -5m/yr and low erosion (LER) coast if it ranges from -0.5m/yr to -2m/yr. Stable coast (ST) is where the erosion or accretion rate is within the range of -0.5m/yr to + 0.5m/yr. Construction of seawalls, groynes, training walls, breakwaters, and other protection structures on the shores to reduce the impacts of SLR, wave action, and erosion are classified as artificial coasts (AC). Shores with continuous sand deposition are classified as accreting coast (DEP). The study undertaken by NCSCM utilising 28 years of satellite data revealed that 33.6 % (i.e. more than one-third of India's coast) is eroding and 32.12% coast is stable or accreting with varying rates of change. Other coastal stretches are rocky coasts or artificial coasts such as seawalls or embankments (NCSCM, 2013). Shoreline changes cause social and economical effects on livelihoods, property, recreation and tourism, ecosystem services, resilience, and vulnerability.

Resilient species have adapted to the change in SST but those vulnerable have migrated to cooler waters or have declining populations. However, there is no site-specific time series data for stock assessment for fishery biomass, biodiversity, and distribution studies in India's coastal region.

Frequency of cyclones and floods

The coastline has undergone physical changes throughout its geological past due to continuous wave actions, floods, cyclones, earthquakes, and tsunamis. Besides cyclones, tidal range, storm period, high tide water level, shoaling waves, river discharge, and rainfall-driven runoff also contribute to flooding in coastal areas (Woodruff Jonathan et al. 2013). During the 21st century, there has been an increase in the occurrence and severity of flood hazards in India. The trend of intense and extreme precipitation events is serious for potential future flood extent (World Bank's Climate Change Knowledge Portal, CCKP 2019). Cyclones and floods cause casualties, and injuries besides the devastation of coastal infrastructures, road networks, schools, cyclone centres, health centres, houses, and, other common properties which are livelihood capitals and assets of coastal communities. In addition, health hazards due to injuries and epidemics enumerate as common problems due to floods, storms, and cyclones (Badjeck et al. 2010; Kovats et al. 2003). National Disaster Management Authority (NDMA) and the India Meteorological Department (IMD) Government of India have prepared a Hazard Profile Map (HPM) of India (Cyclone), where the cyclone, storm, and flood-prone districts have been classified as Not Affected (NA), Moderate Affected (MA), High Affected (HA) and Very High Affected (VHA). This HPM helps to determine the vulnerability status of a particular area.

Saltwater Intrusion

Saltwater intrusions in near-shore areas are very common in many coastal districts of India. Seawater intrusion problem takes place in the dug wells and bore wells of households and enterprises which are close to the shore, during the summer months. The primary data of the coastal villages in coastal districts indicate that there are saltwater intrusions in near-shore freshwater sources during the summer season as most people use bore wells and municipal water for drinking and other domestic purposes. Water sample analysis of the wells in coastal districts results that the ratio of Cl/(CO3+HCO3) being contaminated in many coastal areas. In addition, overharvesting of water from coastal aquifers, SLR by variations in atmospheric pressures, expansion of summer, and melting of ice sheets and glaciers impose additional saline water intrusion (Sherif and Singh 1999). As a result, an aggravated saltwater intrusion is expected in many coastal stretches in the near future. High population pressure, intense human activities, inappropriate and indiscriminate landscape alterations, resource use, and the absence of proper management practices add to the deterioration of water resources (Pillai 2009). Similar to drought, saltwater intrusion affects the productivity of horticulture and livestock. Reduction in income and expenditure for potable water reduces the savings of indigenous communities and increases their debt. Raising the groundwater table in the fishing village using suitable methods may be one way of mitigating intrusion of saltwater in coastal stretches.

Drought

Climate change parameters also increase drought conditions in coastal areas. However, drought affects the coastal village through prolonged shortages in the water supply on the surface and groundwater. An increase in water demand for drinking, domestic purposes, and agricultural and industrial usage are the major consequences of drought. Horticulture crops including coastal plantations and livestock of coastal communities face major problems during drought. During the drought season, coastal communities experience skin allergies and heat-related diseases (NCSCM 2019). The conflict between houses and villages has been encountered due to the water crisis across many coastal areas. Based on the rainfall trend analysis, drought-susceptible land areas drought years, have been identified. Using RS and GIS data, susceptible agriculture and horticulture plantations affected by the drought can be identified.

Climate change impacts the productivity of marine fisheries due to the increase of SST, changing current patterns, and upwelling affecting fish biology, especially reproductive biology, alteration of habitat, and migratory routes (Allison et al. 2005). As different species behave differently based on their habitats to climate change, species that are resilient adapt to the changes whereas species that are vulnerable are susceptible.

Reduction in capture fishery

Climate change impacts the productivity of marine fisheries due to the increase of SST, changing current patterns, and upwelling affecting fish biology, especially reproductive biology, alteration of habitat, and migratory routes (Allison et al. 2005). As different species behave differently based on their habitats to climate change, species that are resilient adapt to the changes whereas species that are vulnerable are susceptible. It is difficult to detect the impacts of climate change on the distribution and diversity of fish populations though there are some indications such as the shift in Indian oil sardine shoals (Hamza et al. 2020) due to the colder temperature and timely intense up-welling leading to nutrient enrichment in the surface waters in the west coast of India. However, long-term data on capture fisheries inferred that the reduction in fish catches is not by overfishing alone but by a combination of fishing and climate change parameters (Vivekanandan & Krishnakumar 2010). A study by NCSCM (2019) estimated the climate change impacts on coastal capture fishery in Malappuram District, Kerala revealing that the sardines and mackerels, which were abundantly available off the Kerala coast, had moved away to deeper waters. While comparing capture fisheries data of 2013 and 2014, a decline of 14.3% has been estimated for the entire Kerala coast. Landing of Sardine has reduced by 37%, Carangids by 19%, Groupers by 32%, Anchovies by 30%, and Trichurus fish by 25% (Ambilikumar et al. 2016). It has been estimated that only 10% of fishermen were engaged in fishing for six days a week while the rest of the fishermen are fishing two or three days/week mainly due to reduced fish stock. Changes in the quantity and quality of fish caught in Malappuram are directly and indirectly influencing the economic and social conditions of fisher folk.

Fishery is the source of income, source of protein, vitamins, and micronutrients for the coastal community. A decrease in capture fishery influences in per capita income, revenues, wealth, and socio-economic status of the fishing community (Garcia and Rosenberg 2010). Additional catch/effort to increase the fish catch shall reduce income and create competition between fishermen and neighbouring fishing villages. However, conflicts in fish catch, an increase in poverty, migration of fishermen, shifting of occupation, and an increase in inequality are the consequences on fishing communities.

Recommendations and Conclusion

Households within the coastal community are not equally vulnerable;

they may be differentially affected by climate variability and change on the basis of their level of adaptive capacity (Smit and Wandel, 2006) and sensitivity, which relates to their livelihood assets and strategies. Roncoli et al., (2001) indicated that poorer households are often less able to adapt and are more vulnerable. To tackle climate change risks; prioritisation of problems due to climate change based on the risk and vulnerability using the Livelihood Vulnerability Index shall support identifying the location-specific problems to mitigate climate change risks.

The codes for the construction of buildings and infrastructure in cyclone-prone areas for disaster preparedness to mitigate climate change impacts should be incorporated into the building plans. Old and dilapidated buildings shall be refurbished to resist flood and erosion with easy evacuation accessible routes during natural hazards triggered by climate change.

Coastal habitats shall be demarcated and suitable locations for shelter during the flood which are the high elevated areas along the coasts shall be identified. In the potential saltwater intrusion areas and drought-prone areas, sites for water tanks in the coastal habitats to mitigate the water scarcity problems due to climate change shall be constructed. The identified suitable evacuation location during cyclone and flood shall be informed to coastal communities through awareness creation activities, capacity-building activities, and mock drills.

To maintain the fish stock in the coastal zone, fish stock trends and assessments shall be conducted to develop policies and schemes to replenish the economically important fishery resources with the involvement of local stakeholders. To reduce captured fishery demand from the natural coastal environment, nearshore cage culture, aquaculture, and mariculture activities shall be encouraged with the participation of local communities under Public-Private Partnership (PPP) mode.

The codes for the construction of buildings and infrastructure in cyclone-prone areas for disaster preparedness to mitigate climate change impacts should be incorporated into the building plans. Old and dilapidated buildings shall be refurbished to resist flood and erosion with easy evacuation accessible routes during natural hazards triggered by climate change. Along artificial coasts, wherever the seawalls are lost, the capacity to protect the coastal community from erosion, and climate change should be in place. Besides, continuous activities including Research and Development on coastal climate change should be conducted with regular finance.

The efficient use of hazard lines, disaster management plans, Hazard Profile maps, and other relevant local management plans thus support the mitigation of climate change risks experienced by the coastal communities. Creating awareness and mock drills on natural disaster through the district disaster management plan, Panchayat plans, and Hazard line map by the district disaster management authority would keep the coastal community prepared. ❑

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