

# INDIA'S MARITIME SECTOR IN THE ERA OF CLIMATE CHANGE: ALIGNING NATIONAL VISIONS WITH THE IMO'S NET-ZERO PATHWAY

**Dilip Ladumor<sup>\*</sup>, Priyesh Chauhan<sup>\*\*</sup>, Rajesh Asati<sup>\*\*\*</sup>**

## **Abstract**

The maritime sector is central to global trade but also represents a hard-to-abate source of greenhouse gas emissions, prompting an urgent transition toward low- and zero-carbon shipping and port systems. This paper examines India's maritime sector from a climate change perspective, situating national developments within the evolving global decarbonization framework of the International Maritime Organization (IMO). The study reviews the importance of maritime transport for India's economy, the sector's emissions challenge, and the IMO's net-zero strategy for international shipping, and analyses India's response through key policy frameworks, including Maritime India Vision 2030, the Harit Sagar – Green Port Guidelines, the National Green Hydrogen Mission, the Maritime Amrit Kaal Vision 2047, and the Green Tug and Green Port Craft programme. Using a qualitative synthesis of policy documents and recent sectorial data, the paper assesses the degree of alignment between India's maritime ambitions and global climate objectives and identifies critical gaps, opportunities, and challenges shaping the transition. The results indicate that India has articulated a multi-horizon maritime decarbonization pathway, combining near-term operational measures, medium-term port-level targets, and long-term net-zero-oriented visions, with strong emphasis on renewable energy integration and green fuel adoption. However, constraints related to emissions monitoring, fuel infrastructure readiness, governance coordination, financing, and technology uncertainty remain significant. The paper concludes that while India's maritime climate strategy demonstrates growing convergence with the IMO's net-zero trajectory, focused action on implementation and enabling mechanisms will be essential to translate ambition into sustained emission reductions and to position India as a leading developing maritime nation in the global low-carbon transition.

**Keywords:** Maritime decarbonization; Climate change; India; Green ports; IMO strategy; Net-zero shipping; Green hydrogen

---

\* Lecturer, GMB Polytechnic, Rajula; [ladumordilip56@gmail.com](mailto:ladumordilip56@gmail.com)

\*\* IITRAM, Ahmedabad

\*\*\* MoPSW, New Delhi

## 1. Introduction

Maritime transport underpins the global economy, carrying more than 80% of world merchandise trade by volume, and enabling international supply chains and energy security (United Nations Conference on Trade and Development [UNCTAD], 2024). Ports act as critical interfaces between sea and land transport, making the maritime sector central to economic development and globalization. For India, this importance is even more pronounced: around 95% of the country's trade by volume and nearly 65–70% by value moves through sea routes, supported by a coastline exceeding 11,000 km, 12 major ports, and more than 200 non-major ports (Ministry of Ports, Shipping and Waterways [MoPSW], 2025). The scale of India's maritime activity positions it among the world's major maritime nations.

Despite being the most energy-efficient mode of freight transport per tonne-kilometre, shipping has a substantial environmental footprint due to the magnitude of global activity. The Fourth IMO Greenhouse Gas Study estimates that international shipping emitted about 1,056 million tonnes of CO<sub>2</sub> in 2018, accounting for approximately 2.9% of global anthropogenic greenhouse gas (GHG) emissions (International Maritime Organization [IMO], 2020). Emissions primarily originate from fossil fuel combustion in ship propulsion and auxiliary engines. In port areas, emissions are further amplified by auxiliary engines at berth, diesel-powered cargo handling equipment, terminal energy use, and hinterland transport.

Beyond climate impacts, maritime emissions contribute to local air pollution through sulphur oxides (SO<sub>x</sub>), nitrogen oxides (NO<sub>x</sub>), and particulate matter, affecting air quality and public health in coastal and port cities (UNCTAD, 2024). As seaborne trade continues to expand, these environmental pressures are expected to intensify unless effective mitigation measures are implemented. For fast-growing maritime nations, rising throughput implies increasing fuel consumption and energy demand, reinforcing the climate relevance of ports and shipping.

The urgency of emission control in the maritime sector is further reinforced by the limited global carbon budget consistent with the goals of the Paris Agreement. Hard-to-abate sectors such as shipping face mounting pressure to decouple growth from emissions, particularly given long vessel lifetimes of 20–30 years, which risk locking in carbon-intensive assets (IMO, 2020). Moreover, emerging carbon pricing mechanisms, green supply-chain requirements, and investor scrutiny mean that maritime emissions are increasingly becoming an economic and competitiveness issue, not merely an environmental one.

For India, the challenge is acute. With total port throughput now exceeding 1.5 billion tonnes annually, maritime activity represents a growing component of the national transport system and its associated emissions footprint (MoPSW, 2025). At the same time, India is highly vulnerable to climate change impacts such as sea-level rise, coastal erosion, and extreme weather, which directly threaten port

infrastructure and coastal communities. Controlling emissions from shipping and ports is therefore essential not only for contributing to global mitigation efforts but also for safeguarding the long-term resilience and sustainability of India's maritime economy.

This growth–emissions nexus establishes the need for coordinated global action in maritime transport. The following section therefore examines the international response to this challenge, as shaped by the evolving decarbonization framework of the International Maritime Organization.

## **2. IMO Strategy and Global Direction for Maritime Decarbonization**

The International Maritime Organization (IMO) is the principal global body responsible for regulating environmental impacts from international shipping. Through its Marine Environment Protection Committee (MEPC), the IMO develops binding regulations and strategic frameworks that guide the sector's response to air pollution and climate change.

The regulatory foundation of shipping's environmental governance is the International Convention for the Prevention of Pollution from Ships (MARPOL). Among its annexes, MARPOL Annex VI addresses air pollution and energy efficiency by setting limits on sulphur and nitrogen oxide emissions from ships and establishing efficiency standards for marine engines and vessels (International Maritime Organization [IMO], 2017). These measures have progressively tightened the environmental baseline for the global fleet and demonstrated the feasibility of coordinated international action.

Building on this framework, the IMO adopted the Initial IMO Strategy on the Reduction of GHG Emissions from Ships in 2018, which for the first time articulated a collective ambition to reduce total annual GHG emissions from international shipping by at least 50% by 2050 compared to 2008 levels, while pursuing efforts toward full decarbonization (IMO, 2018). This marked a strategic shift from incremental efficiency improvements toward a long-term climate transition for the sector.

This ambition was significantly strengthened with the adoption of the Revised IMO GHG Strategy in 2023, which commits international shipping to achieve net-zero GHG emissions by or around 2050. The revised strategy introduces indicative checkpoints to reduce total emissions by 20–30% by 2030 and 70–80% by 2040 relative to 2008, and calls for scaling up the use of zero- or near-zero-emission (ZNZ) fuels and technologies to at least 5%, striving for

10%, of energy use by 2030 (IMO, 2023). These targets signal a fundamental transformation of the maritime energy system within the next three decades.

To operationalize these ambitions, the IMO has introduced technical and operational instruments such as the Energy Efficiency Existing Ship Index (EEXI) and the Carbon Intensity Indicator (CII), which entered into force in 2023. These measures require existing ships to meet minimum efficiency standards and demonstrate continuous improvements in operational carbon intensity, thereby creating near-term compliance drivers aligned with long-term decarbonization goals.

A defining feature of the IMO's approach is its emphasis on a just and equitable transition, acknowledging the diverse capabilities and circumstances of member states. Issues such as technology transfer, capacity building, and the potential economic impacts of climate measures on developing countries are integral to ongoing MEPC deliberations. As such, the IMO framework combines global ambition with flexibility in implementation, while maintaining the principle of uniform standards for international shipping.

Overall, the IMO's evolving strategy establishes a clear global direction: shipping must transition away from fossil fuels and achieve net-zero emissions within mid-century. This framework now serves as the reference against which national maritime strategies are being shaped. The extent to which individual maritime nations translate these ambitions into concrete national actions will determine the effectiveness of the global transition.

### **3. India's Maritime Climate Strategy and Vision**

Within this global framework, India has articulated a set of national visions and missions that embed climate action within maritime development, positioning ports and shipping as key contributors to the country's long-term decarbonization pathway.

#### **3.1 Maritime India Vision 2030 (MIV 2030)**

The Maritime India Vision 2030 (MIV 2030) provides India's medium-term blueprint for port and shipping development while embedding sustainability as a core pillar. The vision envisages expanding national port handling capacity to over 2,500 million tonnes per annum (MTPA) by 2030, supported by investments of about ₹3–3.5 lakh crore, alongside major efficiency improvements to reduce logistics costs to around 8–9% of GDP (Ministry of Ports, Shipping and Waterways [MoPSW], 2021). From a climate perspective, MIV 2030 emphasizes energy-efficient port operations, large-scale deployment of renewable energy, and promotion

of coastal and inland waterway transport as lower-carbon alternatives to road logistics, and adoption of green technologies across terminals and fleets. By linking capacity growth with efficiency and sustainability, MIV 2030 frames decarbonization as essential for improving both environmental performance and global competitiveness of Indian ports.

### **3.2 Harit Sagar – Green Port Guidelines**

The Harit Sagar – Green Port Guidelines translate India's sustainability vision into concrete, measurable port-level actions. The guidelines set a target to reduce carbon emissions per tonne of cargo by 30% by 2030 and by 70% by 2047, signalling a strong commitment to emission intensity reduction in port operations (MoPSW, 2023). They further call for ports to meet at least 60% of their electricity demand from renewable energy by 2030, increasing to over 90% by 2047, and to electrify more than 50% of cargo handling equipment and vehicles by 2030, rising to over 90% by 2047. Harit Sagar also promotes onshore power supply for ships at berth, energy-efficient buildings, and enhanced green cover within port estates. Collectively, these targets position Indian ports as future net-zero energy hubs and anchor points for low-carbon maritime logistics.

### **3.3 Maritime Amrit Kaal Vision 2047**

The Maritime Amrit Kaal Vision 2047 sets the long-term ambition to transform India into a globally leading, technologically advanced, and environmentally sustainable maritime nation by the centenary of independence. The vision envisages cumulative investments of the order of ₹80 lakh crore across ports, shipping, inland waterways, shipbuilding, and maritime services over the coming decades, with sustainability and climate resilience identified as defining features of this transformation (MoPSW, 2022). From a climate perspective, the vision reinforces the aspiration for net-zero-oriented port operations by 2047, large-scale adoption of green fuels, and development of climate-resilient coastal infrastructure. By explicitly integrating green shipping, digitalization, and resilience into long-term sectoral growth, the Amrit Kaal Vision provides strategic continuity between near-term initiatives and India's national net-zero target for 2070.

### **3.4 National Green Hydrogen Mission**

India's National Green Hydrogen Mission is a cornerstone of the country's deep decarbonization strategy and has direct relevance for maritime fuel transition. The mission targets domestic production of at least 5 million metric tonnes (MMT) of green hydrogen per

year by 2030, supported by large-scale renewable capacity additions and expected to abate nearly 50 million tonnes of CO<sub>2</sub> annually (Ministry of New and Renewable Energy [MNRE], 2023). For the maritime sector, hydrogen derivatives such as green ammonia and green methanol are widely considered among the most promising zero-carbon fuels for long-distance shipping. The mission therefore positions major ports as future hubs for production, storage, and bunkering of green fuels, enabling India not only to decarbonize its own fleet but also to emerge as a regional supplier in global green shipping corridors. This linkage between national energy transition and maritime decarbonization represents one of India's most powerful climate opportunities.

### **3.5 Green Tug and Green Port Craft**

At the operational level, India has initiated early decarbonization through the Green Tug and Green Port Craft programme, which targets the replacement of conventional diesel-powered harbour craft—such as tugs, pilot boats, and service vessels—with electric, hybrid, and alternative-fuel-powered variants. The programme envisages deploying at least one green tug at each major port in its initial phase, followed by scaling up across the harbour craft fleet (MoPSW, 2024). Given the high utilization and confined operating environment of such vessels, this segment offers immediate opportunities to cut local emissions, improve air quality in port cities, and build technical and operational experience with low-emission propulsion systems. As demonstration platforms, green tugs and port craft are expected to play a catalytic role in preparing Indian ports and operators for wider adoption of zero-emission vessels in coastal and eventually deep-sea shipping.

Taken together, these frameworks define India's maritime climate strategy across multiple horizons: MIV 2030 drives efficiency-oriented growth, Harit Sagar delivers measurable port-level decarbonization, the National Green Hydrogen Mission enables the fuel transition, the Amrit Kaal Vision 2047 provides long-term sustainable direction, and the Green Tug and Port Craft programme initiates early operational action. Collectively, they reflect a clear strategic intent to align maritime development with climate objectives and to position India's ports and shipping as active contributors to both national mitigation goals and the global transition toward net-zero shipping.

#### 4. Gaps, Opportunities, and Challenges for India

India's maritime decarbonization pathway is shaped by an ambitious set of national visions and missions; however, the effectiveness of this transition will depend on how structural gaps are addressed and how emerging opportunities are leveraged in the face of persistent economic and technological challenges. A synthesis of the key issues is presented in **Table X**, which summarizes the major gaps, opportunities, and challenges across policy, infrastructure, energy, technology, finance, data, and global alignment.

<b>Theme</b>	<b>Gaps</b>	<b>Opportunities</b>	<b>Challenges</b>
<b>Policy &amp; Governance</b>	No unified national maritime GHG inventory; fragmented institutional responsibilities across ports, shipping, and energy	Strong policy signals through MIV 2030, Harit Sagar, and Amrit Kaal Vision provide a foundation for coordinated action	Translating visions into binding targets and ensuring inter-ministerial coordination
<b>Infrastructure &amp; Operations</b>	Uneven readiness of ports for electrification, OPS, and low-carbon operations; legacy infrastructure	New port developments allow integration of low-carbon designs; Harit Sagar targets net-zero ports by 2047	High capital costs and retrofitting constraints at existing ports
<b>Energy &amp; Fuels</b>	Limited bunkering and safety frameworks for green fuels; unclear maritime demand roadmap	National Green Hydrogen Mission (5 MMT/yr by 2030) enables domestic green ammonia/methanol supply	High cost of green fuels; uncertainty over dominant future fuel pathways
<b>Technology &amp; Fleet</b>	Low penetration of zero-emission vessels; limited domestic experience with alternative propulsion	Green Tug and Port Craft programme enables early pilots and learning	Technology maturity risks and scaling from pilots to commercial deployment

<b>Finance &amp; Economics</b>	Absence of dedicated green maritime finance mechanisms; limited access to concessional funding	Growing interest in green bonds, climate finance, and PPP models	Maintaining trade competitiveness while absorbing transition costs
<b>Data &amp; Capacity</b>	Weak MRV systems for port and shipping emissions; skill gaps in green technologies	Opportunity to build digital MRV aligned with IMO and modernize maritime training	Developing reliable data systems and rapidly upskilling workforce
<b>Global Alignment &amp; Resilience</b>	Limited participation in early green shipping corridors; climate risks not fully embedded in planning	Strategic location on major trade routes enables leadership in corridors; scope for climate-resilient ports	Keeping pace with IMO tightening regulations while adapting to sea-level rise and extreme weather

#### 4.1 Policy and Governance

As highlighted in Table X, a central gap in India’s maritime climate framework is the absence of a unified national greenhouse gas inventory for ports and shipping. While Harit Sagar sets port-level emission intensity targets, ship emissions—particularly those associated with international voyages—remain weakly integrated into national climate accounting. Moreover, institutional responsibilities for maritime decarbonization are distributed across multiple ministries covering ports and shipping, energy, environment, and transport, creating coordination challenges. At the same time, the existence of strong strategic frameworks such as Maritime India Vision 2030, Harit Sagar, and the Maritime Amrit Kaal Vision 2047 provides a significant opportunity to build a coherent governance architecture around climate action (Ministry of Ports, Shipping and Waterways [MoPSW], 2021, 2023, 2022). The challenge lies in translating these visions into binding targets, clear timelines, and accountability mechanisms that can drive implementation at scale.

#### 4.2 Infrastructure and Operations

India’s port system exhibits wide heterogeneity in terms of infrastructure age, scale, and technological readiness. As noted in Table X, many legacy ports face constraints in retrofitting

for electrification, onshore power supply, and renewable integration, while newer terminals offer opportunities to embed low-carbon designs from the outset. Harit Sagar's targets—such as achieving 60% renewable electricity use by 2030 and aspiring for net-zero port operations by 2047—create a strong operational pathway for transforming ports into low-carbon energy hubs (MoPSW, 2023). However, achieving these goals will require substantial capital investment, grid integration, and careful planning to avoid disruption to port productivity, making infrastructure financing and phasing a key implementation challenge.

### **4.3 Energy and Fuel Transition**

The transition to zero- and near-zero carbon marine fuels represents both the greatest opportunity and one of the most formidable challenges for India. As summarized in Table X, current gaps relate to the lack of maritime-specific fuel demand roadmaps, bunkering standards, and safety regulations for fuels such as green ammonia and methanol. Conversely, the National Green Hydrogen Mission, with its target of producing 5 million metric tonnes of green hydrogen annually by 2030, positions India as a potential global hub for green fuel production, capable of supplying both domestic and international shipping (Ministry of New and Renewable Energy [MNRE], 2023). The key challenge is the high cost differential between green fuels and conventional marine fuels, coupled with uncertainty over which fuel pathways will dominate in the long term, creating investment risks for both ports and ship-owners.

#### 5.4 Technology and Fleet Readiness

### **4.4 Technology and Fleet Readiness**

India's shipping and harbour craft fleet currently has limited exposure to zero-emission propulsion technologies, as reflected in Table X. The Green Tug and Green Port Craft programme offers a near-term opportunity to pilot electric, hybrid, and alternative-fuel vessels in controlled port environments, enabling learning-by-doing and domestic capability development (MoPSW, 2024). These pilots can serve as precursors to wider adoption in coastal and inland shipping. Nonetheless, scaling such technologies to deep-sea vessels remains challenging due to technology maturity, safety considerations, and retrofit complexity, underscoring the need for sustained R&D and international collaboration.

### **4.5 Finance and Economic Viability**

The maritime energy transition is inherently capital intensive. As indicated in Table X, India currently lacks dedicated green maritime finance mechanisms, and access to concessional

or blended finance remains limited. Yet, the scale of planned investments under MIV 2030 and the Amrit Kaal Vision creates opportunities to mainstream climate considerations into port and shipping finance through green bonds, public–private partnerships, and multilateral climate funds (MoPSW, 2021; 2022). The central challenge is to manage the cost burden of decarbonization without eroding trade competitiveness, particularly for a developing economy that remains sensitive to logistics costs.

#### **4.6 Data, Capacity, and Skills**

Reliable data and skilled human capital are prerequisites for effective decarbonization. As summarized in Table X, India faces gaps in standardized measurement, reporting, and verification (MRV) systems for maritime emissions, limiting transparency and evidence-based policymaking. At the same time, the transition opens opportunities to modernize maritime education and training in areas such as alternative fuels, high-voltage systems, digital energy management, and safety protocols. Building these capabilities across port authorities, operators, and regulators is essential, yet challenging, given the pace and complexity of technological change (International Maritime Organization [IMO], 2023).

#### **4.7 Global Alignment and Climate Resilience**

Finally, India's maritime transition must be viewed in the context of tightening global climate governance and increasing climate risks. As noted in Table X, India has opportunities to leverage its strategic location on major East–West trade routes to participate in green shipping corridors aligned with the IMO's decarbonization agenda. At the same time, ports and coastal infrastructure face growing exposure to sea-level rise, cyclones, and extreme weather, necessitating integration of climate resilience into decarbonization planning (IMO, 2023). The challenge lies in aligning national development priorities with evolving international regulations while ensuring that infrastructure investments remain robust under future climate conditions.

#### **4.8 Synthesis**

In synthesis, Table X highlights that India's maritime decarbonization pathway is characterized by strong strategic intent but uneven readiness. The convergence of policy visions, renewable energy potential, and expanding port infrastructure presents a unique opportunity for India to emerge as a leader among developing maritime nations in the global climate transition. However, addressing gaps in governance, fuel readiness, finance, data, and

skills, while overcoming cost and technology uncertainties, will be critical to converting ambition into measurable emission reductions. The manner in which India navigates these gaps, opportunities, and challenges over the coming decade will ultimately determine its ability to align maritime growth with climate resilience and contribute meaningfully to the IMO's net-zero vision.

## **Conclusion**

This paper has examined India's maritime sector from a climate change perspective, situating national developments within the global decarbonization framework led by the International Maritime Organization (IMO). The study reviewed the importance of maritime transport and its emissions, outlined the IMO's net-zero pathway, and analysed India's response through Maritime India Vision 2030, Harit Sagar – Green Port Guidelines, the National Green Hydrogen Mission, the Maritime Amrit Kaal Vision 2047, and the Green Tug and Green Port Craft programme.

The analysis shows that India has articulated a multi-horizon maritime climate pathway, combining near-term operational measures, medium-term targets for renewable-powered and low-carbon ports, and long-term ambitions for net-zero-oriented maritime infrastructure. The paper demonstrates a clear convergence between India's maritime visions and the IMO's decarbonization milestones, particularly in improving efficiency, enabling fuel transition, and orienting the sector toward a net-zero future.

By synthesizing these frameworks, the study identifies the central outcomes of India's maritime climate approach: ports emerging as low-carbon energy hubs, early deployment of green harbour craft, and the strategic positioning of India within the global green fuel ecosystem. The paper also highlights key areas requiring focused attention, including emissions monitoring, fuel readiness, governance integration, and financing, as critical enablers for translating ambition into measurable climate action.

Overall, this work provides a consolidated assessment of India's maritime decarbonization pathway and its alignment with global climate objectives. The framework developed in this study can support future research and policymaking aimed at ensuring that India's maritime growth remains consistent with national climate commitments and contributes meaningfully to the IMO's vision of net-zero shipping.

## References

*United Nations Conference on Trade and Development. (2024). Review of maritime transport 2024. UNCTAD.*

*Ministry of Ports, Shipping and Waterways. (2025). Annual report 2024–25. Government of India.*

*International Maritime Organization. (2020). Fourth IMO greenhouse gas study 2020. IMO.*

*International Maritime Organization. (2017). MARPOL: International convention for the prevention of pollution from ships (Consolidated Ed.). IMO.*

*International Maritime Organization. (2018). Initial IMO strategy on reduction of GHG emissions from ships (Resolution MEPC.304 (72)).*

*International Maritime Organization. (2023). 2023 IMO strategy on reduction of GHG emissions from ships (Resolution MEPC.377 (80)).*

*Ministry of Ports, Shipping and Waterways. (2021). Maritime India Vision 2030. Government of India.*

*Ministry of Ports, Shipping and Waterways. (2023). Harit Sagar: Green port guidelines. Government of India.*

*Ministry of Ports, Shipping and Waterways. (2022). Maritime Amrit Kaal Vision 2047. Government of India.*

*Ministry of New and Renewable Energy. (2023). National green hydrogen mission. Government of India.*

*Ministry of Ports, Shipping and Waterways. (2024). Green tug and green port craft programme/guidelines. Government of India.*