Pollution Prevention - Implementation Roadmap

Document Control

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1.0	04.02.2026	First Draft

List of Abbreviations

Abbreviation	Full Form
ADB	Asian Development Bank
BIS	Bureau of Indian Standards
CII	Carbon Intensity Indicator
CPCB	Central Pollution Control Board
DG Shipping	Directorate General of Shipping
EIA	Environmental Impact Assessment
EMS	Energy Management Systems
GPPI	Green Port Performance Index
GTTP	Green Tug Transition Programme
HR	Human Resources
IMU	Indian Maritime University
IoT	Internet of Things
JIT	Just-In-Time
MARPOL	International Convention for the Prevention of Pollution from Ships
MoEFCC	Ministry of Environment, Forest and Climate Change
MoPSW	Ministry of Ports, Shipping and Waterways
MRV	Monitoring, Reporting and Verification
OEMs	Original Equipment Manufacturers
OPS	Onshore Power Supply
PCB	Pollution Control Board
PCBs	Polychlorinated Biphenyls
PPP	Public-Private Partnership
REC	Renewable Energy Certificate
SPCBs	State Pollution Control Boards
VGF	Viability Gap Funding

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1. INTRODUCTION

Pollution prevention from maritime activities is a pivotal implementation area contributing to India's transition towards a cleaner, safer, and more resilient maritime sector. Pollution arising from **ships, ports, shipbuilding and repair activities, ship recycling, inland waterways, and coastal shipping** has direct implications for marine ecosystems, coastal communities, and the long-term sustainability of maritime trade. The document addresses pollution prevention as a system-wide intervention rather than a set of isolated compliance measures. It integrates regulatory requirements, infrastructure planning, operational controls, capacity building, and digital monitoring mechanisms to ensure that pollution risks are **addressed at source and managed consistently** across the maritime value chain.

The approach follows a phased and outcome-oriented pathway. Early actions focus on **strengthening compliance, reporting, and transparency.** Subsequent phases enable infrastructure deployment, technology integration, and operational standardisation, while long-term measures embed pollution prevention into performance benchmarks, certification systems, and periodic review processes

Maritime Pollution Map

This visual presents an end-to-end overview of **maritime pollution sources**, including air emissions, water discharges, hazardous materials, solid waste, and spill risks, and demonstrates how pollution prevention interventions are distributed across key maritime activities.

2. POLLUTION PREVENTION ACROSS THE MARITIME VALUE CHAIN

Pollution prevention under the national green maritime policy framework is structured in alignment with the **policy's core pillars**, ensuring that environmental controls are embedded directly within sectoral interventions rather than treated as standalone obligations

2.1 Green Shipping – Ship Repair and Ship Building

Pollution prevention under the Green Shipping pillar focuses on reducing environmental impacts at the design, construction, and maintenance stages of a vessel's lifecycle. Early incorporation of **pollution control systems** during shipbuilding and retrofit enables compliance with MARPOL discharge requirements and reduces long-term operational risks. Key measure include *certified ballast water treatment systems, Sewage treatment plans, Oily water separators and arrangements for safe handling of hazardous materials*

Ship repair activities are required to *manage pollution arising from blasting, painting, cleaning, and machinery maintenance*. Controls include *containment and proper disposal of paint residues, solvents, oils, and metal waste, use of low-toxicity coatings, and alignment with port waste management plans*.

These measures ensure that shipyards and repair facilities operate in a manner consistent with national pollution control objectives

2.2 Green Ports

Pollution prevention under the Green Ports pillar **covers emissions** as well as **discharges from vessels at berth and port-side operations.**

Proper waste reception facilities, including but not limited to oily waste, sewage, garbage, and cargo residues, are to be provided by ports which comply with MARPOL regulations. *Waste segregation, treatment and traceability systems support the waste management of that waste*. *Onshore Power Supply (OPS) is* an important way to mitigate emissions from auxiliary engines during berthing.

The planning of port infrastructure may be integrated with *stormwater management and oil–water separation*, as well as *dredging and dredging-related pollution control mechanisms* (e.g. silt containment and environmentally responsible disposal). This pillar is reinforced by the **Harit Sagar Guidelines**, which also includes requirements for environmental audits, emissions and waste stream monitoring, and environmental performance disclosure

2.3 Green Ship recycling

Pollution control during ship recycling focuses on the prevention of soil, water, and air contamination, while maximizing materials recovery and the safe handling of hazardous substances. The national green maritime policy framework aligns ship recycling practices with the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships.

Mandatory preparation and maintenance of a digital Inventory of Hazardous Materials enables controlled dismantling and disposal of asbestos, PCBs, heavy metals, oils, and other hazardous components. Recycling yards must modernize infrastructure – e.g. the installation of impermeable flooring, drainage and stormwater control systems, enclosed dismantling areas – to prevent pollutant release into surrounding environments. Emissions and waste generated during dismantling and material transport are addressed through structured monitoring and reporting requirements.

2.4 Green Finance

The Green Finance pillar contributes to pollution prevention through **capital access for the investment of pollution control infrastructure and systems**. Such initiatives include OPS deployment, port waste reception facilities, ballast water treatment systems, wastewater treatment plants, and ship recycling yard upgrades. Verified pollution-performance data and audit outcomes will serve as the basis for linking environmental compliance to incentive structures, concessional financing eligibility, and blended finance instruments, in alignment with the national green maritime policy framework.

2.5 Green Skill development and HR

A comprehensive strategy in prevention of pollution needs **trained workers** on every ship, port, shipyard, and recycling facility. This pillar is for managing capacity in MARPOL compliance, ballast water management, hazardous material handling, waste management, environmental auditing, and digital reporting systems. *Environmental officers, inspectors and operational staff* are supported in their implementation and enforcement *through training, certification and competency frameworks*

2.6 Green Fuel

Green Fuel pillar pollution prevention also includes reducing sulphur oxides, nitrogen oxides, particulate matter, and other harmful emissions through cleaner fuel consumption and blending requirements. Measures aim to minimize pollution during fuel storage, handling and bunkering operations, including *spill prevention and emergency response preparedness*. **Fuel quality monitoring and emissions reporting support** compliance and **performance tracking**

2.7 Green Technology

Technology-assisted pollution prevention includes the establishment of emission control systems, ballast water treatment technologies, advanced wastewater treatment, oil–water separation systems, and digital monitoring platforms. **Sensor-based and IoT-enabled solutions** in an integrated manner facilitate real-time monitoring of emissions, waste, and discharges, *increasing compliance verification and enforcement*.

3. KEY POLLUTION PREVENTION OPPORTUNITIES

The pollution prevention pillar consists of essential opportunities such as strengthening existing regulatory frameworks to better enhance their enforcement, integrating pollution data into national digital platforms, scaling OPS and waste reception infrastructure, modernising ship recycling

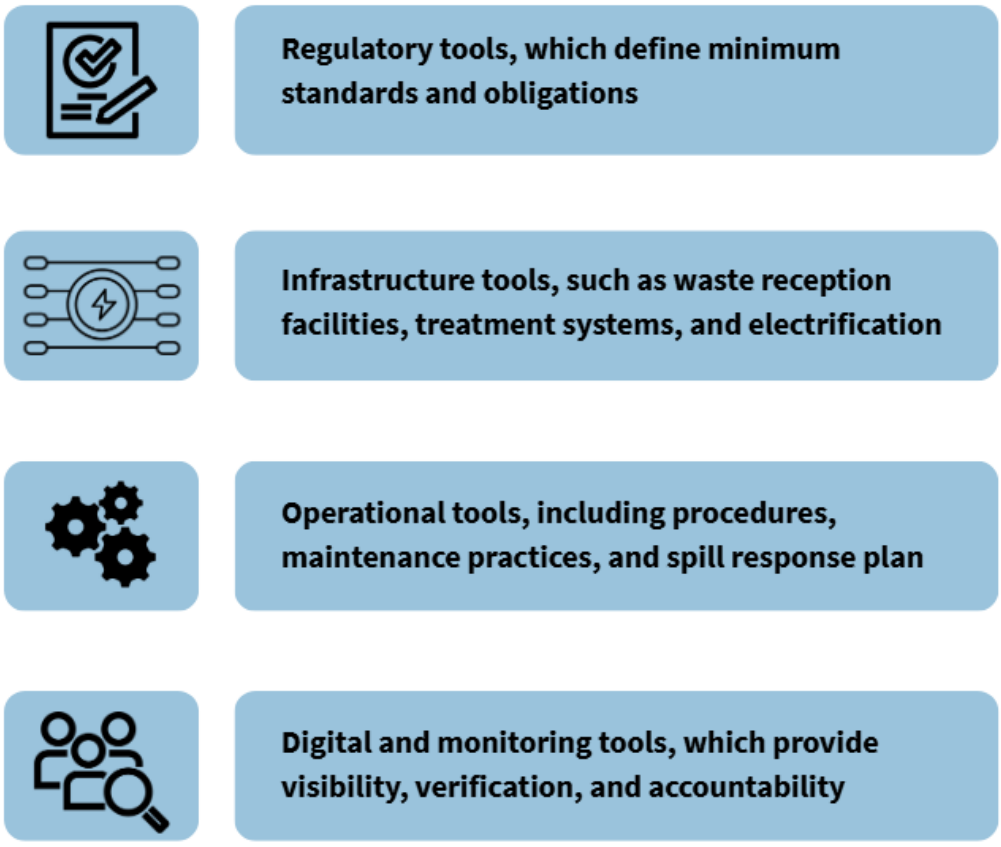
facilities, and building skilled human resources. Alignment of pollution performance with green finance mechanisms adds yet another lever to drive adoption.

3.1 Pollution Control Toolbox

Maritime pollution cannot be adequately controlled by regulation alone, which requires an integrated mix of regulatory standards, enabling infrastructure, operational practices, and digital monitoring systems.

The combination of these complementary tools in the toolbox demonstrates the mechanisms that are being used to control the risks of pollution at source, managed during operations, and verified through monitoring and reporting. It is meant to show that pollution prevention is not a standalone activity, but is embedded across multiple maritime intervention areas, with each pillar addressing specific pollution risks within its natural scope of action. Instead of listing pollution sources in isolation, the matrix highlights where responsibility and leverage lie across the maritime system.

This methodological approach enables realistic implementation, informed investment decisions, and scalable adoption across different maritime contexts.



4. INDICATIVE ACTION PATHWAY

Implementation is sequenced through a phased action pathway that balances urgency, feasibility, and impact. Each phase identifies clear action items along with the primary and supporting stakeholders responsible for delivery.

4.1 Short-Term Actions (0–6 Months)

BASELINE VALIDATION AND READINESS: The period focuses on validating existing pollution control measures, consolidate compliance information and establish a national baseline across the maritime sector.

Implementation focus

Verification, Consolidation and alignment

Key Actions	Suggested Approach	Key Stakeholders
Validate existing pollution control measures and compliance status	• Review existing regulations, circulars, and guidelines • Consolidate data from ports, SPCBs, DG Shipping, and Coast Guard • Standardise reporting formats	MoPSW, DG Shipping, Port Authorities, CPCB/SPCBs, Indian Coast Guard
Identify gaps, overlaps, and high-risk pollution areas	• Desk-based assessment of compliance records • Identification of weak enforcement or monitoring zones	MoPSW, CPCB/SPCBs, Port Authorities
Establish pollution-type–wise baseline	• Prepare consolidated baseline reports for water, air, waste, land, noise, and accidental pollution	MoPSW (lead), Sector Regulators
Validate existing reporting and disclosure mechanism under NGSP and related platforms	• Review current reporting through Swachh Sagar Portal and other port-level systems • Assess completeness, consistency, and usability of reported data • Identify improvements required for integration in Phase 2	MoPSW, DG Shipping, Port Authorities
Notify framework for periodic environmental audits of ports	• Review existing statutory inspections and audit practices • Define audit scope, frequency, and disclosure approach	MoPSW, Port Authorities, CPCB/SPCBs

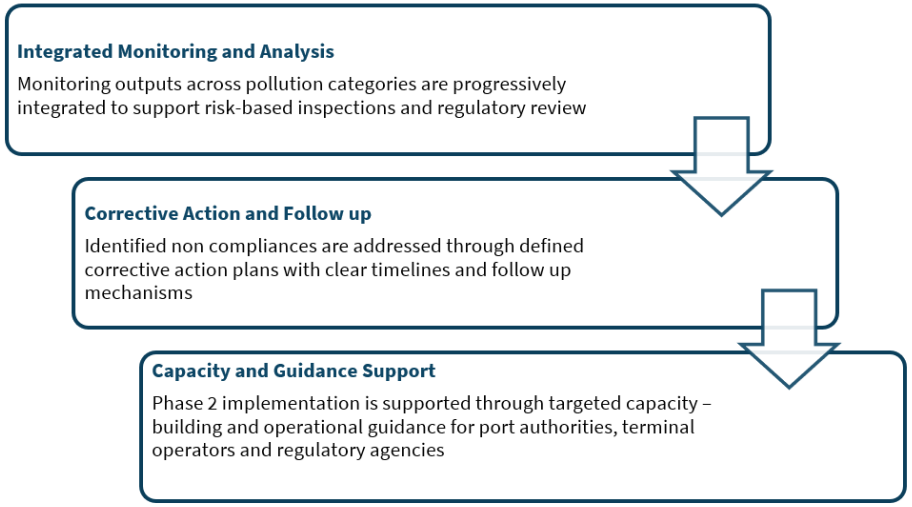
4.2 Medium-Term Actions (Up to 2 Years): To reduce priority pollution risks through targeted, practical actions based on phase 1 findings

Implementation focus

Operational Strengthening and Coordination

Pollution category	Objective	Implementation approach	Key Stakeholders
Water Pollution	Strengthen control of ship- and port-generated water pollution	• Improve monitoring and verification of sewage, grey water, and operational discharges • Strengthen port effluent and runoff management practices • Improve spill prevention and response coordination • Introduce periodic joint inspections to strengthen ship–port interface oversight	Directorate General of Shipping, Port Authorities, SPCBs, Indian Coast Guard
Air Pollution	Reduce emissions from ships and port operations	• Improve monitoring of emissions at berth and within port areas • Prioritise high-activity berths and cargo zones for enhanced oversight • Promote cleaner operational practices and equipment upgrades where feasible	Directorate General of Shipping, Port Authorities, SPCBs, Terminal Operators
Waste & Hazardous Material Pollution	Improve hazardous waste handling and disposal	• Strengthen segregation, storage, and tracking of oily and hazardous waste • Improve waste reception facilities and downstream disposal arrangements • Enhance traceability from waste generation to final disposal through audits and documentation	Port Authorities, SPCBs, Waste Operators

Soil & Land Contamination	Prevent long-term land and groundwater contamination	• Identify high-risk land areas (fuel storage, chemical handling, yards) • Improve containment, drainage, and storage practices • Assess legacy contamination risks to inform future remediation planning	Port Authorities, SPCBs, Shipyards, Recycling Yards
Noise & Light Pollution	Reduce impacts on workers and nearby communities	• Improve noise control during port and terminal operations • Rationalise lighting design, intensity, and direction • Apply time-based or location-specific operational controls where required	Port Authorities, Terminal Operators, SPCBs
Accidental & Emergency Pollution	Strengthen preparedness and response capability	• Update port-level emergency response and pollution contingency plans • Clarify command, communication, and escalation protocols with national and state responders • Conduct periodic drills, reviews, and corrective action follow-ups	Indian Coast Guard, Port Authorities, Terminal Operators



Phase 2 focuses on strengthening operational control and coordination across India's port and maritime sector by translating validated baselines into consistent on-ground implementation. **Integrated use of monitoring outputs supports risk-based oversight, while structured corrective action processes and targeted capacity-building** enable uniform implementation across ports and regulatory agencies.

4.3 Long-Term Actions (Up to 5 Years)

Phase 3: Institutionalization and Continuous Improvement

Implementation focus

1. **Embed pollution prevention into operational systems**

- Integrate pollution control requirements into standard operating procedures (SOPs) of ports, terminals, shipyards, and maritime service providers.
- Align pollution prevention measures with consent and authorisation renewal processes administered by SPCBs and sector regulators.
- Incorporate pollution prevention considerations into port master plans, infrastructure upgrades, and capacity expansion proposals.

2. **Institutionalise monitoring and performance benchmarking**

- Establish routine tracking of pollution performance indicators using existing inspection, reporting, and monitoring systems.
- Compare performance trends across ports, maritime activities, and time periods to identify good practices and persistent risk areas.
- Use benchmarking outputs to inform regulatory reviews, guidance updates, and targeted interventions where required.

3. **Strengthen transparency and accountability**

- Enable periodic disclosure of aggregate pollution performance outcomes through designated public or sectoral platforms.
- Use performance information to support evidence-based decision-making and stakeholder engagement.

4. **Scale up proven technologies and practices**

- Expand adoption of pollution prevention technologies and operational practices that have demonstrated effectiveness during Phase 2.
- Align scale-up with operational feasibility, cost-effectiveness, and sector readiness, avoiding blanket mandates.

5. **Institutionalise continuous improvement mechanisms**

- Periodically review pollution prevention measures, SOPs, and guidelines to reflect monitoring outcomes and evolving best practices.
- Integrate lessons learned from incidents, audits, and operational feedback into updated procedures and guidance.

Key Action Area	Key Stakeholders
Embed pollution prevention into operational systems (SOPs, consent renewals, port master plans)	MoPSW, DG Shipping, Port Authorities, Terminal Operators, SPCBs
Institutionalise monitoring and performance benchmarking across the maritime sector	MoPSW, CPCB, SPCBs, DG Shipping
Strengthen transparency and accountability through periodic disclosure of performance outcomes	MoPSW, Port Authorities, CPCB/SPCBs
Scale up pollution prevention technologies and practices validated during Phase 2	MoPSW, Port Authorities, Industry Stakeholders, Technology Providers
Institutionalise continuous improvement through periodic review and refinement of controls	MoPSW, DG Shipping, CPCB/SPCBs, Port Authorities

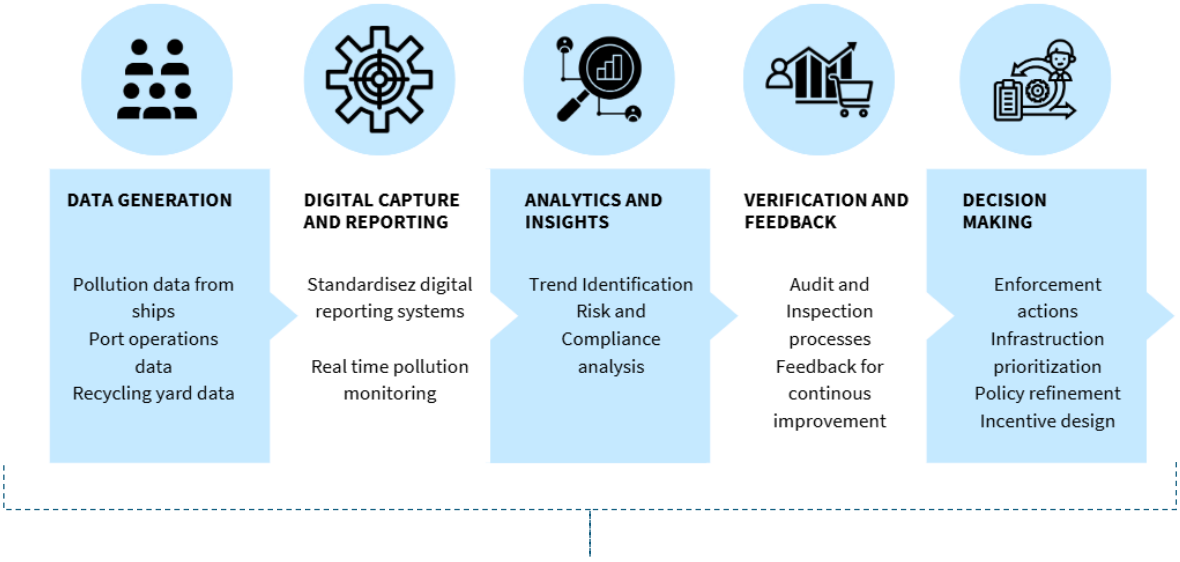
Final aim: *Pollution prevention becomes institutionalised within maritime governance and operations, supported by routine monitoring, benchmarking, transparency, and continuous improvement across the sector*

While the phased action plans define *what* actions are undertaken over time, effective pollution prevention also depends on *how data from these actions is captured, analysed, and used to inform decisions*. The Data-to-Decision Framework provides this cross-cutting mechanism, ensuring that implementation across all phases is evidence-based, transparent, and continuously improved.

Effective pollution prevention requires that data collected for compliance is also used to inform decisions. The data-to-decision framework illustrates how operational data is transformed into actionable outcomes.

Pollution data is generated at source by ships, ports, and recycling yards, digitally captured through standardised reporting systems, analysed to identify trends and risks, verified through audits, and used to support enforcement, infrastructure prioritisation, policy refinement, and incentive design. Feedback loops ensure continuous learning and improvement.

Data to decision framework



This framework shows how pollution-related data across the entire maritime value chain is systematically converted into regulatory, operational, and investment decisions. The data produced at source by ships, ports, and ship recycling facilities is digitally captured through standardised reporting systems and analysed for trends, risks, and compliance gaps. Verified data outputs then inform enforcement actions, prioritise pollution control infrastructure, refine standards and guidelines, and design incentives and financing mechanisms.

The framework plays a distinct role throughout the phased implementation pathway:

Phase 1 establishes baseline visibility and compliance reporting,

Phase 2 enables integration of operational and infrastructure-level data, and

Phase 3 embeds performance benchmarking and continuous improvement.

By closing the feedback loop between data collection and decision-making, the framework ensures that pollution prevention measures remain evidence-based, targeted, and adaptive over time.

5. CHALLENGES

Fundamental Implementation challenges in Pollution Prevention

Pollution-prevention implementation across the maritime sector is influenced by a range of structural, institutional, and operational constraints. Based on sectoral assessments and stakeholder consultations, five key challenge areas have been identified.

1. Infrastructure and Capacity Disparities
Implementation outcomes vary significantly across ships, ports, and ship-recycling facilities due to differences in infrastructure maturity, operational readiness, and access to pollution-control systems. Variations in port infrastructure, waste reception facilities, treatment systems, and monitoring equipment result in uneven pollution-control capabilities. These disparities contribute to fragmented progress and limit the ability to achieve uniform environmental performance across the maritime ecosystem.

2. Skills and Human Resource Gaps
Capacity constraints persist in the availability of trained personnel to operate and maintain pollution-control systems, manage hazardous materials, and implement environmental monitoring protocols. Skills gaps are particularly evident in emerging areas such as digital reporting, emissions monitoring technologies, and waste-handling compliance. Without targeted training and institutional capacity-building, the effectiveness and sustainability of pollution-prevention measures remain constrained.

3. Regulatory and Institutional Coordination Challenges
Pollution-prevention implementation requires coordination across multiple regulatory and administrative entities, including maritime authorities, environmental regulators, port administrations, and state agencies. Overlapping mandates, fragmented approval processes, and limited integration between environmental, maritime, and infrastructure planning frameworks can delay project execution and dilute accountability. Strengthening inter-agency coordination mechanisms remains critical for effective delivery.

4. Technology and Data Integration Gaps
While digital platforms and environmental reporting systems are gradually being introduced, data integration, interoperability, and feedback mechanisms remain at a nascent stage. The absence of unified data architectures limits the systematic use of performance data for compliance enforcement, prioritisation of interventions, and policy refinement. Strengthening Monitoring, Reporting, and Verification (MRV) systems and digital infrastructure is essential for evidence-based pollution management.

5. Evolving International Standards and Compliance Uncertainty
The rapidly evolving nature of international environmental regulations introduces uncertainty in technology pathways, compliance timelines, and investment decision-making. Stakeholders often face ambiguity regarding future standards, approved technologies, and transition commitments, particularly in areas such as emissions control, hazardous materials management, and waste treatment. This regulatory uncertainty can delay investments and slow adoption of pollution-prevention measures.

6. CONCLUSION

This Pollution Prevention Implementation Roadmap serves as a formal and pragmatic approach to marine pollution across the scope of India's maritime value chain. Through the anchoring of pollution prevention to sector-specific interventions, the sequential sequencing of these through a phased implementation pathway and deployment of a variety of regulatory, infrastructure, operational and digital tools, the roadmap facilitates the shift from merely compliance-driven action to consistent positive performance on environmental issues.

The Data-to-Decision Framework integrated allows monitoring and control of pollution and is applied on the continuous basis of data, verification results and performance trends. This permits that oversight, infrastructure planning, and investment decisions at regulators can be flexible, focused and appropriate in reacting with time to new risks and opportunities.

Collectively, the roadmap can contribute to tangible reduction-in-pollution performance and operational and economic feasibility for various maritime actors. It sets a baseline enabling a model of implementation transparency & accountability based on uniform practice and that makes pollution prevention a core element of a sustainable maritime development model in the region