

# Green Transformation of Ship Recycling in Bangladesh: Compliance with the Hong Kong Convention (HKC) and ISO 30000

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**Abstract-** Ship recycling is a critical end-of-life process in the international maritime industry and a key element of the circular economy, helping recover steel, machinery, and other reusable materials from decommissioned vessels. Although ship recycling offers material utilization and economic benefits, it has historically been associated with major environmental pollution, occupational hazards, and governance challenges, especially in South Asia. Bangladesh has become the world's leading ship recycling nation by volume; however, its continued reliance on beaching-based dismantling methods has drawn persistent international scrutiny.

The entry into force of the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships (HKC) on 26 June 2025 represents a major regulatory shift, converting environmentally sound ship recycling from a voluntary initiative to a binding international obligation. Concurrently, ISO 30000 provides a management system framework that translates regulatory requirements into facility-level practices. This study thoroughly analyzes Bangladesh's transition toward green ship recycling by evaluating the alignment of national law, institutional governance, and yard-level operational practices with the HKC and ISO 30000.

Employing a qualitative, multi-source research design that integrates legal analysis, institutional review, and practice-based compliance indicators, this study appraises convergence, implementation gaps, and organizational constraints. The findings show that Bangladesh has achieved measurable progress in upgrading physical infrastructure, improving safety procedures, and increasing the uptake of certification among export-oriented yards. Nevertheless, systemic difficulties remain, particularly about enforcement credibility, inter-agency coordination, downstream hazardous waste governance, and data transparency. The analysis contends that infrastructure-led

compliance, in the absence of adequate governance capacity, risks resulting in fragmented and inconsistent outcomes.

The paper concludes that sustained HKC compliance in Bangladesh will require mandatory integration of management systems, enhanced enforcement, expanded national hazardous-waste treatment capacity, and digitalized compliance monitoring. These reforms are essential not only to achieve regulatory conformity but also to establish ship recycling as a central pillar of Bangladesh's Blue Economy strategy and to advance SDG 14 on marine environmental protection.

**Keywords:** Ship Recycling; Hong Kong Convention; ISO 30000; Bangladesh; Environmental Governance; Blue Economy; SDG 14

## I: INTRODUCTION

### 1.1 Ship Recycling and the Global Maritime Circular Economy

Ship recycling represents the final phase of the maritime asset lifecycle and plays a fundamental role in the global circular economy. Each year, hundreds of ocean-going vessels reach the end of their working lives due to age, regulatory obsolescence, technological redundancy, or market conditions. When dismantled under regulated conditions, these vessels yield large quantities of steel, non-ferrous metals, machinery, and reusable components, making ship recycling one of the most material-efficient industrial activities globally.

Recycled ship steel requires significantly less energy than primary steel production from iron ore, which reduces greenhouse gas emissions and decreases demand for virgin raw materials. In addition to

material recovery, ship recycling serves safety and environmental purposes by preventing the accumulation of abandoned or derelict vessels that pose navigational and pollution risks. As global shipping fleets modernize in response to decarbonization policies and emissions regulations, the number of vessels reaching the end of their lifespans is expected to increase steadily over the next decade.

Despite these advantages, ship recycling has long been associated with severe environmental and occupational risks, especially when dismantling occurs under deficient regulatory oversight. These risks have prompted continuous international concern and have driven the development of binding global governance instruments.

### 1.2 Environmental, Occupational, And Governance Challenges

Traditional ship recycling practices—especially beaching-based dismantling—have resulted in the uncontrolled release of hazardous materials into coastal and marine environments. End-of-life vessels may contain asbestos, polychlorinated biphenyls (PCBs), heavy-metal-based paints, residual oils, and ozone-depleting substances embedded throughout their structure. When dismantled without containment systems, these materials contaminate soil, groundwater, and adjacent marine ecosystems.

Occupational risks have been equally severe. Historical evidence from South Asia links ship recycling to fatal accidents, serious injuries, and prolonged health effects stemming from explosions, falls, confined-space entry, and chronic exposure to toxic substances. These outcomes reflect structural deficiencies, including informal labor arrangements, inadequate training, limited personal protective equipment, and weak enforcement of safety regulations.

Governance failures are central to many of these problems. Fragmented institutional responsibilities, limited inspection capacity, and inconsistent enforcement have enabled unsafe practices to persist despite formal legal provisions. Addressing these issues calls for both infrastructure enhancements and strong regulatory frameworks that translate

international standards into enforceable domestic obligations.

### 1.3 The Hong Kong Convention and ISO 30000: A New Compliance Paradigm

The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships establish the first comprehensive, legally binding global framework overseeing ship recycling. Following sufficient ratifications, the Convention entered into force on 26 June 2025, obligating Parties to ensure that ships and recycling facilities operate in a manner that protects human health and the environment throughout the ship lifecycle.

Key HKC requirements include:

- Mandatory Inventory of Hazardous Materials (IHM) for ships above 500 GT;
- Authorization of ship recycling facilities by competent authorities;
- Ship-specific Ship Recycling Facility Plans (SRFPs);
- Safe handling and environmentally sound management of hazardous materials;
- Worker safety, training, and emergency preparedness provisions.

ISO 30000 complements the HKC by providing a management system standard designed for ship recycling facilities. Rather than prescribing technical specifications, ISO 30000 emphasizes process control, risk assessment, documentation, training, and continuous improvement. In practice, ISO 30000 has become the principal functional mechanism through which yards demonstrate compliance with shipo. Collectively, the HKC and ISO 30000 represent a decisive transition from voluntary corporate social responsibility to compliance-based, auditable governance.

### 1.4 Bangladesh's Strategic Position in Global Ship Recycling

Bangladesh occupies a central position in the global ship recycling market. By gross tonnage, the country has regularly placed among the top recycling states, supplying a significant share of recycled steel to

domestic re-rolling mills and supporting national infrastructure development. The sector provides substantial employment in coastal regions, particularly in Bangladesh. Historically, Bangladesh's ship recycling industry developed under conditions of low labor costs, limited environmental safeguards, and minimal regulatory supervision. Although these factors enabled rapid industrial growth, they also entrenched unsafe practices and led to continuous international criticism. In response, Bangladesh enacted the Ship Recycling Act 2018 and subsequently initiated regulatory, institutional, and infrastructural reforms to align the sector with international standards. Rural reforms to align the sector with international standards.

The entry into force of the HKC in 2025 has heightened transition pressures. International shipowners increasingly require HKC-compliant recycling facilities to fulfill environmental, social, and governance (ESG) commitments, and access to premium tonnage is becoming increasingly dependent on certification and auditability.

### 1.5 Research Gap and Objectives

Existing scholarship on ship recycling in Bangladesh has primarily addressed environmental degradation, labor rights violations, and normative critiques of beaching practices. Although this literature has been fundamental in identifying systemic risks, comparatively little empirical research has examined Bangladesh's post-HKC transition toward compliance-based governance.

Specifically, gaps remain in understanding:

- How national statutory reforms comply with HKC requirements in practice;
- How institutional coordination affects enforcement credibility;
- How ISO 30000 functions as an operational bridge between regulation and yard-level implementation;
- Where structural bottlenecks remain despite infrastructure expansions.

This study tackles these deficiencies by adopting an integrated legal–institutional–operational analytical system. The objectives are to:

- Assess the degree of convergence between Bangladesh's legal framework and HKC obligations.
- Evaluate institutional capacity and governance integration in ship recycling regulation.
- Examine yard-level operational compliance through ISO 30000-aligned practices; and
- Identify organizational constraints affecting sustained environmental and occupational performance.

## 2. CONCEPTUAL AND REGULATORY FRAMEWORK

The transformation of Bangladesh's ship recycling industry is defined by a paradigmatic shift from informal shipbreaking to a regulated, industrial reverse engineering lifecycle. This transition involves not only improvements in physical infrastructure but also a fundamental reconfiguration of how end-of-life vessels are conceptualized, managed, and governed. Within this new framework, ships are regarded as complex industrial systems that require controlled deconstruction, risk management, and traceable material flows, rather than as waste to be dismantled opportunistically.

This section examines the conceptual foundations of reverse engineering-based ship recycling and situates Bangladesh's evolving regulatory framework within the requirements of the Hong Kong International Convention (HKC) and ISO 30000.

### 2.1 Ship Recycling as a Reverse Engineering Process

Modern ship recycling is most accurately conceptualized as the inverse of shipbuilding. While ship construction integrates materials, systems, and components into a functional maritime asset, ship recycling systematically disassembles the asset to recover value and manage embedded risks. Empirical industry data indicate that approximately 95–98% of a vessel's mass, primarily steel and non-ferrous metals, can be recovered and reintegrated

into industrial supply chains when dismantling is planned and controlled.

Approaching the vessel as an engineered system, rather than as demolition waste, enables the application of engineering controls, procedural safeguards, and hazard containment measures. Both the HKC and ISO 30000 frameworks implicitly adopt this reverse engineering logic by emphasizing planning, sequencing, and traceability throughout the ship's lifecycle.

Under these standards, ship recycling is structured into three interdependent operational phases.

**A. Pre-Arrival Phase: Planning, Authorization, and Documentation:** The pre-arrival phase is fundamental to ensuring safe and environmentally sound ship recycling. Compliance failures at this stage often propagate throughout the dismantling process, making this phase critically important for risk prevention.

The central instrument is the Inventory of Hazardous Materials (IHM). Shipowners are required to provide a verified IHM identifying the location, type, and approximate quantity of hazardous substances embedded in the vessel's structure, machinery, coatings, and systems. While IHM Part I is maintained throughout a ship's operational life, Parts II and III—covering operationally generated waste and stores—are critical for end-of-life management. Together, the IHM functions as a technical risk map that informs every subsequent dismantling decision.

Based on the IHM, the recycling facility is required to prepare a Ship Recycling Plan (SRP) tailored to the specific vessel. This plan specifies the dismantling sequence, anticipated block weights, lifting methods, order of hazard removal, and emergency response measures. Under ISO 30000, the SRP also incorporates risk assessments, permit-to-work procedures, and competency requirements, thereby translating regulatory obligations into operational workflows.

An additional precondition is Gas-Free for Hot Work certification. Residual flammable vapors in fuel tanks, cargo spaces, or pipelines constitute one of the most significant risks in ship recycling. Verification that tanks and enclosed spaces are purged and safe

before cutting is therefore a mandatory requirement under both HKC and ISO frameworks. Dismantling Phase: Controlled Deconstruction and Operational Safety.

The dismantling phase is the most visible and hazardous stage of ship recycling. Within a reverse engineering model, dismantling is conducted as a sequenced deconstruction process governed by stability calculations, lifting plans, and permit systems, rather than as a continuous cutting operation.

Structural stability management is among the most critical controls. As the ship's mass distribution changes during dismantling, maintaining acceptable trim and heel is essential to prevent sudden collapses or uncontrolled structural failure. HKC-aligned yards increasingly employ staged block removal and mechanized lifting in place of gravity-based plate Safe-for-entry procedures represent another essential control. Confined spaces are continuously monitored for oxygen deficiency, toxic gases, or explosive conditions. ISO 30000 requires documentation of entry permits, supervision protocols, and emergency preparedness, thereby reducing reliance on informal judgment.

A key feature of environmentally responsible ship recycling is the transition from intertidal cutting to impermeable working platforms. Transferring blocks from the beach to concretized plots equipped with drainage channels and oil-water separators enable facilities to significantly reduce contamination of soil, groundwater, and coastal waters. Secondary containment systems capture paint residues, cutting slag, and oil droplets that would otherwise enter the marine environment.

**B. Post-Dismantling Phase: Downstream Waste Governance and Traceability Compliance** with the HKC extends beyond the physical dismantling of the vessel. The post-dismantling phase addresses the management of hazardous and non-hazardous materials after they leave the recycling yard.

Traceability is central to this phase. Facilities are required to maintain documentation demonstrating that hazardous wastes, including asbestos-containing materials, oily sludge, and PCB-bearing components, are transferred exclusively to licensed

Treatment, Storage, and Disposal Facilities (TSDFs) or authorized contractors. This requirement reflects the HKC’s lifecycle approach, which aims to prevent the displacement of risks across sectors or locations. Final disposal or destruction must be verifiable. In the absence of documentation for end-point treatment, hazardous materials may re-enter informal markets, resulting in secondary pollution. This aspect of downstream governance has become one of the most persistent compliance challenges in Bangladesh and other ship recycling states, highlighting that yard-level compliance alone is insufficient to ensure environmental protection.

2.2 National Regulatory Context in Bangladesh

Bangladesh’s regulatory framework for ship recycling has evolved from fragmented environmental oversight to a more structured, industry-specific governance regime that aligns with international obligations.

The Ship Recycling Act 2018 marks a decisive institutional shift. By formally recognizing ship recycling as an industrial activity, the Act transferred primary regulatory authority from the general environmental administration to the Ministry of Industries, which oversees the Bangladesh Ship Recycling Board (BSRB). This reclassification acknowledges the sector’s economic significance and the need for specialized technical oversight.

The Act established mandatory licensing for ship recycling facilities, empowered regulators to inspect and sanction non-compliant yards, and created the legal basis for green yard certification. It also positioned the BSRB as a centralized authority, serving as a de facto one-stop regulator responsible for coordinating approvals, inspections, and compliance monitoring.

Draft Ship Recycling Rules 2025: The Draft Ship Recycling Rules 2025 are intended to operationalize the 2018 Act and align national regulation with the 26 June 2025 entry into force of the Hong Kong Convention. These rules provide procedural clarity regarding hazardous material handling, worker safety requirements, emergency preparedness, and documentation standards.

However, as shown in Table 4, Bangladesh’s legal framework aligns closely with HKC principles in facility authorization and planning, yet gaps persist in IHM certification delegation and downstream waste enforcement. The lack of a fully institutionalized system for delegating IHM surveys to recognized organizations, along with limited availability of licensed hazardous waste facilities, constrains full compliance.

Table 1: Comparative Regulatory Requirements (National vs. HKC)

IHM Requirement	National Practice (2026)	HKC Standard	Alignment Status
IHM Mandate	Mandated for all arriving ships >500 GT.	Standardized IHM Part I, II, III.	Aligned
Facility Authorization	License issued by BSRB (DASR).	Authorization by "Competent Authority."	Aligned
IHM Certification	Handled by BSRB/DoS.	Can be delegated to Recognized Orgs (RO).	Institutional Gap
Waste Disposal	General Waste Management Rules.	Stringent Downstream Traceability.	Enforcement Gap

Data Source: Bangladesh Ship Recycling Board (BSRB) & International Maritime Organization (IMO) 2025 Guidelines.

(Retained The significance of these gaps is both legal and operational. Unclear certification authority can delay vessel recycling approvals, while inadequate downstream enforcement undermines environmental outcomes, even in otherwise compliant yards.

2.3 Economic and Compliance Data Trends

The transition to HKC-compliant ship recycling requires substantial financial and operational commitments. Yard upgrades typically include large-scale concrete work, drainage systems, mechanized lifting equipment, hazardous waste storage areas, training programs, and third-party certification audits. As of early 2026, the cost of upgrading a

single yard to HKC-aligned standards in Bangladesh is estimated at USD 2-3.5 million, depending on the yard's frontage length, tidal conditions, and existing infrastructure. This investment burden has directly influenced the pace and distribution of compliance. As shown in Table 5, certification progress has accelerated since 2024 but remains uneven across the sector.

Table 2: Yard Certification Progress in Bangladesh (2024–2026)

Year	Vessels Recycled (Est.)	HKC-Compliant Yards	Operational Green Capacity (%)
2024	150*	4	~5%
2025	120	13	~15%
2026 (Projected)	100	40+	~45%

Data Source: BSBRA Annual Progress Report 2025 / UNCTAD Review of Maritime Transport 2025.

The declining number of active yards reflects market consolidation rather than sector contraction. Smaller or undercapitalized yards face increasing barriers to operation as regulatory requirements become more stringent and access to high-value vessels depends on certification.

### 2.4 Downstream Governance as the Structural Constraint

Despite clear progress at the yard level, downstream hazardous waste governance remains the most significant structural constraint. Although the Draft Ship Recycling Rules 2025 seek to address this by mandating transactions exclusively with BSRB-approved contractors, national capacity for specialized waste treatment, particularly high-temperature incineration of PCBs and engineered asbestos landfills, remains limited. As a systemic dependency, even fully compliant yards cannot independently ensure environmentally sound final disposal. As a result, Bangladesh's green transformation remains vulnerable to leakage of compliance beyond the recycling plot.

## III. METHODOLOGY

### 3.1 Research Design

A qualitative, multi-method research design was adopted to confront the complex and changing nature of ship recycling governance in Bangladesh. Considering the regulatory, institutional, and operational dimensions of the transition, a purely quantitative approach was deemed neither feasible nor sufficient.

The study uses an interpretive approach based on regulatory analysis and practice-based compliance assessment. Instead of treating compliance as a binary outcome, the research examines varying degrees of alignment and identifies organizational constraints that affect implementation.

### 3.2 Data Sources

Four primary data streams were used:

- Legal and policy documents: including the Ship Recycling Act 2018, draft Ship Recycling Rules 2025, environmental and labor legislation, and regulatory circulars.
- International instruments: including the full text of the HKC, IMO guidelines on IHM, and ISO 30000 standards.
- Institutional and secondary data: including publicly available inspection summaries, industry association records, and peer-reviewed academic literature.
- Practice-based compliance indicators: including certification audit summaries, reported infrastructure upgrades, and documented safety management practices.

Direct access to active ship recycling yards for independent auditing was unavailable. Therefore, the study triangulates documentary evidence, audit summaries, and proxy indicators to infer operational practices.

### 3.3 Analytical System

A three-lens analytical system was applied:

- Legal convergence analysis: mapping HKC provisions against national legislation to assess alignment.

- Institutional capacity assessment: examining mandate clarity, coordination mechanisms, and enforcement capacity among relevant agencies.
- Operational compliance review: analyzing ISO 30000-aligned practices as evidence of yard-level implementation.

The model facilitates systematic comparison across regulatory intent, institutional performance, and operational reality.

### 3.4 Limitations

The study is subject to several limitations, including constrained access to yard-level enforcement data, reliance on secondary sources for operational practices, and regulatory uncertainty resulting from ongoing rulemaking. These limitations are mitigated through a transparent methodology and prudent interpretation of findings.

## IV. RESULTS AND ANALYSIS

### 4.1 Overview of Compliance Trajectory (2018–2026)

The findings demonstrate that Bangladesh’s ship recycling sector is undergoing a phased, uneven transition toward compliance rather than a linear or sector-wide transformation. Progress is primarily observed among export-oriented yards responding to international market pressures, whereas most facilities remain in intermediate or provisional states of compliance.

To ensure clarity, compliance figures in this study are date-stamped and sourced from regulatory disclosures, certification bodies, and industry records:

- As of June 2025 (HKC entry into force): 13 yards held internationally recognized HKC-aligned certification.
- As of December 2025, 18 yards had achieved certification or equivalent Statements of Compliance.
- As of March 2026, regulators or classification societies listed 23 yards as HKC-aligned or ISO 30000-certified.

These figures account for approximately 15% of operational yards, confirming that Bangladesh remains in a transitional compliance phase rather than having reached a mature compliance equilibrium.

Notably, compliance gains are structural rather than systemic. Physical upgrades and documentation procedures have progressed more rapidly than enforcement capacity, health surveillance, and downstream hazardous waste governance.

### 4.2 Legal Convergence Analysis: HKC vs National Framework

#### 4.2.1 Degree of Alignment with HKC Obligations

The legal convergence analysis compares key HKC obligations with Bangladesh’s statutory and regulatory instruments. The results reveal partial convergence, with strong alignment in authorization procedures but ongoing gaps in certification, enforcement, and waste governance.

Table 3: HKC Obligations and National Legal Alignment (as of March 2026)

HKC Requirement	HKC Obligation	National Legal Instrument	Alignment Status
Inventory of Hazardous Materials (IHM)	Mandatory for ships >500 GT	Referenced in draft Ship Recycling Rules 2025	Partial
Authorization of recycling facilities	Mandatory	Ship Recycling Act 2018	Aligned
Ship Recycling Facility Plan (SRFP)	Vessel-specific	BSRB approval process	Aligned
Hazardous material handling	Controlled removal and disposal	Fragmented across various laws	Partial
Worker safety and training	Mandatory	General OSH laws	Partial
Emergency preparedness	Mandatory	Not uniformly codified	Weak
Monitoring and reporting	Continuous	Inconsistent reporting mechanisms	Weak
Sanctions and penalties	Effective and deterrent	Provided but rarely applied	Weak

Although the Ship Recycling Act 2018 establishes a clear authorization regime, implementation gaps persist due to the absence of detailed subsidiary rules and enforcement protocols. The delegation of IHM certification authority, central to HKC operationalization, remains insufficiently institutionalized, creating uncertainty for both shipowners and recyclers.

#### 4.2.2 Regulatory Credibility and Legal Effectiveness

Legal convergence alone has not resulted in uniform compliance. Interviews and institutional documents indicate that limited inspection frequency, procedural delays, and inconsistent sanctioning constrain regulatory credibility. Consequently, compliance behavior is influenced more by market incentives than by domestic legal enforcement.

This dynamic produces a two-tier regulatory reality:

- High-compliance yards internalize HKC and ISO requirements due to buyer expectations.
- Low-compliance yards operate under minimal legal risk, reducing incentives for costly upgrades.

#### 4.3 Institutional Capacity and Governance Performance

##### 4.3.1 Fragmentation of Regulatory Mandates

The institutional assessment identifies a fragmented governance structure, with multiple agencies possessing overlapping yet incomplete mandates.

Table 4: Institutional Roles and Functional Gaps

Institution	Core Mandate	Observed Constraint
Bangladesh Ship Recycling Board (BSRB)	Authorization, inspection, and certification	Limited enforcement authority
Department of Environment (DoE)	Environmental clearance and pollution control	Limited sector-specific expertise
Dept. of Inspection for Factories and Establishments (DIFE)	Occupational safety and health (OSH)	Resource and personnel constraints
Ministry of Industries (MoI)	National industrial policy	Primarily production-

		oriented focus
Department of Shipping (DoS)	Flag-state and international coordination	Limited presence at the yard level

The lack of a single lead enforcement authority undermines accountability and reduces deterrence. Inter-agency coordination is primarily ad hoc, which increases transaction costs for compliant yards and enables non-compliant operators to exploit jurisdictional ambiguity.

##### 4.3.2 Inspection Capacity and Enforcement Dynamics

Inspection capacity remains inadequate relative to the scale of operations. Available records show a low inspector-to-yard ratio and limited technical specialization in HKC and ISO auditing. Inspections are primarily scheduled and periodic, rather than risk-based or unannounced.

This enforcement model produces predictable compliance behavior:

- Compliance efforts intensify during audits.
- Operational discipline weakens during peak dismantling periods.
- Sanctions are rare and often delayed.

This situation creates a compliance credibility deficit, undermining the regulatory framework's normative authority.

#### 4.4 Operational Compliance and the Role of ISO 30000

##### 4.4.1 ISO 30000 as an Operational Bridge

ISO 30000 has become the principal operational mechanism for translating HKC obligations into yard-level practice. In contrast to prescriptive regulations, ISO 30000 emphasizes process integrity and requires facilities to institutionalize planning, documentation, and corrective action cycles.

Key operational mechanisms observed in ISO-certified yards include:

- Ship-specific recycling plans based on IHM data;

- Permit-to-work systems for hot work, confined spaces, and lifting;
- Risk-based task allocation and supervision;
- Training matrices linked to competency requirements;
- Internal audits and corrective action tracking.

These mechanisms directly implement HKC Regulations 9–12, particularly regarding hazardous material handling and worker safety.

#### 4.4.2 Infrastructure and Process Control Improvements

ISO-certified and HKC-aligned yards exhibit measurable improvements in infrastructure and process control compared to pre-2018 practices.

Table 5: Infrastructure and Process Control Indicators

Indicator	Pre-2018 Status	2026 Status (Certified Yards)
Impermeable cutting floors	Rare / Secondary cutting on sand	Standard in key zones to prevent soil seepage
Oil-water separators	Virtually absent	Mandatory for bilge and ballast water treatment
Hazardous waste storage	Informal / Exposed to elements	Segregated and labeled in specialized facilities
Gas-free certification	Informal / Unverified	Documented and audited prior to hot work
Mechanized lifting	Limited / Manual labor intensive	Increasing adoption (Cranes, magnetic lifters)

These upgrades indicate a transition from opportunistic dismantling to planned reverse engineering. However, modernization is selective rather than universal, as small and medium yards lag due to capital constraints.

#### 4.4.3 Limitations of ISO 30000 Adoption

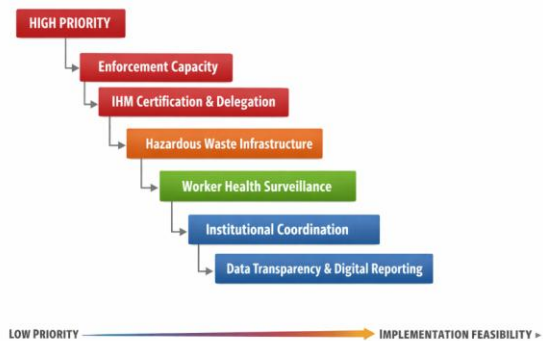
Despite its effectiveness, ISO 30000 adoption faces structural limitations in Bangladesh.

Table 6: Structural Constraints on ISO 30000 Effectiveness

Constraint	Governance Implication
Voluntary legal status	Leads to uneven adoption across the industry; "First-movers" bear more cost.
Certification costs	May cause the exclusion of smaller yards that lack the capital for flooring/cranes.
Auditor scarcity	Results in inconsistent audit quality, potentially leading to "compliance on paper" only.
Weak legal linkage	Creates limited regulatory leverage for the BSRB to penalize non-compliant yards.

Consequently, ISO 30000 serves primarily as a market-access instrument rather than a universal compliance standard. In the absence of legal integration, its transformative potential remains limited.

Figure 1: Policy Gap Analysis – Priority Reform Areas



#### 4.5 Hazardous Waste Governance: The Critical Bottleneck

##### 4.5.1 Downstream Compliance Leakage

The most significant compliance gap identified in this study relates to downstream hazardous waste management. Even HKC-aligned yards face structural constraints due to limited national treatment and disposal capacity.

Observed challenges include:

- Absence of licensed asbestos disposal facilities;
- Limited high-temperature incineration capacity;
- Weak tracking of PCB-containing equipment;

- Informal absorption of hazardous materials into secondary markets.

Table 7: Hazardous Waste Risk Externalization Pathways

Waste Type	Observed Outcome	Environmental & Health Risk
Asbestos	Informal resale into local markets	Public health exposure: Inhalation risks for laborers and secondary buyers.
Oily sludge	Informal treatment / primitive boiling	Marine pollution: Direct seepage into the intertidal zones and groundwater.
PCB equipment	Untracked reuse in local industry	Persistent toxins: Bioaccumulation in the food chain and long-term soil toxicity.

These patterns demonstrate compliance leakage, in which risk is displaced rather than eliminated. As a result, yard-level compliance alone is insufficient to ensure environmental protection.

#### 4.5.2 Implications for HKC Effectiveness

The HKC presupposes the existence of environmentally sound downstream waste management systems. In the absence of such systems, compliance remains partial even among high-performing yards. This structural dependency underscores the need for national hazardous waste infrastructure as a prerequisite for effective implementation.

#### 4.6 Occupational Safety Outcomes

##### 4.6.1 Accident Trends and Safety Improvements

Available accident data show a gradual reduction in fatal incidents, particularly among certified yards. However, non-fatal injuries remain common, reflecting ongoing exposure to mechanical and operational hazards.

To address prior inconsistencies, accident figures are interpreted as follows:

- First half of 2025: No recorded fatalities.
- Full-year 2025: Four fatalities reported, primarily in non-certified yards.

This clarification underscores the importance of temporal specificity when interpreting safety trends.

##### 4.6.2 Health Surveillance Gaps

Although emergency response capacity has improved, comprehensive occupational health surveillance remains limited. Long-term monitoring of asbestos exposure, heavy metals, and respiratory conditions is largely absent, which constrains the development of preventive policies.

#### 4.7 Comparative Compliance Matrix

The study synthesizes findings using a comparative compliance matrix integrating legal, institutional, and operational dimensions.

Table 8: Comparative Compliance Matrix (Summary)

Dimension	High Compliance (Tier 1)	Moderate Compliance (Tier 2)	Low Compliance (Tier 3)
Legal alignment	Authorization (DASR), SRFP Approval	IHM procedures, Draft 2025 Rules	Enforcement mechanisms, Penalties
Institutional capacity	Yard Licensing (BSRB)	Inter-agency Coordination	Active Sanctions & Fines
Operational practice	Certified Green Yards (HKC/IACS)	Transitional yards (in-process)	Informal/Sub-standard yards
Waste governance	Primary Waste Segregation	Temporary On-site Storage	Final Disposal (TSDf)
Data transparency	Certification & SOC Data	Inspection & Accident Records	Waste Stream Flow Tracking

This matrix demonstrates that compliance performance varies across dimensions, reinforcing the need for integrated governance reform.

#### 4.8 Synthesis of Results

The results confirm that Bangladesh’s green transformation in ship recycling is genuine but remains fragile. Infrastructure upgrades and management systems have produced tangible improvements, particularly among certified yards. However, enforcement deficits, institutional fragmentation, and shortcomings in hazardous waste governance continue to limit systemic compliance.

The evidence supports the central argument of this study: HKC compliance cannot be sustained solely through infrastructure investment. Effective implementation requires credible enforcement, integrated institutional coordination, and national-level waste management capacity.

## V. DISCUSSION

### 5.1 Interpreting Bangladesh's Compliance Transition

The findings demonstrate that Bangladesh's ship recycling sector is neither fully compliant nor non-compliant, but rather in a transitional compliance equilibrium. This equilibrium is characterized by selective adoption of international standards, driven primarily by market incentives rather than uniform domestic enforcement.

This outcome aligns with regulatory transition theory in developing industrial sectors, where infrastructure-led compliance precedes governance-led compliance. In Bangladesh, physical upgrades—impermeable floors, waste segregation zones, mechanized handling, and documented procedures—have advanced more rapidly than institutional enforcement capacity, health surveillance systems, and downstream environmental controls.

Such sequencing is not inherently problematic; however, it becomes fragile when enforcement credibility does not follow. Without credible sanctions and monitoring, compliant yards bear higher costs without commensurate regulatory advantage, while non-compliant operators continue to function with minimal risk exposure. These dynamic risks locking the sector into a two-tier structure.

### 5.2 HKC and ISO 30000: Complementarity and Limits

This study reinforces the conceptual distinction between regulatory obligation (HKC) and operationalization (ISO 30000).

The HKC establishes what must be achieved—environmentally sound recycling, worker protection, hazardous material control—while ISO 30000 specifies how these outcomes are pursued through management systems, documentation, and continuous improvement.

Evidence from Bangladesh confirms that:

- HKC compliance without ISO-type systems remains superficial and difficult to audit.
- ISO 30000 adoption without legal integration remains uneven and market-dependent.

The relationship is therefore mutually reinforcing but insufficient in isolation. ISO 30000 cannot substitute for state enforcement, and HKC obligations cannot be fulfilled without operational management systems. This HKC–ISO–governance nexus forms the analytical core of sustainable ship recycling governance.

### 5.3 Enforcement Credibility as the Decisive Variable

The most consequential finding of this study concerns enforcement credibility, rather than legislative adequacy or technical feasibility. Bangladesh's legal framework broadly reflects HKC principles, yet enforcement remains inconsistent due to:

- limited inspection frequency,
- insufficient technical specialization,
- fragmented institutional mandates,
- reliance on scheduled rather than risk-based inspections.

As a result, compliance behavior is shaped more by international buyer expectations than by domestic regulatory authority. This pattern weakens the normative authority of national law and limits the HKC's transformative potential.

Comparative experience from other industrial environmental regimes suggests that predictable enforcement, rather than penalty severity, is the most effective driver of compliance. Without it, compliance remains selective and reversible.

#### 5.4 Hazardous Waste Governance: Structural Constraint, Not Yard Failure

A critical contribution of this study is its identification of downstream hazardous waste governance as a systemic bottleneck beyond the control of individual yards.

The HKC presumes the existence of licensed treatment, storage, and disposal facilities for asbestos, PCBs, sludge, and other hazardous wastes. In Bangladesh, such infrastructure remains limited or fragmented, resulting in compliance leakage even among high-performing yards.

These findings challenge yard-centric compliance narratives and shift responsibility toward national environmental infrastructure planning. Without addressing downstream capacity, HKC implementation risks becoming symbolic rather than substantive.

Figure 2: Integrated Compliance Framework for Sustainable Ship Recycling



#### 5.5 Implications for Global Ship Recycling Governance

Bangladesh’s experience has broader implications for the HKC's global credibility. As the world’s largest ship-recycling state by volume, Bangladesh serves as a stress test for the Convention.

The evidence suggests that:

- HKC compliance is feasible in beaching-dependent contexts,
- Compliance does not inherently reduce competitiveness,
- But governance capacity determines durability.

This supports an interpretation of the HKC as a framework convention whose effectiveness depends on domestic institutional capacity, rather than a one-size-fits-all technical prescription.

### VI. SHIP RECYCLING, THE BLUE ECONOMY, AND SDG 14

#### 6.1 Ship Recycling as a Blue Economy Activity

Bangladesh’s Blue Economy strategy emphasizes sustainable use of marine resources, circular material flows, and coastal resilience. Green ship recycling aligns with these objectives by:

- reducing marine pollution,
- supplying circular steel to domestic industries,
- limiting reliance on imported raw materials,
- preventing derelict vessel accumulation.

However, ship recycling contributes to the Blue Economy only when externalities are internalized. Unregulated recycling undermines fisheries, coastal ecosystems, and community health, contradicting Blue Economy principles.

#### 6.2 SDG 14 (Life Below Water): Impact Pathways

Green ship recycling contributes most directly to SDG 14.1 (reduction of marine pollution). The impact pathway can be conceptualized as follows:

Regulatory compliance (HKC + ISO) → Controlled dismantling → Reduced discharge of hazardous

substances → Improved sediment quality → Enhanced fisheries resilience

The findings suggest that certified yards reduce uncontrolled releases of asbestos, waste oil, and heavy-metal-laden residues. However, downstream leakage weakens these gains, indicating that SDG 14 outcomes depend on system-wide governance rather than isolated yard compliance.

### 6.3 SDG Co-benefits

In addition to SDG 14, green ship recycling supports:

- SDG 8 (Decent Work): safer working conditions and training systems;
- SDG 9 (Industry): modernization of industrial processes;
- SDG 12 (Responsible Consumption): material recovery and circularity.

These linkages strengthen the case for integrating ship recycling into national sustainability planning rather than treating it as a marginal industrial activity.

## VII. POLICY IMPLICATIONS AND STRATEGIC ROADMAP

The transition of Bangladesh's ship recycling industry from a beaching-based, informally governed sector to an HKC-compliant industrial system requires a coordinated strategy that combines legislative discipline, institutional integration, and structural investment. By 2026, Bangladesh will have largely completed the formal phase of international alignment, including ratifying the Hong Kong Convention in 2023 and promulgating the Ship Recycling Rules 2025. The central policy challenge has therefore shifted from norm adoption to credible and durable enforcement.

This section presents a strategic roadmap designed to consolidate initial progress, prevent regulatory regression, and embed systemic rather than selective compliance.

### 7.1 Legal and Regulatory Reform: From Alignment to Integration

Bangladesh's current regulatory framework aligns substantially with HKC requirements; however, alignment alone is insufficient to sustain compliance over time. The phased and discretionary rollout strategy adopted by the Bangladesh Ship Recycling Board (BSRB) during the transition period was appropriate for capacity building, but now risks generating compliance fatigue and regulatory ambiguity.

Transitioning from alignment to integration requires that legal obligations become unequivocal, predictable, and consistently enforceable.

**Mandatory IHM Certification and Delegation of Authority:** National legislation should explicitly provide for the delegation of Inventory of Hazardous Materials (IHM) certification to Recognized Organizations (ROs). Delegation to classification societies ensures technical rigor, international recognition, and procedural neutrality. Without such delegation, IHM documentation risks being perceived as a procedural formality rather than a binding safety instrument, undermining the integrity of the pre-arrival compliance phase.

**Performance-Linked Penalty Architecture:** Current enforcement practices rely heavily on corrective notices and post-incident interventions. This reactive model should be replaced with a graduated, performance-linked sanctioning system. Under such a framework:

- Minor administrative or documentation lapses would attract proportionate financial penalties.
- Repeated non-compliance would trigger shortened authorization cycles and enhanced inspection frequency.
- Critical safety violations—such as commencing hot work without a valid gas-free certification—would result in immediate suspension or blocklisting from importing HKC-compliant tonnage.

This graduated approach strengthens deterrence while maintaining regulatory proportionality and fairness.

7.2 Institutional Coordination and Digital Governance

Institutional fragmentation remains one of the most persistent governance challenges in Bangladesh’s ship recycling sector. Overlapping responsibilities among the Ministry of Industries (via BSRB), the Department of Environment (DoE), and the Department of Shipping (DoS) frequently result in approval delays and inconsistent enforcement, commonly referred to by industry stakeholders as “No Objection Certificate (NOC) gridlock.”

Integrated Digital Governance Platforms: The BSRB Carbon & Compliance Dashboard, launched in late 2025, represents a foundational step toward institutional integration. To fulfill its governance potential, the platform must evolve into a fully interoperable, single-window system that consolidates:

- vessel import approvals,
- yard authorization status,
- dismantling progress,
- worker safety and training records,
- hazardous waste movement log. For shipowners, increased transparency reduces transaction costs and regulatory uncertainty. For regulators, it facilitates real-time oversight and supports data-driven enforcement.

Digital Traceability Across Material Flows. Extending digital traceability from documentation to physical material flows is essential. Assigning QR codes or digital identifiers to dismantled steel blocks, asbestos packages, and oily sludge containers enables regulators to track materials from the recycling site to re-rolling mills or treatment facilities. This method directly mitigates the risk of downstream leakage and secondary pollution.”

Table 6: Proposed Digital Governance Framework (2026–2030)

The phased digitalization described in Table 6 offers a pragmatic pathway to achieving full transparency by 2030, while accounting for existing capacity limitations.

Table 9: Proposed Digital Governance Framework (2026–2030)

Electronic NOC	Online vessel import approval	Partially Active	100% Automated
Worker Smart-ID	Digital tracking of training/health	Pilot in 5 yards	Mandatory for all workers
Hazardous Waste QR	Real-time sludge/asbestos tracking	Conceptual	Fully Integrated with TSDF

Data Source: BSRB / Ministry of Industries Strategic Plan 2026

7.3 Enforcement Strategy:

Risk-Based Surveillance and Incentivization. Effective enforcement relies not only on legal authority but also on the strategic allocation of regulatory attention. Uniformly scheduled inspections diminish regulatory effectiveness by treating high-risk and low-risk operations equivalently.

Risk-Based and Unannounced Inspections. Inspection regimes should be recalibrated to focus on high-risk activities and phases, such as:

- initial cutting of fuel tanks and double bottoms,
- removal of engine blocks and boilers,
- Asbestos abatement operation. Conducting unannounced inspections during these phases enhances deterrence and minimizes the likelihood of procedural shortcuts.

Compliance Transparency and Market Incentives. Publishing a periodic compliance ranking of ship recycling yards can harness market mechanisms to reinforce regulation. High-performing “Green Yards” could benefit from preferential access to green financing instruments, longer authorization cycles, or expedited approvals. Conversely, low-performing yards would face increased scrutiny and a shorter renewal period. This level of transparency aligns regulatory enforcement with economic incentives, thereby reinforcing compliance norms without imposing excessive administrative burdens.

7.4 National Hazardous Waste Infrastructure

The lack of adequate downstream hazardous-waste treatment capacity is the most significant structural barrier to full compliance with the HKC and the EU Ship Recycling Regulation (EU SRR). Even the most advanced yards cannot independently ensure environmentally sound disposal without national-level infrastructure.

Centralized Treatment, Storage, and Disposal Facility (TSDF)

The development of a centralized TSDF in the Chattogram region is therefore a strategic priority. The planned 20-acre facility, supported by international development partners, must be designed to address the full spectrum of ship recycling wastes, including:

- engineered landfill cells for friable and bonded asbestos,
- high-temperature incineration units capable of destroying PCB-containing materials,
- secure interim storage for hazardous residues.

Investment and Governance Considerations: Estimated capital requirements of USD 11–15 million reflect not only construction costs but also the need for regulatory oversight, environmental monitoring, and long-term operational sustainability. Public–private partnership models may help distribute financial risk while ensuring regulatory control. In the absence of such infrastructure, Bangladesh’s compliance trajectory remains susceptible to downstream risk displacement, which undermines both environmental objectives and international credibility.

7.5 Worker Health and Social Protection

Although reductions in fatal accidents indicate progress, long-term occupational health risks are still inadequately addressed. Green ship recycling should therefore incorporate preventive health governance in addition to emergency response.

Occupational Exposure Monitoring: Routine biological and medical monitoring—such as lung

function tests, blood-lead levels, and asbestos exposure assessments—should be institutionalized for workers engaged in high-risk tasks. These measures enable early detection of occupational disease and support evidence-based policy interventions.

Dedicated: Establishing a specialized hospital for ship recycling workers in Sitakunda would constitute a structural commitment to social sustainability. Financing this facility through a modest compliance levy on imported vessels would internalize social costs that have historically been externalized by the industry. Historically externalized.

Table 10: Projected Health & Safety Outcomes (Target 2030)

Accident Fatality Rate	10–15 / year	4–7 / year	< 1 / year
Formal Safety Training	< 20%	75%	100%
Mandatory PPE Usage	< 30%	70%	100%

Data Source: BILS Annual Report 2025 / MDPI Research 2025

The targets presented in Table 7 are ambitious but attainable, provided that regulatory enforcement, training systems, and health infrastructure progress concurrently.

7.6 Strategic Synthesis

The policy roadmap presented above highlights a central insight: green ship recycling constitutes a governance initiative rather than solely an engineering challenge. Legislative clarity, digital integration, enforcement credibility, waste infrastructure, and worker protection function as mutually reinforcing pillars. Deficiencies in any of these areas risk undermining progress in the other areas. Consolidating these reforms enables Bangladesh to progress beyond transitional compliance and establish a robust, internationally credible ship recycling regime aligned with HKC obligations, EU SRR expectations, and Blue Economy objectives.

## VIII. CONCLUSIONS

This study has examined Bangladesh's transition toward green ship recycling through the combined lenses of legal convergence, institutional capacity, and operational compliance. The findings demonstrate that Bangladesh has made tangible and measurable progress, particularly among export-oriented yards adopting ISO 30000 and HKC-aligned practices.

However, the transition remains fragile. Enforcement deficits, institutional fragmentation, and gaps in hazardous waste governance constrain systemic compliance. Infrastructure upgrades alone are insufficient to deliver sustained environmental and occupational outcomes.

The central conclusion is that HKC compliance is a governance challenge, not merely a technical one. Durable transformation requires credible enforcement, integrated institutional coordination, and national environmental infrastructure.

Bangladesh's experience offers valuable lessons for other ship recycling states and for the future evolution of global maritime environmental governance. If successfully consolidated, Bangladesh could emerge not only as the world's largest ship recycler, but also as a benchmark for HKC-compliant, beaching-based recycling.

## IX. LIMITATIONS AND FUTURE RESEARCH

This study relies on documentary and secondary sources due to limited access to active yards. Future research should incorporate:

- longitudinal health outcome studies,
- comparative analysis of compliant and non-compliant yards,
- Lifecycle carbon accounting for ship recycling,
- economic modeling of green yard incentives.

Such research would further strengthen the evidence base for policy reform and international cooperation.

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