Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/NA11.20260243
Published: June 9, 2026

Assessment of Present Challenges of Bangladesh Ship Recycling Industry and Way Forward

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Abstract

Ship recycling generally involves reverse engineering, deconstructing obsolete or End of Life (EOL) ships to recover usable materials in a safe, environmentally friendly manner. Over the past thirty years, most ship recycling has occurred in a few South Asian countries—mainly Bangladesh, India, China, and Pakistan—where vessels are usually beached and dismantled through labor-intensive methods that offer moderate safety protections. Those three countries have played a crucial role in global ship recycling, with considerable efficiency, though often in a reasonable and professional manner. Roughly 90% of the world's tonnage of EOL ships are recycled in South Asian nations. Bangladesh's local recycling yards currently account for almost 40% of the world's ship recycling tonnage, ranking alongside India and Pakistan as the world's top ship recycling nations. Local yards supply the necessary raw materials and employ large numbers of semi-skilled workers in coastal areas prone to poverty. However, the industry faces distinct challenges in managing coastal zones, addressing environmental deterioration, enforcing laws, and ensuring occupational health and safety.

Keywords
EOL, HKC, GT, DoE, sustainable, recycling

1. Introduction

The dismantling and recycling of End-of-Life (EOL) boats is known as the ship recycling industry, widely acknowledged as an important and sustainable global practice. Ship recycling is an important and profitable industry, as thousands of outdated ships are recycled annually (Hossain, 2015a, b). Despite this, the beaching technique is still widely used in South and Southeast Asia due to their geographic locations and tidal conditions. The dry-dock system, on the other hand, is mostly used in wealthy nations like the USA and the EU and is seen as the safest and most environmentally sound, though much more costly to build and operate. Some countries, such as Turkey and China, have adopted a middle-ground approach using the "alongside" or "pier breaking" method rather than beaching (Hossain, 2023a, b, c). Among these, Aliaga in Turkey and certain locations within the European Union are leading advocates for high-standard, environmentally friendly ship recycling practices, openly opposing the traditional beaching or slipway techniques. End-of-life (EOL) ships are usually beached for recycling and deconstruction in South Asian nations including Bangladesh, India, and Pakistan, taking advantage of the region's favorable tidal conditions. These countries have played a significant role in environmental preservation by efficiently recycling obsolete and

decommissioned vessels—many of which, as history suggests, were once discarded in deep seas. Looking ahead, it is estimated that nearly 20,000 ships worldwide aged between 25 to 30 years and are approaching the end of their service life and will soon require recycling (Hossain, 2023f, g).

At the Hong Kong Conference (HKC) in 2009, the International Maritime Organization (IMO) introduced the International Convention for the Safe and Sustainable Recycling of Ships to encourage ecologically conscious practices. Decisions made in 2017 under the European Union Ship Recycling Regulation (EU SRR) are expected to have a major impact on global ship recycling, even though important maritime nations have ratified the HKC and many South Asian ship recycling yards currently follow HKC standards and hold green certifications (Mambra, 2017). Major investments could result from the EU's official recognition of HKC-2009 compliance, particularly in the upgrade of ship recycling facilities in Alang, India; Chattogram, Bangladesh; and Gadani, Pakistan. Closer cooperation between these three nations is essential to the beaching method's continued viability and sustainability in South Asia (Hossain, 2023d, e). To improve business processes, maintain worker safety and environmental standards, and preserve the financial benefits of ship recycling in the area, a concerted effort is required (Khandakar, 2025). Ship recycling contributes significantly to resource recovery and environmental sustainability globally by dismantling end-of-life boats to recover important resources like steel, machinery, and equipment. About 90% of the world's ship recycling is handled by South Asia because of its advantageous location and cheaper labor costs; hundreds of ships, including tankers, bulk carriers, and container ships, are disassembled there annually. In this area, Bangladesh has become a major participant and industry leader.

The coastline of Chattogram, particularly the Fauzdarhat area, serves as the nation’s primary hub for ship recycling operations. Ship recycling has become a billion-dollar business in Bangladesh since its unforeseen beginnings in 1965 (Hossain, 2021, 2024). Currently, it provides over half of the nation's raw resources for domestic shipbuilding and steel production. The industry provides huge employment (around 200,000) and supports the livelihoods of approximately one million people directly/indirectly, and creating it a vital source of income in economically vulnerable regions. Now, around 40% of the global EOL gross tonnage (GT) is recycled annually on the beaches of Bangladesh alone. This sector employs more than 200,000 workers and contributes around USD 1 billion to the national economy. The industry continues to be criticized for using the beaching method, which is economical but compromises the environment, despite its significant economic contributions (Khandakar, 2025). This study will analyze the quantity and types of reusable and waste materials generated by the ship recycling process in Bangladesh, based on field-level data collected by author. It will further assess how these materials are distributed and managed in terms of reuse, recycling, and disposal in a model of a distribution channel.

Although fully green ship recycling, which complies with strict European regulations, is still costly, improving the beaching techniques currently employed in South Asian recycling yards can result in a more practical and ecologically friendly model. This study will assess Bangladesh's ship recycling industry from a broader global standpoint. It examines the industry's historical development, current regulatory challenges, comparative performance against other leading ship recycling nations, and its socio-economic contributions. As an analytical and research-based investigation, the study offers critical insights into the current state of Bangladesh’s ship recycling sector, forecasts its future trajectory, challenges, and outlines actionable pathways for sustainable and competitive growth in the global market. Overall, this study presents an inclusive overview of Bangladesh’s ship recycling industry, along with comparative analysis with global players and offers few contemporary recommendations. However, this is and analytical study on Bangladesh ship recycling industry to evaluate prospect and challenges in line of global perspective. This research study will answer few research questions as mention below.

a. What is the present status of recycling industry of Bangladesh?
b. What is the useable and waste material output from local recycling yards?
c. What is the distribution channel of recycling material?
d. Which investment methods are the most economical for yards to comply with HKC/EU regulations?
e. What are the challenges of recycling industry of Bangladesh?
f. How can Bangladesh minimize health and environmental risks by optimizing industry's economic benefits?

2. Methodology

2.1 Assessment of Local Ship Yards' Material Output

This study's approach seeks to address gaps in previous research that depended on international standards by providing a detailed and targeted analysis of Bangladesh's ship recycling industry. Data were collected over seven years (2011–2017) from multiple ship recycling yards in Chattogram, covering 26 end-of-life ships of different sizes and types—including five bulk carriers, five tankers, six container ships, five cargo vessels, and five other types like passenger ships and offshore vessels. To provide a representative sample, the ships were deliberately chosen to account for differences in ship design, age (15–25 years), and provenance (e.g., Asia, Europe, Americas). LDT range (8,000–60,000 MT), operational history, and adherence to dismantle regulations were among the ship selection criteria. Data collection has been directly aided by the Bangladesh Ship Breakers Association (BSBA), yard operators, and regulatory/law enforcement agencies like the Ministry of Industry (MOI), Ministry of Shipping (MOS), Department of Environment (DoE), Department of Labor (DoL), Ship Building and Ship Recycling Board (SBSRB), Chittagong Port Authority, Bangladesh Navy, and Coast Guard. This multi-stakeholder strategy guaranteed thorough and accurate data gathering that reflected operational subtleties and real-world practices (Hossain, 2015a; Hossain & Zakaria, 2018; Mikelis, 2013, Hossain, 2019b). This study will show the current state and difficulties of Bangladesh's local ship recycling sector along with recommendations for sustainability going forward (Khandakar, 2025). Along with appropriate recycling procedures in Bangladesh, this study also examines the economic and environmental effects of the global ship recycling industry.

2.2 Primary Data Collection

In this study, the author has aimed to illustrate the actual distribution channels of reusable and waste materials generated by local industries in Bangladesh. This was achieved through on-ground analysis (Bois, 2009; Eolog, 2025) and the collection of real data over seven years (2011–2017) through direct involvement. Data on ship recycling activities were gathered from the local ship recycling industry in Chattogram, with contributions from various stakeholders and the Bangladesh Ship Breakers Association (BSBA). The inventory of reusable and hazardous wastes from recycled ships was compiled based on this collected data. Results are grounded in original field data and guided by methodologies outlined in existing literature and research papers. Basic data on the outputs of materials, components, and hazardous substances from different types of recycled ships were obtained through the author's direct engagement (Chowdhury, 2019). However, the scope did not include nuclear waste or other releases, such as atmospheric emissions and diffuse pollution to water bodies (Eolog, 2025; Hoque & Emran, 2016). The average annual production of recyclable materials was estimated from a sample of 26 different ship types, categorized by size (LDT). The sample included five bulk carriers, five tankers, six container ships, five cargo vessels, and five other ship categories. Each ship's inventory took between six to eleven months to complete, involving sustained collaboration with the industry. Table 1 below presents data and figures for these 26 end-of-life ships.

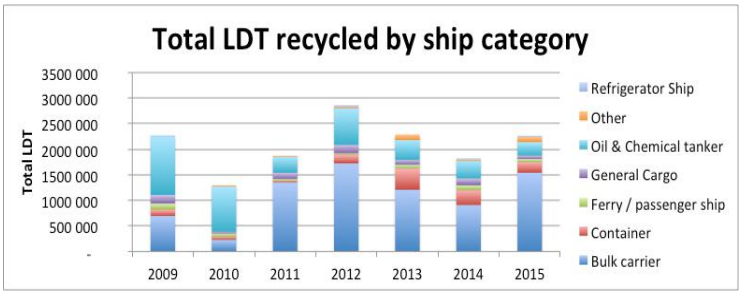

Figure 1. Data collection history including different type/category of ships with LDT

2.3 Secondary Data Collection

Secondary data were gathered from various sources to provide the study's foundational context. These included academic journals, books, policy briefs, industry and yard records (such as tonnage, vessel counts, steel output), government and institutional reports (e.g., MOI, BSRB, DoE), international organizations (IMO, UNCTAD, NGO Ship-breaking Platform), media reports, grey literature, and actual fieldwork carried out over the previous 20 years. To examine Bangladesh's ship recycling industry, the study employs a mixed-methods research strategy that combines

qualitative, quantitative, and policy analysis methods. Data on ship-breaking volumes, employment, scrap steel output, accidents, and environmental breaches were gathered to evaluate industry trends and compliance issues over the past 20 years. Focus groups, quantitative forecasting, benchmarking, expert validation, historical and regulatory analysis, and secondary data collection are all included into the technique. This all-encompassing strategy aims to provide a comprehensive understanding of the industry's social, economic, environmental, and regulatory aspects. The data, analysis, and conclusions outline a complex yet crucial path as Bangladesh's ship recycling sector navigates the post-Hong Kong Convention (HKC) enforcement phase. Based on primary data from more than 500 stakeholders, field observations, the researcher's significant 20-year industry experience, and secondary data from global shipbreaking records (2014–2025), the report offers insights into industry readiness, competitiveness, and future prospects. Market competitiveness, labor and environmental circumstances, institutional readiness, and policy conformity with international standards are the four main areas of the study.

2.4 Focus Group Discussions (FGDs)

To incorporate all ship recycling related stakeholder perspectives, a series of FGDs has done and that conducted with: Shipyard workers (both skilled and unskilled), Yard owners and managers, Government officials (e.g., Department of Environment, BSRB), NGO representatives (e.g., YPSA, Shipbreaking Platform), Local and international expertise, Yard Owners and executives, and Environmental and labor rights activists. Each FGD has involved 6–10 participants, guided by a semi-structured questionnaire. Perceptions of workplace safety, obstacles to compliance, the consequences for social livelihoods, and opinions on the need of modernization are among the themes. FGDs have aimed to capture community-level insights that were often underrepresented in macro-level policy analysis.

3. Material Output Data Analysis and Result in Local Recycling Yards of Bangladesh

3.1 Assumption and Analysis Procedures

All reusable and trash elements of different sizes and types from 27 EOL ships that were disassembled and recycled in Bangladesh make up the essential data for this study, as figure 1 above illustrates. Data input, analysis, compilation, computing, and the calculation of numerical values (such as the industry's annual reusable and waste materials) have all been done using Microsoft Excel and the material flow analysis (MFA) application STAN. This study project does not cover nuclear waste or other outflows, such as air pollutants and diffuse pollutants into water. The non-economic value stream (NEVS) and the economic value stream (EVS) are the two primary material streams for each process (EVS). The recycling yard can profit from the products in the EVS stream that can be recycled or sold in market for other uses. The recycling yard must pay for the materials in the NEVS stream that need to be disposed-off at landfills or waste treatment plants (Chowdhury, 2019; Hoque et al., 2010; Hiremath et al., 2015). So, EVS stream products result cash in-flow for the recycling yard. And NEVS stream products needs to be disposed-off result in cash out-flow for the recycling yard. The distribution of material streams into the EVS and NEVS for yards might change depending on a variety of factors, such as location, recycling practices, demand in the used market, the presence of forward and backward linking companies, laws, and time (Hossain, 2018b, c and 2023a).

3.2 Calculation and Analysis of Reusable Material Output

Ship recycling yields an extensive range of reusable materials, often comprising hundreds to thousands of distinct items per vessel. In this study, the author undertook the challenging task of preparing a comprehensive inventory of materials and components from 26 EOL ships. Given the industry's restrictive nature and the scale of the data involved, the process required sustained effort over 7 years. To facilitate this data-intensive undertaking, the researcher assembled a dedicated team consisting of six data entry personnel and two supervisory managers (Hiremath et al, 2015; Hoque et al, 2010, and Chowdhury, 2019). The reusable materials extracted from the selected sample of ships were categorized into four main groups in accordance with the guidelines set forth in the Hong Kong International Convention for the safe and environmentally sound recycling of ships (HKC, 2009; Gramman et al., 2007; Gregson et al., 2012) and has shown in figure 2 below. This categorization was further refined using principles of ship design and construction, drawing on the researcher's professional expertise as a naval architect. The classification scheme was also informed by existing academic and technical literature (Andersen, 2001; Arab News, 2024; Abdullah et al., 2010; EC Regulation, 2006; Eolog, 2025; Hossain & Zakaria, 2010a). Data collection was conducted through manual tallies and digital entry using Microsoft Excel spreadsheets. The Material Flow Analysis (MFA) has been used as a tool to visualize, compile, estimate, plan, and compare different scenarios that can arise as a result of breaking and recycling of any EOL ships. Results were calculated and cross-checked using Microsoft Excel and the MFA program

STAN (Hossain, 2019b, c). The output of reusable materials and their amount from EOL ships have shown in Figure 3.

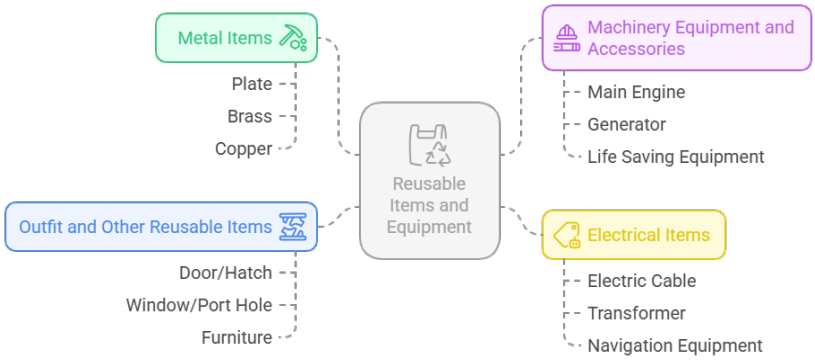

Figure 2. Illustration of reusable items and equipment extracted from EOL ships

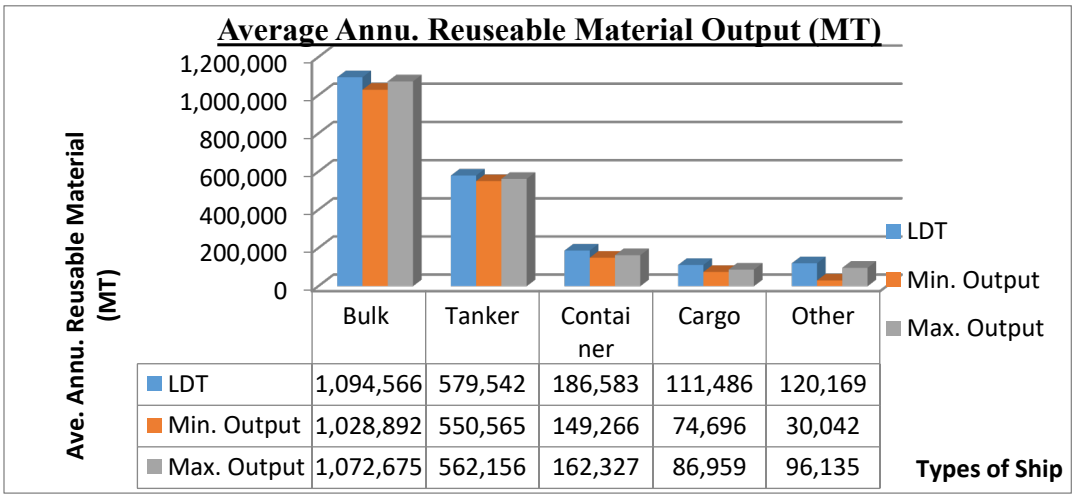

Figure 3. Average annual LDT against reusable material output in MT (Hossain, 2018b, c)

3.3 Calculation and Analysis of Waste Material Output

To quantify waste material output and determine the amount, associated factors, a combination of manual calculations and digital tools has employed. Results were calculated and cross-checked using Microsoft Excel and the Material Flow Analysis (MFA) program STAN (Hossain, 2019b, c). It was observed that results from manual computation varied by no more than 0.4% compared to those generated by STAN, while outputs from Microsoft Excel were fully consistent with manual estimates (Eolog, 2025; Galley, 2014; Hossain et al., 2010a). The average yearly amount of hazardous material (in metric tons) produced from various types and sizes of EOL ships refurbished, restore and reuse has shown in Figure 4. However, figure 5 below illustrates the relation among average reusable, waste and asbestos factor with LDT of EOL ships in Bangladesh recycling yards (Hossain, 2018b, c, and Hossain, 2019b, c).

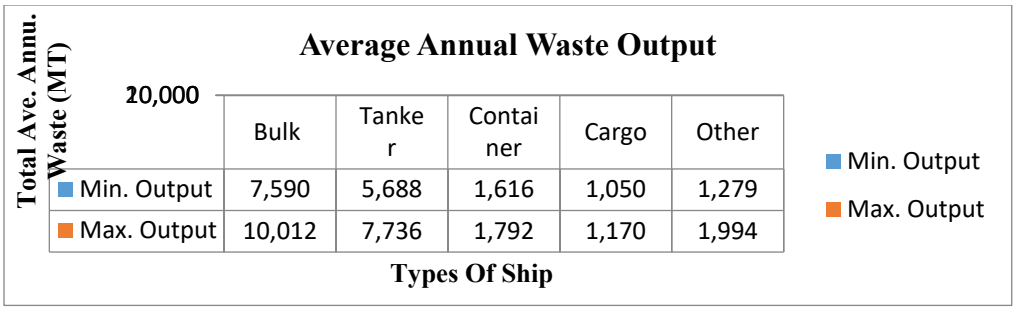

Figure 4. Total average annual HazMat or Waste output in MT from different types and sizes of EOL ships

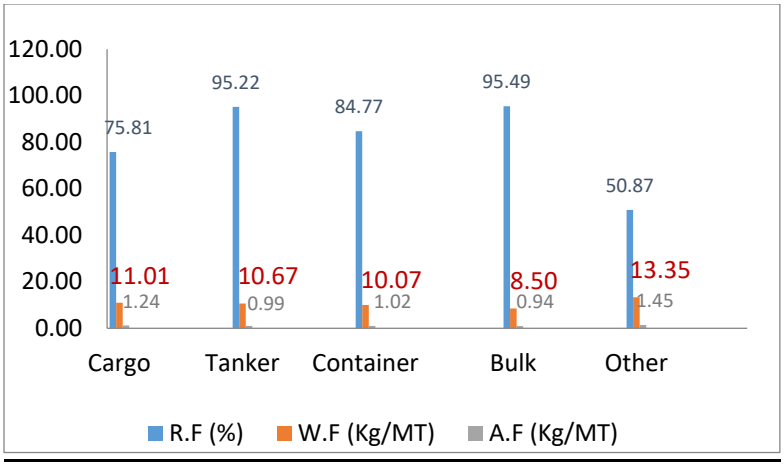

Figure 5. Relation among average reusable, waste and asbestos factor with LDT of EOL ships

3.4 Analysis of Result of Reusable Materials Factor and Annual Output (EVS)

Reusable materials, constituting ~73–95% of LDT (1,833,461–1,989,252 MT annually), are categorized per HKC (2009) guidelines into four groups to facilitate compilation and market distribution as discussed above. These materials are integral to local industries, re-rolling mill, supporting shipbuilding, construction, and small-scale enterprises (Hossain, 2015a; Sujauddin et al., 2017). Approximately 97% of materials, for example metal, even glass wool insulation (valued at USD 110/ton in Bangladesh vs. USD 100/ton in India), are recycled locally, driven by strong demand in secondary markets (Hossain and Zakaria, 2018; Sarraf et al., 2010). However, the reuseable material factors and annual output of local recycling yards have been shown in table 1 below (Hossain, 2019b, c and Khandakar, 2025).

Table 1. Reusable material factors and annual output (2009–2016)

Ship Type	Reusable Factor (% LDT)	Annual Output (MT, Min–Max)
Bulk Carrier	75–92	450,000–550,000
Tanker	73–90	500,000–600,000
Container Carrier	78–95	400,000–480,000
Cargo Ship	76–93	350,000–420,000
Other Types	74–91	133,461–139,252
Total	73–95	1,833,461–1,989,252

3.5 Analysis of Hazardous Material or Waste Factor and Annual Output (NEVS)

Hazardous waste, comprising ~1+ % of LDT (17,215–22,702 MT annually), is categorized into six groups per HKC (2009) and Bangladesh Environment Conservation Act (1995) to ensure systematic management and disposal as

discussed above. Effective management of these materials is critical to mitigating environmental and health risks (HKC, 2009; Demaria, 2010). Approximately 97% of glass wool is recycled locally, with below 2% sent to TSDF. Bilge water, waste oil (USD 10–16/barrel), and solvents are sold to local industries (like brick furnaces). Incineration is technically viable but costly, while landfilling, though cost-effective, poses long-term environmental risks (Hossain & Zakaria, 2018; Reddy et al., 2004). Hazardous material or waste factors and annual output of local recycling yards have been shown in table 2 below (Cencic et al, 2008; Devault et al, 2017 Demaria, 1010; Hiremath et al, 2015; Hoque et al, 2010, and Chowdhury, 2019 and Khandakar, 2025).

Table 2. Hazardous Material or Waste Factors and Annual Output (2009–2016)

Waste Category	Waste Factor (kg/LDT)	Annual Output (MT, Min–Max)
Asbestos (Group A)	0.5–2.0	1,000–4,000
Landfillable (B)	0.3–1.5	600–3,000
Incinerable (C)	0.2–1.2	400–2,400
Bilge/Liquids (D)	0.3–1.8	600–3,600
Heavy Metals (E)	0.1–0.5	200–1,000
Ozone-Depleting (F)	0.05–0.3	100–600
Total	1.45–7.3	17,215–22,702

3.6 Comparative Analysis with Other Countries

A comparative assessment with Alang in India, based on a field survey of 241 ships dismantled between 2011 and 2013, highlights both similarities and clear differences in ship recycling practices. Bangladesh shows a higher average recovery of reusable materials per Light Displacement Ton (LDT), largely due to strong local market demand and fewer resale restrictions. In Table 3, Bangladesh achieves greater material recovery across most categories in compare to India. Reusable outputs range from 750 to 920 metric tons per 1,000 tons of LDT, compared to 600 to 725 metric tons in Alang. In contrast, hazardous waste outputs, including asbestos, incinerables material, and bilge liquids, show relatively similar levels between the two locations, pointing to shared challenges in waste handling. However, table 3 has given a comparative result between Bangladesh and India of reusable and waste material output in kg per ton of LDT of EOL ships (Jain et al, 2013, 2017 and ILPI, 2016). The data shows that: Bangladesh records higher maximum recovery across all vessel types, especially bulk carriers and tankers. However, waste generation remains steady across ship types, but the methods of disposal, such as landfilling and incineration, vary with local management capacity (Hossain, 2019b, c and Khandakar, 2025). A closer comparison reveals that Alang benefits from tighter regulatory oversight, primarily administered by the Gujarat Maritime Board and related agencies. In contrast, Bangladesh relies on the Ship Breaking and Ship Recycling Board (SBSRB) and the Department of Environment (DoE), indicating a greater need for institutional strengthening and monitoring capacity. While Bangladesh achieves efficient material recovery due to strong local demand and an active informal resale network, this also limits transparency and traceability in the supply chain. Moreover, documentation practices in Bangladesh are gradually improving, shifting from informal estimates to more structured inventory records, although notable gaps in data accuracy and consistency still remain (Hossain, 2025c).

Table 3. Comparison of reusable and waste material factors (Bhatiary, Bangladesh vs. Alang, India)

Material Type	Bangladesh (kg/LDT)	Alang, India (kg/LDT)
Reusable (EVS)	730–950	700–900
Asbestos	0.5–2.0	0.6–2.2
Landfillable	0.3–1.5	0.4–1.8
Incinerable	0.2–1.2	0.3–1.5
Bilge/Liquids	0.3–1.8	0.3–2.0

4.Evaluation of Distribution Channel Model

The author has illustrated the actual distribution channels of reusable and waste materials generated by the local recycling industry in Bangladesh, based on on-ground information and detail analysis through direct involvement for

last two decades and a distribution channel model has been illustrated and that has shown in figure–6 below. Distribution channel of a typical container ship illustrates the flow of materials and which has shown in figure-26 below. The material distribution channel shown clearly flow from recycling yards to end markets with disposal facilities, and that optimized through MFA to maximize resource efficiency and minimize environmental impact (Cencic et al, 2008; Devault et al, 2017 Demaria, 1010, Hiremath et al, Hossain 2019a, b). However, during the last decade, there were many significant improvements of ship recycling industry in the areas of: handling hazardous waste; safety during confined space recovery, and at heights; fire; PPE; controlled cutting/paint removal; facilities for workers (rest, recreation, showering, medical, and accommodation); emergency planning; confined space entry procedures; asbestos management; hazardous waste inventory/storage; environmental awareness; worker health/welfare planning; employment of naval architects/technical staff; and training of workers on new technology and regulations (on a regular basis over a period). Now 26 yards from Bangladesh are HKC certified, while another dozen are likely to certify in this year or very soon. Despite around 40 yards expected to be certified as "ready" within the next year, Bangladesh needs more than 40 yards to be active Hong Kong Convention (HKC)-certified facilities, requiring immediate assistance from both the government and yard owners to sustain the leading and holding global position (Hossain, 2019a, b, c and Hossain, 2025c).

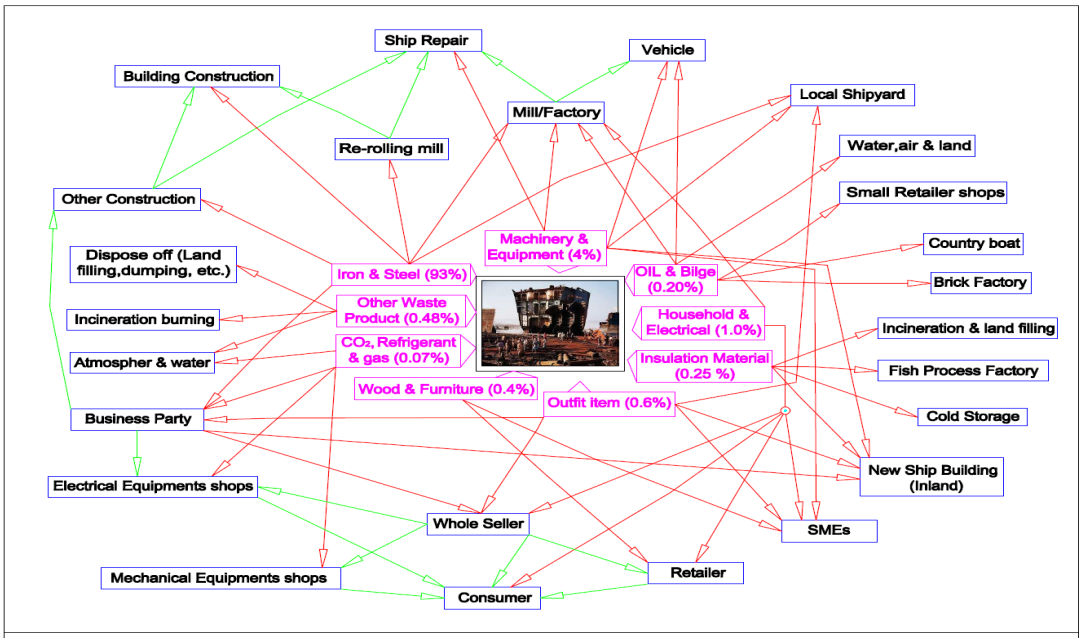

Figure 6. Distribution channel model of scrapped items of EOL ships in Bangladeshi yards.

5. Future Position of Local Ship Recycling Industry of Bangladesh

5.1 Present Status of Local Yards

Recycling yards in Bangladesh have received relatively less national and international investment/funding for upgrading than their regional competitors. Most international support to date has come through IMO's SENSREC initiative, a long-running technical-assistance program funded by Norway. SENSREC has emphasized reforms like enacting national legislation, training programs, and strengthening regulatory frameworks. In late 2023, Norway invested about $1.36 million to fund upgrades to green yards and waste-treatment infrastructure. The primary aim of the project was to reduce the environmental impacts of shipbreaking in Bangladesh. By promoting sustainable practices and green technologies, the initiative seeks to protect local ecosystems and support broader global efforts to mitigate climate change. Currently, the Bangladeshi ship recycling industry generates an annual revenue of Tk 12,750 crore and provides employment to around 200,000 people, especially in poverty-stricken areas. It significantly improves livelihoods and involves over a million individuals directly or indirectly. Each year, this industry earns approximately US$130 million (Mohiuddin et al., 2023). In the fiscal year 2015-16, Bangladesh customs reported the

import of 250 scrap ships, bringing in Tk 8.22 billion in revenue. The following year, 188 ships were imported, earning Tk 6.32 billion. The number of imported ships increased to 202 in the subsequent year, contributing a total revenue of Tk 5.96 billion or Tk 596 crore (Hossain, 2025c). Figure 7 illustrates an estimation of earnings from the ship recycling industry in Bangladesh. It has found that recycling industry earnings increases over time. But without the required HKC-certified recycling yards, Bangladesh cannot maintain its position in the global market; as a result, there will soon be a crisis in the steel and other relevant industries. So, immediate steps are required to prevent this upcoming crisis to continue in the business (Hossain, 2025c).

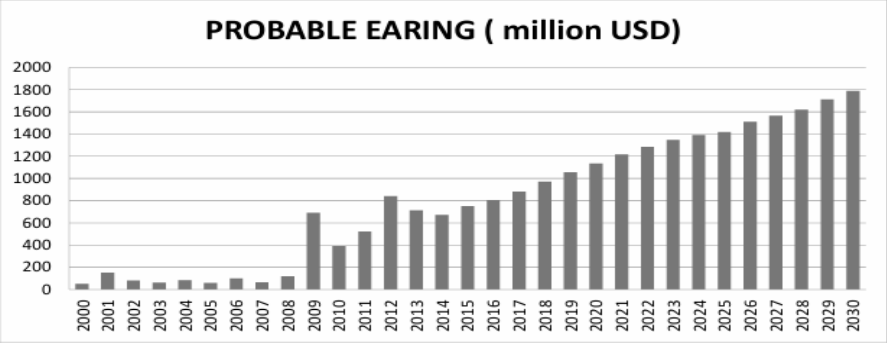

Figure 7. Estimated earnings from the ship recycling industry of Bangladesh

5.2 Estimation of Future Position

Bangladesh's ship recycling industry is expected to develop significantly because to its huge and reasonably low priced labour pool, which gives it a competitive advantage in operational effectiveness. Steel and other metals recovered from ship recycling are in high demand in the local market, supporting the sectors like re-rolling, shipbuilding, house-building, manufacturing and construction (Hossain, 2018c and d). Bangladesh's rapidly expanding infrastructure requires significant iron resources as it gets closer to leaving the Least Developed Country (LDC) category. Bangladesh is largely dependent on imports due to a lack of domestic iron ore, but the ship recycling sector supplies over 60% of the country's steel needs and is vital to both national development and the preservation of foreign currency. Bangladesh's reuse techniques reduce the need for new manufacturing, thereby promoting environmental sustainability, in contrast to wealthy nations, where EOL ship parts are often not utilized (Sivaprasad, 2010; Nikos, 2017). Furthermore, the inland shipbuilding sector is totally reliant on materials from recycling yards, underscoring its vital role in advancing both environmental and economic goals (Hossain, 2015; 2023a, d, and f).

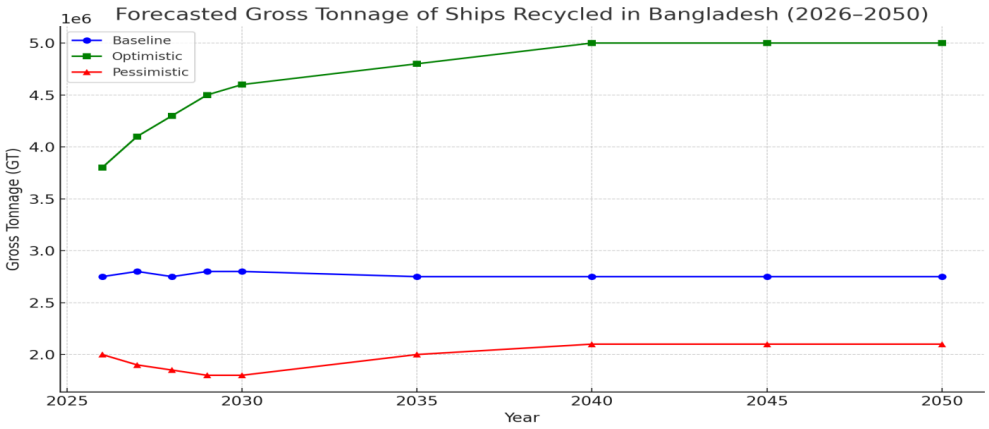

Figure 8. Future projected Gross Tonnage (GT) of Ships Recycled in Bangladesh (2026–2050)

Author employs "ARIMA-style time series forecasting" to predict future scrap levels using gross tonnage (GT) data from IHS and UNCTAD records from 2014 to 2024, aiming to provide a realistic forecast. The projection assumes

that past trends are the best indicators of future developments unless significantly impacted by changes. Figure 8 shows the expected Gross Tonnage (GT) of Ships Recycled in Bangladesh (2026–2050) based on this forecasting method (IMO, 2024, 2025, and Khandakar, 2025). According to ARIMA estimates, a "business-as-usual" baseline of about 2.7 million GT per year is expected until 2050. There is an optimistic scenario where green yards grow capacity to around 5 million GT, and a pessimistic scenario where reforms fail, reducing GT below 2 million. Based on these insights, five strategic policy pillars are recommended: (1) enact and enforce HKC-aligned legislation through a unified regulatory authority; (2) subsidize green infrastructure and institutionalize worker health and safety standards; (3) establish blended financing mechanisms and performance incentives to modernize the local yards as India done; (4) develop a national recycling information system and fund targeted R&D; and (5) engage regionally and globally to position Bangladesh as a preferred "green" destination under ESG mandates (Hossain, 2025c).

6. Future Challenges for Bangladesh

As international restrictions tighten, Bangladesh's ship recycling industry, which supplies around 60% of the country's steel needs and completely supports inland shipbuilding using locally repurposed materials, faces fierce competition from modernizing yards in India and Pakistan (Maritime Executive, 2025, BIMCO, 2025). In contrast to wealthy countries where similar materials are often not reused, this industry benefits from a huge, reasonably priced labor force and a robust local market for almost all recycled items, which minimizes the need for new manufacture and helps environmental sustainability (Maritime, 2025; Olgn, 2025; Eolog, 2025). However, the industry's vital role in sustaining foreign exchange is highlighted by Bangladesh's exit from the Least Developed Country (LDC) category and its expanding infrastructure demands, which depend on imported iron due to a shortage of native iron ore (Maritime Executive, 2025a; Eolog, 2025). Number of EOL ships recycle in India, Bangladesh, Pakistan, and China has been shown in figure 9 below (NGO Ship-breaking Platform, 2024). Though, by volume or total LDT, Bangladesh is still leading the global market. However, India is going to be the market leader soon.

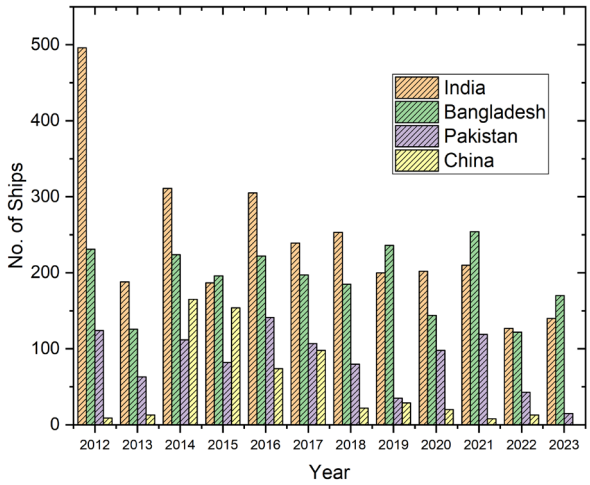

Figure 9: Number of EOL ships recycle in India, Bangladesh, Pakistan, and China.

Despite these advantages, Bangladesh ratified the Hong Kong Convention (HKC) in June 2023, but as of mid-2025, only 26 local yards are HKC-compliant. In contrast, India has 120 conforming yards, or 95% of its total, whereas Pakistan also taken few incentives and prompt action recently (Maritime, 2025; BIMCO, 2025; Maritime Executive, 2025). Bangladesh handled around 46% of the world's recycling tonnage in 2023, compared to 16.6% and 33% for Pakistan and India respectively in 2022 (Dawn, 2023; Eolog, 2025). However, experts caution that if Pakistan's Gadani yards start to modernize and India's donor-backed "green yards" draw in more business, Bangladesh may lose its competitive advantage (Eolog, 2025; Olgn News, 2025). India has a competitive advantage due to its strict regulations, which include strong waste management under the Recycling of Ships Act, 2019 and Ready-for-Recycling certificates (IndustriALL, 2025a, b; Hossain, 2025c). Pakistan is making significant investments to transform Gadani into a "model green" yard after passing the HKC in December 2023. (Arab News, 2024; BIMCO, 2025; Dawn, 2025). If Bangladesh does not quickly certify and modernize its yards to comply with HKC rules in order to stay competitive, it runs the risk of losing EOL vessels to its competitors neighbors.

6.1 Regulatory Enforcement and Policy Frameworks

Since Bangladesh's regulatory framework, which is governed by the Ship Breaking and Recycling Rules, 2011, does not fully align with HKC standards, new ship recycling imports have been temporarily suspended pending compliance (Maritime, 2025, TBSNews, 2025). Early in 2025, potential modifications developed under the IMO's Norway-funded SENSREC project were presented in order to comply with the HKC, Basel, Rotterdam, and Stockholm conventions (IMO, 2024 and 2025). NGOs and other interested parties advocate for severer oversight and penalties to enforce environmental and safety laws (IMO, 2024). Even though new laws are expected in 2025, the current makeshift framework and insufficient enforcement remain shortcomings as compared to competitors. The Recycling of Ships Act, 2019, which mandates authorized facilities, ship-specific recycling programs, and strict waste management with fines for breaches, strengthens India's market leadership (PIB, 2019). After ratifying the HKC in December 2023, Pakistan is developing a Federal Ship Recycling Act and provincial acts in Balochistan, but its Gadani yards continue to operate under outdated regulations with limited oversight, raising concerns about environmental and safety issues (Dawn, 2023). Pakistan is getting help from the ILO and IMO to fix legal gaps including yard authorization and hazardous waste regulations; so that it can fulfill its obligations under the HKC (Dawn, 2023). Bangladesh's modernization efforts indicate impending challenges, while Pakistan's regulatory problems limit its competitiveness until these changes are enacted (Hossain, 2025c).

6.2 Financial Investment and International Support

Bangladesh's ship recycling industry, despite its economic importance, has attracted less foreign investment than its competitors. The IMO's SENSREC initiative, supported by Norway, offers technical assistance, including a USD1.36 million grant in late 2023 aimed at upgrading green yards and waste management facilities (IMO, 2024). However, meeting HKC standards requires almost 100 million USD. But which is challenging due to limited credit access (Maritime, 2025). Conversely, India has invested over USD100 million using donor and public funds to upgrade 120 "green" yards in Alang and other locations with cranes, concrete hard stands, and waste treatment units, allowing for quick certification of 120 HKC-compliant yards (Eolog, 2025; Olgn News, 2025). Pakistan allocated Rs12 billion (~USD 42 million) in June 2025 to transform Gadani into a leading green facility, with modern infrastructure, roads, hospitals, and waste treatment plants (Arab News, 2024; Dawn, 2025). These efforts show Bangladesh's reliance on limited international aid, while India and Pakistan utilize significant funding to expand their ship recycling sectors effectively (Eolog, 2025; Arab News, 2024; Dawn, 2025).

6.3 Technological Modernization and Yard Infrastructure

Only 26, out of over 40 active/operational ship recycling yards in Bangladesh are HKC-certified, and they depend on private efforts rather than systematic renovations. As a result, Bangladesh's ship recycling yards, which are mostly located on tidal beaches, fall behind rivals in terms of technology (IndustriALL, 2025a, b; Islam, 2025; Eolog, 2025). Efficiency and compliance are hampered by limited mechanization, such as slipways or modular cranes. Shore cranes, forklifts, piped water systems, and hazardous waste containment are just a few of the cutting-edge facilities found at India's more than 120 green yards in Alang, which improve throughput, safety, and environmental performance (Eolog, 2025). With the June 2025 Rs12 billion investment, Pakistan's traditionally less mechanized Gadani yards will undergo major modifications with an emphasis on cutting-edge machinery and waste management to meet green shipping objectives (Arab News, 2024; Dawn, 2025). Gadani must modernize or face decline, according to Pakistan's marine minister (Arab News, 2024). So, Bangladesh's market position is at risk if modernization doesn't accelerate through programs like SENSREC, given its reliance on small mechanized beach plots, which contrasts with Pakistan's planned enhancements and India's sophisticated infrastructure (Arab News, 2024; Eolog, 2025; Maritime, 2025; BIMCO, 2025).

7. Way Forwards and Proposition

Unlike Bangladesh's limited foreign investment, India's ship recycling industry has undergone significant modernization, largely funded by around USD 100 million from public and international donors. This funding has led to the establishment of about 120 eco-friendly ship recycling yards equipped with shore cranes, concrete hard-standing areas, and waste treatment facilities along the Alang coast and other locations. Anam Chowdhury, President of the Bangladesh Marine Officers Association (BMOA), pointed out this contrast in an interview with Business Standard, saying: "India has built 120 green yards on the Gujarati coast of Alang to recycle ships in accordance with the HKC thanks to more than $100 million in funding from foreign donors (UNCTAD, 2025)." This substantial investment has

accelerated India's certification process, enabling the development of 120 yards compliant with the Hong Kong Convention (HKC), and lessening dependence on foreign subsidies for basic yard upgrades. In a similar move, Pakistan has recently invested heavily in modernizing its ship recycling sector. In June 2025, the Pakistani government approved a Rs 12 billion (approximately USD 42 million) grant to convert the Gadani shipbreaking yards into a "model green facility."

Planned upgrades involve installing modern cranes, pollution control technologies, improved worker infrastructure, and developing roads, hospitals, training centers, and waste treatment facilities [65]. Meanwhile, Bangladesh is competing for limited foreign aid and credit, unlike India and Pakistan, which have mobilized greater financial resources to support their ship-breaking industries. This disparity poses challenges for Bangladesh to remain competitive in regional and global ship recycling markets. Currently, 26 local yards in Bangladesh are HKC-certified, with another dozen working towards obtaining a green passport. To stay competitive internationally, the remaining yards—about a dozen—must obtain HKC certification quickly; otherwise, Bangladesh risks falling behind. The high costs of establishing green yards deter many local recycling owners, as modernizing a single ship recycling yard costs at least Taka 200-300 million (around $2.5 million USD), and upgrading the entire sector to meet HKC standards could cost approximately Taka 12 billion (about $100 million USD), ensuring competitiveness and resilience in the global market (Khandakar, 2025).

As international regulations tighten, Bangladesh's ship recycling industry faces intense competition from more modern yards in Pakistan and India (once their upgrade plans are completed). Experts warn that India is expected to attract more business in the coming years, potentially overtaking Bangladesh as Indian yards upgrade and expand, supported by large donor-funded 'green yard' projects (Eolog, 2025; Olgn News, 2025; Khandakar, 2025). Meanwhile, Pakistan's efforts to modernize Gadani are progressing rapidly, positioning it as a strong competitor. Consequently, environmental compliance remains a key challenge for Bangladesh. To stay competitive, local recycling yards must swiftly obtain HKC certification and upgrade the yards that do not yet meet standards. Failure to do so will likely lead to more End-of-Life vessels being recycled in India and Pakistan (Arab News, 2024; Eolog, 2025; Maritime, 2025; BIMCO, 2025). India's 2019 'Recycling of Ships Act' mandates 'Ready for Recycling' certificates and strict waste management, while Pakistan is investing heavily to build a 'model green' yard at Gadani (Khandakar, 2025). Ultimately, Bangladesh's recycling yards and the sector as a whole must undertake capital investments, modernization, and upgrades. To strengthen this industry, Bangladesh should focus on the following strategies:

a. Invest in modern infrastructure, modern cutting and dismantling system, including concrete flooring and mechanical lifting equipment (Hossain, 2025a, b).
b. Establish additional TSDF facilities to manage hazardous waste effectively (Hossain, 2021).
c. Enhance worker training and enforce mandatory PPE usage (Hossain, 2024).
d. Create a dedicated monitoring and controlling body similar to India's Gujarat Maritime Board (Hossain, 2023a).
e. Foster stakeholders' collaboration to secure financing and technical support (Hossain, 2023e, f, g).
f. There is a severe need for government financial and technical support (Hossain, 2023b, c).
g. Arrange foreign support/investment (Hossain, 2023b, d).
h. Implement and ensure sustainable recycling process/system (YPSA, 2024).
i. Local recycling yards must have a Ship Recycling Facilities Plan in order to comply with HKC (SRFP).
j. Local yards must get ready to ratify HKC and an EU RRC as soon as possible; otherwise, it will be more difficult and complicated to carry on with local recycling operations in the future (Mohiuddin & Hossain, 2023a).
k. The government might provide financial incentives such as tax refunds, accelerated depreciation, and import duty waivers for investments in green yard infrastructure, including impermeable floors, drainage systems, shore-based cranes, and waste treatment units (Hossain, 23a, b, c; Mohiuddin and Hossain, 2023a, b).
l. Every significant yard cluster must have on-site clinics, safety response units, and qualified emergency workers in order for Bangladesh to create on-site medical and safety facilities (HRW, 2023a, b).
m. A country may establish a blended finance structure to promote local recycling yard upgrades, especially for small and medium-sized recyclers, using both national budget allocations and international funds (such as from the IMO, World Bank, ADB, and JICA) (Khandakar, 2025).

8. Conclusion

This study and analysis indicate a significant compliance and modernization gap between Bangladesh and its key regional competitors, particularly India and Pakistan. While Bangladesh has made important progress—such as ratifying the HKC, initiating Ship Recycling Facility Plans (SRFPs), and participating in international donor-supported programmes—this progress is uneven, largely fragmented, and heavily dependent on external technical assistance. A majority of its yards remain non-compliant or only partially aligned with HKC norms, and institutional enforcement remains weak due to regulatory ambiguity and limited inter-ministerial coordination. Bangladesh's ship recycling industry, the global leader, processes ~2,000,000 LDT annually, yielding substantial economic benefits through significant employment and steel supply. However, challenges such as manual dismantling, environmental pollution, and inadequate SHE standards persist. Bangladesh, along with two other South East Asian countries (India and Pakistan), has taken on the burden of ship recycling as a major effort to protect the global environment. These three populous and developing countries consumed and reused almost 98% of the material output from the recycling process. A small improvement in the process can enhance it as a novel job, helping the global environment and contributing to the green revolution.

Frameworks like the European Union Ship Recycling Regulation (EU SRR) and the Hong Kong International Convention (HKC 2009) for the Safe and Environmentally Sound Recycling of Ships are driving major changes in the global regulatory landscape for ship recycling. Traditional ship recycling yards in South Asia face operational difficulties as a result of these rules, which impose tighter environmental and safety norms. Bangladesh has made somewhat slower progress because to local yard owners' attitudes and a lack of government funding, whereas nations like Turkey and India have successfully updated a significant number of yards to fulfill HKC and EU compliance requirements. To date, very few yards around the nation have achieved green certification. In response, Bangladesh established a national goal to bring all operative yards into line with HKC standards by 2025 and passed the Ship Recycling Act in 2018. Significant progress has been made in infrastructure development, regulatory compliance, and institutional control, especially through the Shipbuilding and Ship Recycling Board (SBSRB) within the Ministry of Industries, even though this goal has not yet been fully accomplished. Bangladesh's historic volume leadership is challenged by India's technological improvement with 120 HKC certified yards, modernization investments combined with legal certainty, and significant modernization inflows (~USD 100 million). Even though it is only in its early stages, Pakistan's Rs. 12 billion (~USD 42 million) renovation plan for Gadani represents a geopolitical shift that, if not accompanied by countermeasures, might weaken Bangladesh's regional influence. However, in Bangladesh, 60% of local ship recycling facilities that are currently in operation are HKC approved (where 26 yards are HKC certified and another dozen yards are waiting). The ship recycling sector in Bangladesh is still mostly reliant on cheap labor and advantageous location, which need for significant government assistance as well as reform using the best and most environmentally friendly practices.

The environment friendly and workable ship recycling process with evaluated material distribution channel provide a framework for sustainable practices, leveraging Bangladesh's low-cost labor and robust market demand. By addressing safety, environmental, and regulatory gaps through infrastructure upgrades, professional training, and compliance with HKC and EU standards, Bangladesh can maintain its global leadership while achieving sustainability. Continuous monitoring, balanced leadership, financing, along with government and stakeholder support are imperative for the industry's long-term viability. In order to collaborate with public and private institutions to create low-interest green loans with technical evaluation help for modernizing recycling infrastructure, we might make commercial credit more accessible. The helpful "Ship Recycling Act," which fully incorporates HKC rules and complies with Basel, Rotterdam, and Stockholm agreements, can be finalized and enforced. Facility permission, waste disposal compliance, hazardous material inventory management, and environmental impact audits should all be required by this regulation. In order to coordinate oversight, inspections, and certifications, we might establish a special Ship Recycling Regulatory Authority (SRRA) with representatives from the MOI, MOE, MOS, DoE, DoL, BSBA, and SBSRB as industry collaborators in addition to BUET and Bangladesh Maritime University (BMU) as academic advisors. Within a predetermined transition period, we can mandate that all yards submit approved SRFPs and receive HKC certification (within couple of years). Penalties for non-compliance should be incorporated into routine third-party audits. The following actions are advised to guarantee sustainable practices in Bangladesh and other Asian ship recycling facilities.

To ensure safe and ecologically sustainable in the ship recycling process, strong rules and international standards must first be put into place and enforced.

a. By developing laboratory facilities and strengthening the capacities of pertinent departments, efforts should be made to improve environmental monitoring and control.
b. The labor and environmental dimensions present perhaps the most urgent challenges. Although some yards have embraced reforms and other yards need also follow the others.
c. All ship recycling yards should immediately adopt HKC 2009 for the Safe and Environmentally Sound Recycling of Ships, which provides a comprehensive framework for ship recycling operations.
d. Steps should be taken to raise the safety standards and working conditions for the employees. It has to be made sure that personal protective gear and equipment are accessible and utilized.
e. Every hazardous substance must be labeled and extra caution must be used before starting the beaching operation. Governments and relevant stakeholders should place a high priority on promoting research and development in environmentally friendly ship recycling technology.

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Biographies

Rear Admiral Dr. Khandakar Akhter Hossain, was commissioned into the Engineering Branch of Bangladesh Navy on 01 January 1991. He has completed his BSc. and MSc. Engineering in Naval Architecture and Marine Engineering with a distinct result from Bangladesh University of Engineering and Technology (BUET). He also holds PhD from Bangladesh University of Engineering and Technology (BUET). He has performed various instructional duties in Naval Academy, Marine Academy, NIT and Military Institution of Science and Technology (MIST). He was also the Dean/Head (On NAME department/ME Faculty) at Military Institution of Science and Technology (MIST). He has served as member Engineering in Chittagong Port Authority. He successfully performed the duties of Managing Director (MD) in all three shipbuilding heavy industries run by Bangladesh Navy, namely Chittagong Dry Dock Limited (CDDL), Dockyard & Engineering Works Ltd (DEW) and Khulna Shipyard Ltd (KSY). He also performed his duties as Area Superintendent Dockyard of Bangladesh Navy. He is a fellow of different prestigious institutes like IEB(BD), RINA(UK), and IAMSP(USA). Before joining here, he performed his duties in the prestigious post of Assistant Chief of Naval Staff (Materiel). He has 236 international publications/papers/books on AI, IoT, Robotics, Satellite Communication, ship recycling, shipbuilding, energy solutions, human resource diversification, port

operations, and advanced technologies which all are available in "Google Scholar". He is happily married with Dr. Sharmin Hasan and blessed with twin daughters and two sons.

Dr. Sharmin Hasan is an accomplished medical professional, counselor, and healthcare leader with over 20 years of experience in medical practice and patient care. She currently serves as the Vice President (Health, Welfare & Counseling) of the Bangladesh Navy Family Welfare Association, where she has been contributing her leadership and expertise for the past three years in promoting healthcare awareness, welfare initiatives, and counseling services. Dr. Hasan earned her Bachelor of Medicine and Bachelor of Surgery (MBBS) from Bangladesh Medical College in 2002 and has since built a distinguished career in clinical assessment, diagnosis, treatment planning, and patient management. In addition to her medical practice, she has over 12 years of experience in counseling, providing guidance in health and mental well-being. To further strengthen her professional expertise, she completed specialized training in Mental Health Counselling and Behavioral Medicine from China and obtained a Master of Health Care Management from the United Kingdom. With strong leadership, communication, and analytical skills, Dr. Hasan continues to make significant contributions to healthcare and community welfare through her dedicated service and compassionate approach. She is happily married to Rear Admiral Dr Khandakar Akhter Hossain, who is the Vice Chancellor of Bangladesh Maritime University, and is blessed with twin daughters and two sons.