Scientific Research Publishing

Open Journal of Safety Science and Technology, 2025, 15(3), 191-215
https://www.scirp.org/journal/ojsst
ISSN Online: 2162-6006
ISSN Print: 2162-5999

Unlocking Opportunities Ahead: A SWOT-Based Assessment of Bangladesh's Ship Recycling Potential

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How to cite this paper: Sabbir Hossen, H.M. and Dev, A.K. (2025) Unlocking Opportunities Ahead: A SWOT-Based Assessment of Bangladesh's Ship Recycling Potential. *Open Journal of Safety Science and Technology*, **15**, 191-215.
https://doi.org/10.4236/ojsst.2025.153011

Received: May 31, 2025
Accepted: September 6, 2025
Published: September 9, 2025

Abstract

Bangladesh has been playing the role of a pioneer in the ship recycling industry for the last two decades. Nearly all South Asian countries have taken advantage of cheap labour, but only Bangladesh has experienced significant growth in this sector. This sector has been a substantial contributor to the local steel and related industries. Besides supplying raw materials, it has also provided employment support to the uneducated people living near the yards. As a recycling industry, it has salvaged enough reusable materials each year, thereby supporting the circular economy. However, the industry faces challenges such as poor infrastructure and conventional recycling methods, which have adverse effects on both the environment and safety. The current study utilises a comprehensive SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis to assess the current state of Bangladesh's ship recycling industry. Strengths of this include cheap labour, advantageous geographic location, and the capability of handling large ships. At the same time, weaknesses such as underdeveloped infrastructure, a lack of trained workers, and inadequate waste management hinder progress. In this darkness of weaknesses, opportunities shed bright light. Opportunities, such as the potential for reforming regulations and technologies, increasing demand for recycled materials, and global collaboration, show promise for a transformed industry. At the same time, existing threats like strict regulations, political issues, and increasing international competition can also create a risk of destabilising the industry. Based on the SWOT investigation, this paper successfully provided recommendations. These recommendations are expected to lead the industry towards sustainable growth.

Keywords

Ship Recycling, Bangladesh, SWOT Analysis, Sustainable Development,

Waste Management, Environmental Challenges

1. Introduction

Ship Recycling refers to the dismantling of ships and the reuse of recovered metals and other components in various industries after processing. Components that cannot be used are disposed of. Usually, EOL (End of Life) ships are recycled when they become obsolete. However, sometimes fully functional ships are also recycled because, due to technological advancements or other reasons, the ships can no longer generate adequate returns. The local shipbreaking industry's overall contribution to Bangladesh's national economy is about US$2 billion [1]. This figure highlights the substantial impact of the ship recycling industry on Bangladesh's economy. Beyond its economic contribution, recycling is paramount, as if we do not recycle the worn-out vessels, it will occupy valuable space and cause serious environmental hazards [1]. Moreover, the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships mandates that each party implement its provisions to effectively prevent and minimise accidents, injuries, and adverse effects on human health and the environment associated with ship recycling [2]. Since Bangladesh has ratified this agreement, the country is expected to comply with Hong Kong Convention requirements by improving safety standards and environmental practices in ship recycling.

The ship recycling industry is regarded as a major contributor to the steel industry in Bangladesh. Nearly 60% of raw materials in the local steel industry are collected from recycling yards [3]. According to Rahman and Handler [4], the secondary rebar (reinforcement bars used in construction sourced from ship scraps) produced from the scraps saves 16.5 GJ of primary energy per ton of rebar and 1965 kg of CO^2 equivalent greenhouse gas emissions per ton of rebar when compared to primary rebar (reinforcement bars used in construction sourced from ore). The ship recycling industry can achieve impressive reductions in energy consumption and greenhouse gas emissions, reinforcing its status as a green and sustainable industry. However, exposure to various hazardous materials such as oily waste, asbestos, poly chlorinated biphenyl (PCB), etc., to the environment during the ship cutting and recycling process makes the environment vulnerable. So, it is also essential to ensure that the environmental benefits of recycling outweigh the risks associated with ship cutting. Environmental considerations are one of the most critical aspects of this industry. At the same time, to gain a more comprehensive understanding of the sector's potential, it is also essential to explore the industry from legal, safety, and infrastructural aspects.

1.1. Background

Bangladesh is one of the leading countries in the ship recycling industry. Though Bangladesh is currently prosperous, all this started with a mere accident when a

Greek vessel, MD Alphin, was found stranded in Chattogram. A local steel house thought it would be profitable to dismantle it. This marked the inception of the shipbreaking industry in Bangladesh. However, commercial decommissioning of ships began much later, around 1974, by Karnafully Metal Works [3]. Globally, the shipbreaking industry initially emerged as a highly mechanised operation dominated by industrialised nations such as the US, UK, Germany, and Italy. However, as the process is labour-intensive, the high labour costs in developed countries have made the industry economically impractical. In the early 1980s, shipowners began sending their decommissioned vessels to scrap yards in Bangladesh, India, Pakistan and other developing countries to reduce costs and maximise profits [5]. These countries offered significantly cheaper labour, which led to a gradual increase in the number of ships decommissioned in Bangladeshi scrap yards. In the last two decades, Bangladesh has established itself as a global leader in the shipbreaking and recycling industry, securing a prominent position among the top shipbreaking nations. According to UNCTAD, in 2023, Bangladesh accounted for 45.7% of the global share in total ship scrapping, making it the most prominent international player in this sector, as shown in Table 1 [6]. The main reasons for this success in this industry are Bangladesh's preference over other countries due to low wages, the environmental advantage of a suitable tidal zone, and the large number of established yards. Despite this outstanding performance of the industry, several challenges exist, including coastal zone management, creating a better environment for workers, ensuring occupational safety and health, and enforcing existing laws, as well as abiding by Hong Kong conventions, rules, and the Ship Recycling Act 2018, Bangladesh. An active competing authority is also required to monitor the overall shipyard process, helping this industry flourish even more.

Table 1. Worldwide ship tonnage sold for scrapping by country [6].

Vessel type	Bangladesh	Pakistan	India	Türkiye	Brazil	Rest of the world	World total	Percentage share
By Type	Thousands of gross tons and percentage share							
Bulk carriers	2185.9	582.9	0.0	254.6	0.0	18	3041.5	40.7%
Container ships	444.7	1132.9	130.6	30.4	0.0	115	1853.8	24.8%
Offshore supply	110.2	93.7	140.5	11.4	273.3	163	792.2	10.6%
Liquefied gas carriers	213.8	295.1	109.7	0.0	0.0	5	623.4	8.3%
Oil tankers	201.4	102.7	1.8	74.4	0.0	35	415.6	5.6%
General cargo ships	158.7	56.1	45.3	0.0	0.0	44	303.8	4.1%
Ferries and passenger ships	26.2	15.5	83.8	0.0	0.0	11	136.7	1.8%
Chemical tankers	3.2	98.2	0.0	0.4	0.0	7	109.1	1.5%
Other/n.a.	74.9	88.5	18.1	0.0	0.0	17	198.4	2.7%
Total gross tons	3419	2466	530	371	273	416	7474	100%
Percentage share	45.7%	33.0%	7.1%	5.0%	3.7%	5.6%	100%	

1.2. Aim and Objectives

This study aims to provide an in-depth, comprehensive SWOT analysis of the ship recycling industry of Bangladesh and thus explore the potentialities and challenges.

The objectives of the project are:

1) Identifying the strengths of the ship recycling industry, including its contribution to the steel industry, job creation and circular economy. The strengths will allow us to focus on utilising the industry's potential for sustainable growth. However, this study also acknowledges the internal factor weaknesses, namely inadequate infrastructure, lack of compliance with international regulations and safety standards and limited technological advancements. Pinpointing the weaknesses will provide an opportunity to find strategic solutions.

2) Addressing the opportunities, including a global focus towards sustainability, increasing numbers of shipbuilding, increasing demand for recycled products and a greener world and potential technological advancements to enhance the economic and environmental benefits. On the other hand, threats like environmental degradation, potential health hazards of the workers, and competition in the industry are also intended to be highlighted so that they pave the path for us to mitigate risks and thus ensure proper practice of ship recycling.

3) Propose feasible plans and policy recommendations based on the SWOT analysis. These recommendations aim to enhance the industry's reputation, market share, overall stability, and environmental and worker safety.

In a SWOT analysis, strengths and opportunities are considered as paths for growth while the weaknesses and threats are acknowledged as challenges that need to be overcome. This comprehensive study emphasises the need of short-term and long-term measures to be taken for achieving prosperity and tackling safety concerns.

2. Literature Review

Bangladesh's ship recycling industry has gained significant attention in academic and industrial research due to its economic and environmental impact, both locally and globally. Shipbreaking activities in Bangladesh have both positive and negative consequences from a socio-economic as well as ecological perspective. Several papers are available on the industry's problems and benefits, but very few have addressed the use of analytical tools. For example, Hossain [7] described the sector's contributions to the Bangladeshi economy. Additionally, the authors provided insights into the challenges faced by the ship recycling industry due to new regulations. The entry into force of the Hong Kong Convention is another notable challenge. He also recommended improving existing ship recycling facilities and ensuring SRFP as per global standards. On the other hand, Zakaria *et al.* [8] discussed the underlying problems of the ship recycling industry. The authors highlighted inadequate worker safety, exposure to health hazards, and severe environmental pollution as the primary challenges faced in shipbreaking yards.

Hossain [9] examined the ship recycling processes and steps involved in ship recycling in Bangladesh. He used a tally register as well as an Excel spreadsheet to collect the relevant data of EOL ships, which he considered samples. He hoped to get more reusable materials and reduce HazMat (Hazardous Materials) from EOL ships in the future. In another paper, Hossain assessed the use of a strategic tool in the shipbuilding industry. Hossain [10] briefly evaluated the current state of the shipbuilding industry. He also conducted a detailed and well-structured SWOT analysis for the shipbuilding industry, which is closely linked to the ship recycling industry. He also noted that only having the advantage of cheap labour alone cannot guarantee a sustainable shipbuilding industry.

Mannan *et al.* [11] demonstrated how South Asian countries, including Bangladesh, could transform the EOL ships into economic drivers. The author also provided a structured framework to understand the socio-economic benefits of the industry, while balancing the associated challenges through the use of a SWOT analysis. Their work emphasises the pivotal role of strategic planning in overcoming inherent industry weaknesses. In a different study, Hossain *et al.* [3] The authors also discussed whether the Bangladesh government should invest in this industry, considering its potential and prospects. They tried to find an answer to this via a data survey. They collected data by visiting shipyards and from NGOs and organisations, and then analysed the dataset. The authors acknowledged the significant contribution of the ship recycling industry and suggested ways to mitigate environmental pollution and enhance occupational health and safety.

A few more papers tried to assess this industry differently. Based on secondary data, Patwary and Bartlett [12] tried to identify and focus on the impacts of the ship recycling industry in Bangladesh. They pointed out how child labour still exists. They also assessed the environmental impact. They also managed to form a matrix to evaluate the negative impacts of this industry using Environmental Impact Assessments (EIA), which was highly beneficial in addressing key environmental concerns. A report named İzmir Aliağa Ship Recycling Sector Analysis [13] also provided a comprehensive overview of the ship recycling industry in İzmir, Turkey. The study analysed the İzmir Aliağa Ship Recycling Sector. It assessed the economic, environmental, and industrial impacts at local and global levels. Besides SWOT and advanced SWOT analysis, it also uses Pareto, Five Forces, Kaizen, PESTLE (Political, Economic, Social, Technological, Environmental and Legal), and Six Sigma to understand challenges and opportunities. The paper also depicted how the global ship recycling industry-dominating countries often use less regulated and hazardous methods like beaching. On the other hand, Turkey employs more environmentally and safety-conscious techniques, aligning with international regulations like the Hong Kong Convention.

3. Methodology

This study employs a SWOT analysis, an acronym for strengths, weaknesses, opportunities, and threats. It has become a fundamental tool for organisations to

assess their market position. It is also widely used to analyse the internal and external environments of organisations when it becomes difficult to make a decision [14]. As illustrated in Figure 1, among the four components, Strengths and Weaknesses are considered internal factors that are within the organisation's control. On the other hand, Opportunities and Threats are considered external factors that are typically beyond an organisation's control. In the SWOT analysis, internal factors such as personnel, finance, manufacturing, and marketing mix are evaluated as strengths or weaknesses. In contrast, external factors such as technological, legislative, and socio-cultural changes are viewed as both opportunities and threats [10]. A SWOT analysis aims to utilise an organisation's knowledge of its internal and external environments to formulate its strategies accordingly [15]. The method is not just applicable to management; it can also be used to create national policies and improve their energy and resource bases [16].

This study is based on data from secondary but reliable sources like published papers, scientific articles, regulations, newspapers, and organisational reports. Several internal and external parameters of the ship recycling industry are investigated using the SWOT tool. Several criteria were considered while choosing the sources. Credible sources like peer-reviewed journals and reports published by the government were given preference. The timeline of the publications was also kept in mind to ensure that only recent data gets included. Data were extracted in such a way so that every element of SWOT gets enough importance. This analysis will help assess the feasibility of Bangladesh's current ship recycling industry.

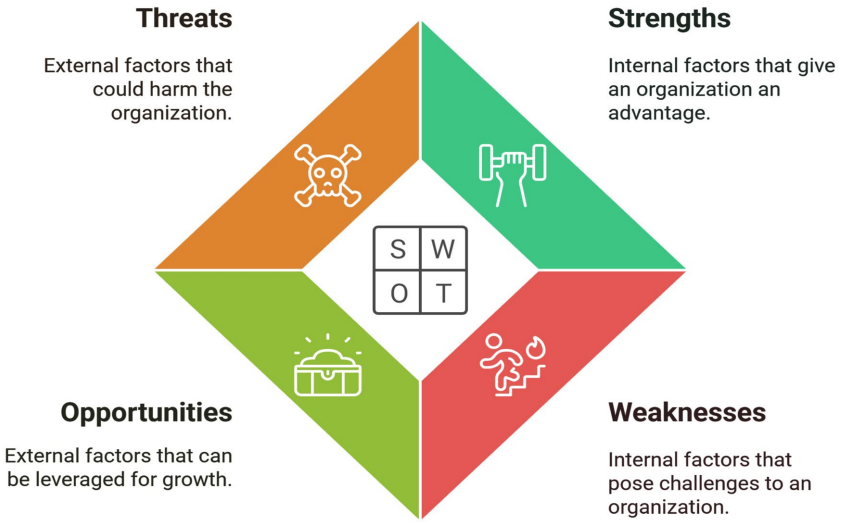

Figure 1. SWOT analysis.

4. SWOT Analysis—Strengths

S1: Cheap Labour: One of the most prominent strengths of Bangladesh's ship recycling industry is the availability of cheap labour. Bangladesh is a densely populated country, which makes it an ideal location for labour-intensive industries like ship recycling. The high population density ensures a continuous supply of

workers willing to take up physically demanding jobs at relatively lower wages. According to a survey by Young Power in Social Action (YPSA) [17]. In 2005, the average monthly salary of a foreman was 3300 - 5400 BDT per month, which is barely $27 - $45. Published on 11 February 2018, the gazette notification fixed the minimum salary at 16,000 to 31,750 BDT for the shipbreakers, which is still pretty cheap for the yard owners to pay [18] [19]. In 2024, under the current payment system, a ship cutter gets a monthly wage of Tk 12,000 - 13,000, while an assistant cutter gets Tk 9000 - 10,000 [20].

S2: High Offer Price in the Demolition Market: The economic advantage of having cheap labour significantly reduces the overall operational costs for shipbreaking yards, which enables Bangladesh to offer a higher price for the EOL ship, and thus, Bangladesh remains in the competition. **Figure 2** illustrates the variation in offer prices among the leading shipbreaking countries. It can be seen from **Figure 2** that China can offer only US$200 - 215 per ton for ship demolition, whereas Bangladesh can offer a considerably higher price of $355 - 385 per ton [21]. This price difference is highly lucrative for ship owners willing to sell their EOL ships. This is one of the significant reasons Bangladesh became an attractive option towards ship owners for ship disposal.

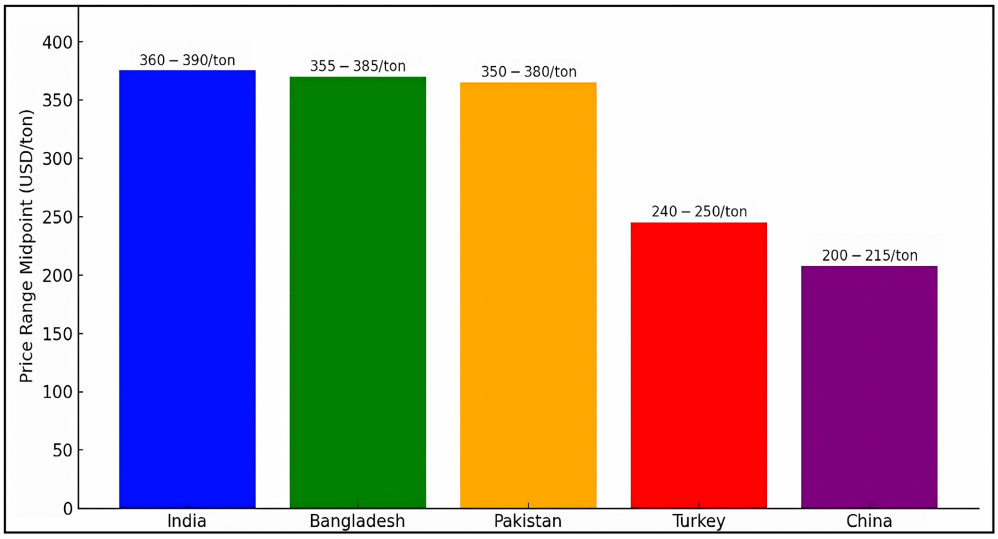

Figure 2. Ship demolition prices by country (USD per ton) [21].

S3: Geographical Advantage: The shipbreaking industry might adopt various methods to dismantle end-of-life vessels, including beaching, dry docking, pier breaking (alongside), and landing (slipway). Among these methods, the beaching method is most suitable for countries with significant tidal differences. This method utilises high-tidal conditions while propelling a ship onto a beach at a shipbreaking yard, where the ship is broken up. As a result, ships can be beached easily during high tide, therefore eliminating the need for complex infrastructure or towing mechanisms. This significant natural tidal difference, as well as the coastal slope, facilitates the towing of a ship [13]. Bangladesh has a significant tidal dif-

ference of up to 6 meters in water depth, as well as a soft, sandy, and muddy beach, which is ideal for employing the beaching method [22].

Figure 3 illustrates the ship recycling process using the beaching method. Initially, the ship is brought into the intertidal zone, which serves as a transitional area where the primary dismantling occurs. Subsequently, winches are utilised to transport materials, including steel blocks, from the intertidal zone to the beach.

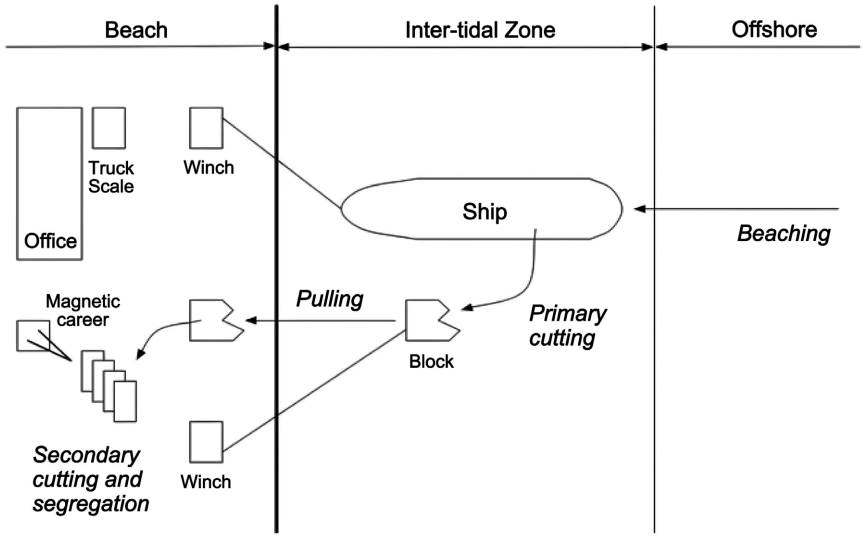

Figure 3. Beaching ship recycling method [22].

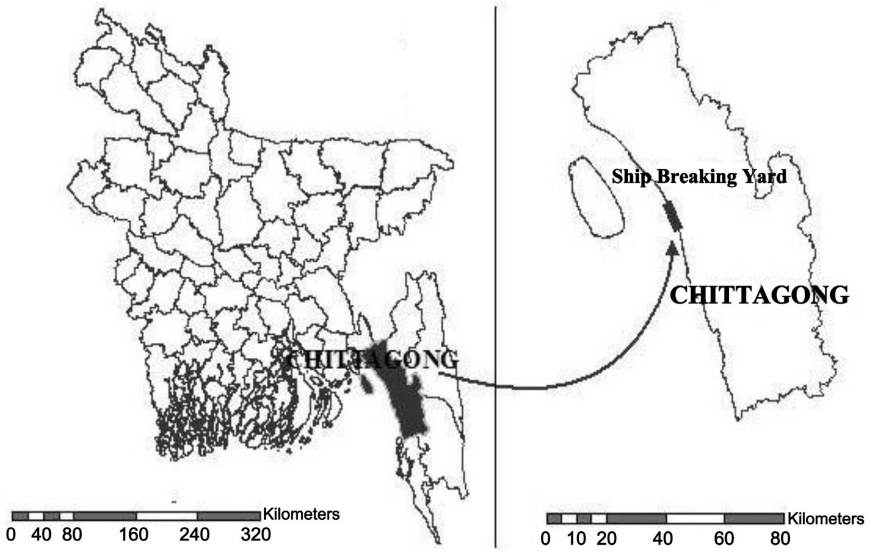

Figure 4. Location of ship breaking yards in Chittagong, Bangladesh [22].

S4: Proximity to Industrial Zone: Most of the ship recycling yards in Bangladesh are situated at Sitakunda, Chittagong [22]. Figure 4 provides a visual representation of the location of yards in Chittagong, Bangladesh, highlighting their proximity to the coast. The yards were initially established in these places due to their geographical advantage, particularly for easier beaching. However, this re-

gion has proven itself to be more beneficial as the national highway is nearby. Apart from that, most of the re-rolling mills are in Chittagong, which makes transportation from yards to mills easier and more efficient.

S5: Handle Large Ships: According to Sujauddin *et al.* [23], Bangladesh imported fewer ships than other shipbreaking countries, but in terms of tonnage, Bangladesh imported more than others, as seen in **Figure 5**. This indicates Bangladeshi ship brokers import larger ships. The reason for importing larger ships is to yield a large amount of steel.

It can also be seen from **Figure 5** that the average weight of broken ships increased from 7300 LDT (Lightweight) in 2006 to 12,000 LDT in 2011. In 2006, smaller ships dominated the industry, with 42% of ships having a capacity of less than 5000 LDT and only 8% exceeding 20,000 LDT. By 2011, 18% of dismantled ships exceeded 20,000 LDT [23]. Between 2012 and 2015, there was a gradual transition away from smaller yards (less than 5000 LDT) towards medium and larger yards, indicating that the industry had become more equipped to handle larger vessels.

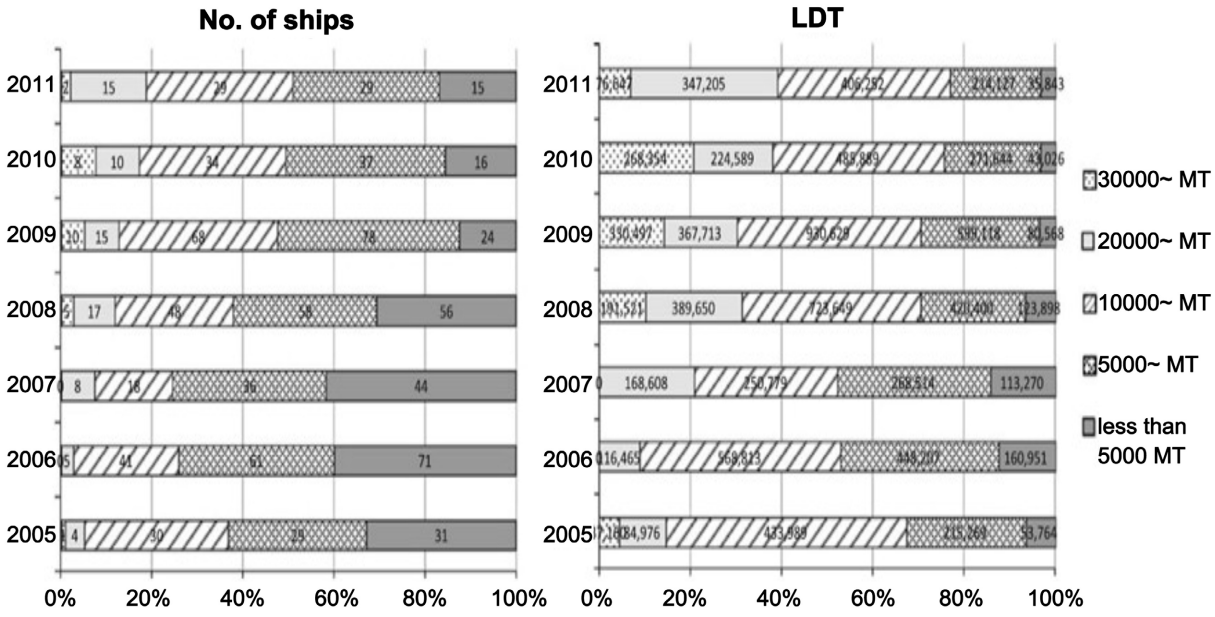

Figure 5. Size distributions of the number and weight (LDT) of imported ships [23].

S6: Supplying Steel Scrap: Ship breaking was officially declared an "industry" in 2011. Since then, this sector has made significant economic contributions. According to a presentation by the Ministry of Industries (MOI), this industry supplies 2 - 2.5 million tons of scrap steel annually [24]. Again, almost 60% of the raw materials of the local steel industry are collected from recycling yards [3]. From these, it is pretty evident that this industry has a decisive role in our steel industry.

S7: Experienced Dismantlers: One of the key strengths of the Bangladesh ship recycling industry is the presence of highly skilled and experienced dismantlers who have been working in the sector for decades. These professionals possess in-

depth technical knowledge and hands-on expertise in efficiently disassembling ships. They know how to maximise material recovery. Besides, they are less prone to accidents. Their experience allows for the effective handling of complex ship structures. Additionally, this local expertise knowledge is passed down through generations, creating a specialised workforce that is difficult to replicate in any other industry. However, formal recognition and structured training programmes can be helpful in further elevating their capabilities.

5. SWOT Analysis—Weaknesses

W1: Current Recycling Method: The usual practice of ship recycling is beaching, as construction and running dry docks are quite expensive [7]. It is not possible to change all the ship recycling facilities overnight. However, measures should still be taken because it is still possible to achieve almost green ship recycling even in the beaching method. China's use of the alongside slipway method can be a great example of this. These Chinese yards have included advanced dismantling facilities along with ballast water and asbestos treatment facilities, which ensured environmental safety [7].

W2: Limited infrastructure: Till now, only four ship recycling yards (PHP, SN Corporation, Kabir Steel, and KR) out of several dozen active yards have met the Hong Kong Convention (HKC) standard for green ship recycling. 87 more yards are currently working towards meeting these requirements. Upgrading to the HKC standard is essential for ship recycling yards to gain international recognition and remain competitive. However, most yards still hesitate to adopt these standards due to the high costs involved. A minimum of Taka 30 crore is required to modernise one ship recycling yard, and around Taka 3500 crore is needed to upgrade the entire recycling industry to attain all such facilities [7]. With the Hong Kong Convention set to enter into force in June 2025, ship recycling yards have very little time left to meet HKC standards.

A significant amount of money is required to convert the current ship recycling yards into a green industry. Many shipbreakers cannot afford to invest such a significant amount. The industry will collapse if the government does not provide financial stimulus and policy support during this crisis period. If the government arranges long-term loans with low interest, it can transform the yards into green yards within the timeframe set by the Hong Kong Convention and survive.

W3: Unavailability of Waste Disposal Facility: According to the Ship Breaking and Recycling Rules, 2011, Article 15 mandates strict guidelines for handling hazardous waste generated during ship recycling activities. Under Article 15.1.a, authorisation is required to handle hazardous waste. Article 15.1.b further requires shipbreaking yards to register as members of the Hazardous Waste Treatment, Storage, and Disposal Facility (TSDF) [25]. These provisions are mandatory to establish effective waste disposal mechanisms and prevent environmental degradation from improper handling of hazardous materials.

W4: Health Hazard and Occupational Safety: Among all the hazardous ma-

terials, Asbestos, Polychlorinated Biphenyl (PCB), Ozone Depleting Substances (ODS), and Tributyltin (TBT) are the primary concerns for workers. Being exposed to asbestos increases the chance of getting affected by asbestosis, which can lead to lung cancer. PCB can lead to Melanoma, a kind of skin cancer. ODS may cause ocular diseases. TBT is responsible for developing malignant tumours that ultimately lead to liver cancer [26]. Because of these issues, new installations of materials containing asbestos, ODS and PCB are banned on all ships under the 2nd chapter of the HKC Convention [2]. These health issues are relatively common among workers, and they rarely result in significant loss of working hours or efficiency.

W5: Large Number of Fatalities: Apart from various diseases, many workers experience mild and severe accidents like breaking bones, amputation, and even sometimes face death. Breakage of the winch rope, explosion, and fall from height are common reasons for these deaths. Between 2005 and 2020, in these 15 years, this industry recorded 226 worker deaths. That means about 15 fatalities per year. However, the situation has improved in recent years. As seen in **Figure 6**, from 2021 to October 2024, 37 workers lost their lives, with the annual death rate dropping to 9.4. This decline reflects industry-wide changes in safety protocols and closer oversight by government bodies and labour organisations. In 2021, 13 workers died, but the number dropped to 10 in 2022. The trend continued in 2023 with only 7 fatalities, which is the same as during the first ten months of 2024 [27].

While these advancements highlight significant progress, the industry still faces ongoing challenges. According to a newspaper report [28], a large number of injury and fatality incidents remain unreported. This happens because the severely sick workers quit, or sometimes they are forced to leave, or might not report for fear of losing their job. Moreover, no registry is kept for the workers, as most are hired on a need basis or by a labour contractor. As a result, it becomes challenging to track fatality or injury cases. There are allegations of hiding worker deaths and bribing local media or police to suppress reports of fatalities.

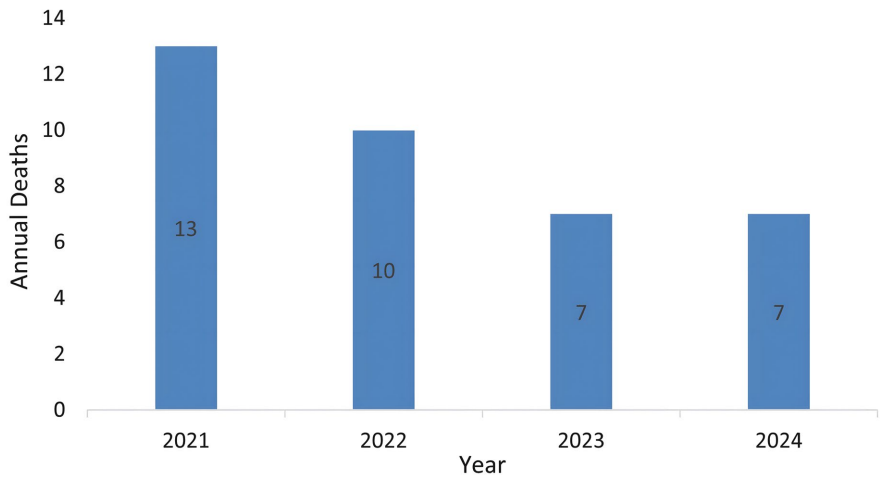

Figure 6. Annual deaths in Bangladesh Ship-Breaking Industry [27].

W6: Inadequate Naval Architects: According to a survey done by Nafisa *et al.* [26], a lack of knowledge of utilising drawings and documents is another drawback. Ship drawings play a pivotal role in ship cutting for ship recycling, as they are the foundational elements for directing the dismantling process. These drawings help identify the most efficient cutting order. Cutting the ship in proper order can significantly reduce the overall cost and time required for recycling. In essence, ship drawings are the essential reference point for ship recyclers, ensuring that the process is conducted safely, efficiently, and in an environmentally responsible manner. With enough naval architects, the drawings could have been utilised more efficiently [26]. If there were enough naval architects with adequate training and knowledge in utilising ship drawings and documents, the ship recycling industry would see marked improvements in efficiency and safety. However, a significant barrier to this improvement is the reluctance of industry owners to hire naval architects due to the perceived additional cost. Many industry players prioritise short-term savings over long-term benefits, overlooking the value that skilled naval architects bring to the process.

W7: Inadequate Worker Training: YPSA has conducted eight Training of Trainers (TOT) sessions focusing on the safe handling of asbestos for ship recycling workers in Bangladesh. These training initiatives have equipped 200 workers from various shipbreaking yards with the necessary knowledge [29]. Additionally, another 700 workers have received similar training through the SENSREC (Safe and Environmentally Sound Ship Recycling) Project [30]. However, the total workforce in the shipbreaking industry is approximately 200,000. Compared to this number, the reach of these training programmes remains significantly inadequate. This highlights the urgent need for establishing training institutions to ensure the safety and well-being of all workers in the industry.

W8: High Dependency on Manual Labour: The shipbreaking industry is continuously evolving due to the introduction of new technological innovations. Innovations like Automated Dismantling Systems utilise robotic machines, including cutting torches, plasma cutters, and shearing machines. These are used to disassemble ships in a controlled and efficient manner [31]. It can be an excellent replacement for manual labour, reducing the risks associated with it. Moreover, these technologies align with the growing global demand for sustainable practices in ship recycling. Despite immense potential, these innovations have yet to be accepted in Bangladesh. The reasons for this lag include high initial investment costs and a lack of technical expertise. However, the main reason is the predominance of manual labour, which is much more economically viable. However, introducing such systems in Bangladesh could revolutionise the industry, improve safety standards and sustainability while maintaining its competitiveness globally.

6. SWOT Analysis—Opportunities

O1: Job Opportunities: Nearly 200 thousand people are employed in the ship recycling industry, which is dependent on it [7]. It eventually improves the na-

tional GDP (Gross Domestic Product) as well.

O2: Demand for Scrap Materials: In 2022, Bangladesh exported scrap steel with a market value of $66.6M, making it the world's 63rd largest exporter of scrap iron. The same year, scrap iron became Bangladesh's 48th most exported product [32]. The recycling industry contributes to the country's local scrap demand for the growing steel sector and also supports export earnings.

O3: Financial Support from Government: Converting current ship recycling yards into green industries requires significant financial investment. Investing such an enormous amount will be very challenging for many shipbreakers. The government's role through economic stimulus and policy support is essential for the industry's sustainability during this critical period. The government can enable shipbreakers to transform their yards into environmentally compliant facilities by offering long-term, low-interest loans. They can convert their yards within the timeframe set by the Hong Kong Convention, ensuring the industry's survival and growth [33]. Recently, the Bangladesh Ship Breakers and Recyclers Association (BSBRA) has also begun investing in PPE (Personal Protective Equipment) and advanced equipment to alleviate the physical burden on workers [27].

O4: Empowering Workers Through Training: The Honourable High Court of Bangladesh has mandated that all individuals involved in ship recycling undergo formal training. A comprehensive training programme must be established to train those engaged in shipbreaking activities. The BSBRA must set up an institute at its own expense for this purpose. The training programme must last at least three months, with the first 20 days dedicated to theoretical instruction and the remaining time focused on practical vocational training. Workers will not be permitted to work in shipbreaking yards unless they possess certificates confirming the completion of this training [34].

According to the Bangladesh Ship Recycling Act, 2018, a provision was made for establishing a training institute dedicated to workers within five years of the law's enactment [35]. This institute was intended to provide systematic training and skill development programmes for workers involved in ship recycling activities, ensuring their safety.

The efforts to upgrade Bangladesh's shipbreaking yards and protective measures for workers are prominent. IMO (International Maritime Organisation) is working to implement a project named SENSREC. One of the primary goals of this project, SENSREC Phase II, is to establish a training management and delivery system with the control, monitoring, certification, and delivery mechanisms necessary for ensuring long-term self-sustainability within internationally acceptable quality standards. Under this project, "Trainers Pool" has been formed for the training of ship recycling workers under the SENSREC project as well as for the in-house training courses of ship recycling yards. This work package includes providing training to 700 ship recycling workers on skill development. As of 28 February 2020, 300 workers received 3 weeks of occupational safety and health training [30].

O5: Integration of Advanced Technologies: The shipbreaking industry is continuously evolving due to the introduction of new technological innovations. There are many innovative technologies available to use in this industry, including automated dismantling, advanced cutting techniques and monitoring systems. Automated Dismantling Systems use robotic machines such as cutting torches, plasma cutters, and shearing machines. Advanced cutting techniques use high-pressure water jets for cutting. Laser cutting is used to achieve better precision and minimise material loss. It is also possible to employ environmental monitoring systems. This system enables the collection of data in real-time and remote monitoring. As a result, tracking water quality, emissions, noise levels, and other environmental parameters becomes more convenient [31].

O6: Adoption of International Regulations: The adoption of international standards, such as the Basel Convention, HKC Convention, and IMO Convention, can significantly alter the scenario of the ship recycling industry. Bangladesh can enhance its existing reputation as a responsible player in the global market by aligning with globally recognised standards. Having goodwill in the market will make it even easier to attract ship owners. This will make Bangladesh's industry competitive and reduce the risk of experiencing a downfall. This goodwill also opens doors for international funding and partnerships, further supporting the industry's growth and modernisation efforts.

O7: Global Collaboration: Bangladesh has a great potential for getting into global partnerships with other ship recycling countries and international organisations. These partnerships can be utilised to ensure better cleaning of hazardous materials. EOL ships arriving at yards contain toxic substances which can pose serious environmental and health risks. Bangladesh can enter into agreements with other nations to impose stricter pre-cleaning of vessels before they are sent for dismantling. This simple yet essential step can significantly reduce hazardous waste exposure in the environment. IMO is attempting to play a vital role in enhancing the overall standard of the shipbreaking industry in Bangladesh, in collaboration with the Norwegian Government [8]. Such global collaboration can bring crucial investments, technological support, and expert guidance to modernise the industry. Developed nations can also assist by providing advanced and eco-friendly technologies and automation machinery. With this support, Bangladesh will be able to reduce the environmental harm. International organisations and ship-owning countries can also provide support by sending expert engineers and knowledgeable professionals to train local workers, thereby enhancing safety standards and efficiency. Setting up dedicated training institutions with the help of global experts can further help the workers to become skilled in modern recycling processes.

7. SWOT Analysis—Threats

T1: HKC Regulations: In FY 2020-21, Pakistan experienced a significant increase in its share of the ship recycling market. Pakistan has grown by 14.7%. On

the other hand, Bangladesh's market share dropped by 15%. This drop is mainly due to stricter government rules for following the HKC. This illustrates how changes in policies and regulations can significantly impact the ship recycling industry [7]. Few local yards adhere to the recommended ship recycling practices established by leading international ship recycling agencies. While other countries swiftly convert their yards to green spaces, Bangladesh may lose its market share if measures are not taken to transform more yards into green spaces before the deadline.

T2: Political Turmoil: Due to the recent political instability in Bangladesh, new construction projects are less likely to get started. At the same time, many mega projects initiated by the previous government are at a standstill. This led to a sharp decline in demand for steel, resulting in nearly 50% less demand for scrap metals. Consequently, scrap metal prices have fallen by 16% in the local market over the past two months (July 2024-August 2024) [36]. Since the ship-breaking industry is a primary supplier to the steel industry, this situation has also impacted the ship-breaking industry. If this continues for a long time, ship breaking yards may become reluctant to break more ships because they do not get a reasonable scrap price. Once the situation becomes normal, the demand for scrap is expected to increase again.

T3: Lack of Implementation: For importing a ship to Bangladesh for breaking, a "No Objection Certificate" must be issued by the Bangladesh Ship Recycling Board. This certificate ensures that there are no hazardous materials onboard. In a 2023 report, Human Rights Watch reviewed 21 leaked hazardous waste certificates for ships entering Bangladesh for dismantling. The HRW (Human Rights Watch) report suggested that the certificates were issued without adequate inspections of the materials onboard [37]. The apparent lack of genuine inspection and oversight makes recycling yards more vulnerable and increases the risk of accidents.

In a recent accident in SN Corporation's ship recycling yard, six workers died and four remain in critical condition. This accident occurred only a few months after the vessel was certified by Nippon Kaiji Kyokai (NKK) in accordance with the requirements of the IMO. That means these yards take certificates but remain unsafe due to not implementing the proper rules and regulations. According to Julia Bleckner, senior health and human rights researcher at Human Rights Watch, "The Hong Kong Convention and its so-called certificates of compliance, like the one granted to SN Corporation, create the dangerous illusion that these yards are safe and environmentally sustainable." [37]

T4: Fluctuation in Foreign Exchange Market: Ship recyclers typically purchase old vessels in international currencies, often in USD, and then sell scrap metal domestically in local currencies. As a result, the depreciation of BDT against the USD increases the cost of acquiring vessels and thus reduces profit margins. Figure 7 shows that, over the past 10 years, the USD value has fluctuated abruptly, posing a serious concern for yard owners. This volatility also creates uncertainty

in setting competitive and stable prices for scrap metal for domestic industries.

Figure 7. Fluctuation in the dollar index [38].

T5: Rising Global Competition: Competition in the ship recycling industry is intensifying daily as rival countries like India and Turkey are making significant efforts to improve safety standards. These advancements have enabled them to align more closely with international regulations, such as the Hong Kong International Convention. As a result, they are becoming increasingly attractive to global shipowners who wish to sell their end-of-life (EOL) ships. India's large investments in modernising facilities and Turkey's reputation for environmentally conscious recycling methods have positioned them as formidable competitors. In India, there are approximately 124 active yards, out of which 90 are green ship recycling yards certified under the Hong Kong Convention (HKC) compliance by various classification bodies. In Turkey, there are a total of 25 ship Recycling yards among which 9 ship recycling facilities in Aliağa have been added to the European Union's list of approved ship recycling yards. Whereas, Bangladesh has approximately 117 shipyards, with 40 currently active. Among these active yards, only 4 yards are approved by the Hong Kong Convention (HKC) [39]. This clearly shows how Bangladesh is lagging behind in complying with regulations. The worldwide shift in the competitive landscape is putting pressure on Bangladesh to enhance its own safety records and to upgrade its infrastructure to retain its market dominance and keep the appeal to the stakeholders.

T6: Environmental Risks in Coastal Areas: Improper disposal of hazardous materials, such as oily waste, asbestos, and toxic chemicals, while ship breaking contaminates the soil and water in coastal areas. According to the World Bank, Bangladesh will import 79,000 tons of asbestos, 240,000 tons of PCBs, and 69,200

tons of toxic paints between 2010 and 2030, which will originate from end-of-life ships [40]. These toxic materials are affecting marine biodiversity, disrupting ecosystems, and threatening the survival of aquatic species. Furthermore, local communities relying on these coastal areas for fishing and other livelihoods face social and economic impacts due to degraded environmental conditions. Addressing these risks requires robust regulatory enforcement, sustainable practices, and investment in waste management infrastructure to protect the environment and the local population's well-being.

T7: Regulatory Challenges and Global Compliance Pressures: The HKC enforces strict controls on hazardous materials, including asbestos, polychlorinated biphenyls (PCBs), and ozone-depleting substances. The convention also requires ship recycling facilities to operate under authorisation from their respective national authorities. Any non-compliance with these regulations could result in trade restrictions from significant shipping nations. The European Union (EU) enforces strict environmental and safety rules for shipbreaking facilities. Since Bangladesh's shipbreaking yards are not fully HKC-compliant yet, they do not appear on the EU-approved ship recycling list, which means they cannot recycle EU-flagged ships. This limits access to a significant segment of the global ship recycling market [41]. Furthermore, foreign financial organisations may impose lending restrictions on companies associated with unsafe ship recycling practices or cut off funding for modernisation efforts.

8. Comparative SWOT Analysis: Bangladesh vs Türkiye

To better understand and evaluate the SWOT analysis of Bangladesh's ship recycling industry, it can be compared with the ship recycling industry of another country. Geographically, Türkiye is far away from South Asia, which is the hub for ship recycling. Yet Türkiye's ship recycling industry is much more advanced than South Asian recycling countries in technological and regulatory aspects.

Strengths

Bangladesh enjoys several advantages, including extremely cheap labour, offering competitive dismantling prices and large tidal differences. Bangladesh also handles larger ships at low cost.

On the other hand, Türkiye has established itself as a pioneer in sustainable ship recycling. Its ship recycling yards are strictly regulated using environmental and safety standards. These yards also possess certifications for necessary international regulations. Türkiye benefits from its proximity to Europe, allowing it to attract vessels from EU countries that are legally required to use compliant yards [42].

Weaknesses

Bangladesh's weaknesses include the absence of proper waste disposal units, beaching methods, and insufficient training facilities. Lack of technical expertise and awareness is also obstacle towards development in this sector.

Türkiye is strong in regulatory compliance, but it faces few limitations too. These include higher operational costs, high shipping charges compared to South

and East Asian countries, and lack of funds and support from the government.

Opportunities

Bangladesh has a wide range of opportunities, including the adaptation of modern recycling techniques, establishing waste management infrastructure, and aligning with international regulations such as the Hong Kong Convention.

One of the key opportunities of Türkiye is proximity to major European countries. As a result, European countries prefer to send ships to Türkiye for recycling purposes. Top recycling facilities and environmentally safe recycling attract the sensible and environmentally concerned ship owners.

Threats

Bangladesh is facing subtle pressures due to international conventions. Without improving environmental safety and standards, Bangladesh may lose environmentally concerned ship owners. Countries that recycle ships more safely are strong competitors. On top of that, Bangladesh faces problems like lack of government initiatives and proper planning.

Conversely, Türkiye is mainly challenged by increasing operational costs. It also faces competition from cheaper countries. But Türkiye is better prepared to handle these problems because it already follows high standards and has strong systems in place [42].

9. Environmental Impact Assessments on Ship Breaking Activities

Several Environmental Impact Assessments (EIAs) have been conducted by independent researchers or agencies. But often most of them are either in small scale or lacks detailing or does not quantify the ecological impacts.

Patwary *et al.* [12] formed an EIA matrix to evaluate the negative impacts of this industry. They concluded that the industry is lagging behind due to environmental impacts and lack of occupational safety. In another study, Yahya *et al.* [43] evaluated EIA using a methodology that was based on Environmental Evaluation System (EES). The industry had a negative Environmental Impact Value (EIV). However, the socio-economic benefits made the total EIV a positive value of +19. Pasha *et al.* [44] conducted a similar study with a yard named SRS Ship Breaking Yard. For that particular yard, they found the EIV to be −53, which clearly portrays the environmental degradation in those areas due to the presence of this yard. Similarly, Talukder *et al.* [45] focused mainly on Fouzdarhat and Vatiary area of Shitakunda. They found the EIV to be −93, which indicates that the yards in those areas are associated with serious ecological damage.

Most of these studies are on a small scale and are often hindered by a lack of data. As a result, a more detailed and comprehensive analysis is required to accurately portray the actual scenario for better quantification of ecological impacts.

10. Recommendations

Based on the comprehensive SWOT analysis of Bangladesh's ship recycling in-

dustry, several strategic recommendations can be offered. By properly executing these recommendations, the strengths and opportunities can be utilised while weaknesses and threats can be mitigated. Key recommendations include:

10.1. Short Term Recommendations (0 - 3 Years)

10.1.1. Establishing Waste Disposal Facilities

Establishing proper waste disposal units or facilities (W3) is crucial. The development of such units is possible through collaboration with environmental organisations and by seeking financial and technical assistance (O3). Proper waste management will ensure compliance with international regulations, particularly the Hong Kong Convention (T1). Complying with the regulations helps to preserve and improve its current reputation worldwide. With financial support from government, NGOs or private organisations, it is possible to develop waste disposal units within a short timeframe. These small units might not change the industry overnight but they will play an important role in the damage control by reducing environmental hazards.

10.1.2. Improving Occupational Health and Safety Standards

Improving occupational safety (W4) and minimising health hazards are necessary for reducing the number of casualties (W5). Moreover, it is essential to have a safe working environment to attract skilled workers. Implementing rigorous safety guidelines, providing Personal Protective Equipment (PPE), and conducting regular health check-ups are essential for ensuring worker safety. Empowering workers through training programmes (O4) will enhance their skills and awareness of safety. Immediate action must be taken to shut down the practice of employing children. Proper steps should also be taken against yards conducting night operations or yards violating workers' rights. Additionally, all injured workers should get enough compensation. In the event of fatalities, their families should also be adequately compensated in accordance with the Labour Act, 2006, and the Shipbreaking and Recycling Rules, 2011. A more detailed and comprehensive compensation and insurance scheme should be introduced to provide financial security to workers and their families in the event of an accident. These legal frameworks can be further strengthened through collaboration between the government and relevant parties, including shipowners, investors, yard owners, labour unions, and NGOs. Proper implementation can further ensure stability and accountability in the sector.

10.1.3. Investing in Workforce Development and Training

The shortage of naval architects (W6) and inadequately trained workers (W7) is a major issue. Resolving the problem demands a significant amount of funding and investment in education and training. Instead of establishing new institutions, initial training can be provided via partnerships with existing vocational training centres to avoid initial investment. Providing specialised training and career development opportunities will improve the overall operational efficiency and create

more job opportunities (O1) within the industry.

10.1.4. Strengthening Compliance with International Regulations

The industry must stick with conventions like the Hong Kong Convention to mitigate threats from international regulations (T1) and rising global competition (T5). Ship recycling countries around the world are complying with HKC, and that creates significant pressure on Bangladesh to align with these regulations. Regular assessment, certifications, and following the guidelines will ensure the industry remains competitive and reliable. International organisations are also eager to provide technical and financial support in implementing these standards.

The Hong Kong Convention has already entered into force on 26 June 2025. As a result, Bangladeshi ship yards must urgently implement regulatory requirements. The most urgent and actionable aspects from HKC include:

1) Inventory of Hazardous Materials (IHM): Each ship must carry a certified IHM. Many yards in Bangladesh still lack the capacity to verify or manage these inventories, posing risks during dismantling operations.

2) Ship Recycling Facility Plan (SRFP): Each yard must prepare and maintain a SRFP. Having a proper plan makes it easier to facilitate the entire process and ensures compliance.

3) Worker Safety and Training: Availability and use of Personal Protective Equipment (PPE) has to be assured. Besides, workers should receive training programmes.

4) Environmentally Sound Management of Hazardous Materials and Waste Disposal: Proper storage and disposal facility of hazardous materials such as asbestos, PCBs, and heavy metals has to be provided.

10.1.5. Implementing Continuous Monitoring and Evaluation

Many measures are taken to improve the industry. However, due to a lack of proper monitoring, the measures and improvements cannot be sustained for a long time. So, there is also a need to establish a monitoring system intended for continuous monitoring and evaluation mechanisms. Key Performance Indicators (KPIs) related to safety, environmental impact, and operational efficiency should be regularly assessed. This will enable quick actions and allow continuous growth.

10.2. Long Term Recommendations (5 Years or More)

10.2.1. Modernising Recycling Methods and Infrastructure

Investing in modern and environmentally friendly ship recycling technologies is crucial to enhance current recycling methods (W1) and address the limited infrastructure (W2). Introducing modern equipment and innovative techniques will reduce the reliance on manual labour (W8) and improve efficiency. It will also enable better handling of hazardous materials, thereby minimising environmental risks in coastal areas (T6). To minimise environmental hazards, a feasibility study should be done to relocate ship recycling operations to designated offshore locations, such as Kutubdia Island. Relocating to a new place can help eliminate the

adverse environmental impacts associated with the beaching method. It is also essential to ensure that the new location has proper facilities and safety measures.

10.2.2. Leveraging Technological Advancements

Introducing advanced technologies (O5) alongside current manual labour can revolutionise the entire ship recycling process. Bringing automation and innovative recycling techniques will enhance productivity and environmental compliance. But that needs to be in the proper ratio with the human labour. Replacing the entire setup of yards is not feasible yet, as cheap labour is a prime strength of this sector. Investing in research and development can also lead to the discovery of new methods to recycle ships more efficiently and safely.

10.2.3. Enhancing Environmental Sustainability

Implementing environmentally sustainable practices is critical to reduce environmental risks (T6) and meet the growing global demand for green industries. Establishing waste management systems and assessing environmental impacts are essential to protect the environment from damage. Although getting official environmental certifications takes time, it can greatly improve the industry's reputation and bring overall stability.

11. Conclusion

Bangladesh has become one of the largest hubs for dismantling obsolete ships. Bangladesh's ship recycling industry plays a crucial role in various sectors, including the steel, construction and shipbuilding industries. However, its prospects and stability depend on improving worker safety, reducing environmental risks, and meeting international standards. Dealing with environmental hazards, outdated practices, and untrained workers is difficult but not impossible. If this effort becomes successful, it can pave the way towards sustainable development.

One of the industry's primary strengths is its vital contribution to Bangladesh's economy. The availability of cheap labour, strategic location, and huge demand for recycled steel make the sector highly lucrative. Shipbreaking yards efficiently handle large vessels and supply raw materials to local industries. These advantages help Bangladesh stand out as a global leader in ship recycling and support its role in the circular economy.

Despite its strengths, the industry struggles with some serious issues too. Poor infrastructure, outdated recycling methods, and inadequate worker safety measures pose significant risks. Lack of compliance with safety standards, limitations in technological advancements, and unavailability of waste management systems further restrict the industry's growth. These issues will continue to limit the industry's potential unless there is significant improvement.

Despite having a few weaknesses, there are numerous growth opportunities. Opportunities include the global focus on green ship recycling, increasing demand for recycled materials, and the potential for global collaboration. Introducing waste management practices, integrating automation, and investing in worker

training can improve efficiency. Strengthening regulations and aligning with international standards will further reinforce Bangladesh's position in the global market.

However, the industry faces significant threats, including strict international regulations, environmental challenges, and rising competition from other ship recycling countries. Political and economic instability could also disrupt regular operations. Without necessary reforms, the country risks losing its competitive advantage. This can affect both economic growth and market share.

It is essential to follow a timeline to avoid delays and for ease of implementing recommendations. In the short term, improving worker safety, enforcing existing rules and regulations, and starting training programmes should be preferred, as these can bring results in less time. On the other hand, in the long term, recommendations like infrastructural improvement, using advanced technologies and sustainable recycling processes will have to be implemented. The right balance between short-term and long-term actions will help in the continuous development of the industry.

Bangladesh's ship recycling industry has experienced promising growth over the years and is well-positioned to expand the market. To achieve this, the sector must modernise ship recycling practices, strengthen safety regulations, and improve environmental compliance. It will only need the right investments and reforms to maintain its leadership and advance towards greener practices.

Acknowledgements

This work was conducted as part of the collaborative project "Safety Envelope for Ship Recycling Practices in Bangladesh: Hazard Identification and Risk Evaluation" funded by the Royal Academy of Engineering (RAEng) and Lloyd's Register Foundation (LRF) under Engineering X. The authors thank all project partners for their contributions. We have made every effort to acknowledge all sources used in the preparation of this article. However, some references may have been inadvertently missed. We sincerely apologise for any such oversight and gratefully acknowledge the contributions of all whose work has informed this article.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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