

Research Article

Evaluation of Ship Recycling Industry in View of Present Global Circumstances and Way Forward

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Abstract

Ship recycling, commonly referred to as ship dismantling, is an inherently sustainable practice with global implications. It involves the reverse engineering process of disassembling obsolete ships to recover reusable materials in a safe and environmentally friendly manner. Over the past two decades, ships have predominantly been beached in South Asian countries such as Bangladesh, India, China, and Pakistan, allowing local yards to dismantle vessels with moderate preventive measures and substantial manual labor. Ship recycling stands as a significant and environmentally conscious industry, witnessing the annual recycling of approximately 1000 obsolete ships globally. Currently, this industry is predominantly led by three South Asian countries—India, Bangladesh, and Pakistan. In Bangladesh, the industry commenced with the dismantling of stranded ships, evolving into a large and profitable sector that generates substantial employment opportunities for thousands of semi-skilled workers in poverty-prone areas. While the ship recycling industry presents opportunities, it also poses challenges for coastal zone management, encompassing environmental, law enforcement, and worker safety concerns. The surge in demand for ship recycling has prompted increased regulatory scrutiny at both national and international levels. This pressure culminated in the development of the Hong Kong International Convention (HKC) by the IMO in 2009, mandating safety and environmental protection standards at recycling yards. Achieving a perfectly green ship recycling process in line with European standards is inherently costly. However, a viable and almost green ship recycling approach, integrating the current common practice of beaching methods in Asian countries, is entirely feasible. Despite limitations and challenges, the industry significantly contributes to Bangladesh's GDP and the overall socio-economic landscape. Currently, there has been a visible reduction in Bangladesh's market share due to stringent environmental regulations, while competitors have experienced increases. This study represents an analytical effort to evaluate the current global ship recycling scenario, exploring its potential, challenges, and the future trajectory of both local and global ship recycling industries.

Keywords

Ship Recycling, Compliance, Beaching, Viable Practice, HKC

1. Introduction

Recycle an obsolete ships at the end of life (EOL) is not frequent issue. Ship recycling industry refers to the process of dismantling [1] and recycling End of Life (EOL) ships and it's globally accepted. [7] Actually old ships after severe hull

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Received: 24 September 2023; **Accepted:** 20 November 2023; **Published:** 20 February 2024



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corrosion, metal fatigue, a lack of spare parts of machinery, [5] and beyond economic use, they have placed for dismantling and recycling process [11]. A ship can last up to 25 to 30 years and end of its lifespan; they go for recycle to recollect its materials and machinery [14-16]. The global ship recycling industry dismantles around thousands of ocean-going ships annually, including container ships, cargo and bulkers, oil and gas tankers, passenger ships, and more, to salvage steel, other metals, useful equipment, household items, furniture and recyclable materials. South Asia is the principal hub for ship breaking and recycling operations, with Bangladesh, India, and Pakistan leading the recycling business [2]. South East Asian four countries usually recycled 90% of EOL ship globally. However, beaching as ship recycling method is mainly used in South East Asia due to geographical advantage and tidal condition. Whereas, constructing and running dry docks is quite expensive, though dry-docking is the safest method. More environment concern countries like USA and EU usually adopt the dry-dock technique [50]. However, a few countries in Asia and in Europe have adopted the alongside or pier breaking approach instead of beaching like Turkey or China. Right now, Aliaga in Turkey and a few other places in the EU are the most vocal against slipway or landing recycling technique with highest environment friendly technique. In fact, those South Asian Countries are doing a great job as they are doing recycling of obsolete old and EOL ships with good efficiency, but with less professional manner [30, 32, 33].

The recycling industry has had a significant effect on the Bangladesh national economy, leading to an average growth of 14% annually since 1980. Its contribution to the overall success of our country is unquestionable. Presently, the local ship recycling industry is contributing annual revenue around US\$ 1 billion. [4]. The industry is creating scope of jobs for people in poverty-prone areas, with an estimated 200 thousands individuals directly involved. It has been estimated that around 60% of materials and machinery for local ship shipbuilding comes from Ship recycling industry. The Bangladesh customs authorities revealed that 250 scrap ships were brought in during the FY 2016 and Taka 8.22 billion was paid as revenue to the government. This further grew to 272 ships during FY19 with a revenue collection of Taka 7.92 billion. Custom duties, income taxes and value added taxes amounting to an average of Taka 5 billion are paid each year by the local ship recycling industry. The ship recycling industry pays considerable fees and charges to the ministry of industry according to the regulations in place. Bangladesh is currently taking major strides in its infrastructure growth, with ambitious megaprojects such as the Padma Bridge, Metro Rail, Elevated Expressway, Rooppur Nuclear Power Plant, Karnafuli Tunnel, Bay Terminal, etc. These projects provide a tremendous boost to the country's infrastructure needs. There is a strong demand for steel in the country due to rapid economic growth. People are more likely to invest in and build new homes and infrastructure, which has led to greater need of steel and other materials. The ever-growing demand for domestic steel has

put pressure on local steel mills to secure raw materials from the ship recycling industry. [19]

One of the mandates of HKC is that an approved ship recycling facility has to create a SRFP. The SRFP provides crucial information regarding a ship recycling facility, including its layout, water depth, accessibility, routine maintenance, dredging, etc. South Asian recycling yards/plants largely employ the open beaching method/system. While this method has been profitable, it can also release hazardous materials into the coastal region. As of recently, the EU's SRR is in effect. This law states that all ships registered under the EU flag must be recycled in a facility from the European List and forbids beaching as a valid recycling method. Countries such as China, Turkey and India are vigorously competing to bring their ship recycling facilities in line with global standards. Bangladesh's ship recycling yards need to strengthen their operations in order to maintain global standards and remain competitive in the world. The Bangladesh Ship Recycling Act was implemented in 2018. Local ship recycling yards need to abide by the HKC 2009 guidelines by 2023. Upgrading of local yards may cost around few thousand crore Taka as a whole. However, most of the yards of India and Pakistan have already implemented the HKC standard. Bangladesh is one of the active players in the HKC initiative, alongside India and Turkey who have already accessed it. China has already achieved the standard. Bangladesh has set a goal to achieve the standard and ratify HKC by 2023. Necessary improvements must be taken by local yards in order to ensure compliance with international regulations. It is an analytical study to evaluate the potential, challenges and future of local and global ship recycling industry in respect present global situation. Moreover, an effort has been taken to depict the sustainable ship recycling solution in view of global recycling regulations for ship recycling major player in the world.

2. Global Major Ship Recycling Locations

The ship recycling global industry dismantles around 1,000 ocean-going EOL vessels annually. Those EOL ships are container ships, cargo ships, bulkers, oil tankers, LNG, LPG, cruise ship etc. for recovering steel and other valuable metals as well as recyclable items. At present almost all ship recycling activities are concerted in five countries. From those, four are South Asia (like India, Bangladesh, China, Pakistan), and Turkey. Further ship recycling capacity is available in few North American countries (like US, Canada, Mexico) and few within the European Union (like Denmark, Belgium and UK). At present, South East Asia is certainly the global centre for ship recycling industry and business. South Asian countries are contributes around 90% of global ship recycling activities [24]. In February 2016, the NGO ship recycling Platform Secretariat in Brussels published a report detailing ship breaking and recycling data by countries. The statistics show that in one year, 768 large ships were disman-

ting globally, while 469 vessels ran aground on coasts of India, Pakistan and Bangladesh [25, 46]. Number, percentage and gross tonnage of EOL ship dismantled around the globe (by countries) in between 2012-2022 has been shown in figures 1, 2 and 3 respectively below. Ship recycling comparison and statistics around the globe by major vessel types in 2021 has been shown in figure 4 and table 1 below [46, 43]. Beaching as ship recycling method is usually followed in all South East Asian countries except China. Ship recycling becomes economically viable in the LDC and developing countries where the actual operation has carried out in

beaches due to geographical advantages. There are number of guidelines in ship recycling and when those followed strictly then whole industry become safe and environment friendly [49]. Considering careful operations in beaching method with the guidelines from IMO, a set of viable roles and procedures can be formulated for recycling industry. If these viable roles and procedures could be implemented through a user friendly knowledgebase system [40] and good monitoring, it is possible to make this method useful and sustainable, competent and viable as ship recycling method for South Asian countries [46].

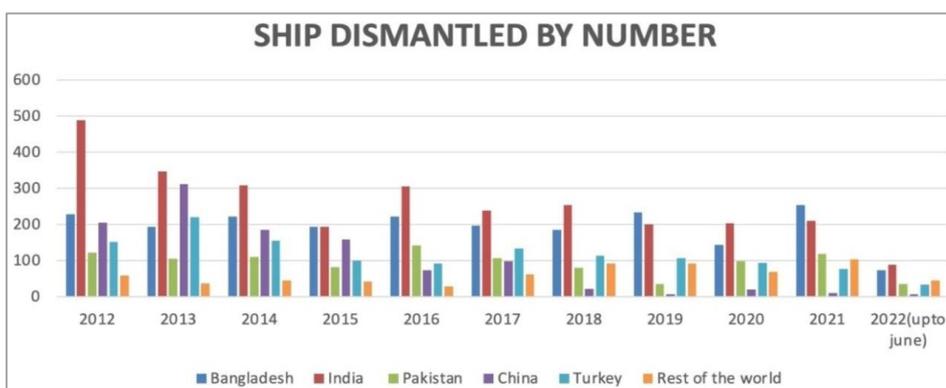


Figure 1. Number of EOL ship dismantled around the globe in between 2012- to 2022 [43].

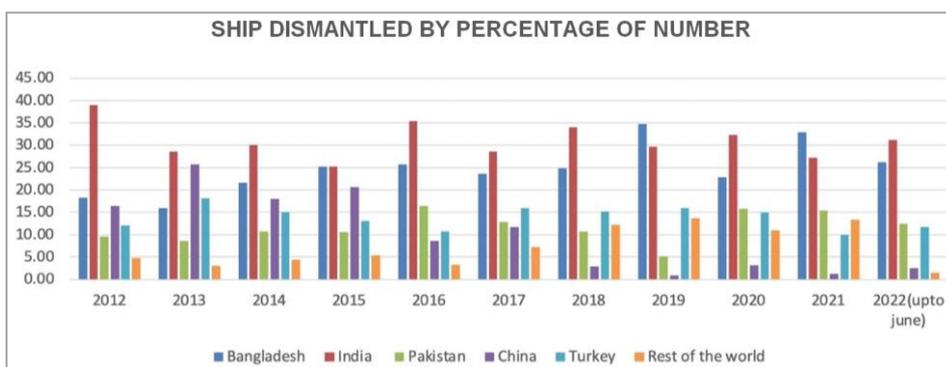


Figure 2. Percentage of EOL ships in number dismantled around the world in between 2012 to 2022 [43].

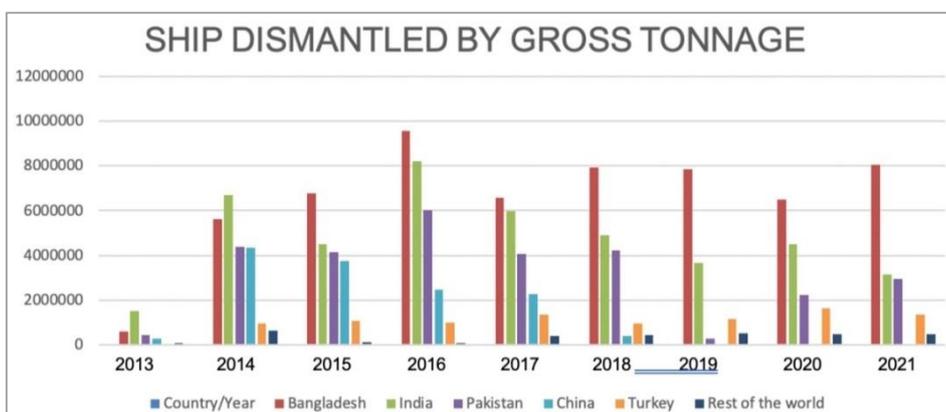


Figure 3. Comparison among major ship recycling nations based on Gross Tonnage [51, 46].

3. Present Status of Global Ship Recycling Industry

Ship recycling is a reverse engineering process of dismantling obsolete ship to recover reusable materials [20] in a safe and environmental friendly way. It is a rapidly developing global industry that involves dismantling and recycling ships when those reached EOL. Approximately thousand old ships recycled across the globe every year [21]. This process helps to recover steel and other valuable metals along with household items and equipment's from these EOL ships. Currently, most of the ship recycling activities around the world are conducted in five countries: India, Bangladesh, Pakistan, China and Turkey and those have become hubs for all ship recycling activities due to their geographic advantages, cheap workforce, tradition and availability of resources. North America (the United States, Canada and Mexico) and the European Union (Denmark, Belgium and the United Kingdom, among others) have the recycling capacity; but those are very expensive. As a result ship recycling activities has become a booming business in South Asia. Big players in ship recycling like India, Bangladesh and Pakistan, have their own yards where they perform such activities. In Bangladesh around 200 EOL ships are recycled in local yards at the port city of Chattogram [52]. This has been a hub for recycling old, obsolete ships for many years. According to research, about 2 million LDT of different types of ships are recycled in Bangladeshi yards in each year. However, Pakistan and India have seen the highest rise in share, with 14.7% and 3.2% respectively in FY 2020-21. On the other hand, Bangladesh and China found as a reduction by 15% and 2%, respectively. Such decrease in market share of China is likely due to their ban on international ships recycling. Whereas, Bangladesh market share has been on the decline because of government regulations [46].

3.1. Bangladesh

Chattogram is the major ship recycling location in Bangladesh. At Fauzdarhat, a city 16 km Southwest of Chittagong with 8 square kilometers area is covers the recycling related activities. Due to high tidal difference local yards are suitable for dismantling of big merchant ships [55, 30-32]. Few local yards follow recommended ship recycling practices given by leading international ship recycling agencies. The Ship Breaking and Recycling Rules or SBRR, 2011 issued by the MoI encompasses the overall administrative and legal framework for safe and environmentally sound ship recycling in Bangladesh [5]. Again, Section 15 of SBRR orders local yards to obtain approval of Ship Recycling Facility Plan (SRFP) from the MoI. Each yard must have an authorization for handling hazardous waste generated from ship recycling activities issued by the DoE under MOI. As a result Bangladesh is closing to viable ship recycling process by

improving its dismantling activities in the local yards.

3.2. India

Major ship dismantling centres in India are located at Alang in Gujarat. Alang has around 150 potential plots for use as ship recycling facilities by using beaching method. The modes operating remains the same as other neighboring countries like Pakistan and Bangladesh. Gujarath (Alang) Maritime Board has an exclusive wing for monitoring ship recycling in Gujarath region. Currently, there are around 132 registered recycling yards at Alang, 17 have been awarded Statements of Compliance (SoC) with the Hong Kong Convention, a further 26 are expected to receive SoCs shortly, and another 20 are expected to apply [7].

3.3. Pakistan

In Pakistan main ship recycling yards are located at Gaddani near Karachi. The yards are under the control of Baluchistan Development Authority situated in Gaddani. These yards use mainly beaching method to position the obsolete ships arriving at Gaddani [15]. The yards have the capacity to dismantle more than 50 large ships at a time. The recycling yards are underdeveloped and they are using combination of manual and mechanical method for dismantling activities [48]. There is limited inspection and control over the downstream industries which collect the waste and pre-used items from the dismantled ships. The government with few agencies control over ship dismantling is effective. Recently government formulate and implement ship recycling rules for safe and environmentally sound ship recycling in Pakistan. Pakistan will also achieve viable ship recycling process soon.

3.4. China

China has accelerated its ship recycling capability. Chinese ship recycling yards are located in Jiangmen and Jiangsu provinces beside in Pearl and Yangtse river deltas. In these provinces, there are more than 50 ship recycling yards has located. There are a few inland recycling yards which are operating exclusively for inland vessels. Beaching is banned in China and ship recycling is undertaken alongside slipway method. In this method dismantling is done by using vertical lift off with concrete support base. And the process is controlled from ship to landfill. Chinese recycling yards are relatively and strongly regulated by the government and can also be subject to intense scrutiny from the local authorities [7]. Those yards developed asbestos treatment and ballast water treatment facilities. Advanced dismantling facilities, futuristic vision based recycling policy, stringent laws and regulations which formed "stakeholders' cooperative working model are consider the four pillars of enterprising ship recycling industry in China [45]. Lloyd's Register has visited the yards in

Shanghai and Guangzhou, and they found safety, welfare and environmental awareness was excellent. China takes pride in their membership of the International Ship Recycling Association (ISRA).

3.5. Turkey

Ship recycling industry in Turkey was established in Aliaga and Itmir regions early in early stage. The industry got recognition and the ship recycling was declared as a legal industrial activity in 1986. Now, the Turkish government allows ship recycling at Aliaga, near Izmir, on the west coast. As Mediterranean has very small tidal range, Turkish yards at Aliaga are using slipway approach by controlling the inter-tidal zone. Hard standing has been permanently provided in large areas of the yards with permanent drainage systems to control the sea pollution [46]. Environmental and occupational safety has been ensured rigorously by the concerned government authorities.

Turkey is placed 5th in the current ranking of world ship recycling output. Lloyd’s Register has visited all the yards in Turkey and has satisfied to their activities.

3.6. America

Ship recycling facilities in the American yards are subject to intense scrutiny by the U.S. Environmental Protection Agency and the U.S. Maritime Administration (MARAD). Operational recycling yards in the U.S. include: All Star Metals and Esco Marine Inc in Texas and Marine Metals Inc and Bay Bridge Enterprises in Maryland [46, 43]. Ship recycling yards in the U.S. are operating with very high standards. They use dry docking method for recycling activates. As a result, there recycling costing is very high to recover material and other useful items in compare to South Asian recycling yards.

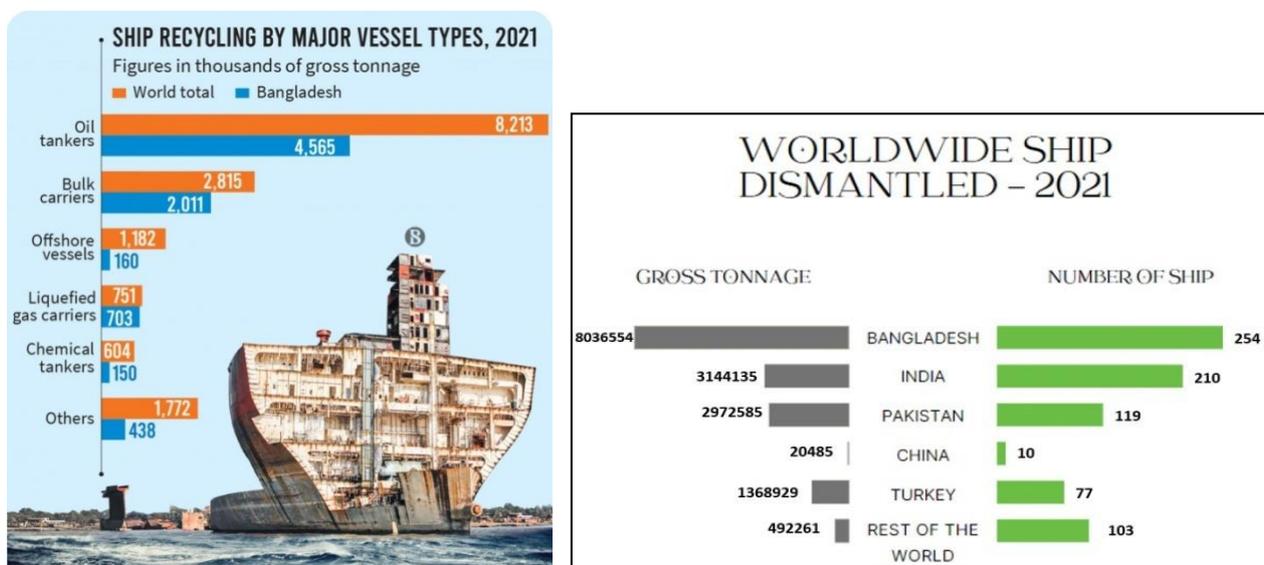


Figure 4. Ship recycling comparison and statistics around the globe by major vessel types in 2021 [46, 43].

Table 1. Number of ship dismantled globally between years 2012 to 2022 [43].

Country	Year									
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bangladesh	229	193	222	194	222	197	185	234	144	254
India	488	347	309	194	305	239	253	200	203	210
Pakistan	121	105	110	81	141	107	80	35	99	119
China	205	312	185	158	74	98	22	6	20	10
Turkey	151	220	155	100	92	133	113	107	94	77
Rest of the world	59	36	45	41	28	61	91	92	69	103
Total ship dismantled	1253	1213	1026	768	862	835	744	674	629	773

4. Recent Trend of Bangladesh Ship Recycling in Contest of Global

During the last decade in local ship recycling very steady growth has been observed in Bangladesh. Local ship recycling industry of Bangladesh has started its journey accidentally from Chattogram through ‘the dismantling of a Greek ship M D Alpine which was brought to shore near Fauzdarhat by the 1960’s cyclone. The abundant ship was dismantled in 1965 by Chittagong Steel House.’ [8, 9] Subsequently, the Pakistani ship Al Abbas was salvaged, beached at Fauzdarhat and dismantled in 1974 by Karnafully Metal Works.’ [11-13] These incidents draw the attention of a few entrepreneurs on the suitability of the coast line near Fauzdarhat for beaching. Over the years, ‘the ship recycling industry in Chattogram has gone through lean and boom periods, to become the world’s largest ship recycling industry and now the ship breaking and recycling industry (SBRI) spans over 20 km coast of the Bhatiary- Fauzdarhat- Baroiyawlia area.’ [14, 15] The local ship recycling organization is Ship Breaking and Recycling Industry (SBRI) consists more than hundred ship recycling yards in register. ‘From where few dozen are in regular operation and the industry directly employs over 200,000 laborers and accounts for the supply more than half of all the steel products in Bangladesh.’ [10] Around one million people are indirectly earning their bread and butter from this industry. In 2021, Bangladesh has once again become the top ship recycling country with more than half of the world’s ships recycled here, according to a report of United Nations Conference on Trade and Development [57]. As per report of ‘Review of

Maritime Transport 2022’ published on 29 Nov 2022 in the period of 2021-2022, Bangladesh recycled 8.02 million tons of EOL ships accounting for 52.4% of the world total, where nearly 57% were oil tankers, 25% bulk carriers and 9% liquefied gas carriers. Again, as per the annual flagship report, in the previous year (2020-2021), around 54% of the world’s oil tankers, 18.4% of bulk carriers and 5% of liquefied gas carriers were recycled in Bangladesh [52].

In 2021, the ship recycling sector in Bangladesh saw a sharp increase, from 144 in 2020 to 254 in 2021, representing a growth of almost 56.69%. [17] In the first three quarters of 2021, 582 ships were scrapped worldwide, of which 197 in number (about 34%) were in Bangladesh, and it became top in the ranking of ship recycling in contest to Globe. Bangladesh has continued to be the top ship recycling country in 2021 according to the latest report from NGO Ship breaking Platform. However, in 2022, EOL ships imports have drastically dropped for dollar scarcity and demand-side problems in Bangladesh. The number of imported ships for dismantling has drastically fallen during the first half of 2022. Bangladesh has imported only 64 ships during the January-June 2022 of the calendar year and which is about 59% lower than that of the same period of last year (2021) and which has been shown in figure 5 below [53, 54]. Again, according to data available with NGO Ship-breaking Platform (NSP) during the January-June period of 2022, India has also imported a lower number of 88 EOL ships and that is less from 124 in the January-June 2021 of the same period in previous year [52]. Percentage trend of ship recycle of Bangladesh in between 2013 to 2021 has been shown in figure 6 below [45, 52].

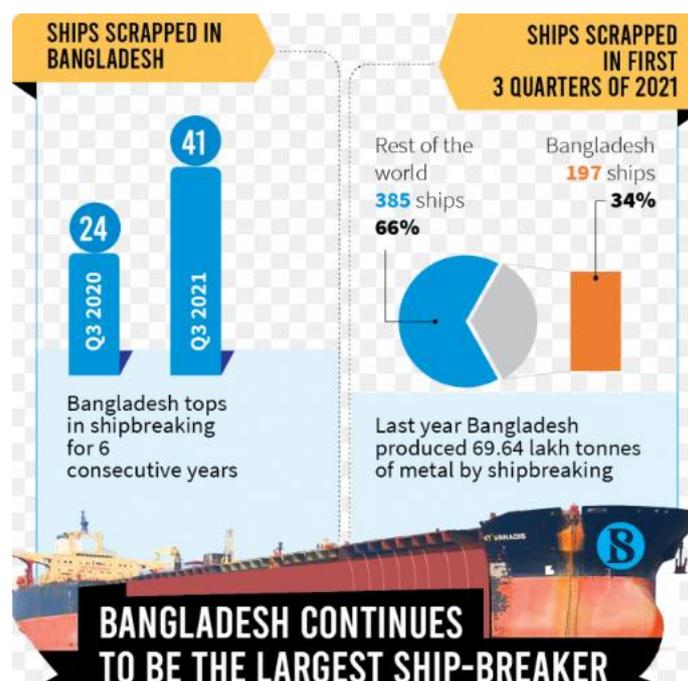


Figure 5. Local ship recycling position and statistics of Bangladesh (TBS, 2021; [52]).



Figure 6. Percentage trend of ship recycle of Bangladesh in between 2013 to 2021 [45, 52].

5. Assessment of Bangladesh Ship Recycling Industry

A number of factors have pushed the growth of this sector over time in this region. Those important factor are “the favorable beaching condition which is God gifted, the closeness of the beach to the industrial hub of Chattogram, mainly the steel rerolling mills which consume most of the output from the industry, availability of risk taking entrepreneurs, access to abundant labor from the northern districts of Bangladesh, the favorable legislative framework allowing the operation of the industry for decades even without it being considered as an industry. The high demand in the local market for scrap ferrous and non-ferrous metals and other cheaper items recovered from the industry, access to finance from the formal financial institutions and informal money lenders. Again, the growth of upstream and downstream industries has formed an informal industrial symbiotic and inter-dependent network. Interesting point is that, almost every output from the EOL ships sold in the local market and consumes or process by the forward and backward linkage industries closer to the recycling yards [34, 35]. At present, the SBRI is bound by the Ship Breaking and Ship Recycling Rules 2011 under the MOI along with Environmental Protection Act 1995, and Environmental Protection Rules 1997 of the supervision of DoE under the Ministry of Environment and Forest (MOEF). Presently the labor safety and the environmental management standards in the local yards have been shown signs of distinct improvement after the implementing those roles and regulation and taking those measures.” [26, 27]. Now, “Bangladesh Government has established Ship Building and Ship Recycling Board (SBSRB) as the one-stop service provider under the MOI [34, 44]. It is providing integrated services including granting required permissions and certificates for Ship breaking, recycling and other related activities in cooperation with other responsible departments and ministries. DoE is working to ensure sustainable environmental governance for pollution control. This department is solely responsible for issuing an ECC prior to the establishment of any industrial unit in Bangladesh and thus ship recycling yards as well. It also issues authorizations for handling hazardous

wastes generated from ship recycling activities” [43]. At present major recycling yards of Bangladesh is following a viable recycling technique and almost at the door of achieving international standards for Health Safety and Environment (HSE) aspect [43, 51].

India, Bangladesh and Pakistan are the frontrunners in this industry. Despite certain restrictions limitations, the ship recycling industry of Bangladesh has been significantly contributing to the country's Gross Domestic Product (GDP) and its overall socio-economic development. [18] In recent times, however, its market share has been declining as a result of strict environmental regulations. In 2011, two key regulations were implemented by the Ministry of Industry (MoI) to supervise Ship Breaking and Recycling, these being the Ship Breaking and Recycling Rules 2011 and the Environmental Protection Act 1995. The Ship Breaking Regulatory Authority was then formed to abide by these laws. In order to safeguard the environment, the Ministry of Environment and Forest (MoEF) has laid out the Environmental Protection Rules 1997. These regulations are useful, viable and essential for implement to prevent environmental damage and keeping our planet healthy. The Department of Environment (DoE) is solely responsible for enforcing the regulations. Before participation in any activities, ship recycling yards must acquire authorization from the DoE to continue their operations. This authorization is known as an Environmental Compliance Certificate (ECC). Local yards are doing their best to keep their workers safe and have also become aware of the need for environmental conservation. As a result, some have been able to meet international standards in terms of green ship-recycling practices. Considering the record and quantity of ship-recycling from 2015 to 2022, the local yards have been stated in three categories; active, idle and inactive. Besides, the Ship Recycling Facilities Plan (SRFP) status of the yards has been identified by the MoI letter dated 04 Nov 2020. It has been estimated that, the top twenty groups of local active yards have been tabulated according to their quantity of LDT of EOL ship handled and stated as their continuity of ship breaking over last decade.

6. Ship Recycling Demand and Market Forecasting

Forecasting involves using past and present data to predict

future events, serving as a valuable planning tool for businesses to manage uncertainty. Ship recycling demand refers to the number of EOLships available for dismantling within a particular time frame. Factors that impact ship recycling demand forecasting can be grouped into cost and regulatory aspects [26, 27]. Cost-related factors include scrap steel prices, freight market conditions, dismantling costs, fuel prices, labor Cost and shipbuilding costs. [23] Regulatory factors include the implementation of rules and regulations, as well as options for conversion [34, 44]. The market forecasting of ship recycling in Bangladesh has been done by linear regression

method based upon a possible number of ships that might be scrapped, amount of earnings that could be reached and finally the demand factors that actually influence the market. This method will be used by taking account into the past and present data with some other parameters [37, 43]. To get all the probable values of the future we have used the forecasting function in Microsoft Excel. Factors influenced to ship recycling demand have been shown in figure 7 below. Possible number of EOL ships, estimated earnings and probable iron and steel materials from scrapped ship has been shown in figures 8, 9 and 10 respectively below.

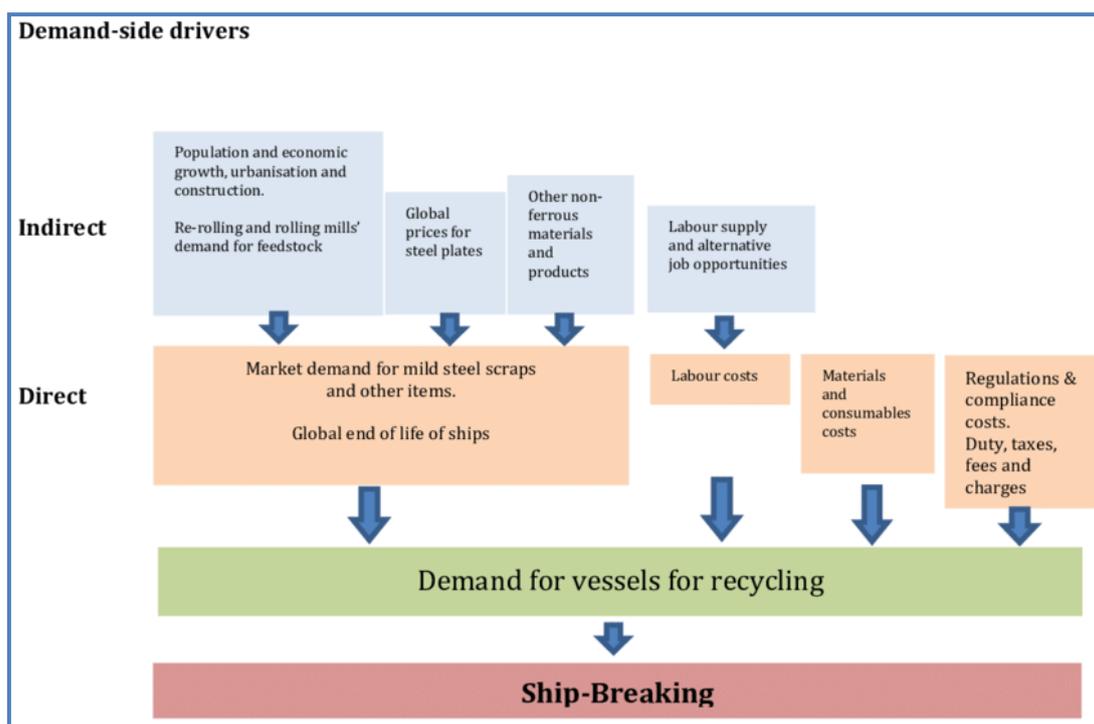


Figure 7. Factors influenced to ship recycling demand [52].

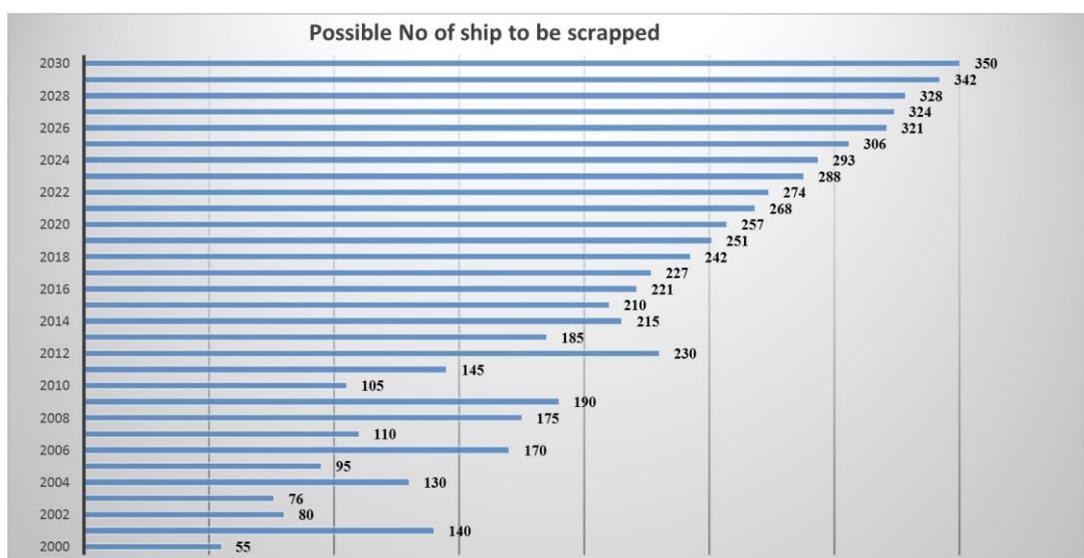


Figure 8. Estimated number of EOL ships to be scrapped in BD within 2030 [51, 52, 43, 44].

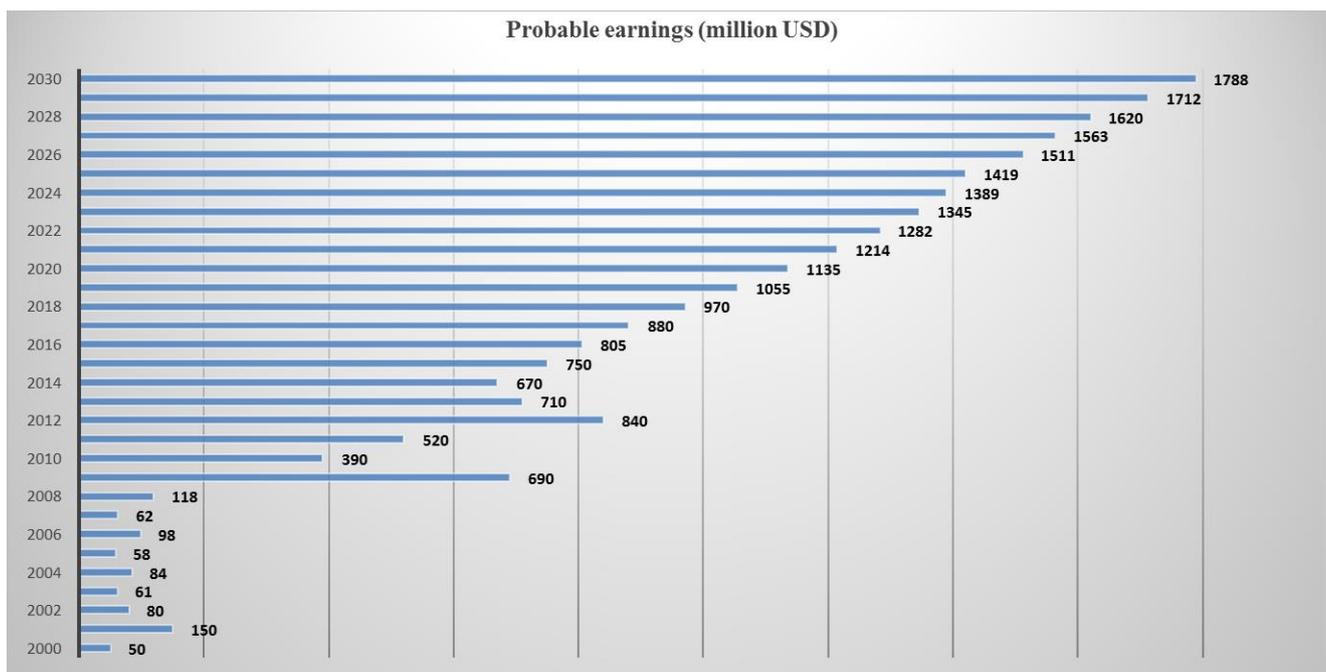


Figure 9. Estimated earnings from scrapped ship in BD within 2030 [51, 52, 43, 44].

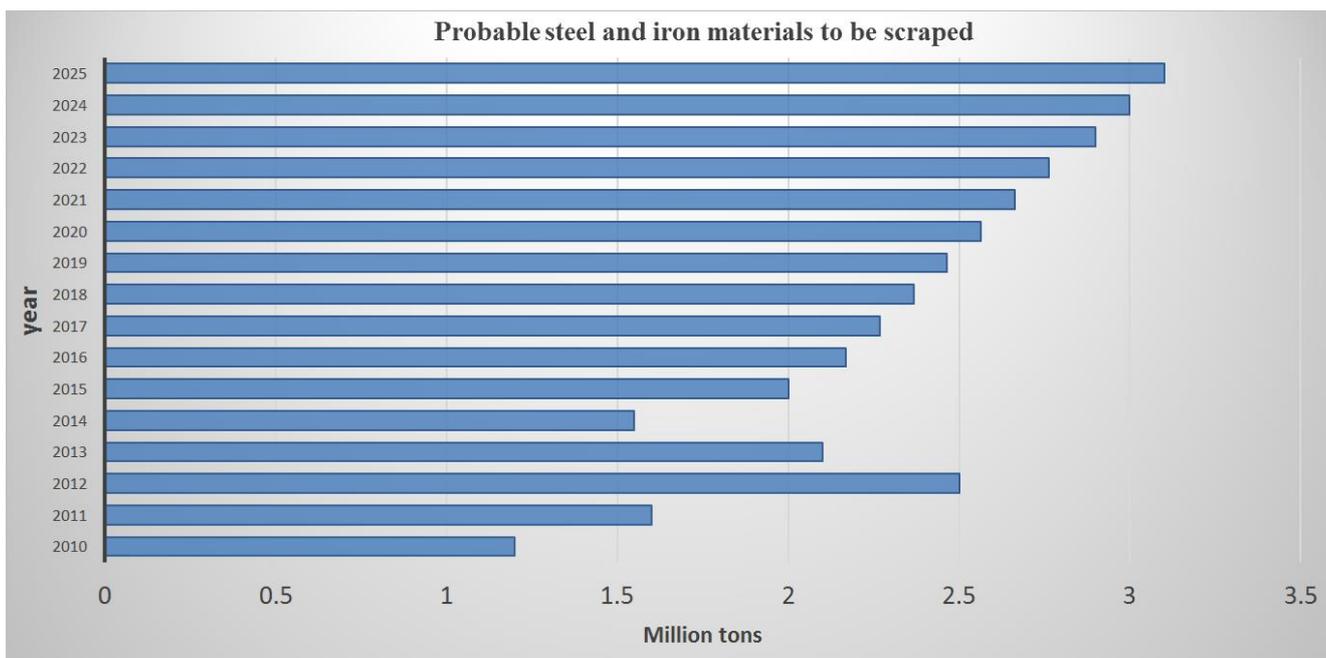


Figure 10. Probable iron and steel materials produced from scrapped ships within 2025 [51, 52, 43, 44].

7. Contribution of Global and Local Ship Recycling in Socio-Economic Development

In South Asian countries like Bangladesh, India, China and Pakistan, EOL ships are beaches for dismantle and recycling the vessel with taking advantage of high tidal surge. However,

those countries are doing a great job to save the environment by doing recycling of obsolete and unused ships with good efficiency [22], which earlier buried at the deep sea as we have learn from history [3]. Currently around 35% of the shipping tonnage recycled annually occurs on the beaches of Bangladesh, employing around 200 thousand workers in recycling process. Moreover, it is estimated that ship recycling industry generates around US\$ 1 billion for the national economy. On the other hand, it is estimated that as of today,

globally around 20,000 ships over 500 Gross Tonnage are around 25-30 years old and will shortly be sent for recycling [52]. IMO has introduced Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships in 2009 [51]. But the HKC has not been ratified yet by the important and related countries involved with it. Significant decisions that have been made in 2017 as per EU ship recycling regulation and that is going to alter the global ship recycling industry significantly [16, 32, 34, 36]. If the EU approved and allow the Statement of Compliance (SOC) standards it could be a huge boost to the booming investment in improving standards in Alang as well as other yards of South Asia countries [46]. In this way, viable ship recycling process and practice will continue to progress and achieve standard ship recycling at HKC certified yards and that will become the custom for all ship-owners, not the omission. To make viable and sustainable ship recycling standard [28], all three Asian ship recycling major players need to be work together jointly and effectively to continue ship recycling beaching method as it is practicable for this area. Statistical comparison of ship recycled by number, tonnage, percentages, and individual countries around the globe from 2013 to 2022 has been shown in figures 11 to 18 respectively below [30, 43, 51, 45].

From the above data it can easily be seen that the earnings from the ship recycling sector is and will be remarkable and that will contribute our national economy distinctly. If, the demand for steel and other scrapped materials and all other parameters that affect the market remains same as observed last couple of years then the prospect of the ship recycling industry in Bangladesh will enrich future (as shown in figures 8, 9 and 10 above). Again, despite of the ups and downs in the global shipping and ship recycling markets, ship recycling industry makes considerable contribution to the national economy of Bangladesh and 'managed a respectable growth, estimated at about 14% per annum on average since 1980. [24] At present, the average annual turnover of the ship recycling industry in Bangladesh is more than US\$ 1 billion (around 12,750 crore BDT). In addition, the industry is creating employment opportunities for thousands of people in the poverty prone areas of the country' and nearly 200 thousand people are directly involved to the industry and 1 million indirectly [43]. Annual revenue earning from the industry is more than US\$ 130 million per annum. Trend of Iron and Steel material produced from scrapped or EOL ship in Bangladesh has been showed in figure 10 above. More than 60% materials and machineries for local shipbuilding come from recycling industry. The Bangladesh customs authorities revealed that 250 scrap ships were brought in during the FY 2016 and Taka 8.22 billion was paid as revenue to the government. And it's grown further to 272 ships during FY19 with a revenue collection of Taka 7.92 billion. Custom duties, income taxes and value added taxes amounting to an average of Taka 5 billion annually by the ship recycling industry. The ship recycling industry pays considerable fees and charges to the ministry of industry

according to the regulations in place. Bangladesh is currently taking major strides in its infrastructure growth, with ambitious megaprojects like the Padma Bridge, Metro Rail, Elevated Expressway, Rooppur Nuclear Power Plant, Karnafuli Tunnel and Bay Terminal etc. These projects provide a tremendous boost to the country's infrastructure needs. There is a strong demand for steel in the country due to rapid economic growth. People are more likely to invest in and build new homes and infrastructure, which has led to greater need of steel and other construction materials [43, 44]. The ever-growing demand for domestic steel has put pressure on local steel mills to secure raw materials from the ship recycling industry and that will continue further.

8. Existing IMO Ship Recycling Regulation and Future Challenges

In 2009, IMO adopted the HKC 2009 on ship recycling, with the aim of improving safety and environmental protection. Unfortunately, it still has not entered into force after all these years. The EU's Ship Recycling Regulation or EU's SRR No. 1013/2006, which implements the Basel Convention [56] and its Amendment in Europe, forbids the disposal of hazardous waste to non-OECD countries and prohibits any exports of waste outside the EU/EFTA region for disposal. Effective as of 31 December 2018, the European Union Ship Recycling Regulation (EU SRR) has come into effect. The Regulation requires ship recycling activities to satisfy various environmental and occupational health and safety standards that are more stringent than the HKC 2009 [43, 44]. All vessels with European Union (EU) flags must be recycled in facilities that have been approved and included in the EU's list of authorized locations worldwide. [38, 39] The EU maintains an up-to-date record of these sites for this purpose [51]. Summaries of ship recycling legislations entry into force has been shown in table 2 below. The nations involved in ship recycling make a significant contribution to their nation's economy, so they are not eager to enact any laws that would regulate the sector. Several global laws have been issued and those need to address and practices across South Asia, to ensure safety, health, security, and environment and safeguarding the industry. Taking these changes into account will help and ensure the safety and environment [52]. The EU has decided to take action by themselves due to the ineffectiveness of international regulation of ship recycling (Basel Convention) and the non-entry into force of the HKC 2009.

The EU has taken steps to regulate ship recycling and is already implementing parts of the HKC [46]. Regulation No 1257/2013 on Ship Recycling (EU's SRR) was effectively enforced in December 2013, which has achieved tangible results [45]. The HKC does not provide the necessary security criteria for ship recycling and making it crucial for yards to be listed in the EU directory. This will guarantee that a yard has adhered to a quality assurance program that meets an ac-

ceptable standard. To provide clear legal regulations and reduce administrative complexity, ships specified in the new legislation will be excluded from the scope of the Waste Shipment Regulation. However, non-EU flagged vessels sold for scrapping while in European waters will still be subject to this regulation. The EU's SRR seeks to achieve early ratification of the HKC, thereby promoting a global, rule-based system. All experts have agreed that global regulations should be present for the shipping industry. However, there is disagreement on whether the HKC is an appropriate solution, since it does not meet the standards set by the EU's SRR [43, 44]. Again, European ships are usually recycled according to the EU's SRR or/and HKC regulations. Otherwise, the BC guidelines come into effect, which can be quite tedious and difficult to manage [51]. In legal point of view, the HKC has yet to be enforced; however, it could still serve as a guideline for non-EU flagged vessels; when practicing due meticulousness. Furthermore, the intentions behind this protocol are accepted and recognized internationally.

The Basel Convention prevents the export of waste ships to non-OECD countries (Basel 2011). However, this is often circumvented by labeling recycling as taking place in international waters, where the Convention's regulations cannot be enforced. Once the HKC Amendment to the Basel Convention (BC) takes effect, ships will no longer be subject to its scope. Additionally, if handled in accordance with the EU SRR,

these vessels are excluded from the convention's purview. For ships in particular, "exporting state" can refer to either the flag state or the country of origin of its beneficial owner. This alternative interpretation is more suitable and accurate. In response to the need for regulation on ship recycling, the IMO took swift action to create a new convention with legally binding properties. This convention would depend heavily on enforcement from both the flag state and the recycling state [41, 44]. To close all ambiguities of the BC in 2009, the IMO approved the HKC 2009, which holds ship owners responsible for sustainable recycling of ships. Even after a decade; this convention has not been implemented yet. The EU's SRR furthers the goals of the 2009 HKC for Safe and Environmentally Sound Recycling of Ships, while introducing higher safety and environmental measures than those outlined in IMO's HKC 2009. Specifically, the EU's SRR contains standards surpassing those set by IMO. As per EU's SRR, the beaching method has been strictly prohibited and strict regulations relating to the management of hazardous materials and labor rights are in place. Again ship dismantling sites listed by the EU are subject to a much stricter level of monitoring, including third-party certification and auditing, as well as complaints from NGOs if they are concerned that facilities are not following the regulations [51]. So, overall situation has become tougher for South Asian countries like Bangladesh.

Table 2. Summaries of ship recycling legislations entry into force [51].

Ship recycling legislation	Done	Entry into Force	Contracting States
The Basel Convention (BC) On the control of trans boundary movement of hazardous wastes and their disposal	1989	05.05.1992	186
Hong Kong Convention (HKC) On the Safe and Environmentally Sound Recycling of Ships.	2009	Not yet in force	17
EU Regulation on Ship Recycling (EU SRR) Regulation (Eu) No 1257/2013 of the European Parliament and of the Council on ship recycling and amending Regulation (EC) No 1013/2006 and Directive 2009/16/EC	2013	13 December 2013 and fully applicable on 31.12.2018	28 EU Member States

9. Challenges of Local Ship Recycling Industry of Bangladesh

The government of Bangladesh enacted the Bangladesh ship recycling Act in 2018 and issue order to owners of ship breaking and recycling yards to adopt safe and environmentally friendly recycling methods as per the Hong Kong International Convention 2009 (HKC 2009). However only four yards (PHP, SN Corporation, Kabir Steel, KR) out of around

few dozens of active recycling yards have achieved Green Passport. Most yards are reluctant to adopt the green ship recycling standards [49] because of the costs associated with the process. Currently, 87 yards are trying to achieve those standards. Ship recycling yards should be desperate to upgrade themselves and achieve HKC standard. However, local recycling owners found a bit reluctant to build green yards due to high costs, and that need minimum Taka 30 crore to modernize one ship recycling yard, and around Tata 3,500 crore needed to upgrade entire recycling industry to attain all such facilities, and to remain in the competitive business [46].

Whereas, recycling business competitors of Bangladesh like India and Pakistan who are fur ahead of us and they already following HKC standard” India, China and Turkey have already turned their ship recycling facilities green as prescribed by the HKC adopted back in 2009. Bangladesh had set a target to turn all ship-recycling yards into green facilities by end of 2023. But the current situation poses uncertainties as this target is may not be achievable within the deadline [45]. The government had also set the same deadline for modernizing this industry. Some of the major challenges for SBRI in Bangladesh are as follows:

According to the UNCTAD report, maritime trade in 2022 was more uncertain and riskier than it was in 2021 due to the complex atmosphere created by present geopolitical situation. However, 2021 was a positive year for maritime trade growth as shipments increased 3.2% or 11 billion tones. Whereas, 3.8% decreased in 2020. Again, the current growth rate is 1.4% (2023-2027) and this considerable growth is expected to remain consistent in the coming years, or may increase of 2.1%. This is slightly slower than that was seen in the preceding decades [57].

In the post-pandemic world demand is surging, and that push to increase the shipping fees. This has created an obstacle for owners of old or EOL ships to send them to recycling yards. Moreover new ship construction orders are descending due to increase of price [51].

The current geopolitical situation, with the lingering effects of Ukraine-Russia conflict and the effect of COVID-19 pandemic, has significantly impacted global businesses. Inflation has risen and pervasive uncertainty has created a challenging environment for global business including ship recycling industry [51].

Today, it become essential for local ship recycling yards to change their attitude and implement a corporate culture in order to reach their objectives like other global competetors. By taking inspiration from highly efficient industrial nations and implementing suitable strategies and practices, local yards can be successful in business and remain competitive in global recycling business [51].

Local recycling yards need to take necessary steps to maintain health, hygiene and safety standard as per ILO and

IMO regulations [47].

As an essential part of being HKC compliant, local recycling yards must have Ship Recycling Facilities Plan (SRFP). Local yards need to prepare themselves to ratify HKC and some sort of EU RRC within shortest time, otherwise it will be more challenging and complicating to continue with local recycling business in future [52].

However, according to the number of vessels and amount of LDT scrapped from the year 2015 to 2022, it observed that, there are around sixty local yards (in 20 groups) have actively participated in ship recycling activities. Top twenty ship recycling groups and their status has been shown in [table 3](#) below. Evaluating their continuity of contribution to the ship recycling industry over those years, different status has been discovered for the groups. Considering the record and quantity of ship recycling from 2015 to 2022, the yards have been stated in three categories as active, idle, and inactive. Besides, the SRFP status of the yards has been identified by the Ministry of Industry (MoI) letter on dated 04 Nov 2020. Hence, the top twenty group names have been tabulated according to their quantity of LDT scrapped/production and stated as their continuity of ship breaking over last decade. Here it needs to mention that Active means the yards were continuous in the ship recycling activities in last 5 years or more; Idle means the yards were not continuous but participated in the ship recycling activities in last 3-5 years; and Inactive means the yards were neither continuous nor participated in the ship recycling activities in last 3 years. [51]. So, there are around 150 ship recycling yards in the country; from them around 60 are still active and only 4 of them could have achieved Safety and Operation Compliance (SOC) standard. Other could not achieve the SOC standard due to high capital investment needed and lack of proper initiatives. Moreover, currently local ship recycling yards are incurring losses due to rise of US dollar prices. According to the Bangladesh Ship Breakers and Recyclers Association (BSBRA)'s report, scrap vessel imports declined in 2022-2023 due to the appreciation/crisis of USD and LC issues. For example, there were only 114 vessels imported from January to September 2022, and that is indicating huge deficiency in business [43].

Table 3. Top twenty groups of local recycling yards in Bangadesh [45].

Ser	Group	Yard	Present Status	SRFP Status
1.	K R	SNT Ship Recycling	Active	SO
		King Steel	Active	Not submitted
		K R Steel	Active	Submitted
		K R Ship Recycling Yard	Active	Submitted
		N B Steel	Idle	Not submitted
2.	MAK Corporation	Master & Brothers	Active	Submitted

Ser	Group	Yard	Present Status	SRFP Status
		M. A. Ship Breaking	Active	Submitted
		Mother Steel Ltd	Active	Submitted
		A P S Corporation	Idle	Submitted
		Z H Enterprise	Active	Submitted
		Mak Corporation	Active	Submitted
		Motaleb Steel	Active	Submitted
		GOLDEN Iron Works Ltd	Active	Submitted
		H M Steel & Industry Ltd	Active	Submitted
		T R Ship Breakers Ltd	Active	Not submitted
		Taher & Co. Ltd	Active	Not submitted
3.	Taher & Co.	Taseen Steel	Active	Not submitted
		Golden Ispat	Active	Submitted
		H M Ship Bre. Ind. Ltd	Idle	Submitted
		Taher Ship Bre. &Recy	Idle	Not submitted
		Kadamrasul steel ship breaking	Idle	Not submitted
4.	SN Corporation	S N Corporation	Active	SOC
5.	S L	S L Ship Reprocess	Inactive	Submitted
		S L Steel	Active	Submitted
6.	ASADI	Asadi Steel Enterprise	Active	Submitted
		Jamuna Ship Breakers	Active	Submitted
		Arefin Enterprise	Active	Submitted
7.	Arefin Enterprise	S. H Enterprise	Active	Not submitted
		Sea Shore International	Active	Not submitted
		Janata Steels Ltd.	Active	Submitted
8.	Simni	Simni Ship Recycling	Active	Submitted
9.	Kabir Steel	Kabir Steel	Active	SOC
		Khaja Ship Breaking	Active	Submitted
10.	Crystal Shippers	Crystal shippers Ltd.	Active	Submitted
11.	Haji Babul Ho.	Pacific HSteelent	Active	Submitted
		Pacific steel enterprise	Active	Submitted
12.	Macca	Asian Marine	Active	Submitted
		ZiriSubader Steel Mills	Active	Not submitted
13.	Ziri	Zirisubedar steel re-rolling mill	Inactive	Submitted
		Ferdous Steel	Active	Submitted
14.	PHP	PHP Ship Recy.	Active	SOC
15.	Premium Trade	Premium Trade Cor.	Active	Submitted
		Mahinur Ship	Active	Not submitted
16.	Chittagong Ship B & R Ind.	Chittagong Ship B & R Inds	Active	submitted

Ser	Group	Yard	Present Status	SRFP Status
17.	KSB	KSB	Active	Submitted
		Ocean Ispat	Active	Submitted
18.	Lalbag	Lalbag Ship	Active	Submitted
		S A ship breakers	Idle	Submitted
19.	Sagarika	R A ship breaking	Active	Submitted
		Sagarika ship breaking ind	Active	Submitted
20.	SAM	M M Ship Breaking	Active	Submitted
		SAM steel	Active	Submitted

Table 4. Global ship recycles statistics LDT in thousand gross tons sold in 2020 [45].

Ship Types	Bangladesh	India	Pakistan	Turkey	China	Rest of the world	World Total	Percentage
Bulk Carries	5,254	1,317	1,718	34	125	61	8,509	48.9
Container	160	1,428	282	206		68	2,143	12.3
Oil Tankers	616	410	617	159	10	226	2,038	11.7
Offshore supply	125	257	4	308	3	273	969	5.6
Ferries	26	279		545	3	26	879	5.1
General cargo	176	219	175	203	47	29	848	4.9
LPG/ LNG	169	241		8		176	594	3.4
Chemical Tankers	12	125	94	1		10	241	1.4
Others	157	786		135	9	93	1,180	6.8
Total	6,694	5,061	2,890	1,598	195	962	17,401	100
Percentage	38.5	29.1	16.6	9.2	1.1	5.5	100	(%)

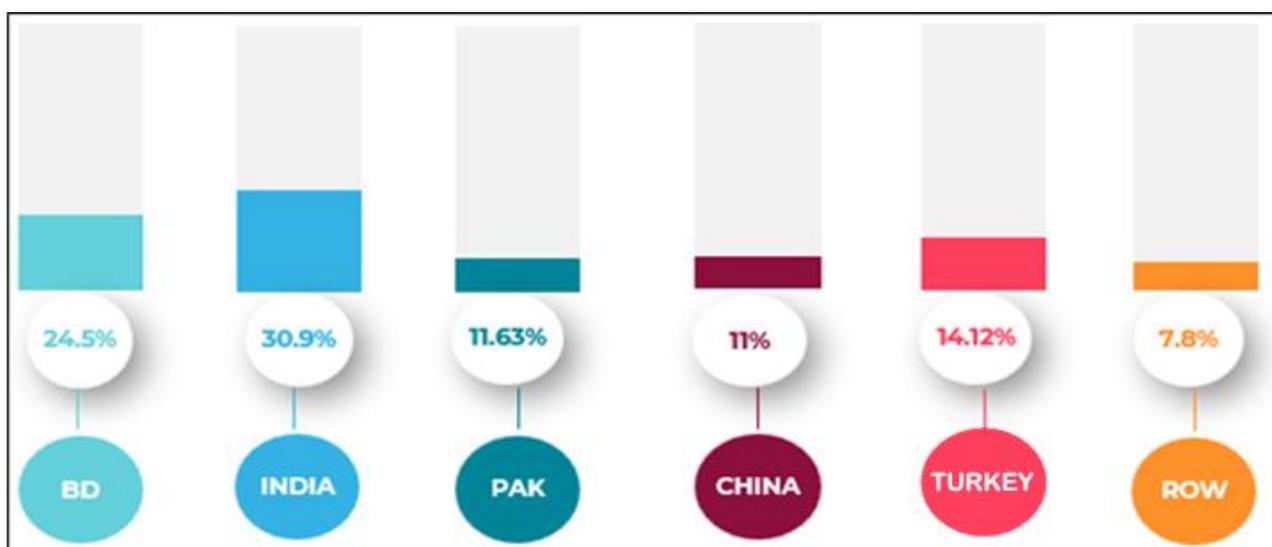


Figure 11. Comparison of ship recycled by number from 2013 to 2022 [43].

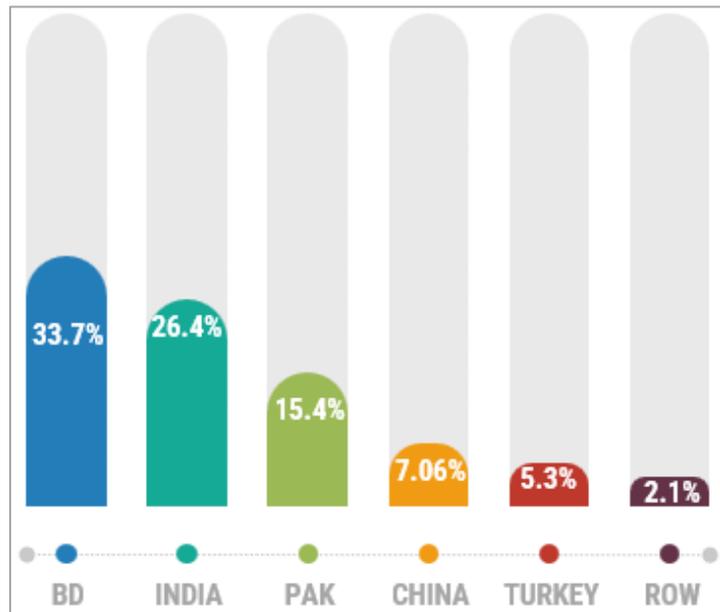


Figure 12. Comparison of ship recycled by gross tonnage from 2013 to 2022 [43].



Figure 13. Percentage of ship recycled in Bangladesh between years 2013 to 2021 [45, 52].

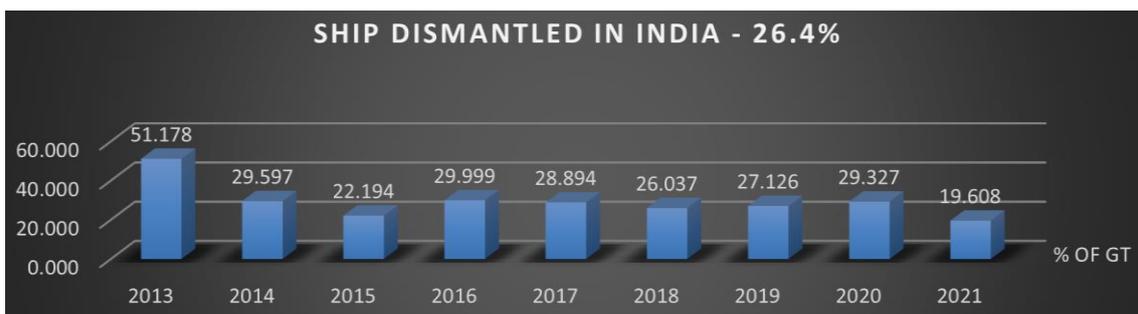


Figure 14. Percentage of ship recycled in India between years 2013 to 2021 [45, 52].



Figure 15. Percentage of ship recycled in Pakistan between years 2013 to 2021 [45, 52].

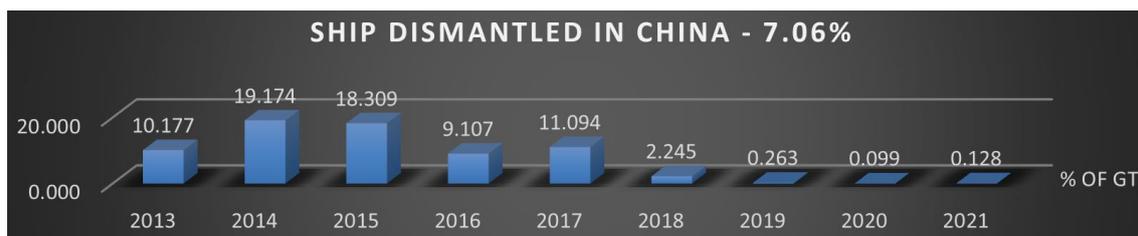


Figure 16. Percentage of ship recycled in China between years 2013 to 2021 [45, 52].

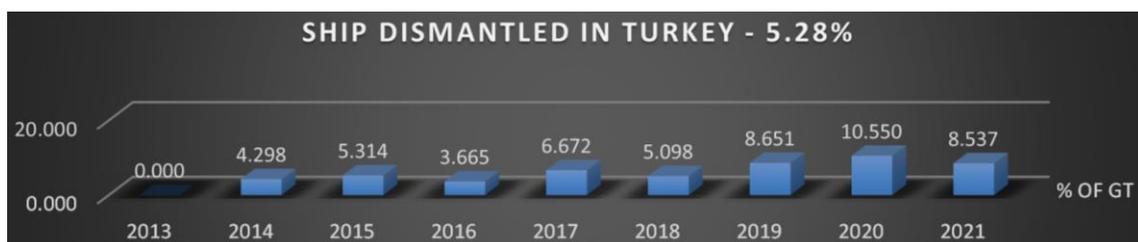


Figure 17. Percentage of ship recycled in Turkey between years 2013 to 2021 [45, 52].

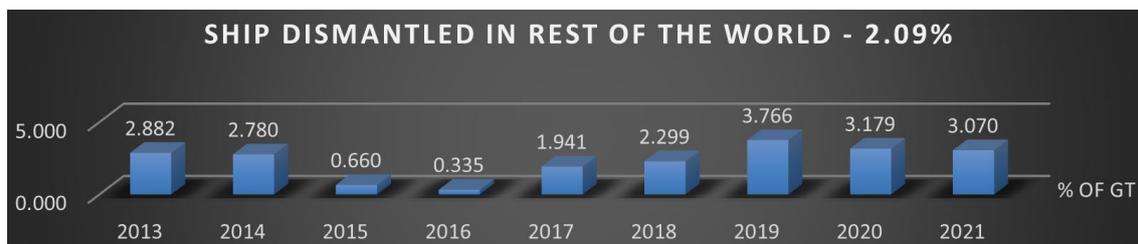


Figure 18. Percentage of ship recycled in rest of the world between years 2013 to 2021 [45, 52].

10. Conclusion

Ship recycling is a global industry limited to few South Asian countries and developed rapidly by involves dismantling and recycling EOL ships. Around one thousand of obsolete vessels, like container ships, cargo, bulkers, oil and gas tankers and cruise ships, are recycled in every year. This process helps to recover steel and other precious metals along with recyclable items and equipment from EOL ships. Currently, ship recycling activities around the world is conducted in five countries like India, Bangladesh, Pakistan, China and Turkey. South Asian countries have become hubs for ship recycling business due to their geographical advantages, cheap and plenty workforce, tradition and resource capabilities. However, 90% of ship-recycling activities take place in three locations in South Asia like Chattogram (Bangladesh), Alang (India), and Gadani (Pakistan). Bangladesh has become a hub for recycling EOL ships traditionally with cheap and huge labour force. [29] Actually ship breaking industry has made notable contributions to the economy of Bangladesh and is of paramount importance to the macro and micro economies to reduce poverty. In every year, some 200 EOL ships are recycled in local yards at the port city of Chattogram. Ac-

ording to research, about 2 million LDT of different types of ships are recycled in Bangladeshi yards in each year. In FY 2020-21 Pakistan and India have seen the rise in market share, with 14.7% and 3.2% respectively. On the other hand, Bangladesh and China have seen a fall by 15% and 2% respectively. This decrease in market share of China is due to their ban on international ships recycling and Bangladesh due to strict implementation of ship recycling and environment regulations. However, ship breaking industry is contributes more than US\$ 1 billion to the national economy of Bangladesh.

For the last two decade, ship recycling yards of Bangladesh, India, Pakistan and China, have been recycled globally 90% of EOL ships in tonnage [43, 44]. The Bangladesh Ship Recycling Act was implemented in 2018 and it requires ship-breaking yard owners to abide by the Hong Kong International Convention (HKC) guidelines by 2023. As of now, only a handful of the active recycling yards have achieved Green Passport certification and many yards are going to achieve the certification very soon. Meanwhile, many small yards are striving to meet these criteria in order to get certified. Yards in Bangladesh are in dire need of restoration and up-gradation. However, the owners of some yards are little relax to invest the substantial amount of money needed which could be around Taka 30 cr for single

ship-breaking yard due to present global geo and eco-political situation. Upgrading all such local yards can cost around few thousands crore Taka in total. However, vast number of ship recycling yards in India and Pakistan has already implemented the HKC standard. Bangladesh is one of the active players in the HKC initiative, alongside India, Pakistan and Turkey who have already accessed it or going to achieved it. China has already got the certificates. Bangladesh has set a goal to achieve accessibility and standard by 2023. Despite the current situation, there are still uncertainties about what can be accomplished in a given time frame. Some of the major hurdles for local Ship Breaking and Recycling Industry (SBRI) are include: As per the UNCTAD report, maritime trade in 2022 were more uncertain and risky than it was in 2021 due to the complex atmosphere created by current financial and geo-political situation of the globe. However, 2021 was a positive year for maritime trade growth; shipments rose 3.2% or 11 billion tones. Whereas, maritime trade growth was 3.8% dip in 2020. Again the current growth rate of 1.4% (2023-2027) is substantial and is expected to remain consistent in the coming years. The post-pandemic world has seen a surge in demand, resulting in an increase in shipping fees. This has created an obstacle for owners of obsolete or EOL ships to send them to dismantling facilities, while new construction orders have taken a hit. Actually, the current geopolitical situation, compounded by the lingering effects of the Ukraine-Russia conflict as well as the COVID-19 pandemic, and those have significantly impacted global businesses. Inflation has risen and pervasive uncertainty has created and makes a challenging environment for global ship recycling industry. However, its reality that HKC has not been ratified yet by the majority of the countries involved. It is essential for local ship recycling yards to change their mind-set and implement actual corporate culture in order to reach their objectives. Local yards need to learn and take inspiration from highly efficient industrial nations and implementing sustainable strategies and practices as per global regulation (like HKC 2009, EU's SRR). It is very much possible to achieve the goal and remain competitive as well as to become successful in ship recycling business in future using AI. [42]

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] Basel Convention Implementation Overview, (2011), available at: <http://www.basel.int/Implementation/ShipDismantling/Overview/tabid/2762/Default.aspx>, accessed on 28 Jul 2023.
- [2] Business Inspection BD, (February 18, 2022), accessed on 28 Jul 2023.
- [3] Banglapedia, (2011), Ship Recycling Industry, June 18, 2011, available at: https://en.banglapedia.org/index.php?title=Ship_Breaking_Industry, accessed on 28 Jul 2023.
- [4] The Financial Express, (2022), Trade Market, The Financial Express, on 23 September 2022, available at: <https://today.thefinancialexpress.com.bd/trade-market?date=23-09-2022>, accessed on 28 Jul 2023.
- [5] Jobaid M. I., Khan M. M., Haque A. K. M. K, and Shawon I. A., (2014), Ship Recycling and Its Environmental Impact: A Brief Overview of Bangladesh, IOSR Journal of Business and Management, Volume 16, Issue 10. Ver. I, Oct. 2014, accessed on 28 Jul 2023.
- [6] Hiremath, A. M., Tilwankar, A. K. and Asolekar, S. R. et al., (2015), Significant steps in recycling vis-a-vis wastes generated in a cluster of yards in Alang: A case study. Journal of Cleaner Production 87, pp: 520-532, accessed on 28 Jul 2023.
- [7] Hiremath A, (2016), Doctorate thesis paper on the "Development of integrated risk assessment framework for best practices in ship recycling". Indian Institute of Technology of Mumbai, available at: India. <https://www.green4sea.com/the-best-practices-in-ship-recycling>, accessed on 28 Jul 2023.
- [8] Hossain K A, et al., (2010a), "Ship Recycling Prospects in Bangladesh", Proceeding of Martec 2010; The International Conference of Marine Technology, BUET, Dhaka, Aug 2010, accessed on 28 Jul 2023.
- [9] Hossain K A, et al., (2010b), SWOT analysis of shipbuilding industries in Bangladesh and its challenges to become potential ship exporting nation, Journal of Ship Technology India, Volume 6, Issue 2, July 2010, accessed on 31 Jul 2023.
- [10] Hossain K. A. and Zakaria M. N. G., (2012), "Underlying Problems of ship-recycling industry in Bangladesh and way forward", 6th International Mechanical Engineering Conference & 14th Annual Paper Meet 2012; 28-29, Sep 2012, accessed on 31 Jul 2023.
- [11] Hossain K. A. (2015a), Overview of Ship Recycling Industry of Bangladesh, Journal of Environmental and Analytical Toxicology, Volume 5, Issue 5, 297-302 pp, Sep 2015, accessed on 31 Jul 2023.
- [12] Hossain K A, (2015b), Leadership qualities for 21st century leaders, Journal of Management, Social Science and Humanities, Published on 19 May 2015, available at: <http://pearlresearchjournals.org/journals/pjmssh/archive.html>, accessed on 31 Jul 2023.
- [13] Hossain K. A., (2015c), "Essential Tips and Tactics of motivation, Journal of Management", Social Science and Humanistic, Volume 1, Issue 1, April 2015, accessed on 29 Jul 2023.
- [14] Hossain K. A. (2017a), Ship Recycling Practice and Annual Reusable Materials Output from Bangladesh Ship Recycling Industry, Journal of Fundamentals of Renewable Energy and Applications, Volume 7, Issue 5, Sep 2017, accessed on 29 Jul 2023.

- [15] Hossain K. A. (2017b), Ship Recycling Status in Bangladesh and Annual Reusable Materials Output, Journal of Biomedical Journal of Scientific and Technical research, Volume 1, Issue 5, Oct 2017, accessed on 29 Jul 2023.
- [16] Hossain, K. A., (2017c), "Future of Energy Resources", International Journal of Renewable Energy Technology Research (IJRETR); Vol. 4, No. 5, Nov 2015b, accessed on 31 Jul 2023.
- [17] Hossain K A et al., (2017d), A Study of global shipbuilding growth trend and future forecast, Procedia Engineering, Elsevier, Jul 2017, available at: <https://www.sciencedirect.com/science/article/pii/S1877705817332927>, accessed on 31 Jul 2023.
- [18] Hossain, K. A., (2017e), "Global warming and effect to the third world countries", Journal of recent advancement of petrochemical science, Volume 7, Issue 5, Jun 19, 2017, accessed on 31 Jul 2023.
- [19] Hossain, K. A., (2018a), "Calculation of Yearly output of reusable material of Ship Recycling Industry of Bangladesh," Journal of Recent Advancement of Petrochemical Science, Vol 5, Issue 3, Jun 2018.
- [20] Hossain, K. A., (2018b), "Material Flow Analysis (MFA) is A Better Tool to Calculating Reusable Material For Ship Recycling" 11th International Conference of Marine Technology, UTM, Malaysia, Aug 13-14, 2018, accessed on 11 Aug 2023.
- [21] Hossain, K. A., (2018c), "SWOT Analysis of China Shipbuilding Industry in the Third Eyes", Journal of recent advancement of petrochemical science, Volume 4, Issue 2, Jan 2018, accessed on 11 Aug 2023.
- [22] Hossain, K. A., (2018d), "Analysis of important steering factors which give Success to Global Shipbuilding Leaders", Journal of recent advancement of petrochemical science, Volume 4, Issue 5, Jan 2018, accessed on 11 Aug 2023.
- [23] Hossain, K. A., (2018e). SWOT analysis of China shipbuilding industry in the third eyes, Journal of Recent Advancement of Petrochemical Science, Volume 4, Issue 2, 22 Jan 2018, available at: <https://juniperpublishers.com/rapsci/pdf/RAPSCI.MS.ID.555632.pdf>, accessed on 11 Aug 2023.
- [24] Hossain, K. A., (2018f), Proposed viable ship recycling process for South East Asian recycling yards specially for Bangladesh, Procedia Engineering, Elsevier, Published on 27-07-2018, available at: https://www.mtc-utm.my/wp-content/uploads/MARTEC_2018_Paper/I2.pdf, accessed on 11 Aug 2023.
- [25] Hossain K A, (2018g), "Proposed Sustainable Ship Recycling Process For South East Asian Recycling Yards" 11th International Conference of Marine Technology, Proceeding MARTEC 2018, UTM, Malaysia, Aug 13-14, 2018.
- [26] HossainK A, (2019a), 'Material Flow Analysis Technique for Material Assessment of Ship Recycling Industry' Bangladesh Maritime Journal, BSMRMU, Vol 3, Issue 1, Jan 2019.
- [27] Hossain K A, (2019b), "Development of an Assessment Model for Ship Recycling Industry in Bangladesh" Proceedings of the 2nd International Conference on Industrial and Mechanical Engineering and Operations Management (IMEOM), Dhaka, Bangladesh, December 12-13, 2019, accessed on 11 Aug 2023.
- [28] Hossain, K. A., (2021a), Sustainable Ship Recycling Regulation and Process in Contest of Bangladesh, Navy Journal 7 (1), 1-23, Dec 2021, accessed on 11 Aug 2023.
- [29] HossainK A (2021b) Strength Weakness Opportunity, Threat (SWOT) analysis of Bangladesh shipbuilding industry, Technical Paper: NAME, MIST, 16 Dec 2021, available at: <https://www.mist.ac.bd/storage/files/name/TECHNICAL>, accessed on 11 Aug 2023.
- [30] Hossain, K. A., (2023a), Tale of LNG and LPG Ships, Global Scientific Journals (GSJ), Vol 11, Issue 6, June 2023, ISSN 2320-9186, accessed on 11 Aug 2023.
- [31] Hossain, K. A., (2023b), Tale of Buik Ships, Global Scientific Journals (GSJ), Vol 11, Issue 6, June 2023, ISSN 2320-9186, accessed on 12 Aug 2023.
- [32] Hossain, K. A., (2023c), Tale of Container Ship, Journal of Software Engineering and Simulation, Quest Journals 9 (7), page: 48-61, accessed on 13 Aug 2023.
- [33] Hossain, K. A., (2023d), Evaluation of global and local ship designing software trend and way forward, Global Scientific Journals (GSJ), Vol 11, Issue 5, May 2023, ISSN 2320-9186, accessed on 13 Aug 2023.
- [34] Hossain, K. A., (2023e), Analysis of present global ship recycling status and challenges for Bangladesh, Global Scientific Journals (GSJ), Vol 11, Issue 4, April 2023, ISSN 2320-9186, accessed on 13 Aug 2023.
- [35] Hossain, K. A., (2023f), Technological advancement and future of warship building, International Journal of Research and Development (IJNRD), Vol 8, Issue 5, May 2023, ISSN 2456-4184, accessed on 13 Aug 2023.
- [36] Hossain, K. A., (2023g), An overview of merchant ships, International Journal of Research and Development (IJNRD), Vol 8, Issue 6, June 2023, ISSN 2456-4184, accessed on 13 Aug 2023.
- [37] Hossain, K. A., (2023h), An Overview of Naval Ships, Scientific Research Journal (SCIRJ) 11 (6), ISSN: 2201-2796, June 2023, accessed on 15 Aug 2023.
- [38] Hossain, K. A., (2023i), Analysis of development trend of ship designing software and future of ship design, American Journal of Engineering Research (AJER), Vol 12, Issue 6, June 2023, ISSN 2120-0847, accessed on 15 Aug 2023.
- [39] Hossain, K. A., (2023j), Evaluation of local industry of Bangladesh including shipbuilding, Global Scientific Journals (GSJ), Vol 11, Issue 6, June 2023, ISSN 2320-9186, accessed on 14 Aug 2023.
- [40] Hossain, K. A., (2023k), Evaluation of Influence of Internet of Things (IOT) Technologies and Devices in 21 Century, Scientific Research Journal 11 (7), accessed on 14 Aug 2023.

- [41] Hossain, K. A., (2023l), SWOT Analysis of Shipbuilding Industry of Bangladesh, Science Publication Group (Science PG) 4 (3), accessed on 14 Aug 2023.
- [42] Hossain, K. A., (2023m), Evaluation of Influence of Artificial Intelligence (AI) on Technologies in 21st Century, Journal of Electronics and Communication Engineering Research, Quest Journal, accessed on 15 Aug 2023.
- [43] Hossain, K. A., (2023n), Analysis of present global ship recycling status and challenges for Bangladesh, *Global Scientific Journals (GSJ)*, Vol 11, Issue 4, April 2023, ISSN 2320-9186, accessed on 16 Aug 2023.
- [44] Hossain, K. A., (2023o), Bangladesh Ship Recycling and Marine Pollution Aspect, PAAL, A Publication of BIMRAD 6 (01), 18-20, Jul 2023, accessed on 16 Aug 2023.
- [45] Hossain, K. A., and Mohiuddin G., (2023a), Evaluation of present ship recycling scenario and opportunity for Bangladesh, *Journal of Environment and Analytical Toxicology (JEAT)*, Vol 13, Issue 4, April 2023, ISSN 2161-0525, accessed on 16 Aug 2023.
- [46] Hossain, K. A., et al., (2023), Global Major Ship Recycling Players and Their Fate in Future, International Journal of Novel Research & Development (IJNRD) 8 (5), Jun 2023, accessed on 18 Aug 2023.
- [47] IMO, Resolution, (2004), IMO Res: A. 951 (23), IMO Guidelines on Ship Recycling (resolution A. 962 (23), 4 March 2004, International Maritime Organization. Regulatory Guidance, available at: <http://www.iadclexicon.org/ship-recycling>, accessed on 28 Jul 2023.
- [48] ILPI Paper, (2016), Ship-breaking Practices in Bangladesh, India and Pakistan; Published by International Law and Policy Institute (ILPI) on May 18, 2016, accessed on 28 Jul 2023.
- [49] Mambra S., (2017), What is Green Ship Recycling, Green Shipping Marine Environment, Marine Insight, Oct 04, 2017, available at: <https://www.marineinsight.com/environment/what-is-green-ship-recycling>, accessed on 28 Jul 2023.
- [50] Nikos Mikelis, (2017), What Will 2017 Bring to the Ship Recycling Industry? Available at: <http://www.maritime-executive.com/editorials/what-will-2017-bring-to-the-ship-recycling-industry>, accessed on 28 Jul 2023.
- [51] Mohiuddin G., and Hossain, K. A., (2023a), Strategic Plan to Ratify HKC 2009 by Bangladesh: Challenges & Approach toward implement SRFP in local yards toward Green Ship Recycling, International Journal of Novel Research & Development (IJNRD) 8 (5), May 2023, accessed on 17 Aug 2023.
- [52] Mohiuddin G., and Hossain, K. A., (2023b), Analysis of Present Global Ship Recycling Status and Challenges for Bangladesh, *Global Scientific Journal* 11 (4), May 2023, accessed on 17 Aug 2023.
- [53] TBS Report, (2021), Bangladesh remains on top in shipbreaking, October 22, 2021, available at: <https://www.tbsnews.net/dropped/industry/bangladesh-remain-s-top-shipbreaking-319333>, accessed on 17 Aug 2023.
- [54] Sohel Parvez, (2022), Bangladesh: The Daily Star, "Shipbreaking slumps by half amid lower imports", October 12, available at: 2022, <https://www.thedailystar.net/business/economy/news/shipbreaking-slumps-half-amid-lower-imports-3140436>, accessed on 17 Aug 2023.
- [55] TERA international, 2004; Report on Chittagong port trade facilitation project, Bangladesh by Asian Development Bank and Bangladesh Ministry of shipping, Chittagong Port Authority (TA 4136-BAN), accessed on 30 Jul 2023.
- [56] UNEP, (2012), Basel Convention - Technical guidelines on the environmentally sound co-processing of hazardous wastes in cement kilns. Zhang, D., Huang, G., Xu, Y. and Gong, Q. (2015). Waste-to-Energy in China: Key Challenges and Opportunities. *Energies* 8, 14182-14194, accessed on 31 Jul 2023.
- [57] UNCTAD, (2023), *Ship recycling Report*, available at: <https://unctadstat.unctad.org/shiprecycling>, accessed on 31 Jul 2023.