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Study to Formulate Development Strategy of Local Shipbuilding in Bangladesh to Earn Foreign Currency

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Abstract

Shipbuilding is the engineering technology for manufacturing ships and is an integral part of the development of many nations. Shipbuilding is an early industry that constructs ships and various floating structures. Bangladesh has the necessary resources to become a significant global shipbuilding nation by capitalising on its youthful and cost-effective labour force, rich maritime heritage, and abundant natural resources. However, it is a challenging task to depict the accurate picture and consolidate result of local shipbuilding due to availability of information, constrain behaviour of local and deficiency of global shipbuilding data. The value of present global shipbuilding is approximately 200 billion USD, including the small ship sector alone representing USD 20 billion. The future global shipbuilding market will be approximately USD 500 billion (where small shipbuilding valued 50 billion USD) within 2035. This study found that, Bangladesh has all potential to capture 2% to 5% of global share and to earn about 10 billion USD from global shipbuilding. This study recommends that, the government support, sustainable policy, inclusion of advanced technology, application of contemporary manufacturing process, skill development of workforce, foreign direct investment (FDI), and comprehensive effort are paramount to sustainable development of Bangladesh shipbuilding industry. This study depicts the opportunities obstacles, challenges of local shipbuilding. We need to solve the inherent problems, develop capability and enhance capacity of local shipbuilding before losing the golden opportunity. It is an analytical study, which may help to formulate national shipbuilding strategy to catch the small share (2% to 5%) of global shipbuilding market and earn significance foreign currency.

Keywords

Shipbuilding, SMEs, Potential, Technology, Labour Wages, FDI,

Opportunity, Challenges

1. Introduction

Reviewing global industry trends reveals that Japan dominated shipbuilding in the 1960s but gradually lost its edge to South Korea, which benefited from lower wages, strong government support, and a weaker currency, and overtook Japan in ship production by 2003. From 2009 onwards, China emerged as the global leader in shipbuilding, exceeding both Korea and Japan due to robust state support and favourable government policies (Hossain et al., 2017; Hossain, 2018a). China accounts for approximately 50% of the global shipbuilding market. The middle-class populations of Asia and Africa are experiencing rapid growth in the 21st century. Additionally, labour costs in China have risen substantially in recent years. Consequently, China is expected to decrease its share of the global market for small and medium-sized container ships, cargo vessels, tankers, and multipurpose ships over this decade. This transition presents opportunities for emerging shipbuilding nations, including Vietnam, the Philippines, India, Bangladesh, Brazil, and Türkiye (Hossain, 2024b). Indigenous shipbuilding in this region has a renowned and extensive history. Bengal is acknowledged as an early hub of shipbuilding, rooted in its longstanding boatbuilding traditions (Alam, 2004). Bangladesh represents one of the emerging shipbuilding nations that may benefit from changes in the global shipbuilding market. The country possesses a long-established boatbuilding tradition, a comparatively large and cost-competitive workforce, and experience in constructing small and medium-sized vessels (Azam, 2015; World Bank, 2016; BIDA, 2025). However, the sector continues to face challenges related to technological capability, labour productivity, infrastructure, backward and forward linkages, financing, quality standards, and integration into international markets (World Bank, 2016; Hossain, 2023b; BIDA, 2025). These constraints have become increasingly important as global shipbuilding moves toward digitalization, automation, advanced manufacturing, and smart shipyard technologies (Zakaria et al., 2023; Hossain, 2023b). Against this background, the present study examines the position and development prospects of Bangladesh's shipbuilding industry by analyzing global market trends, local capabilities, labour productivity and costs, technological development, market opportunities, and major constraints. The study further evaluates the potential market segments for Bangladesh and proposes strategic measures for strengthening the industry's international competitiveness and foreign-exchange earning capacity.

In this era, ports are becoming increasingly intelligent, integrating advanced technologies to enhance shipping, customer service, and operations while maximising efficiency and profitability. Instead of pursuing broad automation, the immediate priority for emerging shipbuilding nations should be "Industrial IoT (IIoT) for Process Visibility". Deploying low-cost wireless sensors to monitor crit-

ical welding parameters (current, voltage) in real time can significantly reduce defects and rework, addressing the quality consistency issues often encountered in manual welding. Furthermore, Computer Vision technology can be applied to rigorously monitor worker safety compliance, such as PPE usage, a crucial step in meeting international safety standards like the Hong Kong Convention. Again, automation streamlines management and operations, reducing environmental impact while ensuring safety (Hossain, 2024d). Technologies such as AI and ML can optimise logistics by processing data from multiple sources, including shipping schedules and cargo information. Innovative technologies also automate multiple tasks, significantly decreasing manual labour requirements and boosting overall efficiency (Hossain, 2025b). Furthermore, these technologies facilitate improved design and construction processes, identify anomalies, and forecast potential incidents, thereby enhancing safety, security, and compliance with international standards (Hossain, 2025a; Hossain, 2023b). By optimising operations and production costs, innovative technologies reduce resource consumption, minimise downtime, ensure safety, improve quality, and ultimately lower costs. Additionally, they contribute to sustainable shipbuilding by optimising energy use, waste management, and environmental monitoring. For improved efficiency, accountability, sustainability, competitiveness, customer satisfaction, and effective monitoring, the entire maritime sector, including shipbuilding, must adopt smart, safe, and cost-effective practices. Smart shipyards employ digital solutions, including sensors, data analytics, augmented reality, big data, digital twins, blockchain, and automation, to shorten production timelines while ensuring quality, reducing waste and emissions, and providing better service to customers, local communities, and stakeholders (Hossain, 2025a). The economic gains are primarily derived from supply chain dynamics, timely delivery, and adherence to quality standards, rather than solely from internal activities. Thus, ensuring quality assurance, adhering to safety standards, meeting delivery deadlines, providing aftersales service, and maintaining goodwill are crucial to national competitiveness and the sustainable advancement of the shipbuilding industry.

A crucial characteristic of smart ports and smart shipbuilding lies not in the complete removal of human involvement, but in the effective integration of AI-assisted decision support and human-in-the-loop operational control. Rather than fully autonomous operations, contemporary smart shipyards rely on digital systems to augment human judgment in areas such as production planning, safety monitoring, quality assurance, and environmental management. This hybrid operational model enhances efficiency and consistency while remaining realistic for developing and emerging shipbuilding economies, where workforce availability and skill transition remain critical factors (Hossain, 2025b; Hossain, 2024c). This significantly boosts efficiency while reducing labour costs with perfect security (Hossain, 2024e). These dynamics optimise production costs, improve operational efficiency, and ensure optimal resource use, with timely, accurate data playing a vital role in the maritime industry. Additionally, innovative shipbuilding

practices are more environmentally friendly, focusing on reducing carbon emissions and protecting marine ecosystems. Modern shipyards increasingly adopt renewable energy, sustainable practices, and innovative technologies to minimise environmental impacts while ensuring sustainable growth and maximising profitability. Smart shipbuilding and port systems are also designed for greater integration with logistics and industrial networks. By employing advanced technologies, they enhance the movement of goods, streamline production processes, and improve information flow and workforce coordination within the broader supply chain. Furthermore, these industries adopt an open innovation approach, enabling continuous improvements in design, operations, construction, production, safety, and efficiency by incorporating new technologies and ideas. However, even minor disruptions to production processes or workflows in large shipyards can have serious consequences. For ports, disruptions could empty grocery store shelves and gas station tanks within days, due to the breakdown of the zero-inventory, just-in-time delivery systems that underpin global trade (Hossain, 2024e). Similarly, cyber-attacks targeting energy supplies or automated systems could severely impact the global economy, and such risks also apply to the shipbuilding industry to a considerable extent (Hossain, 2025a).

Alongside other criteria, the average operational lifespan of ships is a significant factor in vessel disposal decisions. Environmental rules, bunker fuel costs, technical obsolescence, freight rates, new-building pricing, EOL or used ship prices, and demolition prices are examples of policy-related factors (Hossain, 2018c). Typically, ships are scrapped after 25 to 30 years of service, with minor variations depending on ship type and region. For example, tankers typically have a disposal age of 25 - 30 years, whereas container ships have a shorter average lifespan of 17 - 26 years. Bulk carriers, however, exhibit a more variable age at disposal, ranging from 20 to 35 years. Between 2006 and 2012, the proportion of ships scrapped relative to the global fleet rose from 1% to 3.5%, before declining to 2% in 2014. These disposal rates vary significantly between countries. Despite these fluctuations, overall disposal rates remained low, which is usually the case. However, due to inflation and the global economic crisis, the rise in the average age of scrapped vessels and anticipated trends in vessel demolition will be slowed. According to the research, tankers often have greater survival rates than container ships and bulk carriers. Notably, even after 40 years of service, double-hull tankers continue to have a survival rate of about 25%. On the other hand, because double-hull tankers are required to follow IMO standards to enhance safety, single-hull tankers are decommissioned early. New vessel needs are expected to total approximately 690 million GT, with 200 million GT for tankers, 315 million GT for bulk carriers, and 170 million GT for container ships. From 2030, disposal-related requirements will decline as activity returns to pre-crisis levels. Total new-building requirements from 2016 to 2035 have been estimated at 1500 million GT, including 460 million GT for tankers, 710 million GT for bulk carriers, and 335 million GT for containers. Without capacity closures, excess capacity will likely persist for 15 years. The

global population was 6.83 billion in 2010 and is expected to reach 9.08 billion by 2050. The urban population is growing faster than the overall population; approximately 50% of the global population lives in cities, and by 2030, about 70% will be urban (IHSSeaweb, 2016; OECD, 2011). A larger urban population creates a strong domestic market for goods and services, boosting economic growth and innovation, which should benefit seaborne trade. Urbanisation may also increase the middle class, enhancing the consumption of goods and services. Finally, global shipping and shipbuilding will continue to grow.

Today, the global shipbuilding market faces challenges such as inflation, geopolitical tensions, overcapacity, falling prices, thin profit margins, trade distortions, widespread subsidies, conflicts, and more. Despite these difficulties, Asia continues to dominate the global shipbuilding industry, followed by Europe and America, which hold smaller niche markets. Since the post-WWII era, Asian countries, in general, and China, South Korea, and Japan in particular, have maintained their leadership in shipbuilding due to several inherent advantages (Hossain, 2023a). These advantages include relatively low labour costs, strong governmental support, stable and sustainable policies, favourable political environments, robust economic conditions, and extensive forward and backward linkage industries. Shipbuilding is a highly capital-intensive sector, producing costly individual units rather than mass-produced items like ready-made garments. Therefore, its growth and survival in the competitive global market depend on consistent and appropriate government policies, strategic management, and political stability. Additionally, ensuring safety standards and maintaining global benchmarks are essential for remaining competitive (Hossain, 2025b). The vision of the Fourth Industrial Revolution (4IR) and smart shipbuilding emphasises the development of intelligent shipyards characterised by adaptability, resource efficiency, ergonomic design, and close integration among all stakeholders. For the local shipbuilding industry to achieve substantial growth, it requires a balanced approach that includes strategic investments, government backing, the adoption of innovative technologies, and the development of a skilled workforce to address future challenges. This analytical study evaluates local and global shipbuilding trends to assess the future of the domestic shipbuilding industry, based on an analysis of local shipbuilding potential, and constrains, in the context of ongoing technological advancement, global trends, future market predictions, and other relevant factors. This is an analytical study, that mcan help to formulate national shipbuilding strategy to earn foreign currency for the nation.

2. Background and Literature Review

In 21st century maritime transport is widely regarded as the backbone of global trade and the industrial supply chain. Around 80% of global goods and product trade by volume is carried by sea. Global trade volume and size have increased by around 10% over the last decade. Consumer demand, particularly in developing countries, is rising, and the volume of imports and demand for commercial ships

is also increasing (Zou, 2009). Shipbuilding activities typically take place in facilities equipped with heavy machinery, known as shipyards or dockyards. The sector encompasses the design and construction of both ocean-going and inland ships and vessels (Hossain, 2015). Historically, shipbuilding has faced challenges due to the lack of global regulation and a tendency toward over-investment, as shipyards encompass diverse technologies, employ large numbers of workers, and generate income in a globally interconnected market. Shipbuilding has always been profoundly supported by the state, often benefiting from government subsidies, making it an appealing sector for developing nations (Hossain, 2024a). After WWII, Japan used shipbuilding in the 1950s and 1960s to rebuild its industrial sector base. Subsequently, in the 1970s, South Korea designated shipbuilding a strategic industry, and, later, China adopted a similar approach by implementing large-scale state-supported investments in shipbuilding. Since World War II, shipbuilding has grown into a significant and strategic global industry, particularly in certain South Asian countries (Hossain et al., 2017). Currently, the international shipbuilding market is challenged by inflation, geopolitical tensions, excess capacity, low profit margins, market distortions, and persistent subsidisation.

Shipbuilding is always an attractive industry for developing nations. Actually, "shipbuilding encompasses the shipyards, the marine equipment manufacturers, technical workforce, related knowledge, services providers, and related stakeholders" (Hossain et al., 2017). Historically, shipbuilding has suffered from a lack of global coordination and a tendency toward over-investment, owing to its involvement in a wide range of technologies, its capacity to enhance other small industries, its employment of a significant number of workers, its income generation, and, overall, its global nature. This phenomenon and trend are common to all leading and successful shipbuilding nations. After World War II (WWII), Japan used shipbuilding to rebuild its industrial structure (McCarthy, 2005). Subsequently, South Korea began to develop shipbuilding as a strategic industry in the 1970s and 1980s. Interestingly, China also follows the same path, repeating these policies and strategies, with significant state-supported investments in shipbuilding in the 2010s (Michael, 2010; Hossain et al., 2010). However, a few nations, such as the Philippines, Vietnam, and India, are privatising their domestic shipbuilding. In 2021, the global shipbuilding market was valued at USD 132.52 billion and is projected to reach USD 175.98 billion by 2027, with an average annual growth rate of 4.84% (OECD, 2021). However, shipbuilding is usually a slow-moving industry, facing challenges from unsteady market growth and economic and environmental changes. Again, the recent COVID-19 pandemic and the current geopolitical situation further increase uncertainty in shipbuilding (Mordor Intelligence, 2022).

Today, the global shipbuilding market is characterised by inflation, overcapacity, depressed prices, low profit margins, trade distortions, widespread subsidisation, financial and pandemic crises, volatile global politics, trade imbalances, and more. There are fluctuations in shipbuilding growth. The United Kingdom (UK)

was the global market leader in shipbuilding before World War II. After that, Japan became the dominant shipbuilding nation in the 1960s and gradually lost its competitive advantage to the promising industrial nation, South Korea, which had lower wages, a more suitable shipbuilding strategy, strong government support, and a weaker currency. South Korean shipbuilding overtook Japan's in 2003 (Zou, 2009). From 2009 onward, during and after the global financial crisis, China became a global shipbuilding leader, surpassing South Korea and Japan by adopting the same strategies and techniques as those two shipbuilding giants (Hossain, 2018a). China uses the global financial crisis to develop its shipbuilding industry, initially targeting the medium- and small-sized global container, tanker, and cargo ship markets. High-labour-cost countries have consistently lost global shipbuilding market share following the removal of state subsidies; even with strong domestic policies, they have failed to provide sufficient support. Shipbuilding in the UK, the USA, and other European countries is a prime example of this (Stopford, 2009). The market share of US and European shipbuilders began to decline in the 1960s, and their production is now primarily for military use, with few specialised ships such as cruise liners or pleasure Yachts. Today, China is the global leader in shipbuilding, with approximately 50% of the global market share. Their shipbuilding quality and technology have improved significantly, and they have earned the confidence of global customers. South Korea and Japan are following China, securing second and third positions in the global market with 19% and 15% shares, respectively (Hossain, 2021; UNCTAD, 2021; Hellenic Shipping News, 2024).

The literature identifies shipbuilding as a capital-intensive, globally integrated, diversified, and technology-centred industry with extensive forward and backward linkages. Its competitiveness depends on substantial investment, technological capability, skilled human resources, production efficiency, and integration with international markets (Hossain, 2015; Hossain, 2018b; Stopford, 2009). Previous studies indicate that countries such as China, South Korea, and Japan have strengthened their global positions through technological upgrading, industrial policy, productivity improvement, and strong integration with maritime supply chains. These experiences suggest that emerging shipbuilding countries cannot rely solely on low labour costs to achieve long-term competitiveness. Instead, technological capability, workforce skills, productivity, infrastructure, quality standards, financing, and industrial linkages are increasingly important determinants of shipbuilding performance.

Shipbuilding is a capital-intensive, global in nature, diversified, forward and backwards linkage-oriented, and technology-centred heavy industry, which needs huge capital investment (Hossain, 2015; Hossain, 2018b). Export-oriented shipbuilding, particularly smart shipbuilding, is inherently a global industry (Stopford, 2009). Bangladesh has a distinguished shipbuilding history and a low-cost, abundant young workforce. Local shipyards have the capacity and capability to construct small and medium ships (10,000 DWT) in accordance with international standards at approximately 10% - 30% lower cost than similar ships built in

Japan, Korea, China, and Western countries (Hossain, 2018a). However, in the era of intelligent, digitised technologies, the impact of the Fourth Industrial Revolution (4IR) has become a defining discourse and a challenge for the maritime and manufacturing sectors worldwide. 4IR combines digitisation with manufacturing using smart tech, such as AI, ML, DL, DS, IoT, blockchain, digital twin, big data, cloud, VR/AR, simulation, human-machine interaction, 3D printing, advanced materials, and automation (Hossain, 2025a; Hossain, 2024e). The main goal of 4IR in shipbuilding (shipbuilding 4.0) is to create intelligent shipyards that are not only flexible, resource-efficient, and profit-focused but also promote close collaboration among shipowners, shipbuilders, suppliers, and all other stakeholders across different business and value chains (Hossain et al., 2017; Noordstrand, 2018). Therefore, cheap labour and an abundance of young population are no longer sufficient drivers for industrial development in a developing nation in this century. Productivity and a technology-centred skilled workforce are paramount requirements. Suppose Bangladesh fails to develop its young population into a skilled workforce with a technology-friendly attitude. In that case, there is a high likelihood of missing this critical opportunity for economic advancement and sustainable growth, and of falling behind on the global development trajectory (Hossain, 2023b).

3. Research Gap and Methodology

3.1. Research Gap and Research Questions

Shipbuilding is a capital-intensive industry that competes globally and cannot flourish and sustain without government support. Bangladesh's shipbuilding sector has significant potential. However, Bangladesh has failed to keep pace with the ongoing technological advancements in global shipbuilding. Moreover, several common problems and challenges have hindered development (Hossain et al., 2010; Hossain, 2018b). It is anticipated that, if local shipbuilding can select appropriate and optimal ship types and sizes, capture a small share of the global market, and address the challenges, the nation can develop a sustainable shipbuilding industry. To become a sustainable ship-exporting nation after meeting domestic demand, we need to develop our shipbuilding to global standards. To date, few studies have examined the local and global shipbuilding industry, and none have focused on this particular issue. Therefore, this research will endeavour to evaluate the global shipbuilding trend and provide recommendations to help local shipbuilding become a sustainable industry. Bangladesh has 100 indigenous dockyards/shipyards across various locations. These shipyards are operating principally under individual management, except that BN runs three public shipyards. Most local private shipyards use materials, plates, fittings, engines, components, and machinery from old merchant ships collected from the Bhatiary ship-recycling industry in Chittagong (Banglapedia, 2003; Hossain, 2015). There are versatile types and sizes of ships built in local shipyards/dockyards. There are four local shipyards capable of building ships with a capacity of around 10,000 DWT. We

need to find a suitable market for local shipbuilding. Local shipbuilding also needs to address these challenges with an appropriate strategy to become a sustainable industry. Against this backdrop, the study aims to evaluate the global shipbuilding trend and to propose viable recommendations for local shipbuilding. There is a gap in identifying the strengths and weaknesses of the local shipbuilding industry, as well as its opportunities and threats. The local industry's resources and potential, as well as its limitations, require evaluation. The study has been conducted using a combination of primary and secondary data, including valid inputs from industry stakeholders in the domestic and international contexts. Despite extensive literature on global shipbuilding trends and cost competitiveness, limited research has examined the digital productivity gap between emerging shipbuilding nations and global industry leaders, particularly in safety governance, environmental compliance, and workforce capability transformation. Moreover, existing studies rarely address how AI-enabled and data-driven industrial practices can be realistically integrated into labour-intensive shipyards in developing economies. Primary and secondary data and information on global shipbuilding practice, history, trends, and markets, and on local shipbuilding practice, potential, and challenges, have been collected from local and international sources. Relevant data and information have been collected from relevant personnel at local shipyards and dockyards, as well as associated stakeholders, through interviews, discussions, and FGDs, using available secondary sources. This study seeks to address these gaps by analysing Bangladesh's shipbuilding industry through a digital transformation lens, focusing on applied, human-centric technological adoption rather than abstract automation models. The research has used a mix of qualitative and quantitative methods, integrating study and data-collection techniques. There are a few distinct research questions as mentioned below:

1) What is the brief shipbuilding history of the world?
2) What is the trend of shipbuilding market of the world?
3) What is the labour wage rate and productivity in local shipbuilding?
4) How SMEs contribute to local shipyard?
5) What market is the forecasted global shipbuilding market?
6) What market is suitable for local shipbuilding?
7) What are the opportunities of local shipbuilding?
8) What are the challenges of local shipbuilding?
9) What are the findings and required action need to be taken for local shipbuilding?

3.2. Research Design

This is a comprehensive study of global shipbuilding trends, aimed at evaluating local shipbuilding potential, prospects, and challenges in the context of global shipbuilding history and trends, as well as market demand. The author will make every effort to assess the suitable market segment, future challenges, and sugges-

tions for the development of local shipbuilding. This analytical study will also evaluate local and global shipbuilding trends, assess the capacity and capabilities of the present and future local shipbuilding industry through a meticulous SWOT analysis, examine ongoing technological advancements, review the global status, forecast future markets, and identify suitable market segments. This study adopts a mixed-methods research design to investigate the ship recycling industry in Bangladesh, integrating qualitative, quantitative, and policy analysis tools. The lead researcher of this study is a naval architect with over two decades of executive and operational experience in shipbuilding and ship recycling projects across domestic and international shipyards. This experience includes direct involvement in yard-level productivity assessments, safety audits, and process optimisation during periods of operational expansion. Such engagement enabled access to first-hand operational data, informal decision-making processes, and labour-management dynamics that are often inaccessible through conventional academic surveys. This practitioner-researcher perspective strengthened data triangulation and enhanced the contextual validity of the findings. The methodology combines secondary data collection, historical and regulatory review, focus group discussions, quantitative forecasting, comparative benchmarking, and expert validation.

Local shipbuilding practice, potential, and problems; local shipbuilding labour wage and cost breakdown for a sample export ship; and related data have been collected from available sources, including books, publications, research papers, websites, journals, reports, and financial reviews. Information has also been collected through interviews with relevant personnel at local shipyards and dockyards, as well as related stakeholders. The manufacturing process, labour wages, and other data have been observed and collected in person. This multi-pronged approach is intended to provide a comprehensive understanding of the sector's economic, environmental, regulatory, and social dimensions. The research will draw on primary and secondary data, incorporating insights from relevant stakeholders, the literature, and academic journals. An effort has been made to collect financial data to evaluate the cost breakdown and the distribution of foreign and local contributions for a sample ship exported by a local shipyard. The research has focused on evaluating the global shipbuilding market and trends to determine suitable ship types and sizes, and on how to capture market share in local shipbuilding. Research has also been conducted to identify and address the problems and challenges of local shipbuilding. Questionnaires have been distributed to the labour force, shipyard management, and concerned stakeholders to identify the challenges and a suitable market for local shipbuilding. The information and data received in the aforementioned manner have been analysed and evaluated to formulate recommendations for the sustainable development of the local shipbuilding industry. This study will analyse global shipbuilding trends and the markets, and lessons from prosperous shipbuilding nations, to select a suitable market for local shipbuilding. At the same time, the local shipbuilding industry needs to iden-

tify its challenges and develop potential solutions to transition to a sustainable industry. The study has primarily dealt with merchant shipbuilding, whereas naval shipbuilding has received little attention.

3.3. Focus Group Discussions (FGDs) and Stakeholder Interviews

Heavy industries are the multiplier of all other SMEs and are a national industrial development. Shipbuilding is a heavy and strategic industry. It needs backward and forward linkages. But for Bangladesh, such linkages are still very weak. There are gaps between the ambition and the capability of the local shipbuilding. The research objective was to evaluate the global shipbuilding trend and ascertain the challenges and the suitable market for local shipbuilding. However, for gathering information, an online Focus Group Discussion (FGD), involving personnel experienced in the respective field, was held. Interesting to know that, through the FGD, important information and ground reality have been discovered on both local and global shipbuilding. The discussion with FGD and resource personnel from home and abroad was very useful and helpful for the research. Primary data were collected through stakeholder interviews, focus group discussions (FGDs), and informal discussions with individuals having direct or professional knowledge of the shipbuilding sector. The study used purposive stakeholder sampling to obtain perspectives from different groups involved in shipbuilding and its associated regulatory, technical, financial, environmental, academic, and industrial activities. Participants were selected based on their professional involvement, experience, knowledge, or direct association with shipbuilding and related maritime activities. The stakeholder groups included shipyard workers, shipyard owners and managers, naval architects, engineers and technicians, government officials, classification and quality-assurance professionals, economists and financial experts, SME representatives, component and equipment manufacturers, NGO/CSO representatives, academics and researchers, and national and international experts. To incorporate stakeholder perspectives, a series of focus group discussions (FGDs) were planned and has conducted with:

1) Shipyard workers (both skilled and unskilled)

2) Shipyards managers, architects, engineers, and administrative personnel

3) Government officials and professionals

4) Members and experts of the classification society, quality assurance professionals, economists, financial experts, and NGO representatives. Local and international expertise in this sector

5) Shipyard executives and owners

6) Environmental and labour rights activists

Eligibility for participation was based on direct employment, managerial or ownership responsibility, professional expertise, regulatory involvement, academic or research experience, or other relevant involvement with shipbuilding and associated maritime activities. Both skilled and unskilled shipyard workers were included, together with managerial, technical, regulatory, professional, ac-

ademic, environmental, and industry stakeholders. The study reports more than 775 stakeholder participants/interviews between May 2022 and March 2026. These comprised both structured interviews/questionnaire-based consultations and informal discussions. The respondent profile includes 395 shipyard workers, 55 shipyard owners/managers, 95 engineers/technicians, 39 government officials, 38 SME representatives, 42 component/equipment/material manufacturers, 34 NGO/CSO representatives, 42 academics/researchers, and 35 foreign experts. FGDs were conducted using a semi-structured questionnaire, with each FGD involving approximately 6 - 10 participants. The discussions addressed shipbuilding practices, production optimization, digital and smart technologies, productivity, job satisfaction, labour and workplace safety, quality assurance, standardization, barriers to compliance, social and livelihood implications, modernization, and advanced design and manufacturing technologies. In addition to formal/semi-structured FGDs and interviews, repeated informal discussions were conducted with resource persons and stakeholders to obtain contextual information and validate issues identified through the structured data-collection process. The manuscript records more than 100 FGD and informal discussion engagements conducted at different times and locations between May 2022 and March 2026.

3.4. Mixed-Methods Data Analysis and Triangulation

Quantitative questionnaire data were analyzed using frequencies, percentages, mean scores, and comparative rankings. Key variables included labour wages, productivity, workforce characteristics, perceived industry challenges, technological readiness, and suitable market segments. Questionnaire items using ordered response scales were assigned numerical scores, with higher scores indicating greater importance or agreement. Qualitative data from interviews, FGDs, and informal discussions were analyzed through thematic coding. Responses were coded into major themes, including labour and productivity, technology, infrastructure, financing, skills, quality standards, market opportunities, and policy barriers. The study included diverse stakeholder groups and used FGDs and informal discussions to validate issues identified through structured data collection. Quantitative and qualitative findings were triangulated with observed shipyard practices and secondary evidence from published studies, industry reports, and international market data. A finding was considered strongly supported when consistent evidence emerged from multiple sources. This integrated approach was used to identify major challenges, assess market opportunities, compare Bangladesh with international shipbuilding nations, and formulate development recommendations.

3.5. Profile of Interview Respondents

A total of 490 interviews were conducted between May 2022 and Mar 2026 to gather multi-perspective insights into the shipbuilding industry of Bangladesh.

These interviews included stakeholders from operational, technical, regulatory, environmental, professional and academic domains. The aim was to reflect the full spectrum of experiences, from grassroots labourers to global policy advisors. Table 1 below presents the summary profile of the respondents.

Table 1. Respondent categories and summary profile.

Respondent Type	No	Age Range	Gender (M/F)	Typical Role/Qualification	Location
Shipyard Workers	210	18 - 50	195/15	Semi-skilled/unskilled labourers	Dhaka, Khulna, Narayanganj, Barisal, Chattogram
Shipyard Owners/Managers	32	35 - 65	32/0	Business owners, managing directors	Dhaka, Khulna, Narayanganj, Barisal, Chattogram
Engineers/Technicians	94	25 - 60	90/4	Mechanical/Marine/Naval Architects	Yard premises, BUET, CUET, Foreign
Government Officials	28	30 - 60	25/3	Ministry of Industries, DoE, BSRB, Customs	Dhaka, Narayanganj, Khulna, Chattogram
SME	25	20 - 55	20/5	Semi-skilled/skilled worker, Manager Business owners	Dhaka, Narayanganj, Khulna, Chattogram
Component, equipment, furniture, material Manufacturers	23	20 - 50	20/3	Semi-skilled/skilled worker, Manager Business owners	Dhaka, Narayanganj, Khulna, Chattogram
NGO/CSO Representatives	36	25 - 55	19/17	Environmental and labour-rights activists	Dhaka, Khulna, Chattogram
Academics, Researchers	22	30 - 70	20/2	Professors, policy researchers	Dhaka, BUET, CUET, BMU, DU, etc., Foreign
Foreign Experts	20	35 - 65	17/3	HKC/EU/IMO consultants, class surveyors	Dhaka, Chattogram, Remote, Online,
Total	**490**				

There are 20 foreign experts included in the study were selected based on their active involvement in many aspects. All foreign experts were interviewed either physically or virtually via structured digital questionnaires and Zoom-based sessions, or sometime provided written responses through standardised forms. Their perspectives were crucial in evaluating how Bangladesh is perceived internationally, where its compliance gaps lie, and what global ship-owners require to consider Bangladesh a long-term recycling destination. Those are as follows.

1) Classification societies (e.g., BV, CCS, DNV, LR, ClassNK, RINA, IRS, etc.)

2) International funding agencies (e.g., IMO, UNDP, JICA, World Bank, ADB, environmental units)

3) Technical consultants involved in shipbuilding industry around the globe (Japan, China, South Korea)

4) Shipyards (from China, Japan, South Korea, UK, USA, Canada, India, Pakistan, etc.)

5) Foreign Universities (WMU, Osaka University, University of Yokohama, etc.)

4. Results and Findings

4.1. Trend of Global and Local Shipbuilding

4.1.1. Trend of Global Shipbuilding

Shipbuilding is a primitive industry that constructs ships and other floating vessels. Shipbuilding activities typically occur in shipyards or dockyards, where heavy machinery is installed. The shipbuilding industry typically designs and constructs oceangoing and inland vessels. Today, the global shipbuilding industry is dominated by Asia, followed by Europe and the Americas, with a small niche market. Asia (mainly China, South Korea, and Japan) maintains its dominance in the global market due to well-defined and inherent advantages (Hossain et al., 2017). Those advantages are: comparatively lower labour costs, strong government backing, sustainable government policy, a positive attitude, political stability, economic strength, and forward and backward linkages with industry. It is a highly capital-intensive industry that produces unit-level production rather than mass production, as in RGM. Shipbuilding requires sustainable government policy and support, a viable strategy and management, and political stability; these are prerequisites for survival in a competitive global market. In the 1860s, the modern era of shipbuilding began with the development of the manufacturing industry. Since then, the use of iron and advanced steamers has added a new dimension to shipbuilding. "Ship owners like strong and reliable ships because of longer voyages their ships can sail, and they can use those for better commercial operations. As a result, in the late 19th century, successful steam ships could be confirmed by the phasing out of sailing vessels" (Banglapedia, 2003). In the late 19th century, the UK was the biggest shipbuilding nation. From 1892 to 1894, the UK accounted for 80% of the world's shipbuilding by gross tonnage (gt). At that time, the UK held the leading position in world trade and needed large merchant fleets to control global trade. Moreover, to maintain its colonial supremacy, the UK needs such vast shipbuilding (Hossain et al., 2017).

4.1.2. Trend of Local Shipbuilding

Bangladesh has a long-established shipbuilding tradition rooted in the traditional boatbuilding activities of Bengal (Alam, 2004). Historical accounts indicate that Bengal developed significant shipbuilding capabilities with connections to both regional and international maritime activities. Ibn Battuta visited Bengal in the fourteenth century and reportedly returned on a wooden vessel built at Sonargaon, while the European traveller Caesar Frederick identified Chittagong as an important centre for the construction of ocean-going vessels in the fifteenth century. During the seventeenth century, vessels were constructed at Chittagong for the Sultan of Türkiye, while the region also produced warships during the Mughal period. The construction of wooden-hulled vessels in Chittagong for international maritime use, including the frigate *Deutschland* built in 1818 for the German Navy, further demonstrates the historical significance of Bengal's shipbuilding industry (Hossain et al., 2010; Hossain et al., 2017).

In the modern period, Bangladesh's shipbuilding industry has gradually evolved from traditional boatbuilding toward the construction of steel inland, coastal, and small- and medium-sized ocean-going vessels. The private sector has become the major participant in the industry, with approximately 100 shipyards operating across the country. Local shipyards have developed the capacity to construct small and medium-sized vessels, and some shipyards have successfully secured orders for international markets. The industry has also benefited from collaborations and institutional initiatives supporting the development of domestic shipbuilding capacity.

Despite these developments, Bangladesh's shipbuilding industry continues to face challenges related to technological capability, labour productivity, infrastructure, financing, industrial linkages, and the adoption of advanced technologies. The literature further indicates that low labour cost alone is insufficient to ensure long-term competitiveness in the contemporary shipbuilding industry. Productivity improvement, technological upgrading, and the development of a skilled, technology-oriented workforce are increasingly important for Bangladesh to strengthen its position in the international shipbuilding market (Hossain, 2018a; Hossain, 2023b).

4.2. Forecast of Global Seaborne Trade and Shipbuilding Market

4.2.1. Structural Characteristics of the Shipbuilding Industry

Table 2. Structural characteristics and business nature of the shipbuilding industry.

Sl No	Subjects or Characteristics	Situation of the Shipbuilding Industry
1	Production pattern	Unit and specialised production
2	Delivery time	Naturally long (2 - 3 years)
3	Production factor intensity	Usually a labour-intensive industry.
4	Trade ability	Very high and diversified Play a significant role in ship finance in the exports Multiplier of other businesses connected with backwards and forward linkage
5	Possible change areas in the future	An offshore business involves high risks Repair and maintenance of ships Steel construction and fabrication business
6	Product heterogeneity	Very high, as a wide variation of ship types
7	Demand accelerates	Expansion of seaborne trade Replacement of ships Changes in regulations Changes in the owner's requirements
8	Challenges	Eco-system or environment-friendly product Automation and digitalisation Impose regulation Design as unit production Overcapacity Trade fluctuation
9	Uses	Versatile EOL ships also have value

Economic interconnection among trading partners worldwide is increasing. Moreover, the shipbuilding and shipping industries are responsible for the production and operation of merchant ships, and shipping is considered the heart of international trade and commerce. The shipbuilding industry is inherently complex and diverse. The shipbuilding industry is characterised by high heterogeneity among ships due to the wide variety of types and uses. These include: Bulk Carriers, Tankers, Container ships, Offshore vessels, Passenger Ferry, Cruise ships, Yachts, Warships, etc. "The range of prices is also varying widely. The Cost of a large cruise ship is around USD 1 billion, whereas a Handy-size bulk ship costs around USD 25 million" (Clarksons Research, 2015, 2020). However, major drivers of the shipbuilding market include the growth of seaborne trade, the demand for and price of EOL ships, and the diversified use of ships. On the other hand, excess ship supply, inflation, and overcapacity of shipyards are the leading causes of market imbalances in shipbuilding. The structural characteristics and business nature of shipbuilding are presented in **Table 2**.

4.2.2. Forecast of Seaborne Trade by "ITF, Sea Europe, SAJ, OECD"

The International Transport Forum (ITF) and the OECD developed a network model for forecasting seaborne trade, which projects international freight transport activity until 2050, encompassing three world trade scenarios depending on the degree of trade liberalisation (Martínez et al., 2015; OECD, 2017). For analysis, "ITF uses the international trade scenarios that OECD's Economics Department derived and that are based on the equilibrium model". The seaborne trade projections for 2035, based on ITF, Sea Europe, and SAJ, are shown in **Figure 1**. However, according to the ITF's network model, seaborne trade would reach 20.8 billion tonnes in 2035. Again, Europe and SAJ predict that the seaborne trade will reach 16.2 billion tonnes in 2035 (ITF, 2015; Sea Europe, 2015; SAJ, 2015; OECD, 2017).

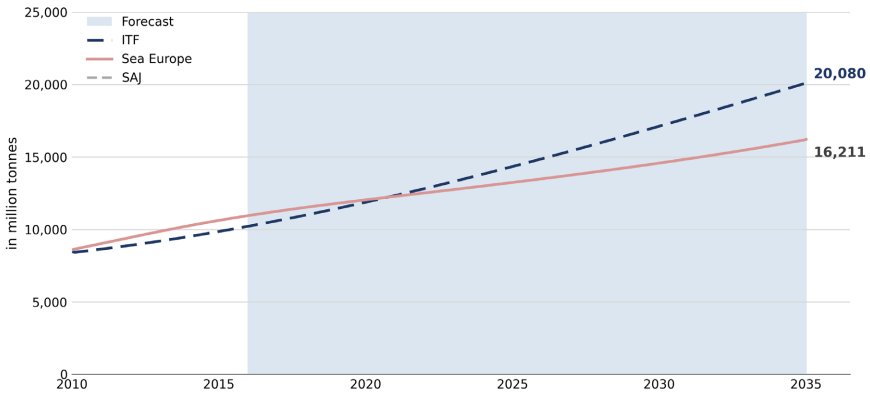

Figure 1. Forecast of seaborne trade from 2010 to 2035 by IFT, Sea Europe, SAJ, OECD (ITF, 2015; Sea Europe, 2015; SAJ, 2015; OECD, 2017).

4.2.3. Forecast of Shipbuilding Market

Today the global shipbuilding market is undergoing a transformative phase driven

by sustainability and technological advancements. North America remains the largest market for shipbuilding, driven by robust commercial shipping activities. However, technological advancements and rising demand for energy-efficient vessels are key drivers shaping the market landscape. Currently, the commercial shipping section continues to govern, while the defense section is perceiving rapid growth due to geopolitical tensions. As per Market Research Future (MRFR) investigation and forecast, the shipbuilding market Size was estimated at USD 201.4 Billion in 2024. The shipbuilding industry is projected to grow from USD 218.04 Billion in 2025 to USD 500.63 Billion by 2035, where exhibiting a compound annual growth rate (CAGR) of 8.67% during the forecast period 2025 to 2035 and that has shown in **Figure 2** below. The shipbuilding market is progressively concentrating on sustainability initiatives. Shipbuilders are adopting eco-friendly materials and advanced technologies to minimize environmental impact. AS a result, such trend echoes a broader commitment to reducing carbon footprints and conforming to harsh regulations (MRFR, 2025). In the global shipbuilding market, the application segment is primarily dominated by commercial shipping, and that remains to represent the largest share compared to other sections like defense, leisure, fishing, and research. Additionally, the commercial shipping sector paybacks from the increasing global trade and the need for efficient transport solutions, leading to important investment in larger and more advanced and eco-friendly vessels. In the meantime, the defense segment is gaining traction as nations prioritize maritime security and increasing defense budgets. And that creating extensive demand for naval vessels and global shipbuilding market forecast up to 2035 has been shown in **Figure 2** below.

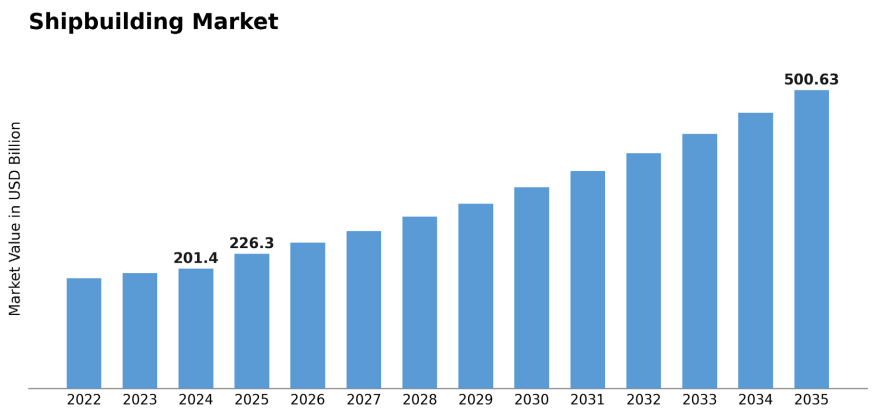

Figure 2. Global shipbuilding market size and prediction up to 2035.

4.3. Impact of 4IR and Smart Technology on Shipbuilding

4.3.1. Impact of 4IR on Shipbuilding

The ocean and shipping are the lifelines of global trade, and technology has been central to their strategies since the inception of ships and shipping, which have witnessed the previous three industrial revolutions. Likewise, there will be a significant impact on the maritime industry in the near future with the incoming 4th

Industrial Revolution (4IR) or Industry 4.0, and future ships will be controlled by Artificial Intelligence (AI), IoT, and automated systems. Modern technology will steadily reduce the number of seafarers in shipping due to uncrewed ships and AI. "The 4IR is anticipated to reach its peak around the middle of the 21st century and bring disruptive changes by exploring and implementing new technology in all spheres of trade and shipping to create safer, efficient, greener, and viable solutions. Technologies like Robotics, AI, Machine Learning, IoT, Blockchain, Drones, and Augmented Reality (AR) are going to change the equation of the job sectors and give a new dimension to the maritime industry" (Wikipedia, 2022). To address the current situation and future complexities, several measures may need to be adopted by the government, the maritime administration, shipyards, shipowners, MET, and technical institutes. We need to make the necessary preparations to meet the demands of 4IR. The policy, strategy, context, and learning processes in mass and technical/MET education need to be formulated to develop the skills and knowledge of the new generation. There may be skill development programmes for seafarers and the shipbuilding workforce to meet the future challenges. Such programmes include: communication and coordination; QHSE; adaptability and cognitive flexibility; automation and AI; digital proficiency; innovation and creativity; critical thinking; emotional intelligence; technical skills; self-learning (online); data-based decision-making; people management and negotiation; complex problem-solving; service orientation; etc. In FGD, Captain Noman Shiblee, DC, BMA, and Captain Farid, DC, CPA stated that, "we have a strategic vision to adapt with disruptive changes in 4IR, but the main obstacle in this transformation is poor motivation of employees due to fear of losing their job, unawareness, and rigidity in the old style of work".

4.3.2. Smart Shipbuilding and Its Impact

Innovative ships incorporate advanced digital technologies, such as AI, ML, DL, Blockchain, and big data, into their design, propulsion, systems, and manufacturing processes to enhance efficiency, safety, and operational performance. They utilise advanced materials, such as glass fibre, carbon fibre, and reinforced polymers (GFRP), in hull plating. Additionally, they develop innovative structures, including adaptive damping systems for thrusters and composite sandwich panels incorporating Phase Change Materials (PCMs) to improve insulation in refrigerated cargo ships. Phase change materials (PCMs) are substances that absorb or release thermal energy as they transition between solid and liquid states. This characteristic enables them to store and release significant amounts of energy at specific temperatures, making them well-suited for thermal energy management and temperature regulation applications. Key aspects include digital twins, advanced materials, and automated monitoring and control systems. Digital replicas of ships and their components enable concurrent development alongside the physical product, supporting detailed analysis and continuous optimisation throughout the lifecycle. Using automation in shipbuilding, including robot work for welding and assembly, as well as integrated systems for power management,

navigation, and alarm monitoring, all help generate more data and improve operational efficiency. Innovative technologies optimise performance across varying conditions, including changing cargo loads, shallow waters, and waves. They also lower maintenance costs by using corrosion-resistant materials and increase cargo capacity by employing lightweight composites. However, not all innovative ships are fully autonomous. The development of autonomous vessels is a key aspect of the "smart ship" concept, which utilises advanced digital systems for autonomous operation (Figure 3).

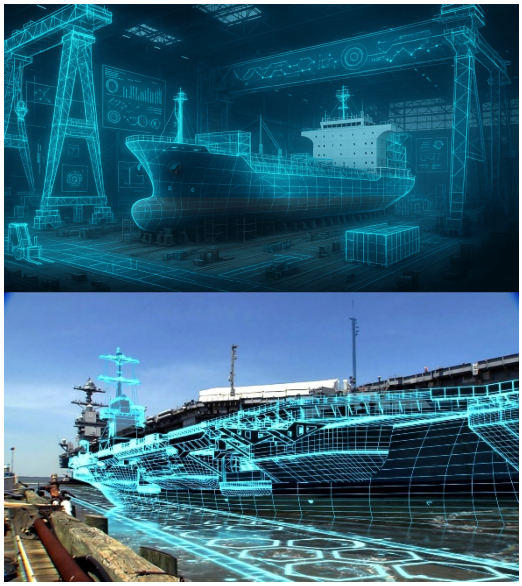

Figure 3. Smart shipyards are using innovative and advanced technology in shipbuilding.

Smart shipbuilding offers numerous benefits, including increased efficiency, cost savings, improved safety, and enhanced environmental sustainability. Incorporating technologies such as AI, automation, and data analytics enhances multiple stages of the process, from design and engineering to construction and maintenance. This results in quicker production, lower operational costs, fewer human errors, and a reduced ecological impact. Additionally, digital twins and simulation tools are used to refine designs, minimise errors, and accelerate development. Robotics and automation enhance manufacturing efficiency, resulting in faster production and lower labour costs. Intelligent systems optimise material flow and inventory control, decreasing delays and waste. Smart shipyards employ prefabricated sections and modular construction methods to significantly reduce assembly time. Automation and robotics can reduce reliance on manual labour, particularly for repetitive or hazardous tasks. Data-driven predictive maintenance helps detect potential problems early, lowering repair costs and reducing downtime. Clever shipbuilding techniques reduce material waste and improve resource efficiency. Automated systems and AI-based navigation can reduce human error, a key factor in accidents in traditional shipbuilding. Additionally, intelligent systems can detect early signs of equipment failure, prevent accidents and promote

safer operations. AI-powered systems enhance emergency response by analysing situations and automating safety protocols. Innovative shipbuilding practices reduce material waste and improve resource utilisation. Automation and robotics enhance precision and accuracy in manufacturing and assembly processes. Intelligent systems can detect and fix defects early, enhancing the overall quality of the ship. They continuously monitor the quality of materials and processes throughout the shipbuilding lifecycle, ensuring high standards. Considering the large pool of young, unskilled workforce in Bangladesh, Augmented Reality (AR) and Virtual Reality (VR) based training systems are more effective than traditional methods. These digital tools can accelerate skill acquisition for complex tasks such as precision welding and fitting, without the safety risks and material waste associated with physical training. Additionally, adopting a "Digital Twin" approach for ship repair and retrofitting, creating 3D digital replicas of existing vessels, will allow local yards to precisely engineer modifications, giving them a competitive edge in the high-value retrofitting market.

Smart shipbuilding represents a significant shift in the industry, offering a more efficient, cost-effective, safer, and sustainable approach to ship construction. Smart shipyards can incorporate green technologies, such as alternative fuels and energy-efficient systems, thereby reducing emissions and supporting environmental sustainability. Today, in the production sector, shipyard management, materials, and machinery are highly integrated with advanced technology. Like steam engines, internal combustion engines, electricity, and computers, AI is now widely used in both industry and academia. Currently, ML, DL, ANN, and DS are employed in ship and port operations and in the shipbuilding industry to enhance efficiency, reduce costs, and improve overall performance. These technologies support data-driven decision-making, predictive analytics, and automation, leading to significant progress in port management. In modern shipbuilding, AI and related innovations are used to develop intelligent, automated shipyard infrastructure that addresses current challenges. In addition to construction and maintenance, smart shipyards also place a strong emphasis on security enhancements. Digitalisation is transforming shipyard facility management through collaborative platforms and advanced technologies, thereby ensuring safety, profitability, and timely delivery. To optimise shipbuilding processes and profits, smart shipyards utilise digital tools such as automation, sensors, data analytics, the IoT, AI, and DL. Smart Shipyards and their activities have been shown in **Figure 4** below.

Smart asset and logistics management systems enhance this transformation by tracking the location, condition, and performance of key shipyard assets such as cranes, vehicles, machinery, and infrastructure (Hossain, 2024e). These intelligent systems contribute to extending equipment lifespans, enabling proactive maintenance, and increasing overall asset utilisation. The adoption of predictive maintenance techniques, in which algorithms analyse sensor data, maintenance records, and operational performance, facilitates early detection of potential failures and the scheduling of repairs. This strategy improves the reliability and safety of ship-

yard operations, while also reducing downtime and maintenance costs. Today, real-time monitoring and assessment of infrastructure and equipment are enabled by big data analytics, AI, and IoT sensors. Furthermore, ML and DL algorithms can analyse historical data to forecast future ship demand, informing better decisions regarding inventory, workforce, logistics, work scheduling, and resource allocation (Hossain, 2024d).

Figure 4. Smart shipyards and their activities.

Digital technologies and IoT are poised to play a key role in the future of AI integration within the shipping sector. IoT and AI devices will deliver real-time information and market data. AI algorithms can be used to optimise production, operations, and management (Hossain, 2025b). AI will also support the maritime industry's sustainability efforts by optimising fuel consumption, minimising emissions, and improving supply chain efficiency. AI-driven solutions will enable shipping companies and shipowners to comply with environmental regulations and advance their sustainability objectives. Looking ahead, AI is expected to fuel the development of more sophisticated predictive analytics tools. These tools will provide valuable insights into market dynamics, empowering industry stakeholders to make informed, data-driven decisions and maintain a competitive edge. However, adopting AI, ML, DL, data science, and other innovative technologies demand substantial investment in hardware, software, and skilled human resources. These high initial costs may pose challenges for the small and medium-sized shipping and shipbuilding industry. Additionally, integrating such technologies entails collecting and processing large volumes of data, raising concerns about data privacy, cybersecurity, and overall safety.

The shipbuilding industry stands on the brink of a technological revolution,

spearheaded by groundbreaking research and development initiatives. Leading companies are advancing fuel-efficient engines and innovative ship technologies, paving the way for faster, more sustainable maritime solutions. This surge in innovation is not only redefining efficiency but also transforming eco-friendly practices into a standard for modern shipbuilding. Eco-friendly shipbuilding practices are crucial for mitigating the maritime industry's environmental impact. The adoption of sustainable design principles, innovative materials, green construction methods, and digitalisation alongside green technologies enables the industry to reduce its ecological footprint. Implementing sustainable practices necessitates a holistic approach that engages all stakeholders, including designers and shipyard operators (Lloyds Register of Ships, 2022).

Focus on maritime innovation and technological excellence. Hyundai Heavy Industries (HHI) is a leading innovator in the maritime industry, transitioning from a traditional shipbuilder to a "future builder" focused on decarbonization and digitalisation. HHI is doing this by developing intelligent and secure engine control systems, eco-friendly technologies, and innovative ship solutions, and by being a global leader in shipbuilding that invests heavily in R&D to push the boundaries of maritime innovation. Their key focus areas include autonomous shipping, green energy solutions, and digitalisation. HHI has been developing innovative ships equipped with AI-driven navigation systems to enhance safety and efficiency. They are also investing in alternative fuels such as ammonia and hydrogen to reduce carbon emissions in line with IMO regulations. HHI collaborates with other companies to develop innovative solutions, such as blockchain-enabled class registers with Lloyd's Register. Their research into blockchain-based logistics is improving transparency and security in global shipping operations. With a strong technological foundation and world-class production facilities, HHI is a global leader in shipbuilding, delivering thousands of vessels to clients worldwide.

Focus on Fuel-Efficient Engines. Shipbuilding companies are focusing on making their ships more fuel-efficient. They are researching ways to reduce engine fuel consumption. This helps reduce harmful gases released into the atmosphere. By improving fuel efficiency, ships can also save on fuel costs. Embracing these methods can lead to cleaner oceans. Encourage shipbuilders to prioritise fuel-efficient technologies. HHI is actively developing eco-friendly technologies such as LNG- and ammonia-fueled vessels, as well as next-generation propulsion systems, to reduce carbon emissions. Advanced Materials for Faster Ships. Many shipbuilders are turning to advanced materials for their ships. These materials are lightweight yet highly strong. Using lighter materials helps ships move faster and use less fuel. This can reduce the wear and tear on the ship. It also reduces maintenance costs. Advise shipbuilders to explore the possibilities of advanced materials. HHI is investing in advanced materials and propulsion systems to build faster, more efficient ships.

Investing in Smart Ship Technologies. Innovative technologies are becoming a key area of focus in shipbuilding. These include systems that enable ships to operate autonomously. Research is being done to improve these intelligent systems.

This can make ships safer and more reliable. It can also reduce the need for large crews, saving costs. Advocate for greater investment in innovative ship technologies. HHI is involved in developing autonomous shipping technologies and digital tools to improve shipbuilding efficiency. They have even conducted autonomous ship demonstrations. Artificial intelligence can enhance ship design and production methodologies, leading to increased efficiency and minimised waste. Blockchain technology enhances supply chain transparency and mitigates potential environmental impacts. The Internet of Things (IoT) enhances the monitoring and control of ship systems, thereby reducing energy consumption and increasing efficiency. Digital Tools Improve Shipbuilding Efficiency. Digitalisation is significantly transforming the shipbuilding process. With digital tools, the design and production of ships have become more efficient. These tools can catch mistakes early, saving time and money. Digitalisation helps streamline the supply chain as well. It supports better communication among different teams. Promote the benefits of digitalisation in shipbuilding. Digital tools can optimise ship design to improve energy efficiency and reduce environmental impact. Digital planning tools enhance production efficiency and cut waste. Supply chain management improves transparency and reduces environmental risk.

Eco-Friendly Practices in Modern Shipbuilding. Sustainable practices are critical in modern shipbuilding. Companies are using eco-friendly materials to build ships. They are also adopting methods that cause less environmental harm. This trend is important for preserving marine life. Sustainable practices can lead to long-term savings and regulatory compliance. Urge shipbuilding companies to invest in sustainable practices. The shipbuilding industry is being transformed by digitalisation and green technologies. These technologies offer substantial opportunities to enhance efficiency, minimise waste, and advance sustainability. Electric and hybrid propulsion systems have the potential to substantially reduce greenhouse gas emissions. Energy-efficient systems, such as LED lighting and HVAC systems, can reduce energy consumption. Technologies like recycling systems and waste-to-energy converters effectively reduce waste. Implementing lean manufacturing principles minimises waste and optimises production processes. Green shipyard practices, such as the use of renewable energy and the minimisation of water consumption, can substantially reduce a shipyard's environmental footprint. Damen Shipyards has adopted various sustainable practices, such as modular construction and the use of energy-efficient facilities. Fincantieri has made investments in green technologies, including solar power and energy-efficient lighting, to mitigate its environmental impact.

Three-dimensional printing has the potential to decrease material waste and enhance manufacturing efficiency. Digital twin technology enables virtual testing and simulation, reducing reliance on physical prototypes. Automation has the potential to improve production efficiency and reduce labour costs. Adopting green practices often involves higher costs than traditional methods, and regulatory barriers can hinder their implementation. A lack of awareness about green technolo-

gies also presents challenges. Hyundai Heavy Industries has invested in renewable solutions like solar power and energy-efficient lighting to lower its environmental footprint. Adopting sustainable practices is essential for minimising the environmental footprint of shipbuilding. This effort requires a comprehensive strategy that engages all stakeholders, from designers to shipyard workers. Setting clear sustainability objectives and targets can foster meaningful change. Offering training and education on sustainable methods helps cultivate a culture of sustainability. Working together with suppliers, clients, and other partners can reveal areas for enhancement. Mitsubishi Heavy Industries has adopted various eco-friendly initiatives, including energy-efficient facilities and waste-reduction programs.

4.4. Labour Productivity and Cost in Shipbuilding

Shipbuilding labour productivity in Bangladeshi shipyards is the lowest (around 11.43), whereas that of Japanese shipyards is the highest (around 1). As a result, the productivity of Japanese shipbuilding labour is 11.43 times higher than that of Bangladeshi labour. A comparison of labour productivity across nations in 2009 is shown in **Table 3** and **Figure 5** (Hossain, 2010; Hossain et al., 2010; ResearchGate, 2022). Relative labour wage is the product of the labour wage and labour productivity, and it is the primary determinant of overall labour wages across nations. Labour productivity in Bangladesh's shipbuilding industry is the lowest in the world. However, appropriate training of labour and automation in shipbuilding will definitely improve productivity, as it has in Japan, South Korea, and China. Many shipyards worldwide have implemented modern technologies to enhance their production facilities over the past decades. Today, shipbuilding methodologies and construction procedures have changed dramatically. Implementing the module construction process and lean manufacturing approach in shipyards requires an analysis of current shipyard facilities and labour capabilities. Labour competency and skill level also need to be evaluated. Again, continuous workforce training can improve the quality and productivity of any shipyard. The average labour wage (per hour) in Bangladesh is the lowest in the world. The average hourly labour wage (in USD) for class ship in local shipyards in 2009 is shown in **Figure 6**. On the other hand, the comparison of labour wages across nations worldwide in 2009 is shown in **Table 4**.

Table 3. Shipbuilding labour productivity of different nations in 2009 (Hossain, 2010; Hossain et al., 2010).

Country	Formula for Labour Productivity = Man-Years/Unit Output (in CGT)	Productivity
Japan	Using a basic formula	1
European countries	Same	2
United States	Same	4
China	Same	6
India	Same	10
Bangladesh	Same	11.43

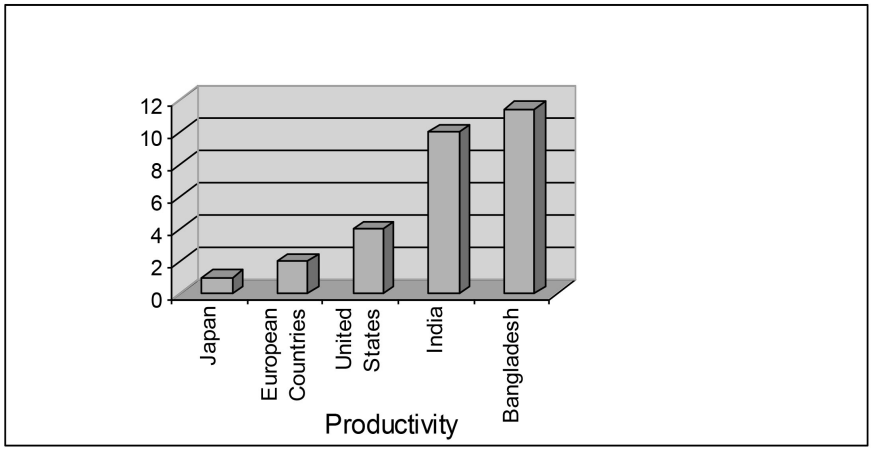

Figure 5. Shipbuilding labour productivity of different nations around the globe in 2009 (Hossain, 2010; Hossain et al., 2010).

Table 4. Average hourly semi-skilled labour wage of different nations in 2009 (Hossain, 2010).

Countries	Average Hourly Labour Charge in US$
Bangladesh	1.50 (Evaluated by Author)
India	2.50
China	9.00
South Korea	27.00
Japan	30.00
USA	30.00
UK	29.00
France	27.00
Italy	26.00
Germany	35.00

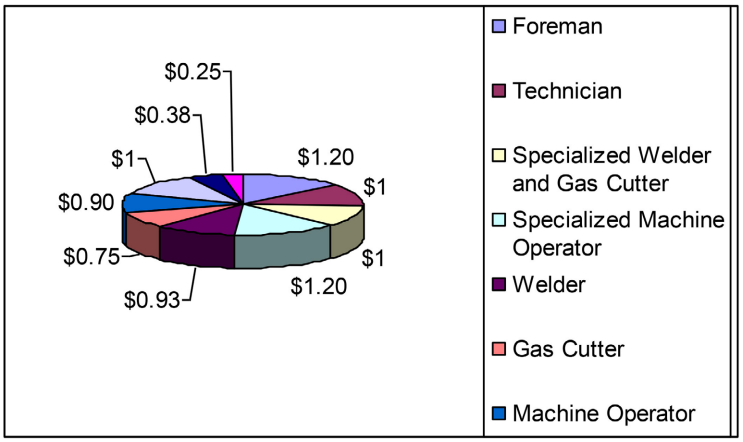

Figure 6. Average hourly labour wage (in USD) for class ship in local shipyards in 2009 (Hossain, 2010; Hossain et al., 2017).

The average hourly labour wage across shipbuilding nations is shown in Figure 7. The relative labour wage in Bangladeshi shipyards is 0.45, the lowest in the world. A comparison of relative labour wages or rates across nations is shown in Table 5 (Hossain, 2010; Hossain et al., 2010). However, the average hourly labour wage in Bangladesh increased in 2026 and remains comparatively low worldwide. Ultimately, Bangladesh's shipbuilding industry remains in a strong position globally in terms of labour costs.

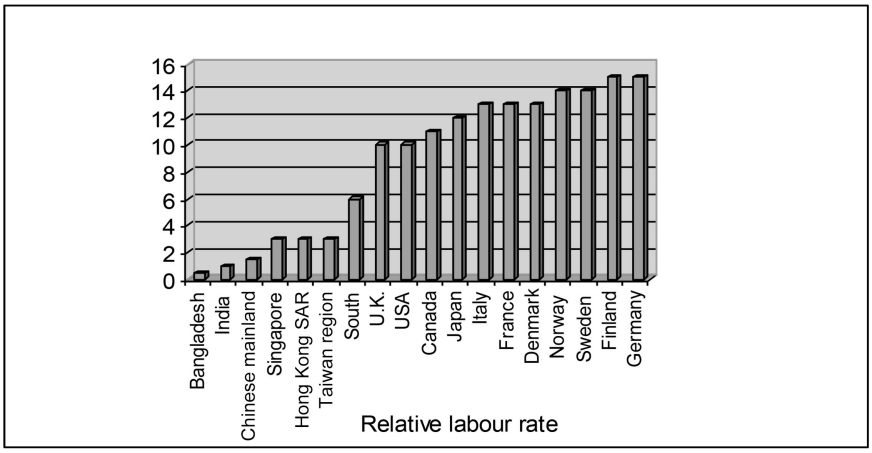

Figure 7. Relative labour wage for different nations around the world (Hossain, 2010; Hossain et al., 2010).

Table 5. Relative labour wage for different regions around the globe in 2009 (Hossain et al., 2010).

Region	Relative Labour Wage	Region	Relative Labour Wage
Bangladesh	17.145	Canada	11
India	1	Japan	30
Chinese mainland	1 to 2	Italy	13
Singapore	3	France	13
Hong Kong SAR	3	Denmark	13
Taiwan region	3	Norway	14
South Korea	6	Sweden	14
UK	10	Finland	15
USA	10	Germany	15

4.5. Contribution of Local SMEs and Component Manufacturers on Shipbuilding

4.5.1. Small and Medium-Sized Enterprises (SMEs)

SMEs of Bangladesh are often described as enterprises with a small number of employees and a low turnover, account for around 45% of value addition and employ almost 80% of Bangladesh's industrial workforce. These SMEs account for

over 90% of all industrial units and employ a quarter of Bangladesh's entire work force. Furthermore, they play a significant part in the country's export revenues, accounting for 75% to 80% of total. Bangladesh has 7.9 million SMEs, with 93.6% classified as small and 6.4% as medium-sized. These businesses employ around 24.5 million people, with men accounting for 83.5% of the workforce (Markedium, 2022). They engage in diverse economic activities, spanning manufacturing, services, and agriculture, cementing their role as key GDP drivers. These enterprises contribute to GDP by delivering value through their goods and services, catering to both domestic and international markets. According to 2013 research, more than 40% of SMEs did not have access to formal finance (Future Startup, 2022). The World Bank predicts a $2.8 billion funding deficit in Bangladesh's SME sector (World Bank Group, 2019). Financing costs and credit availability are important issues, prompting many SME entrepreneurs to seek alternate sources of funding, such as microfinance institutions, local traders, informal lenders, or support from friends and family (Future Startup, 2022). According to the SME Foundation, SMEs employ more than 70% of the country's non-agricultural labor force. This job creation is especially important in rural regions, where major businesses are sparse, as it contributes greatly to poverty reduction and improves general living standards (SME Foundation, 2021).

4.5.2. Shipbuilding Process

A ship is a highly compound and comfortable structure, both in the construction of its hull form and the installation of machinery. The commercial and technical considerations require not only that the main machinery units should provide reliable and efficient propulsive power but also that the large number of engines, auxiliaries and other equipment are also able to withstand the dynamic loads which the ship structure is subjected due to waves. Ship structures are subjected to varying loading that result in repeated stresses caused by cyclic loading on some of the machinery components along with dynamic condition of ship's motion. The operational area of the ship is also not smooth and well defined. Therefore, it needs high degree of service reliability and performance. To meet these rigorous requirements, the reliability of design, materials and workmanship has to be ensured and proven through inspection during manufacture and specified performance tests, and those are specified for certification of these material, machinery and equipment. That is why shipyards and classification societies step in and thus the relationship is born between them. The various ancillary industries for shipbuilding fall into following categories and they require expertise in their respective areas and these are suppliers of the following categories.

1) Prime mover (diesel engine, steam turbine, electric motor in case of electric propulsion)

2) Reduction gears

3) Steam boilers and equipment associated with boiler plant

4) Stern gear comprising of shafting, propeller, stern bearings, seals and associated equipment

5) Rudder assemblies consisting of rudder, rudder stock, bearings, etc.

6) Power generating sets

7) Electrical equipment such as alternators, switchboards, transformers, distribution panels, electrical cables

8) Auxiliary machinery such as pumps, air compressors, air receivers, valves

9) Automation and control systems

10) Deck machinery such as windlass, winches, mooring equipment, etc.

11) Navigation equipment such as radar, echo sounder, gyroscope, etc.

12) Communication equipment

13) Air conditioning and refrigeration machinery, galley equipment, etc.

14) Materials like steel aluminium, castings/forgings, pipes and fittings

15) Welding equipment, electrodes, etc.

16) Carpentries for furniture and special accommodation fixtures and fittings

17) Paints

18) Material safety, anodes, etc.

4.5.3. Contribution of SMEs for Local Shipbuilding

Bangladesh has a long experience in shipbuilding and naturally the component and service suppliers and manufacturers are doing the job in an unorganized manner. As a result, there has been a good growth of such SMEs for local shipbuilding. The products manufactured by the SMEs are of good quality and many products are being exported from Bangladesh. Although these SMEs are mostly for land-based products, many features of this engineering production are common with those for marine industries. For export-oriented ships, the concerned shipyards, local marine component manufacturers, some local steel companies and SMEs all together are now attempting the situation of small orders that have been placed in Bangladesh. Bangladesh has a big fleet of trawlers, inland, and coastal vessels, which with sustainable growth. Most of the components for these vessels are either procured from reconditioned market (as coming from ship-recycling industry) or from foreign market as new. There are many instances that the local shipyards have done all the installation work of such ships. Shipyards like KSSL, WMSL, KSY Ltd, CDDL, DEW Ltd, ASSL, and many more are either manufacturing or buying from local component manufacturers and using those for shipbuilding successfully since decade. However, the exporter shipyards, due to the non-availability of organized components and service supply manufacturers, they have either procured form abroad or have been engaged themselves for manufacturing of the same. Manufacturing the components by the shipyards themselves sometimes hindered their mainstream work. Nowadays, some local entrepreneurs take challenge to produce some quality items.

As per local shipyards view, 25% of the total components in terms of money can be manufactured locally for a classed vessel; but for inland/coastal vessels 60% can be manufactured locally, the rest can be procured either new from foreign market or second-hand market at ship-recycling yards, at Bhitiary, Chattogram. Locally made navigational aids, search lights, electrical switchboard, firefighting

items, angle, stiffener, bar, valve, flanges, metal parts, etc can be used for class vessels. Consumables items like, electrodes, gas, acetylene, LP gas, etc. are produced by Bangladesh Oxygen Ltd and few other local manufacturers. Engine starters and batteries are locally manufactured. Some small compressors, motor, steel plate, deck equipment, capstan, winch, anchor and cable, bush for shafting propeller etc are manufactured locally. Rahim Steels Ltd. and few other manufacturers have started producing steel for class vessel, which has been certified by GL, a member of IACS. Mechanical steering gear and chain can be constructed in few local shipyards. Furniture's, fittings, fund, plywood interior decoration, galley, deck equipment, stainless steel buoy etc are constructed in most of the renowned shipyards. In 2003, Highspeed installed the cooling chamber for their fishing trawler; for which they constructed the coil, piping, trawl door, etc. They purchased the main engines, auxiliary engines, motor and pumps, rudder, rudder shaft, hydraulic steering gear, winch, marine cable etc. as reconditioned from Bhatiary ship-recycling yards. Battery, bush, stern tube, electrical wearing, gas, bollard, fairleads, all panelling in accommodations, fitting and furnishing have done by them. They purchased the net from Korea. Some leading SMEs are capable of manufacture ship components and they are producing many items for local shipbuilders. A consolidate list has been shown in annex L.

4.5.4. Proposed for Future Development

The existing component and service suppliers of Bangladesh are not yet organized and not up to the quality or standard required for class vessels with few exceptions. This is due to the fact that Bangladesh had started construction of exportable vessels recently and the requirement for components used in thousands of inland and coastal vessels registered under local regulations are not of international standard. But an interesting point is that, the experience of manufacturing of the local components, is as old as the experience of shipbuilding history and tradition in Bangladesh, which is few hundreds of years. Local Shipyards and SMEs have enough potential to contribute extensively in local shipbuilding. The local components and services that are manufacturing or can be manufactured/supplied to local shipbuilders or shipyards of Bangladesh including the exportable class vessel are: welding rod, gas, bubble plate, angle, grinding store, grinding machine, short blasting, cable, pipes, steel plates, furniture, windows, doors, insulation material, bollard & capstan, fairleads, stairs and ladders, masts, hatch cover, anchor & chain, winches, fish processing equipment, rudder, propeller, paint, flanges, manhole cover, shaft, bush, valves, pipes, pumps, electric panel and switchboard, electric cables, some electric fittings, firefighting fittings items, mechanical steering gears, small & medium gears, blocks and chain cable, some essential casting items, accommodation items, some others deck fittings.

At least 60% of the components/services required for construction of inland and coastal vessels are manufactured in Bangladesh by various SMEs that also do other types of land-based manufacturing. And the rest comes from either reconditioned market (ship-recycling) or form new procurement (foreign countries).

Bangladesh has also a good base for preparation of design, drawing, electrical, automation, system support, and construction/fabrication personnel for shipbuilding as the graduates coming from BUET, BMU, MIST, KUET, CUET, RUET, IIT, DU, NSU, Brack, Daffodils and other private and public universities are available. Some appropriate training and skill development program can convert those graduate efficient. However, the weaknesses in this respect are only lack of modern software and the effective trainers. Now existing cost distribution of various items of local and foreign components and services of a sample ship are: 60% foreign and 40% local. The existing and proposed percentages of cost of various items of local and foreign components and services of a sample combine cargo ship have been shown in Table 6.

Table 6. Percentage of cost of a sample exported ship (combine cargo-2850 DWT).

		Existing			Proposed		
Sl	Item	Total %	Foreign %	Local%	Total %	Foreign %	Local%
4.1	Design, Drawing & Classification	3	3	0	3	0	3
4.2	Steel, Cable, Paint, Component	17	17	0	17	3	15
4.3	Propulsion plant	18	18	0	18	14	4
4.4	Machinery, Equipment, and System	22	10	2	22	13	9
4.5	Labour and Manpower	15	2	13	15	0	15
4.6	Financing Cost	18	0	18	14	0	18
4.7	Overhead	2	0	2	2	0	2
4.8	Mark up and others	5	0	5	5	0	5
	TOTAL	100	60	40	96	30	71

4.6. Present State and Opportunities of the Local Shipbuilding Industry

The shipbuilding industry in Bangladesh has the potential to grow significantly and secure a small share of the global market. Bangladesh has the necessary resources to become a significant global shipbuilding nation by capitalising on its youthful and cost-effective labour force, rich maritime heritage, and abundant natural resources. The local shipbuilding industry is characterised by indigenous shipyards, a rich legacy of shipbuilding, and a large pool of young workers, all of which create significant potential for the sector to expand. Nevertheless, it faces several unique obstacles that must be addressed and harnessed to enable sustainable expansion. Bangladesh is well-positioned to develop labour-intensive heavy industries, such as shipbuilding, automobile manufacturing, food production, and mass production, owing to its large and youthful population. The primary potential and capacity are defined below:

- A significant advantage for Bangladesh is the availability of low-cost shipbuilding labour. Compared with other countries, the nation has an abundance of young, low-wage labour, and its manual welding quality and the qualifications

of welders are frequently superior to those in countries such as China, Vietnam, and the Philippines. Bangladeshi marine workers have demonstrated discipline, diligence, hard work, obedience, and rapid learning in the international labour market, including in countries such as South Korea, the Middle East, Malaysia, and Japan.

- Local shipyards receive little support from upstream and downstream industries, which provide materials and components at competitive prices. Re-rolling factories in Bangladesh produce various shipbuilding accessories using scrap metal sourced from the Bhatiary ship-recycling yards, thereby ensuring a steady and cost-effective supply of materials. Numerous SMEs are actively contributing to heavy industries such as shipbuilding by serving as critical backwards and forward linkages.
- The maritime nation of Bangladesh, with a rich history of shipbuilding, is a natural magnet for both local and foreign businesses to invest in the sector. Additionally, Bangladesh's geographic location, with its vast coastline and riverine regions, is particularly conducive to shipbuilding and other maritime operations.
- There is ample availability of semi-skilled white-collar and blue-collar workforce, including naval architects, marine engineers, electronics and IT engineers, management professionals, welders, grinders, cutters, mechanics, carpenters, painters, and helpers. With minimal training and skill development programmes, this workforce can be efficiently transformed into productive human resources for the shipbuilding sector.
- A growing number of vocational training centres and technical schools are producing trained labour for heavy industry. Shipyards such as Khulna Shipyard (KSY), BN Dockyard, Western Marine Shipyard Ltd (WMSL), Karnaphuli Shipyard and Slipway Ltd (KSSL), and Annada Shipyard and Slipway Ltd (ASSL) annually generate thousands of skilled shipbuilding workers employed in a variety of trades, including welding, cutting, painting, carpentry, blacksmithing, mechanics, and electrical works.
- Classification societies provide significant support for the development of high-quality, class-certified shipbuilding and for certifying material lists for export-oriented ship construction. Renowned societies such as Germanischer Lloyd (GL), Bureau Veritas (BV), and Nippon Kaiji Kyokai (NKK) are contributing to the development of Bangladesh's export shipbuilding capabilities.
- The cost of shipbuilding in China has increased dramatically due to the country's rising standard of living. It is anticipated that China will soon lose a portion of its share of the small- and medium-sized shipbuilding market, creating opportunities for Bangladesh.
- Policy incentives such as tax-free activities for export-oriented shipyards, simplified regulations, import taxes on foreign-built ships, strategic development plans for the local industry, river dredging, and coordinated efforts with related sectors will further enhance the growth and competitiveness of Bangla-

desh's shipbuilding industry.

- The current global financial crisis and geopolitical landscape may increase demand for cost-effective ships, presenting a favourable opportunity for Bangladesh's shipbuilding sector. The local shipbuilding sector has the potential to generate substantial foreign cash and capture a share of the global market by producing and exporting high-quality ships.
- This sector offers considerable employment opportunities. Bangladesh has an abundance of young, easily trainable workers. Through focused training and skill development programmes, this workforce can be elevated to international standards. Additionally, there is a large pool of semi-skilled white-collar manpower available across various disciplines who, with appropriate training and guidance, can become highly competent assets for the industry.
- Existing local shipyards are capable of manufacturing quality ships at competitive prices. Moreover, there is a golden opportunity to expand supporting backup industries to strengthen the local shipbuilding ecosystem, alongside developing backwards and forward linkage industries through foreign collaboration. Within the next few years, shipbuilding could become a dominant foreign currency-earning sector for Bangladesh.
- Given Bangladesh's export-import imbalance and existing export deficiency, it is essential to explore new sectors to narrow this gap. Shipbuilding offers a sustainable solution, providing access to duty-free markets in developed countries, alongside creating significant employment opportunities.
- There is strong potential for Foreign Direct Investment (FDI) in the shipbuilding sector, with countries such as China, Türkiye, the Netherlands, and Australia showing keen interest. Many foreign buyers, particularly in Europe and North America, are looking beyond China due to prevailing international tensions. These buyers often impose requirements for the use of their own equipment on ships they order, creating opportunities for Least Developed Countries (LDCs) and developing nations such as Bangladesh.
- Stakeholders, including the government, investors, shipbuilders, ship owners, and related entities, increasingly recognise shipbuilding as a promising sector, with the potential to emerge as an alternative to the Ready-Made Garments (RMG) industry in the near future.
- Discussions with focus groups indicate that Bangladesh is particularly well-suited for small and medium-sized shipbuilding. Experts believe the country has the opportunity to capture a significant share of the global market for multipurpose, container, tanker, and cargo ships in the 3000 - 20,000 DWT range. These niche markets for small and medium-sized vessels are expected to remain robust in the coming years.

Scenario-Based Estimation of Potential Shipbuilding Export Revenue

The USD 10 billion estimate is treated as a potential annual export contract value, rather than guaranteed delivered output. The calculation is based on the global shipbuilding market relevant to Bangladesh's target small- and medium-sized ves-

sel segment. Under a conservative scenario, a 2% market share would represent the lower-bound opportunity, while a 5% share represents the upper-bound scenario. Achieving the upper-bound value would require substantial expansion of shipyard capacity, investment in modern production facilities and technology, access to export and working-capital financing, competitive vessel pricing, improved labour productivity, and sufficient capacity to contract and deliver vessels within agreed construction schedules. Therefore, the USD 10 billion figure should be interpreted as a scenario-based potential, not a guaranteed annual export outcome.

4.7. Constrain and Future Challenges of Local Shipbuilding

Shipbuilding is typically a labour-intensive, low-tech industry. Since 1950, high-tensile, tough steel with excellent physical and chemical properties has been introduced into ship construction. Modern shipbuilding showcases superb aesthetics and fine craftsmanship (Stopford, 2009). Today's shipbuilding employs extensive automation, advanced technology, and line production methods, supported by a skilled workforce. Modern shipbuilding heavily relies on prefabricated blocks or modules, in which entire multi-deck sections of the hull are built elsewhere in the yard, transported to the assembly area, and then lifted into place to complete fabrication. This approach is well known as block or module construction (Hossain, 2018a). Modern shipyards pre-install equipment, pipes, electrical cables, and other components within blocks or modules to simplify installation within the hull, which is then welded together. Naval architecture and ship design are supported by model testing in towing tanks or basins. The upcoming Fourth Industrial Revolution (4IR) will significantly impact the maritime sector, making the new transformation in shipbuilding especially crucial. An analysis of the local shipbuilding industry reveals several key findings.

- Bangladesh boasts a rich and historic shipbuilding and maritime tradition. It aims to motivate local entrepreneurs and foreign investors to invest in this sector, thereby generating foreign currency for the national economy.
- Approximately 40,000 inland and coastal ships, along with around 100,000 mechanised country-boats and trawlers, operate across the country. These vessels transport over 85% of oil products, 75% of cargo, and 25% of passengers. All of these ships and boats are built and maintained in local shipyards.
- Bangladesh has approximately 100 indigenous shipyards, employing over 200,000 skilled and unskilled workers in shipbuilding.
- Approximately 2,000,000 people are either directly or indirectly involved with shipbuilding.
- There are four local shipyards capable of constructing export-quality ships of small and medium sizes (10,000 dwt). Several other shipyards are in the process of developing their facilities and increasing capacity to enter the export market.
- The tentative size of the global shipbuilding market is USD 200 billion, with

the small shipbuilding market valued at USD 20 billion. The world will require a few thousand ships, mostly small to medium in size. The old single-hall tanker, including other ships, will soon be replaced due to IMO regulations. There is also significant demand for containers and other ships.

- The government allocates less than 5% of the Annual Development Programme (ADP) to waterways and water transport, whereas more than 70% is dedicated to roads. A mindset in favour of waterways development and transportation will enhance local shipbuilding.
- Local shipyards tend to have a negative attitude and are often hesitant to enhance quality, health, safety, and environmental (QHSE) standards. However, government pressure, demands from foreign buyers, and increased awareness and training programs on QHSE can help elevate local shipyards to meet international standards.
- Local private shipyards are often hesitant to adopt a corporate management style, as family members tend to hold key managerial positions. This family-centric management approach acts as a barrier to the shipbuilding industry's growth. For instance, ASSL was unable to sustain its success in the ship export market due to this familial management culture.
- Individuals must alter their mindset regarding the pursuit of wealth through expedient means. It is essential to prioritise sustainable development and well-being. WMSL has not sustained its success in ship exports due to competing investments.
- Local shipyards lack a corporate management culture. The shipbuilding workforce exhibits low job satisfaction because they do not receive industrial benefits, such as production bonuses, fringe benefits, or welfare benefits, including medical, pension, travel allowances, and compensation. Owing to the availability of cheap labour, local owners do not prioritise creating a healthy work environment or ensuring employee welfare. Consequently, many graduates and skilled workers leave the shipyards to seek opportunities abroad.
- The additional financial cost of local shipbuilding ranges from approximately 10% to 20%, which is higher than that of competing nations such as China, Korea, Japan, India, and Vietnam.
- High costs and inconsistent electricity and gas supplies, along with other inadequate infrastructure, are major barriers to the smooth growth of the shipbuilding industry.
- Weak state diplomacy, a poor national image, and limited efforts to promote local shipbuilding are hindering the growth of export shipbuilding.
- Local shipbuilding remains vulnerable and requires numerous improvements for sustainable development and meeting international standards. If this sector receives facilities comparable to those provided to RMG, the overall benefits could surpass those of RMG.
- The productivity of local shipbuilding labour is quite low, but the average hourly wage is very inexpensive, resulting in the lowest relative labour wage in

the world.

- The present government has taken some steps and drafted a shipbuilding policy aimed at improving the shipping and shipbuilding sectors overall. Before implementing the policy, it is important to conduct a proper evaluation and establish clear priorities to ensure that both public and private shipyards benefit equally.
- Previously, the cost of shipbuilding in China was more economical. However, currently, owing to improved living standards, labour wages have risen. It is predicted that, in the future, China will relinquish a portion of its small- and medium-sized shipbuilding market share, creating a niche market opportunity for our local industry.
- Recently, there has been an opportunity for FDI in the shipbuilding sector. Countries like China, Türkiye, and the Netherlands are actively interested in investing. Establishing an export shipyard zone dedicated to export shipbuilding could significantly promote healthy growth in the local shipbuilding industry.
- Small and medium-sized containers, tankers, cargo ships, multipurpose vessels, and other specialised ships with 3000 to 20,000 DWT are suitable for Bangladesh. The country has the potential and capacity to enter this niche market competitively.
- Bangladesh has the potential and capacity to capture 5% of the global market share by 2030, worth approximately USD 10 billion.

Relying solely on cheap labour is not sufficient for the sustainable development of the shipbuilding industry. While advanced technology can reduce costs, overdependence on labour costs alone risks undermining our competitiveness. Bangladesh has the potential to achieve significant economic growth by properly supporting and leveraging its export-oriented shipbuilding sector. Local entrepreneurs are confident in the industry's promising prospects. Bangladesh benefits from its long maritime history, advantageous geographical location, and access to affordable labour. As a global industry, export-driven Bangladeshi ships of international standards are approximately 10% to 30% cheaper than those built in Japan, Korea, China, Vietnam, or India (Hossain, 2018b). Recently, the influence of Industry 4.0 (4IR) and smart technology has been widely discussed. The first industrial revolution used water and steam-powered machinery. The second introduced electrically powered mass production, while the third brought electronic and IT advancements to automate manufacturing (Wikipedia, 2022). In contrast, 4IR involves complex digitisation that merges the cyber and physical worlds, incorporating AI, ML, DL, Blockchain, Digital Twin, IoT, big data analytics, cloud computing, virtual and augmented reality, simulation, human-machine interaction, 3D printing, and advanced materials technology (Hossain, 2025b). Cheap labour and a young population alone do not determine a nation's industry for development and sustainable growth. The key factors are productivity and a skilled workforce. If we don't develop and transform our young people into a ca-

pable human resource, we will lose both the opportunity and the development trajectory.

The Sixth-generation (6GP) massive ports capable of managing 50,000 TEU megaships with a 20-meter draft, equipped with advanced automation and strong hinterland connections, will become operational very soon (Michael, 2010). The ship, shipping, and shipbuilding sectors are set to become more advanced and intelligent in the near future. The primary aim of the Fourth Industrial Revolution (4IR) is to develop smart shipyards that are not only adaptable, resource-efficient, and ergonomic but also feature close collaboration among ship owners, shipbuilders, suppliers, and other stakeholders involved in business and value processes. Again, without adopting smart technology and advanced ship design and manufacturing processes, we will fail to produce ships that meet global standards for safety, quality, and customer satisfaction in a competitive market. This sector needs to be balanced for substantial growth and to capture a larger share of the global market through effective strategies, planning, government support, appropriate capital investment, strict discipline, the development of a skilled workforce, and the adoption of smart technology to address future challenges. The global shipbuilding market is estimated at around US$200 billion, with the small-ship segment valued at US$20 billion. However, local shipbuilding must be carefully guided and balanced to achieve significant development and gain a share of the global market through feasible strategies, affordable planning, ongoing government support, proper capital investment, strict discipline, and a skilled labour force ready to face upcoming challenges.

4.8. Key Findings and Recommendation

Shipbuilding has traditionally been a labour-intensive, low-tech industry. However, since the 1950s, the development of high-tensile, tough steel with enhanced physical and chemical qualities has revolutionised ship construction (Stopford, 2009). Modern shipbuilding combines high-quality aesthetic finishes with precise craftsmanship. It now features extensive automation, cutting-edge technologies, and line production methods, all supported by a skilled workforce. Today, shipyards widely use block or module construction, in which large multi-deck sections are prefabricated off-site, transported to the dock or slipway, and assembled to complete the build (Hossain, 2018a). These modules come pre-equipped with systems, pipes, and electrical cables, minimising installation work after assembly. Ship design and naval architecture are also enhanced through model testing in towing tanks or basins. The advent of the 4IR is set to significantly reshape the maritime industry, including shipbuilding.

- Bangladesh has a rich and storied maritime and shipbuilding tradition that attracts local entrepreneurs and foreign investors alike, allowing the country to generate substantial foreign currency from this sector.
- Approximately 40,000 inland and coastal ships, along with about 100,000 mechanised country boats and trawlers, operate across the country, transport-

ing over 85% of oil products, 75% of cargo, and 25% of passengers. All these vessels are built and maintained in local shipyards.

- Around 100 indigenous shipyards is employing more than 200,000 skilled and unskilled workers.
- Approximately 2 million people are directly and indirectly involved in shipbuilding activities.
- Four local shipyards are capable of building small to medium export-quality ships (up to 10,000 dwt), while several additional yards are upgrading their facilities to participate in the export market.
- The present global shipbuilding market is valued at approximately USD 200 billion dollars, including the small ship sector alone representing USD 20 billion. Same global shipbuilding market will be approximately USD 500 billion dollars, including the small ship sector alone representing USD 50 billion within 2035.
- The government allocates less than 5% of the Annual Development Programme (ADP) to waterways and water transport, whereas over 70% is dedicated to roads.
- Local shipyards frequently show hesitation in enhancing Quality, Health, Safety, and Environmental (QHSE) standards. To raise these standards to meet international levels, it is essential to have government pressure, requirements from foreign buyers, and increased awareness and training programs.
- Private shipyards typically lack a formal corporate management culture. Management tends to be family-led, which hampers professional growth. For example, ASSL faced difficulties sustaining its export success due to family-centric management practices.
- A mindset focused on "getting rich quickly" hampers sustainable growth. For instance, WMSL was unable to sustain its export success due to shifts in investment focus.
- Shipyard workers often experience low job satisfaction. They lack industrial benefits such as production bonuses, fringe benefits, and welfare facilities, including medical care, pensions, travel allowances, and compensation. Owners overlook employee welfare because of the availability of cheap labour, which leads skilled graduates and trained workers to seek employment abroad.
- Local shipbuilding costs are 10% - 20% higher compared to competitors like China, Korea, Japan, India, and Vietnam.
- High costs, combined with unreliable electricity and gas supplies and poor infrastructure, hinder steady industrial growth.
- Weak state diplomacy, poor country branding, and inadequate promotional efforts impede growth in export shipbuilding.
- The sector continues to be vulnerable and needs substantial interventions to reach sustainable development and align with international standards. With support similar to that provided to the RMG sector, shipbuilding could yield even greater net benefits.

- Despite having the lowest relative labour wages globally due to cheap hourly rates, workforce productivity remains low.
- The government has drafted a shipbuilding policy aimed at enhancing the sector. However, its implementation should include proper evaluation and consistent prioritisation to ensure that both public and private shipyards benefit equally.
- As living standards improve in China, rising labour wages are likely to reduce some of its small and medium shipbuilding market share, creating an opportunity for Bangladesh.
- Recent FDI opportunities have arisen, with countries such as China, Türkiye, and the Netherlands showing increased interest. Creating dedicated export shipyard zones could foster sustainable growth. In the coming years, thousands of ships ranging from small to medium in size will be needed, driven by IMO regulations that mandate the replacement of old single-hull tankers and by the rising demand for container ships.
- Bangladesh is well-suited for building small to medium-sized container ships, tankers, cargo vessels, multipurpose ships, and specialised ships (3000 - 10,000 dwt), with strong potential to compete in this niche market.
- Bangladesh needs to develop/set-up new shipyards with higher capacity (around 50,000 DWT) in the area near Matar-Bari, Chattogram and near Payraport, Patuakhali. That can be joint venture with suitable countries around the globe.
- By 2035, Bangladesh can capture 2 to 5% of the global shipbuilding market, valued at about 10 billion USD. And nation has all potential to earn the amount from global share.

Cheap labour alone cannot guarantee the sustainable growth of the shipbuilding industry. While historically low labour costs have given a competitive advantage, adopting advanced technologies is now essential for lowering costs and staying competitive globally. Relying too much on cheap labour threatens Bangladesh's standing in the global market, especially as other shipbuilding nations continue to implement automation and smart technologies. Bangladesh has great potential for economic growth through the proper development and use of its export-focused shipbuilding sector. Entrepreneurs remain optimistic about the bright future of local shipbuilding, drawing on the country's rich maritime history, strategic location, and abundant workforce. Export-oriented shipbuilding is fundamentally a global industry. Ships built in Bangladesh, following international standards, are about 10% to 30% cheaper than comparable vessels built in Japan, Korea, China, Vietnam, or India (Hossain, 2018b). However, maintaining this advantage requires technological adaptation. The influence of the Fourth Industrial Revolution (4IR) has become a key topic in the maritime and manufacturing industries. The first industrial revolution introduced water and steam-powered mechanical manufacturing; the second employed electrically powered mass production; and the third integrated electronics and IT for automation (Wik-

ipedia, 2022). In the context of the 4IR, the strategic focus must shift from general digitisation to "Digital Product Passports (DPP)" backed by Blockchain technology. For Bangladesh's ship recycling industry, implementing a blockchain-based traceability system for hazardous materials (HazMat) will provide immutable proof of compliance with environmental regulations. This transparency is the key to gaining the trust of international shipowners and transforming the industry's image from "dirty" to "sustainable and compliant" (Hossain, 2025b). Therefore, low-cost labour and a large, young population are no longer enough to drive industrial growth. Efficiency and a skilled workforce are essential. If Bangladesh does not develop its young people into a skilled labour pool, it risks missing out on a vital chance for economic progress and falling behind in global development.

The concept of 6th Generation Ports (6GP), capable of handling megaships carrying up to 50,000 TEUs with a 20-meter draft, is nearing operational readiness. These ports leverage advanced automation and have strong hinterland connectivity. The entire maritime industry—including ships, shipping, and shipbuilding is poised to become significantly more advanced and intelligent. The main aim of the Fourth Industrial Revolution (4IR) in shipbuilding is to create smart shipyards that are adaptive, resource-efficient, and ergonomic, while also fostering close collaboration among ship owners, shipbuilders, suppliers, and other stakeholders in business and value chains. Without adopting smart technologies and advanced ship design and construction methods, Bangladesh will face difficulties producing ships that are competitive on the international market, ensuring safety, quality, and customer satisfaction in an increasingly competitive market. To achieve substantial growth and secure a significant share of the global market, the sector requires a balanced, strategic approach. This encompasses viable strategies and realistic planning, continuous government support and capital investment, stringent operational discipline, workforce development, and the integration of smart technologies to address future challenges. The global shipbuilding market is estimated at approximately USD 500 billion, including the small ship segment valued at USD 50 billion within 2035. To realise this potential, the local shipbuilding industry must be properly guided and managed. Sustainable development and increased global market share will depend on coordinated efforts, strategic investments, technological advancements, and human resource development. Bangladesh has all potential to capture 2% to 5% of global share and to earn about 10 billion USD from global shipbuilding.

5. Discussion

The findings indicate that Bangladesh has a realistic opportunity to strengthen its position in the international shipbuilding market, particularly in the small- and medium-sized vessel segment. The country benefits from a young and comparatively low-cost workforce, an established shipbuilding tradition, approximately 100 local shipyards, and experience in constructing vessels for domestic and export markets. However, these advantages are constrained by low labour produc-

tivity, limited technological capability, weak backward and forward linkages, inadequate financing, and insufficient adoption of advanced production systems. Labour cost remains an important competitive advantage, but the results suggest that low wages alone cannot ensure international competitiveness**.** The study reports substantially lower labour productivity in Bangladesh than in leading shipbuilding countries, indicating the need for systematic training, process improvement, modular construction, lean production, and automation. This is consistent with the broader shipbuilding literature, which identifies productivity, technological capability, skilled human resources, infrastructure, financing, and industrial linkages as major determinants of competitiveness (Stopford, 2009; Hossain et al., 2010).

The study also demonstrates the importance of developing domestic supply chains. Greater participation of SMEs and local component manufacturers could increase domestic value addition and reduce dependence on imported materials, machinery, and equipment. At present, weaknesses in backward and forward linkages remain a major constraint to sustainable industrial development. Strengthening local supplier networks, classification capability, technical training, and access to finance would therefore improve both cost competitiveness and export readiness. Technological upgrading is another critical requirement. Modern shipbuilding increasingly depends on digitalisation, automation, artificial intelligence, IoT, digital twins, and data-driven production management. The findings suggest that Bangladesh should adopt these technologies progressively rather than attempting immediate full automation. Such an approach could improve productivity, quality control, safety, production scheduling, and delivery performance while maintaining the benefits of a labour-intensive production system.

Finally, the projected USD 10 billion export opportunity should be interpreted as a scenario-based potential rather than a guaranteed annual export outcome. The manuscript appropriately frames this estimate as a potential annual export contract value and links the 2% - 5% market-share scenario to expanded shipyard capacity, modern technology, competitive pricing, export financing, improved productivity, and timely delivery. Therefore, Bangladesh's transition toward a competitive shipbuilding-export industry will require coordinated government policy, long-term investment, workforce development, technology adoption, stronger industrial linkages, and access to international markets. These measures would allow the country to convert its existing cost and workforce advantages into sustainable productivity and export competitiveness.

The global shipbuilding industry is versatile. The global shipbuilding market is highly dynamic and frequently fluctuates due to its nature and interrelationships with other trades. Research data collection has been more severely constrained by the limited availability of local sources and availability in secondary sources. The study and analysis have been mainly focussed to merchant ships, and has limited excess to the warship and other specialized segment. Such study requires huge and accurate information; which is a costly matter. To counterbalance these limita-

tions, available and accessible resources, such as information gathering from FGD, interviews, discussions with resource personnel's, publications and online information, have been utilised in this research. Again, there is minimal research on the local shipbuilding industry, and little original work has been conducted on this subject. Analysis and appropriate evaluation using comprehensive global and local shipbuilding market data, along with the preparation of an appropriate regression model, would yield better results. However enough effort has been taken to minimise the limitations with the help of FGD and resource personnel. Author acknowledges all the contributors and participants who have given their valuable idea, concept, view, etc. during FGDs, interviews and discussions both from home and from abroad.

6. Conclusion

Shipbuilding is a heavy industry involving shipyards, marine equipment manufacturers, skilled workers, service providers, and supporting institutions. Historically, the UK dominated global shipbuilding, followed by the USA, Japan, South Korea, and China. Bangladesh has a long shipbuilding tradition, but its modern industry remains at an early stage, with limited technological capability, weak industrial linkages, and limited integration into global markets. Strategic foreign collaboration and coordinated policy support are therefore essential for industrial upgrading. Bangladesh has significant potential to expand its shipbuilding industry and participate in the growing global market. The sector benefits from relatively low-cost labour, maritime heritage, geographic advantages, and experience in producing small and medium-sized vessels. However, achieving substantial export growth requires skilled workforce development, technological upgrading, improved infrastructure, financing, stronger supplier linkages, and compliance with international standards. The previously stated USD 10 billion export potential should be treated as a scenario-based estimate, dependent on future market share and expanded production capacity. The government should support the sector through appropriate investment, policy incentives, foreign partnerships, and development of export-oriented shipyard facilities. Adoption of digitalization, robotics, IoT, AI, and other smart technologies can improve productivity and competitiveness. A phased, partnership-driven strategy focusing on capacity expansion, technology, skills, financing, safety, and global market integration is essential for sustainable growth of Bangladesh's shipbuilding industry.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Appendix A. Questionnaires for Workforce Job Analysis

General Information:

1. Name:
2. Name of Shipyard:
3. Address of Shipyard:
4. Job Title:
5. Type of Employment:
6. Duration of Employment:
7. Education:
8. Training:
9. Experience:
10. How did you learn your Profession/Skill:
11. Language Skill:
12. Any Specialisation:
13. Marital Status:
14. Sex:
15. Age (Years):
16. Position/Grade in the organization (first appointment):
17. Position/Grade in the organization (at present):
18. Income Per Hr in Taka/USD:
19. Income Per Day in Taka/USD:
20. Work per week in hr:

Job Information:

	What are your opinions of:	Good	Satisfactory	Needs Improvement	Not Apply
1.	About your job				
2.	About your appointment				
3.	About your employee				
4.	About job environment				
5.	About your salary				
6.	About your working time				
7.	About your welfare				
8.	About your motivation				
9.	About other benefit				
10.	About your medical facilities				
11.	About your job safety				
12.	About your personal safety				
13.	About working environment				
14.	About discipline				
15.	About employee behaviour				
16.	About your belongingness to organization				

Continued

17.	Are you looking for better opportunity?	Yes	No
18.	Does the organization have maintained carrier plan for worker?	Yes	No
19.	Do they give any punishment or reward for your performance	Yes	No
20.	Do you feel that your organization will go ahead?	Yes	No

Appendix B. Questionnaires for Workforce Perform Analysis

General Information:

1. Name:
2. Name of Shipyard:
3. Address of Shipyard:
4. Job Title:
5. Type of Employment:
6. Duration of Employment:
7. Education:
8. Training:
9. Experience:
10. How you learn your Profession/Job:
11. Language Skill:
12. Any Specialization:
13. Marital Status:
14. Sex:
15. Age (Years):

Other Information:

16. Is it your 1st Job?
17. How frequently you change organization?
18. Monthly income at present position (in thousand Taka):
19. No of person(s) depends on your income including you:
20. How many hour/days you work?
21. How many hour/weeks you work?
22. How many day/months you work?
23. How many day/years you work?
24. What is your usual income/hour?
25. What is your income/day?
26. What is your income/week?
27. What is your income/month?
28. Do you have any kind of benefit or bonus?
29. Do you have any other income?
30. Do you get any medical/other allowance?
31. Do you receive any other welfare?
32. Do you receive any training by the organization?
33. Do you have job security?

Appendix C. Questionnaires for Shipyard Owners' Performance Analysis

General Information:

1. Name:
2. Name of Shipyard:
3. Address of Shipyard:
4. Position:
5. When you start this Shipyard:
6. Joint Adventure:
8. Family Initiative:
7. Education:
8. Technical Education:
9. Previous Experience:
10. How you start your business:
11. Language Skill:
12. Any Specialization:
13. Marital Status:
14. Sex:
15. Age (Years):
16. No of total partner:
17. Starting Capital (in Taka):
18. Present Capital (in Taka):

Local Shipyard/Business Information:

19. Year in Established?
20. Year in Production?
21. Type of Shipyard:
22. Capability:
    No of Yards:
    Size of Yards:
    Capacity/Yards (in DWT):
    Design and building:
    Other Facilities:
23. Financial:
24. Total manpower: Technical: Administrative: Others:
    Permanent: Temporary: Total:
25. Labor/Worker (in Number):
    Skilled:
    Semi-skilled:
    Unskilled:
26. Payment pattern:
    Hourly Daily Weekly Monthly
27. Usual Payment for different types of labour (in Taka/Hour):
    Skilled:

Semi-skilled:

Unskilled:

28. Usual total working hour/day (in hour):
29. Usual total working hour/week (in hour):
30. Labor Turnover rate (in percentage):
31. Any Labor Union?
32. Any Labor Complain Handling System?
33. Bonus/Other benefit:
34. Any Motivational System:
35. Any Punishment/Reward System:
36. Any Carrier Planning:
37. Any Employee Welfare System:
38. Job Security Plan:
39. Govt Rules/Regulations:
40. Implement of Govt Regulations:
41. Govt Subsidy Needed:
42. Review of Govt Rules/Regulation:
43. Ship Building Monitoring:
44. Performance of DOS:
45. Performance of BIWTA:
46. Types of Ship New-build in this Shipyard:
47. Last year Ship New-build (in no):
48. Types of Ship Repair in this Shipyard:
49. Last year Ship Repair (in no):
50. Annul Turn-over (Crore Taka):
51. Organization is in Profit:
52. Working environment:
53. Job environment:
54. Any future Training Planning:
55. Any future planning for employee Motivation:
56. Any future planning for employee Welfare:
57. Future Plan: Expansion Downsizing
58. Standard of Local Labor:
59. Quality of Local Work:
60. Performance of Local Shipbuilder:
61. Shipbuilding Quality:
62. Standard of Local Ship Survey:
63. Standard of Supervisory Panel:
64. Standard of Local Ship Inspection:
65. How many Local Shipyards already gained International Standard?
66. How many Additional Shipyards will be gained International Standard?
67. Local Shipbuilding Potentiality:
68. Future of Shipbuilding Industry of Bangladesh?

69. View of International Ship Owner:
70. What is suitable types, size, and market for local Shipbuilding?
71. Effect of World Recession on Local Shipbuilding Industry?
72. Comment on Shipbuilding Strength of Bangladesh?
73. Comment on Shipbuilding Opportunity of Bangladesh?
74. What are the main Weaknesses of the Local Shipbuilding Industry?
75. What are the Future Threats of the Local Shipbuilding Industry?

Appendix D. Questionnaires for Surveyor, Official, Expert, Academician, Stakeholder Shipbuilding Assessment

General Information:

1. Name: .....
2. Name of the Organization: .....
3. Address of Organization (local office): .....
4. Position:
5. When you join in your appointment:
7. Education:
8. Technical education:
9. Previous experience:
11. Language Skill:
12. Any Specialization:
13. Marital Status:
14. Sex:
15. Age (Years):

Local Shipbuilding Information:

16. Type of survey:
17. Your survey performance?
18. Problem faced by you?
19. Any suggestion?
20. Govt rules/regulations:
21. Implementation of Govt rules/regulations:
22. Govt subsidy needed:
23. Review of Govt rules/regulation:
24. Ship building monitoring:
25. Performance of DOS:
26. Performance of BIWTA:
27. Working environment:
28. Standard of local labour:
29. Quality of local work:
30. Performance of local shipbuilder:
31. Standard of local ship surveyor:
32. How many local shipyards have already gained an international standard?
33. Effect of world recession on local shipbuilding?
34. Comment on the shipbuilding potential/strength of Bangladesh?
35. Comment on the shipbuilding prospect/opportunity of Bangladesh?
36. What are the main problems/weaknesses of the local shipbuilding?
37. What are the future challenges/threats of the local shipbuilding?
38. Any suggestion/comment on DOS?
39. Any suggestion/comment on BIWTA?
40. Any suggestions for local shipbuilding improvement?

41. How local shipbuilding/repairing facility be improved?
42. Any suggestions for the government?
43. What are the suitable types, size, and market for local Shipbuilding?