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MESSAGE FROM THE CHIEF OF NAVAL STAFF

‘Bismillahir Rahmanir Rahim’

I am pleased to note that the publication of "Navy Journal 2026" continues to uphold and enrich the proud intellectual tradition of Bangladesh Navy. Over the years, this journal has emerged as a reputed and credible platform where officers articulate their professional insights, strategic analyses and reflect on the increasingly complex and dynamic maritime domain. The thoughtful and scholarly contributions featured in this edition once again show the depth, creativity and professionalism of our naval leaders.

As Bangladesh steadily advances towards its vision of a prosperous and resilient maritime nation, Bangladesh Navy remains at the forefront of safeguarding national maritime interests. In the year 2026, we need to pursue achieving new milestone in our ongoing transformation, driven by technological innovation, strategic foresight and unwavering commitment to national development. Our enhanced operational capabilities, induction of modern platforms and development of skilled manpower clearly demonstrate a force prepared to address evolving challenges, be it the protection of sea lines of communication, conduct of humanitarian assistance and disaster response operations or promotion of stability in the Bay of Bengal and beyond through maritime diplomacy.

In an era increasingly shaped by climate change, cyber threats and non-traditional security challenges, it is evident that strength is derived not only from ships and systems but also from intellectual capacity, adaptability and professional thoughts. The research, analyses and reflections presented in this volume will serve as valuable guideline for younger officers who aspire to develop into professional and forward-looking naval leaders.

Bangladesh Navy continues to broaden its role beyond conventional defence responsibilities. Our contributions to blue economy initiatives, maritime diplomacy, disaster response and regional cooperation reflect a comprehensive vision focused on peace, stability and shared prosperity. Through professionalism, preparedness and partnership, Bangladesh Navy is steadily strengthening its position as a responsible maritime force committed to safeguarding national interests while contributing to regional and global harmony.

I take this opportunity to convey my sincere appreciation to the editorial board, contributors and all those who have worked diligently to bring out this edition of Navy Journal 2026. Their dedication and intellectual effort have ensured that this publication remains a valuable repository of professional knowledge. I am confident that the ideas presented herein will continue to inspire critical thinking and support the professional growth of our officers.

May this edition serve as a beacon of continuous learning and innovation and inspire all naval personnel to pursue excellence in thought and action. Let us remain united in purpose and steadfast in our devotion to the Navy and the Nation.

May Allah bless Bangladesh Navy with strength and success in all its noble endeavours.

M NAZMUL HASSAN
Admiral
Chief of Naval Staff

EDITORIAL

The publication of Navy Journal 2026 marks yet another milestone in our ongoing journey to bridge the rich legacy of naval knowledge with the contemporary demands of naval research and intellectual exploration. This issue reflects the collective effort and dedication of our esteemed contributors, whose shared knowledge strengthens the naval community. It is a privilege to be part of a publication that showcases the intellectual strength of our naval officers.

Navy Journal 2026 upholds a proud legacy of excellence by presenting a thoughtfully curated collection of articles that reflect the dynamic and evolving landscape of naval affairs. This edition explores a wide range of subjects, from operational strategy and advanced technology to reflective perspectives on naval leadership. Drawing on the officers' deep professional insight and field experience, the journal continues to serve as a valuable reference for both experienced practitioners and emerging leaders.

Innovation and forward thinking are central to this edition, as contributors thoughtfully blend rigorous research with creative vision to present original ideas that inform and inspire. Each article has undergone a meticulous editorial review to ensure clarity, relevance, and academic integrity. This journal is the result of the dedicated efforts of our editorial board and contributors, whose commitment has shaped a comprehensive and thought-provoking publication. While every effort has been made to maintain accuracy and quality, we sincerely welcome readers' feedback and constructive suggestions as part of our ongoing pursuit of excellence.

In addition to the academic and intellectual content, 'Navy Journal 2026' also serves as a platform for reflecting on the challenges and opportunities that lie ahead for the naval profession. The themes discussed in this edition offer valuable insights into the future of naval strategy, innovation, and leadership. They serve as a call to action for all naval officers to remain vigilant, adaptive, and committed to the pursuit of excellence, both on and off the battlefield.

We extend our deepest gratitude to the Chief of Naval Staff and the Chief Patron for their continued support and guidance. Their leadership ensures that the 'Navy Journal' remains a beacon of knowledge and a vital instrument for intellectual growth within the naval community. We also express our sincere thanks to all contributors, whose unwavering dedication has brought this publication to life.

May Allah's mercy guide us as we continue to serve our nation and our Navy, upholding the values of professionalism, integrity, and dedication. We look forward to another year of continued growth and innovation in our beloved naval profession.

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EVALUATION OF PRESENT STATUS OF LOCAL SHIPBUILDING IN DUSTRY AND MAJOR CHALLENGES

Rear Admiral Khandakar Akhter Hossain, NBP, NUP, ndc, psc, PhD

Abstract

The shipbuilding industry is considered as one of the most profitable and sustainable industries around the globe. Shipbuilding has long been an appealing industry for many develop and developing countries like Japan, South Korea, and China. Historically, this sector has lacked strong global regulation and often faced problems of over-investment, as it involves diverse technologies, stimulates numerous backward and forward linkage industries, creates significant employment opportunities, generates income, and remains global in nature. Such patterns have been evident among all major shipbuilding nations throughout history. Today, China is the global shipbuilding market leader. Bangladesh, endowed with its traditional shipbuilding expertise and glorious history, progressed to become a small but competitive player in the global market, though it could not sustain its momentum. The global shipbuilding industry is projected to reach approximately USD 200 billion soon and Bangladesh holds the potential to secure at least USD 4 billion of this market share. By addressing challenges such as low productivity, the need for advanced technology integration, and safety standards, Bangladesh's shipbuilding sector can significantly enhance its international competitiveness and contribute meaningfully to national development and economic growth. This study evaluates the status of local shipbuilding by depicting the challenges within the context of global trends, technological progress, and future market share.

Key Words: Local shipbuilding, global market, smart technology, AI

Introduction

Ship is the main mode of transportation and shipbuilding is the integral part of development for many nations. Shipbuilding is an ancient industry engrossed on constructing ships and various floating structures. These activities typically ensue in facilities equipped with heavy machinery installations,

known as shipyards or dockyards. The sector encompasses designing and building both ocean-going and inland ships and vessels (Hossain, 2015). Today, in modern ports are now highly advanced, integrating smart technologies to enhance their services and operations. They utilize digital, computerized, and cutting-edge tools such as artificial intelligence (AI), machine learning (ML), deep learning (DL), the Internet of Things (IoT), big data, blockchain, and automation to streamline management processes and reduce environmental impact (Hossain, 2024d) in port, shipping, and shipbuilding industry. Technologies like AI and ML can optimize logistics by processing data from numerous sources, including shipping schedules and cargo information. Smart technologies also automate numerous tasks, significantly decreasing manual labour requirements and boosting overall efficiency (Hossain, 2025b). Moreover, these technologies assist in better design and construction processes, detecting anomalies and predicting potential incidents, which enhance safety, security, and compliance with global standards (Hossain, 2024a, 2025a). By optimizing operations and production costs, smart technologies reduce resource consumption, minimize downtime, ensure safety, improve quality, and ultimately lower expenses. Additionally, they contribute to sustainable shipbuilding by optimizing 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 such as sensors, data analytics, augmented reality, big data, digital twins, blockchain, and automation to enhance production timelines with quality assurance, reduce waste and emissions, and provide better service to customers, local communities, and stakeholders (Hossain, 2024e). The economic gains are largely derived from supply chain dynamics, timely delivery, and maintaining quality standards rather than solely internal activities. Thus, ensuring quality assurance, adhering to safety standards, delivering on time, providing after-sales service, and maintaining goodwill are crucial for national competitiveness and the sustainable advancement of the shipbuilding industry. Modern shipyards increasingly adopt renewable energy, sustainable methods, and smart

technologies to minimize environmental impacts while ensuring sustainable growth and maximizing profits. Smart shipbuilding and port systems are also designed for greater integration with logistics and industrial networks (Brookings, 2024). By employing advanced technologies in this sector, it enhance the movement of goods, streamline production processes, and improve information flow and workforce coordination within the broader supply chain. Furthermore, these industries embrace an open innovation approach, allowing continuous improvements in design, operations, construction, production, safety, and efficiency by incorporating new technologies and ideas (Hossain, 2024e). On the other hand, cyberattacks 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).

The global shipbuilding market suffers from inflation, geopolitical situation, over-capacities, depressed prices low profit margins, trade distortions, widespread subsidization, war crisis, and many more in this decade. 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—particularly China, South Korea, and Japan—have maintained their leadership in shipbuilding due to several inherent advantages (Hossain K, 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. The vision of the Fourth Industrial Revolution (4IR) and smart shipbuilding focuses on developing intelligent shipyards characterised by adaptability, resource efficiency, ergonomic design, and close integration among all stakeholders (Andi Reni et al., 2020). For the local shipbuilding industry to achieve substantial growth, it requires a balanced approach that includes strategic investments, government backing, adoption of smart technologies, and development of a skilled workforce to address future challenges. This analytical study evaluates both local and global shipbuilding trends, assesses the future of the domestic industry based on potential and challenge analysis, technological advancement, and market predictions. The research draws from primary data and secondary sources, incorporating insights from relevant stakeholders, literature, and academic journals.

Shipbuilding History and Global Trend

Historically, shipbuilding has faced challenges due to the lack of global regulation and a tendency for over-investment, as shipyards encompass various technologies, employ enormous 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). Following WWII, Japan utilised shipbuilding during the 1950s and 1960s to reconstruct its industrial base. Subsequently, South Korea made shipbuilding a strategic industry in the 1970s, and later, China adopted similar approaches by implementing large-scale state-supported investments in shipbuilding. Since WWII, shipbuilding has grown into a significant and strategic global industry, especially in certain South Asian countries (Hossain, 2017). Currently, the global shipbuilding market is challenged by inflation, geopolitical tensions, excess capacity, low profit margins, market distortions, and persistent subsidization. Reviewing the global industry trend reveals that Japan dominated shipbuilding in the 1960s but slowly lost its edge to South Korea, which has benefited from lower wages, strong government support, and a weaker currency, and overtaking Japan in ship production by 2003. From 2009 onwards, China emerged as the global leader in shipbuilding, surpassing both Korea and Japan due to robust state support and favourable government policies (Hossain, 2017).

The middle-class populations of Asia and Africa are growing rapidly in the 21st century. Concurrently, labour costs in China's shipbuilding sector have increased significantly in recent years. As a result, China is expected to reduce its market share in small and medium-sized container ships, cargo vessels, tankers, and multi-purpose ships within this decade. This shift creates opportunities for emerging shipbuilding nations such as Vietnam, the Philippines, India, Bangladesh, Brazil, and Turkey (Hossain K, 2024b). Notably, indigenous shipbuilding in this region has a rich and illustrious history. Bengal is recognized as an early centre for shipbuilding, rooted in its traditional boat construction practices (Banglapedia, 2003)). The renowned traveler Ibne Batuta visited Bengal in the 14th century and returned with a wooden ship built at a shipyard in Sonargoan, Dhaka, and some of his ships are

still preserved in European museums. European traveller Mr. Caesar Frederick observed that Chattogram was a major hub for constructing ocean-going ships in the mid-15th century (Hossain et al., 2010). During the 17th century, a fleet of ships was built in Chattogram for the Sultan of Turkey. Under Mughal rule, Chattogram produced numerous warships for the Mughal naval forces. Furthermore, the British Navy deployed wooden-hull warships built in Chattogram, including those used successfully in the Battle of Trafalgar in 1805. In 1818, the wooden-hull frigate *Deutschland* (1000 dwt) was constructed in Chattogram for the German Navy (Hossain et al., 2017). However, modern 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 K, 2025).

Global Shipbuilding Demand and Market

Ship is the major mode of transport of goods due to its minimum cost and versatility. One of the key factors influencing vessel disposal is the average operational lifespan of ships, alongside various other determinants. These include policy-related aspects such as environmental regulations, bunker fuel costs, technological obsolescence, freight rates, newbuilding prices, prices of end-of-life (EOL) or second-hand ships, and demolition prices (Hossain K, 2018). Typically, ships are scrapped after 25 to 30 years of service, with minor variations depending on ship type and region. In Figure 1 below future vessel demolition trends are estimated based on survival rates by ship type and age, as illustrated in the figure. The data indicates that tankers generally have higher survival rates compared to bulk carriers and container ships (double-hull tankers maintain a survival rate even 40 years). In figure 2 presents the trends in World GDP, Global Seaborne Trade, and Global Active Fleet Growth (OECD Report, 2021; UNCTAD Report, 2021; Clarksons Research, 2021). Figure 3 below illustrates seaborne trade projections up to 2035 as estimated by ITF, Sea Europe, and SAJ. According to ITF's network model, seaborne trade is expected to reach 20.8 billion tons by 2035. In contrast, Europe and

SAJ forecast a slightly lower figure, predicting seaborne trade to reach approximately 16.2 billion tons by the same year (ITF, 2015; Sea Europe, 2015; SAJ, June 2015; OECD, 2017).

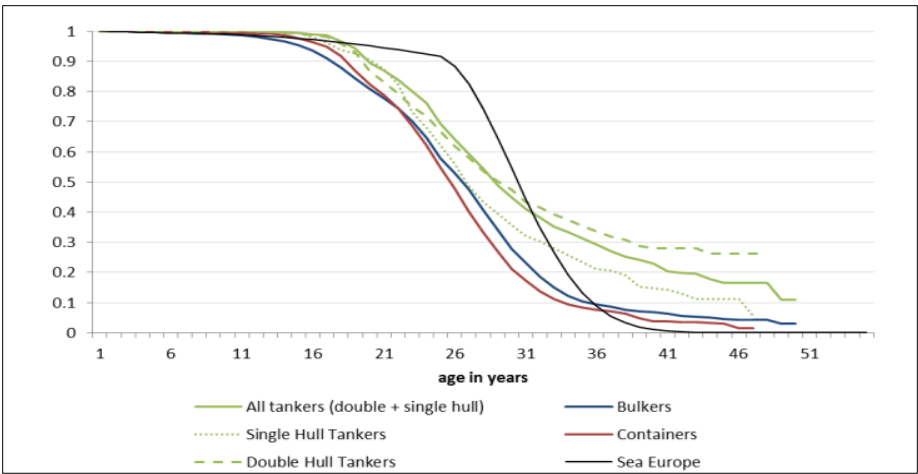


Figure 1: Survival Rate by Ship Age (IHS Seaweb 2016, OECD 2020)

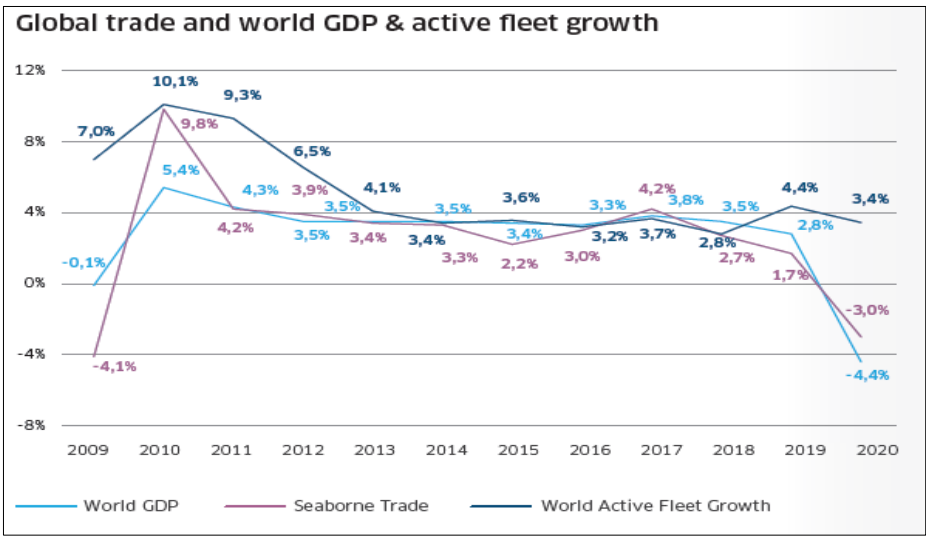


Figure 2: World GDP, Global Seaborne Trade and Global Active Fleet Growth

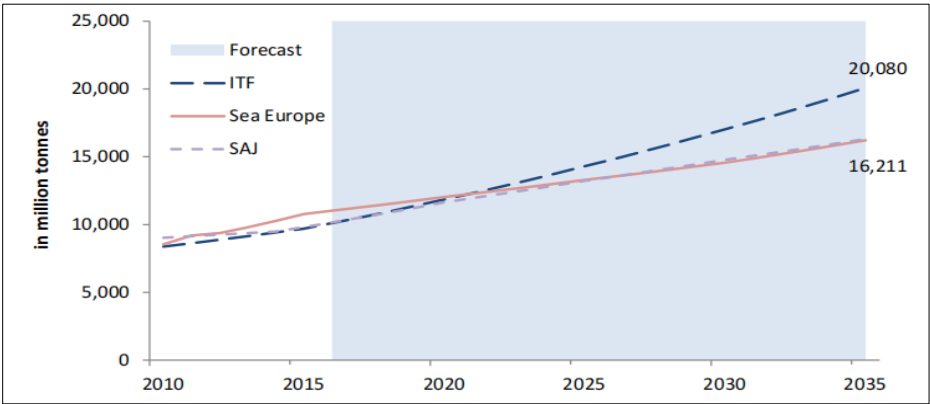


Figure 3: Forecast of Seaborne Trade from 2010-2035 by IFT, Sea Europe, SAJ, OECD (ITF 2015, Sea Europe 2015, SAJ Forecast 2015, and OECD 2017)

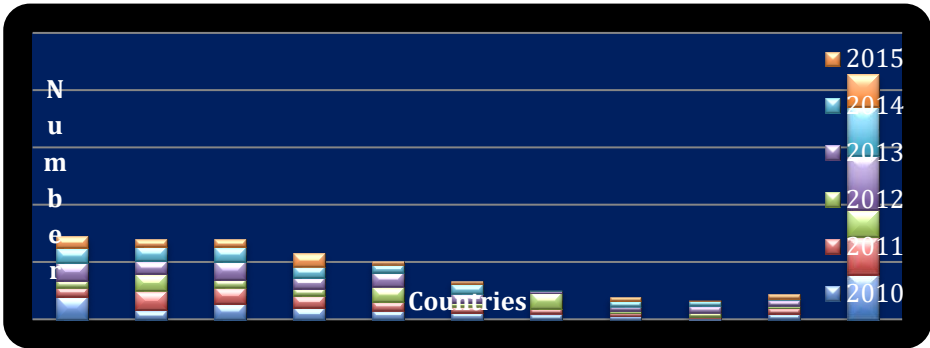


Figure 4: Trend of Investment in Local Shipbuilding by Own Countries in 2010-2015 (Hossain, 2018)

This industry needs its own government investment for its survival as shown in figure 4 below which depicts the trend of domestic investment in own shipbuilding by different countries (Hossain, 2018). In Figure 5 shown below, future vessel requirements by ship type, associated with ship disposals, have been estimated using demolition rates and historical completion levels from previous years, as depicted for the period between 2016 and 2035. Additionally, the global population stood at around 6.83 billion in July 2010 and is projected to rise to 9.08 billion by 2050 (EIA, 2011; OECD, 2011). The urban population worldwide is also growing at a faster rate than the overall population growth, with over half of the world's population now residing in urban areas (EIA, 2011;

OECD, 2011). This trend is expected to positively influence seaborne trade, as a larger urban population not only creates a strong domestic market for goods and services but also stimulates economic growth and innovation.

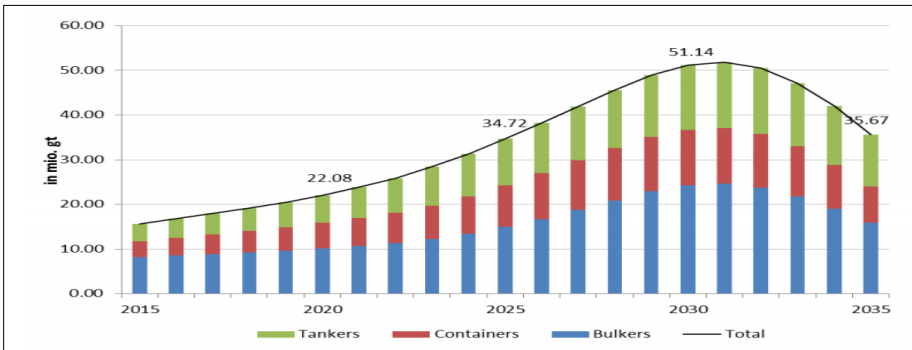


Figure 5: Forecast of Future Ship Requirements from 2015 to 2035
(IHS Maritime & Trade)

Global Shipbuilding Market Forecast

Ships remain the primary mode of transportation, making shipbuilding an essential component of national development for many countries. According to Zakaria et al. (2012), “R&D collaborations across business lines are driving the creation of innovative solutions and services that can be leveraged by other units or groups.” Designing and constructing modern specialized ships today involves high levels of technology and complexity. For example, nuclear-powered aircraft carriers function like mobile airports, capable of carrying hundreds of aircraft and operating globally for decades without refueling. Similarly, nuclear submarines can remain submerged for up to six months and launch attacks from deep within the sea while remaining undetected (Hossain, 2024b). Contemporary cruise ships, oil tankers, and bulk carriers are so massive that they resemble floating cities. Key factors propelling the growth of the global shipbuilding market include GDP expansion, overall economic growth, rising global seaborne trade, increasing demand for cargo transportation by sea, trade agreements, technological advancements, market trends related to end-of-life (EOL) ships, marine regulations, and the growing trend of automation within the maritime transport sector (Hossain K, 2023a). However, the industry faces potential setbacks due to fluctuations in transportation and inventory costs, environmental concerns, and global crises such as the COVID-19 pandemic, the Russia-Ukraine war, or the Israel-Iran conflict, all of which can significantly impact market growth (Hossain, 2023b).

In Figure 6, projected global shipbuilding market, encompassing both commercial and military sectors, has been illustrated. It is anticipated that the market will grow to USD 176.1 billion by 2027, with an average compound annual growth rate (CAGR) of 3.4% over the forecast period from 2017 to 2027. The key drivers behind this growth include the expansion of seaborne trade, increasing demand for cargo transport, growing trade agreements, technological advancements in ship design, and increased automation (KBV Research, 2022). In contrast, Research and Market (2022) estimated the value of the global shipbuilding market at USD 241.5 billion in 2021. According to their projections, the market is expected to reach USD 271.4 billion by 2026, reflecting a CAGR of 2.4%, as depicted in Figure 7. Furthermore, new shipbuilding orders are anticipated to rise, supported by the rollout of large-scale LNG projects (Hossain K, 2023a). Demand for new container vessels is also projected to grow, fueled by a stronger VLCC (Very Large Crude Carrier) market, stricter environmental regulations, the need to replace older ships, and efforts to enhance vessel efficiency (Roussanoglou N, 2021).



Figure 6: Forecast Global Shipbuilding Market (Commercial and Military) in Billion USD (KBV Research, 2022)

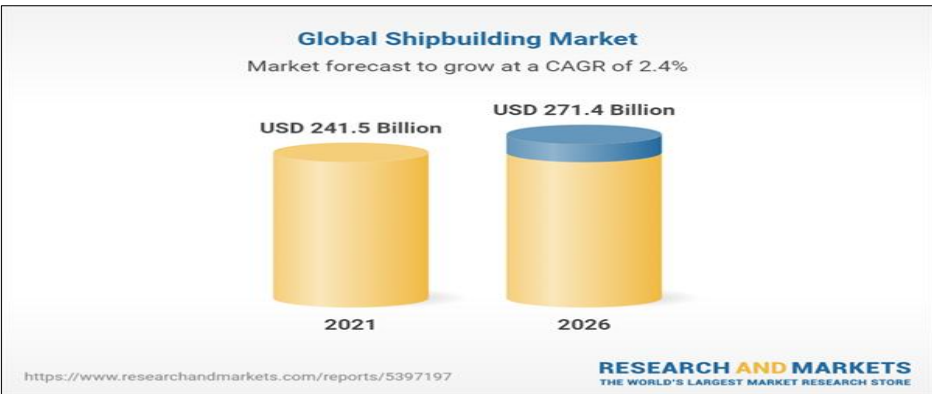


Figure 7: Forecast of Global Shipbuilding with CAGR (Research and Market, 2022)

Smart Shipping and Shipbuilding

Today, the concept of smart cities is gaining increasing popularity, driven by rapid technological advancements and urban growth. Within this context, smart ports are emerging as technologically sophisticated seaports that leverage digitalization, automation, and data-driven technologies to enhance logistics, boost operational efficiency, strengthen security, and minimize environmental impact (Chen, 2019). Smart ports play a critical role not only in facilitating global trade but also in shaping the future of sustainable and interconnected urban systems. These ports utilize advanced digital tools to optimize resource usage, reduce ecological footprints, and streamline port activities. Technologies such as blockchain, artificial intelligence (AI), machine learning (ML), deep learning (DL), and Internet of Things (IoT) sensors are among the innovations being integrated into port operations (Hossain, 2025b). Automated ports, in particular, are adopting digital solutions like smart sensors and data analytics to improve their infrastructure and day-to-day operations. These include real-time tracking of cargo, monitoring of port facilities, and vessel movement coordination. Technologies involved in these efforts may include predictive analytics, communication systems, cybersecurity tools, supply chain integration, interoperability solutions, digital twin technology, as well as augmented and virtual reality applications, among others (Hossain, 2024e). In this digital transformation, AI stands out as a versatile, general-purpose technology with wide-ranging applications—including automation, robotics, language translation, image processing, decision-making, online banking,

digital healthcare, credit evaluation, e-commerce, smart agriculture, and many more (Mc Corduck, 2004). Future ship, shipbuilding and shipping business will be related with AI and smart technology (Hossain, 2025a).



Figure 8: AI Transforming Shipping Sector (Andre, 2024) and Future Port Operation (All-Forward, 2024)

Today in this sector production line, shipyards management, material, machinery are highly collaborated with advanced technology. Like the steam engine, internal combustion engine, electricity, or computers, AI is now widely applied across both industry and academia (Deng, 2014, Hossain, 2025a). Today ML, DL, ANN or DS are using in ship/port operations and shipbuilding industry to improve efficiency, reduce costs, and enhance overall performance. These technologies enable data-driven decision-making, predictive analytics, and automation, leading to significant advancements in various aspects of port management (Stanford News 2021, Hossain, 2024c). In modern shipbuilding, AI and related technologies are being used to create smart or automated shipyard infrastructure to meet contemporary needs. Beyond construction and maintenance, smart shipyards also place strong emphasis on enhancing security. Digitalization is playing a transformative role in shipyard facility management. Innovations such as collaborative platforms, and safe and quick production by using smart technology will ensure safety, profit and on time delivery. To optimize shipbuilding production and profit, smart shipyards employ digital tools like automation, sensors, data analytics, and the Internet of Things (IoT), AI, DL.

Smart asset and logistics management systems further support this transformation by monitoring the location, condition, and performance of essential shipyard and material assets like cranes, vehicles, machinery, and infrastructure (Hossain, 2024e). These smart systems help extend the lifespan of critical equipment, enable proactive maintenance, and improve overall asset utilization. Predictive maintenance techniques are also being adopted, where algorithms analyze sensor data, maintenance histories, and operational performance to forecast potential equipment failures and schedule repairs in advance. This approach not only increases the reliability and safety of shipyards operations and management but also minimizes downtime and reduces maintenance costs. Today, big data analytics, AI, and IoT sensors allow real-time monitoring and evaluation of shipyard infrastructure and equipment. Additionally, ML or DL algorithms can analyze historical trends to forecast future ship demand, helping shipyards make informed decisions on inventory control, workforce management, logistic allocation, work schedule completion, and resource distribution (Hossain, 2024d).

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 process to optimize production, operations and management (Hossain, 2025b). AI will also support the maritime industry's sustainability efforts by helping optimize fuel consumption, minimize emissions, and improve supply chain efficiency. AI-driven solutions will enable shipping companies and ship-owner to comply with environmental regulations and work toward achieving 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 smart technologies demands substantial investment in hardware, software, and skilled human resources. These high initial costs may pose challenges for small and medium-sized shipping and shipbuilding industry. Additionally, the integration of such technologies involves the collection and processing of large volumes of data, raising concerns related to data privacy, cybersecurity, and overall safety.



Figure 9: An Automated Port (Togo-Port, 2024) and their Smart Activities (Manik, 2024)

Capacity and Capability of Local Shipyards

There are hundreds of indigenous private shipbuilding and ship repair yards located across the country along sides of many rivers, and which build and maintain almost all inland and coastal water transport vessels. Some of these yards boast a long history and strong reputation in shipbuilding. For instance, High-Speed Shipyard Ltd (HSSL) has been operating for over 60 years in this sector. In recent years, several private shipyards have reached international standards, producing small and medium-sized ships for export markets. A few have even developed the capacity to manufacture merchant ships of up to 10,000 DWT. Notably, shipyards such as Annada Shipyard and Slipway Ltd (ASSL), Western Marine Shipyard Ltd (WMSL), Khulna Shipyard Ltd (KSYL), and Karnaphuli Shipyards and Slipway Ltd (KSSL) have received orders from foreign ship-owners in countries including Germany, Japan, Denmark, the Netherlands, the European Community, Mozambique, India, and Nigeria. These promising yards have already delivered dozens of ships to international clients. Moreover, other local shipyards are continuously enhancing their capabilities. This progress has created new opportunities for attracting foreign direct investment (FDI) into Bangladesh's shipbuilding sector (Hossain et al., 2017; Hossain, 2023c).

Country has a long and distinguished history in shipbuilding and maritime activities, which continues to inspire both local entrepreneurs and foreign investors to engage in this sector. Currently, approximately 40,000 inland and coastal ships, along with around 100,000 mechanized country boats, operate throughout the country. These vessels transport more than 85% of oil products, 65% of cargo, and 25% of passengers nationwide. All of these ships and boats

are manufactured and maintained by local shipyards. There are around 100 indigenous shipyards in Bangladesh. Among them, four shipyards possess the capability to construct classed and export-standard ships up to 10,000 DWT, while several others are upgrading their facilities and capacity with the aim of entering the export market. The shipbuilding industry employs approximately 200,000 skilled, semi-skilled, and casual workers, while nearly two million people are directly or indirectly associated with this sector. As of 2009, the productivity of Bangladeshi shipbuilding labour was 11.43, with an average hourly wage of only USD 1.00, as shown in Table 2 and Figure 11 below. Moreover, the relative labour wage index was merely 0.45 in 2009, the lowest in the world, as presented in Table 3 and Figure 12. Although average hourly wages increased by 2021, they remain comparatively the lowest globally, maintaining Bangladesh’s advantageous position in terms of cheap labour in shipbuilding. However, despite low labour costs, the sector continues to face challenges in terms of productivity and safety standards within shipyards. To address these challenges and remain competitive, the adoption of smart technologies in shipbuilding has become imperative. This includes implementing modular construction concepts alongside extensive digitization, robotics, artificial intelligence (AI), machine learning (ML), deep learning (DL), and data science (Hossain, 2024d; Hossain, 2025a).

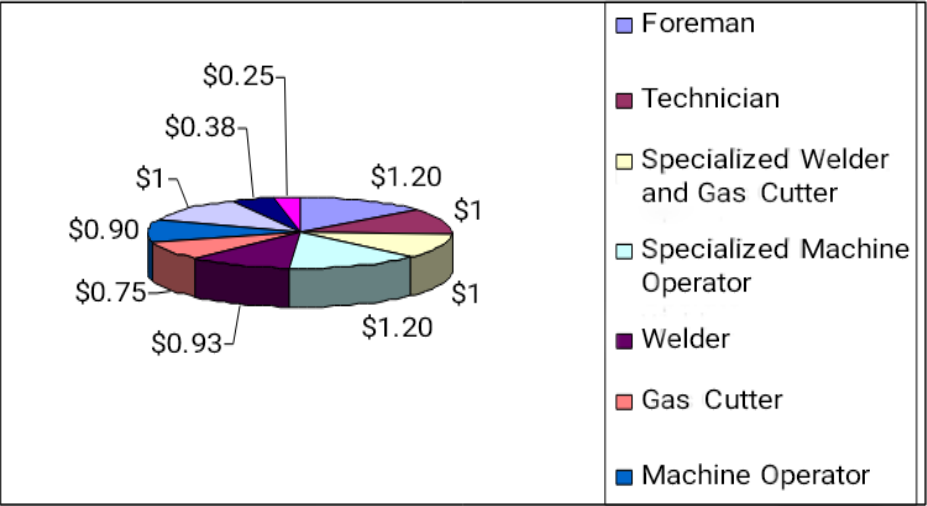


Figure 10: Average Labor Wage for Class Ship Build in Local Shipyards in 2009
(Hossain et al 2017)

Table 1: Shipbuilding Labor Productivity of Different Nations in 2009 (MSC Thesis 2010, Hossain et al 2010)

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

Table 2: Relative Labor Wage for Different Nations in 2009 (Hossain et al 2010)

Country	Relative Labor Wage	Country	Relative Wage
Bangladesh	0.45	Canada	11
India	1	Japan	12
China	1 to 2	Italy	13
Singapore	3	France	13
Hong Kong	3	Denmark	13
Taiwan	3	Norway	14
South Korea	6	Sweden	14
U.K.	10	Finland	15
USA	10	Germany	15

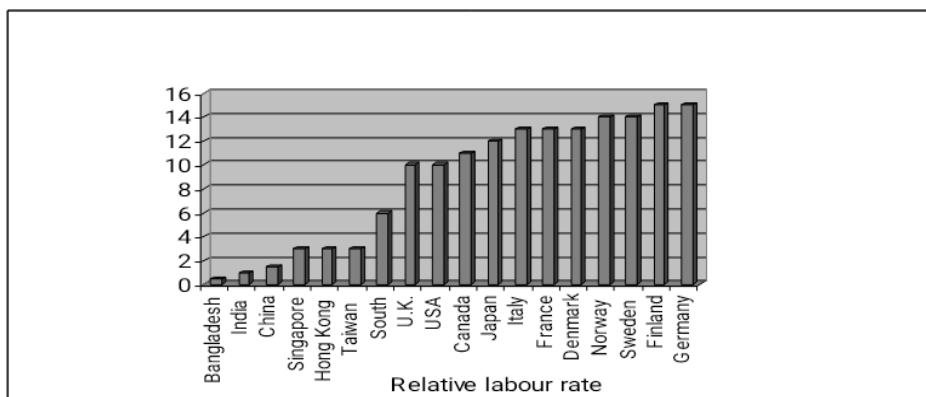


Figure 11: Relative Labor Rate of Different Nations (MSC Thesis 2010, Hossain et al 2010)

In Bangladesh a wide range of ships and vessels are constructed in local shipyards around the country. The types of vessels built include multipurpose vessels, coasters, dry cargo vessels, cargo coasters, passenger vessels or ferries (including lunchtype vessels), double-decker passenger vessels, tankers, container vessels, landing crafts, tugs, dump barges, supply barges, deck loading barges, self-propelled barges, dredging barges, research vessels, survey ships, hospital ships, tourist ships, inspection vessels, pleasure crafts, yachts, Ro-Ro ferries, crane boats, speed boats, hydrographic survey boats, work boats, pilot boats, water taxis, pontoons, catamaran vessels, sand carriers, troop-carrying vessels, fast patrol boats, offshore patrol vessels (OPVs), patrol crafts (PCs), light patrol crafts (LPCs), landing crafts vehicle (LCVs), landing craft tanks (LCTs), deep sea trawlers, among others. Currently, approximately 40,000 inland vessels operate in the country's rivers and along its sea coast, with about half of these registered under the Department of Shipping (DOS). Additionally, there are more than 100,000 mechanized and manually operated country boats that remain outside formal registration and organized statistical records. Over 500 coastal ships are registered with the Mercantile Marine Department (MMD). Therefore, the actual number of vessels built by local shipyards is significantly higher than those registered with either DOS or MMD. The principal data – including length (L), breadth (B), draft (d), deadweight tonnage (DWT), and other particulars – of the most common types and sizes of ships built locally for inland and coastal operations are presented in Table 4 below (Hossain et al 2010, MSc Thesis, 2010).

**Table 3: Principal Data of Common Types and Sizes of Ships Built Locally for
Inland Water**

Types of Vessels	Dwt or no of passenger	Length in Meter	Breadth in Meter	Draught in Meter	Usually Ply
Multipurpose ship or Coaster	1500- 4000	60- 120	10- 16	3.5- 6.0	Coastal
Cargo	1000- 3500	50- 100	10- 15	3.0- 5.0	Inland & Coastal
Passenger ship or Launch	300- 1500 Passenger	60- 110	10- 20	3.0- 4.0	Inland
Tanker	1000- 4000	50- 120	10- 16	3.0- 6.0	Inland & Coastal
Sand Carrier	200- 500	20- 40	5- 10	2.0- 3.0	Inland
Barge	200- 1000	20- 60	6- 14	2.5- 3.5	Inland
Dredger	30-100	10-30	4-8	2.0-3.0	Inland

Suitable Market for Local Shipbuilding

Bangladesh has enough potential and opportunity, both domestic and export oriented product mainly in mass or heavy industry like shipbuilding, garments, food, etc. Internally, the need for inland and coastal ships for cargo, passenger, container, and oil transport is insignificant, with a big existing local inland fleet requiring maintenance and replacement. Export markets as well are also emerging, particularly for small or medium ocean-going vessels and specific types of ships. In the global point of view the middle-class societies of Asia and Africa are expanding rapidly in the 21st century. Simultaneously, shipbuilding labour costs in China have increased significantly in recent years,

leading to a likely reduction in China's market share of small and medium-sized container ships, cargo vessels, tankers, and multipurpose ships in the near future (Hossain, 2018; Hossain, 2024a). This shift has created opportunities for emerging commercial shipbuilding nations such as Vietnam, the Philippines, India, Bangladesh, Myanmar, Australia, Turkey, and others. Shipbuilding in this region has a rich and illustrious history. To identify suitable target markets for Bangladesh, empirical research has been conducted using both quantitative and qualitative data collection methods, including Focus Group Discussions (FGDs) with seafarers serving on various merchant ships worldwide and professionals working at leading shipping companies in Bangladesh. Experts suggest that Bangladesh is well-positioned to cater to the niche market of small-sized container ships, tankers, cargo vessels, multipurpose ships, and special-purpose ships within the 3,000–10,000 DWT range. This segment is often overlooked by large global shipyards, enabling countries like Bangladesh to compete with advantageous pricing.

In addition, other experts propose that Bangladesh can also target the small and medium-sized ship market, particularly vessels within the 3,000–10,000 DWT and 12,000–20,000 DWT ranges, including multipurpose, container, tanker, and cargo ships. These niche markets are expected to remain viable in the coming years. Additionally, to sustain Bangladesh's export and import operations in cargo, energy, and other goods, it is imperative to develop the country's own merchant fleet, creating another promising local market. The maritime area of Bangladesh, covering approximately 118,813 sq. km, is of immense strategic importance as it serves as the only direct link to the rest of the world in times of regional crises (Hossain K, 2023c). Ensuring constant naval and coast guard presence is crucial for safeguarding sea lanes, maintaining sovereign rights, and securing economic benefits. To counter both traditional and non-traditional security threats, the Bangladesh Navy (BN) and Bangladesh Coast Guard (BCG) must remain vigilant by deploying various ships at sea. Moreover, troop transportation in coastal areas necessitates landing crafts for both the navy and army. Consequently, there is a consistent demand for military vessels for operational readiness in both peacetime and wartime.

This represents a promising niche market for BN-operated private shipyards alongside the substantial local inland and coastal commercial fleet.

Today, the global shipbuilding market is valued at around USD 200 billion, with the small shipbuilding segment accounting for around USD 20 billion. There is a significant and increasing global demand for container ships across all sizes. Reports from UNCTAD, the World Bank, WTO, and OECD project a sustained rise in the need for container vessels in the coming years. The small niche shipbuilding market is particularly suitable for local shipbuilders in countries like Bangladesh. In the near future, the world is expected to require several thousands new vessels, predominantly small to medium-sized. Furthermore, under IMO regulations, the existing global fleet of old single-hull tankers will soon need to be completely and urgently replaced, driving additional demand for new builds in this category. Previously, China dominated the shipbuilding sector due to its low costs. However, with the rise in living standards and increased labour wages in China, the competitive advantage has shifted. Bangladesh now holds a favourable position with its lower labour costs and growing technical capabilities. Analysts predict that China will gradually relinquish a portion of its small and medium-sized shipbuilding market share, opening up new opportunities for countries like Bangladesh. Since 2009, Bangladesh's shipbuilding industry has been exporting small and medium-sized ships and boats to more than a dozen countries. With its current potential and capacity, Bangladesh is projected to capture at least 2% of the global shipbuilding market by 2030, which would translate to an annual export value of approximately USD 4 billion (Hossain K, 2023b). By developing a skilled workforce, ensuring strategic government investment, and adopting meticulous planning, Bangladesh can generate USD 2 to 4 billion per annum from this promising sector. Technological advancements such as digitization, robotics, IoT, AI, machine learning (ML), deep learning (DL), and data science have significantly enhanced productivity and operational efficiency in shipbuilding. Therefore, improving labour productivity and building a highly skilled workforce are essential for sustaining the growth of this industry (Hossain K, 2024d). Moreover, maintaining safety standards and global compliance remains paramount to remain competitive in international markets (Hossain K, 2025). For substantial growth in the 21st century, strategic investments, strong government support, and continuous development of skilled human resources are vital to ensure Bangladesh's

shipbuilding sector meets emerging challenges and secures its rightful place in the global market.

Challenges of Local Shipbuilding Industry

The shipbuilding industry of Bangladesh has struggled to maintain pace and consistency in its development due to a lack of coordinated initiatives from the stakeholders, along with common initiative both in public and in private sector. This has resulted in slow progress and an inability to effectively penetrate the global shipbuilding market. The key challenges are described below:

Despite its long history in shipbuilding, Bangladesh has found it difficult to keep up with rapid global technological progress. The availability of low-cost labor has made many shipyard owners hesitant to invest in modern technologies. As a result, local shipyards have been slow to adopt smart and advanced methods in ship design and construction. This delay has often led to gaps in quality control and product standards when compared with international requirements.

There exists a clear gap between industrial requirements and the curricula of mainstream educational institutions. Greater emphasis is needed on technical and vocational education to bridge this divide. Different organizations has largely failed to develop a skilled workforce and sustainable human resources due to inadequate training facilities, outdated curricula, insufficient research infrastructure.

Policy planners, bureaucrats, bankers, and other key stakeholders often lack awareness of the shipbuilding sector's potential. For meaningful progress, this industry must receive the same nurturing support as the Ready-Made Garments (RMG) sector.

The major local shipyards are situated in and around Dhaka, far from coastal areas, thereby restricting their capacity to produce larger ships. Additionally, high bank interest rates and service charges remain a major obstacle to developing the shipbuilding industry. Additionally, international buyers often require bank guarantees, but local banks need counter-guarantees from foreign banks, incurring further costs and reducing competitiveness.

Bangladesh does not manufacture class-approved mild steel plates, frames, girders, stiffeners, longitudinals, machinery, fittings, and other essential shipbuilding materials and equipment required for the growth of export-oriented shipbuilding. There is poor backward linkage to support the industry. Bangladesh's shipbuilding industry is heavily dependent on imports for prime raw materials and resulting in increased production costs and vulnerability to global market fluctuations.

The sector faces an image problem along with difficulties related to the Ease of Doing Business (EODB), which discourages Foreign Direct Investment (FDI). There is limited proactive sharing of information, motivation, and effective promotion of the industry to potential foreign buyers. Greater involvement from Bangladeshi ambassadors abroad in promoting the sector is needed, alongside a positive shift in mindset within the local shipbuilding community.

Local shipyards also lack technical expertise in modern technologies and receive inadequate financial support from the government to keep pace with the Fourth Industrial Revolution (4IR) and adopt smart technologies. This technological shortfall continues to pose a major obstacle to the sector's long-term and sustainable growth. (Hossain, 2024d).

Private shipyards often lack a professional corporate culture, as management and key appointments are usually dominated by Individuals. This creates lack of confidence, undermining employees' sense of belonging to the organization. Moreover, family industrial legacies, which are critical in capitalist societies, remain rare in Bangladesh.

The technology currently used in local shipyards is still rudimentary, leading to inefficiencies and low productivity. There is a significant shortage of advanced shipbuilding tools, machinery, and expert operators, particularly those skilled in digital and AI-enabled systems (hossain, 2025a). Furthermore, Bangladesh still depends heavily on foreign expertise for ship design.

The sector faces limitations in access to government support for capital formation and financial risk management, which are important factors for

the growth and sustainability of heavy industries. In addition, costs related to import LC commissions, bank guarantees, and other banking charges increase production expenses, affecting the competitiveness of Bangladesh's export-oriented shipbuilding industry when compared with several other shipbuilding nations.

Several countries, including Vietnam, the Philippines, Indonesia, India, and Brazil, are actively positioning themselves to serve surplus and niche segments of the global shipbuilding market. This growing competition creates challenges for Bangladesh's shipbuilding industry. To capitalize on emerging opportunities, the local sector will benefit from a clear vision, strategic planning, timely implementation, and a stable and supportive policy environment.

Market analyses indicate that the global demand for new ships, measured by the Compound Annual Growth Rate (CAGR), is increasing at approximately 4%. This growth, while presenting opportunities, also implies formidable risks and heightened competition for new entrants and local investors.

Insufficient infrastructure, unreliable energy supply, insufficient industrial land, and a poor Ease of Doing Business (EODB) environment are major obstacles to the rapid development of shipbuilding in Bangladesh. Moreover, few issues like image crisis, issues of integrity and some local investors pose threats to the overall credibility of Bangladesh's shipbuilding sector. These factors undermine the ability to maintain goodwill and build confidence among foreign buyers.

Poor management practices in local shipyards lead to low employee motivation and job satisfaction. Consequently, indiscipline, high absenteeism, and poor retention rates of skilled manpower are common challenges in the sector. Additionally, there is an ongoing problem (like naval architects and engineers, managers, etc) including skilled manpower drain, from Bangladesh's shipbuilding industry to foreign industries, weakening the local talent pool.

The global economic recession triggered by the post-COVID-19 situation, coupled with severe geopolitical crises such as the Russia-Ukraine war and

Israel-Iran tensions, have negatively impacted the global shipping and shipbuilding markets, leading to order cancellations and a general slowdown in business.

The shallow draught of Bangladeshi rivers (maximum ~4 metres) limits the size of ships that can be built and launched from local shipyards. Maintaining navigable draughts is further challenged by heavy siltation. Additionally, bridges and overhead cables impose air draught restrictions, with a minimum clearance of 22 metres above high water levels (monsoon) required for major rivers, further constraining ship size and design.

There is a lack of comprehensive and supportive government policies and strategic frameworks for the shipbuilding sector. The absence of effective formulation, implementation, monitoring, and regular updating of export-oriented shipbuilding policies and strategies continues to hinder the sustainable growth of this industry.

Major Findings and Way Forward

Shipbuilding has traditionally been a labour-intensive, low-tech heavy industry. Since the 1950s, however, the introduction of high tensile and tough steel with superior physical and chemical properties has transformed ship construction (Stopford, 2009). Modern shipbuilding incorporates superb aesthetic finishes and work precision. Significant automation, advanced technologies, and line production manufacturing processes are now integrated, supported by a skilled workforce. Today's shipyards extensively adopt block or module construction, where large multi-deck segments are prefabricated elsewhere, transported to the building dock or slipway, and assembled to complete fabrication (Hossain, 2018). These modules are pre-fitted with equipment, pipes, electrical cables, and other systems to reduce installation efforts post-assembly. Ship design and naval architecture are further supported by model testing in towing tanks or basins. The incoming 4IR is poised to transform the maritime sector further, including shipbuilding. Bangladesh has a long and glorious maritime and shipbuilding history, which encourages both local entrepreneurs and foreign investors, enabling the nation to earn significant foreign currency from this sector.

The government has drafted a shipbuilding policy to improve the sector. However, its implementation must ensure proper evaluation and uniform

priority so that both public and private shipyards benefit equally. The sector remains vulnerable and requires significant interventions to achieve sustainable development and international standards. If supported with facilities similar to the RMG sector, shipbuilding could generate greater net benefits. Government allocation for waterways and water transport under the Annual Development Programme (ADP) is below 5%, while roads receive over 70%. Insufficient promotional activities hinder export shipbuilding growth. Local shipbuilding costs are 10-20% higher than competitors such as China, Korea, Japan, India, and Vietnam due different bank, tax, charges and import cost. High prices, coupled with inconsistent electricity and gas supply and inadequate infrastructure, obstruct smooth industrial development. Local shipyards often demonstrate reluctance towards improving Quality, Health, Safety, and Environmental (QHSE) standards. Government pressure, foreign buyer requirements, and awareness and training programmes are needed to elevate these standards to international levels.

Export-oriented shipbuilding is inherently a global industry. Bangladeshi-built ships, constructed to international standards, are approximately 10%-30% less costly compared to similar ships built in Japan, Korea, China, Vietnam, or India (Hossain, 2018). However, sustaining this advantage requires technological adaptation. The impact of the Fourth Industrial Revolution (4IR) has become a defining discourse in the maritime and manufacturing sectors. The first industrial revolution introduced water and steam-powered mechanical manufacturing; the second brought electrically powered mass production; the third integrated electronics and IT for automation (Wikipedia, 2022). In contrast, 4IR integrates digitization with physical manufacturing through technologies such as 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 (Kobylnski, 2018). Therefore, cheap labour and a abundance young population are no longer sufficient drivers for industrial development. Productivity and a skilled workforce are paramount requirements. If Bangladesh fails to develop its young population into a skilled human resource pool, it risks missing this critical opportunity for economic advancement and falling behind on the global development trajectory.

The concept of 6th Generation Ports (6GP), capable of handling megaships carrying up to 50,000 TEUs with a 20-meter draft and utilizing advanced

automation alongside strong hinterland connectivity, is set to become operational in the near future. The entire maritime sector – encompassing ships, shipping, and shipbuilding – is on the verge of becoming far more advanced and smarter. The core objective of the 4IR in shipbuilding is to develop intelligent shipyards, which are not only adaptive, resource-efficient, and ergonomic but also ensure close integration among ship-owners, shipbuilders, suppliers, and all other stakeholders within business and value chains (Noordstrand, 2018). Without incorporating smart technologies and advanced ship design and construction processes, Bangladesh will struggle to produce globally competitive ships that guarantee safety, quality, and customer satisfaction in an increasingly competitive market. For substantial growth and capturing a significant share of the global market, this sector requires a balanced and strategic approach. This includes viable strategies and feasible planning, Continuous government backing and appropriate capital injection, strict operational discipline, Development of a skilled workforce and Integration of smart technologies to meet future challenges. The global shipbuilding market is estimated at approximately USD 200 billion, with the small ship segment valued at USD 20 billion. To tap into this potential, the local shipbuilding industry must be properly guided and balanced. Achieving sustainable development and gaining global market share will depend on coordinated efforts, strategic investments, technological upgrades, and human resource development.

Cheap labour alone cannot ensure the sustainable development of the shipbuilding industry. While historically low labour costs have provided a competitive edge, the integration of advanced technologies is now crucial for cost efficiency and global competitiveness. Overreliance on cheap labour risks eroding Bangladesh's position in the global market, especially as other shipbuilding nations continue to adopt automation and smart technologies. Bangladesh possesses immense potential for economic progress through the proper nurturing and utilization of its export-oriented shipbuilding industry. Entrepreneurs remain confident about the promising future of local shipbuilding, leveraging the nation's long maritime heritage, favourable geographical location, and availability of a large workforce. However, private shipyards generally lack corporate management culture. Management remains

family-dominated, hindering professional development, as seen in ASSL and other, which struggled to sustain its export success due to family-centric management practices. A prevailing mindset of “getting rich quickly” undermines sustainable growth. For example, WMSL failed to continue its export success due to diversions of investment focus. Poor job satisfaction prevails in shipyards. Workers do not receive industrial benefits like production bonuses, fringe benefits, or welfare facilities (medical, pension, travel allowance, and compensation). Owners neglect employee welfare due to abundant cheap labour, resulting in skilled graduates and trained personnel leaving for overseas jobs. Productivity of the workforce is low despite the lowest relative labour wage globally due to cheap hourly rates.

Approximately 40,000 inland and coastal ships, alongside around 100,000 mechanized country boats and trawlers, operate nationwide, carrying over 85% of oil products, 75% of cargo, and 25% of passengers. All these vessels are constructed and maintained by local shipyards. There are around 100 indigenous shipyards employing more than 200,000 skilled and unskilled workers. Approximately 2 million people are directly and indirectly engaged in shipbuilding activities. Few local shipyards can construct small to medium export-quality ships (up to 10,000 dwt), and several others are upgrading to enter the export market. Rising labour wages in China due to improved living standards are expected to shift some small and medium shipbuilding market share away from China, presenting an opportunity for Bangladesh. Recent FDI opportunities have emerged, with countries like China, Turkey, and the Netherlands showing interest. Establishing export shipyard zones could promote healthy growth. Bangladesh is suitable for constructing small to medium-sized container ships, tankers, cargo vessels, multipurpose ships, and specialized ships (3000–10000 dwt), and it has the potential to capture this niche market competitively. The global shipbuilding market is approximately USD 200 billion, with the small ship segment accounting for USD 20 billion. Thousands of ships, particularly small to medium-sized, will be required in the coming years, driven by IMO regulations replacing old single-hull tankers and increasing container ship demands. By 2030, Bangladesh could achieve 2% of the global shipbuilding market share, valued at approximately USD 4 billion.

Conclusion

Ship and Shipbuilding is an important sector to transport goods around the globe. It is a comprehensive sector encompassing shipyards, marine equipment manufacturers, technical workforces, knowledge networks, service providers, and related stakeholders. Bangladesh has glorious shipbuilding history. Local shipbuilding possesses immense potential to emerge as a competitive player in the global shipbuilding market, which is expected to reach around USD 200 billion by 2030. With focused development of a skilled workforce, strategic government investment, and effective planning, the nation can realistically earn around USD 4 billion annually from this sector. The current positive trajectory, combined with rising export opportunities and foreign investment interests from countries like China, Turkey, and the Netherlands, further strengthens this prospect. Establishing dedicated export shipyard zones and adopting smart, viable strategies will be critical. By leveraging its geographical advantage, maritime heritage, and competitive pricing in small and medium ship segments (3000–10000+ DWT), Bangladesh can successfully capture this niche market and achieve sustainable industrial growth in the coming decades. The global shipbuilding market is typically categorized by ship type, end use, and region. Historically, the industry has suffered from a lack of global regulatory control and a tendency toward over-investment. This is due to its involvement of diverse technologies, its role in supporting numerous ancillary industries, its capacity to generate significant employment, and its inherently global nature. These trends have been common among all leading shipbuilding nations.

The global shipbuilding market at present faces multiple challenges, including inflation, overcapacity, depressed prices, geopolitical instability, war-crisis, low profit margins, trade distortions, widespread subsidization, financial crises, the impacts of the COVID-19 pandemic, volatile geopolitical situations, and trade imbalances. As a result, shipbuilding remains a slow-moving industry, vulnerable to unsteady market growth, as well as economic and environmental shifts. In Bangladesh, the government has taken initial steps and drafted a primary shipbuilding policy to strengthen both the shipping and shipbuilding sectors. However, before its implementation, proper evaluation and prioritization are essential to ensure that both public and private shipyards benefit equally. Additionally, the government must support this promising

sector with appropriate capital injections and strategic interventions to unlock its full potential and ensure sustainable growth. Global shipbuilding industry increasingly leverages smart technologies, including advanced fifth and sixth-generation mega-ports and smart shipping systems, to ensure effective, sustainable, and market-driven shipbuilding that optimizes profits and supports long-term growth.

Considering the glorious tradition, present opportunities, future challenges, and the suggested measures highlighted in this research, Bangladesh's shipbuilding sector should formulate viable policies (the means) and develop effective strategies (the ways) to capture suitable market segments while optimizing production capacity. This approach could sustainably revitalize the nation's lost glorious shipbuilding heritage. Advanced technologies such as digitization; robotics, IoT, AI, machine learning, deep learning, and data science have significantly transformed the global shipbuilding landscape. Therefore, enhancing labour productivity and developing a skilled workforce is essential to sustaining growth in this sector. Simultaneously, ensuring safety and adherence to global standards is paramount to remain competitive in the international market. For substantial growth, the sector requires a balanced approach, including strategic investments, continuous government support, and focused human resource development to meet future challenges effectively. By addressing critical issues such as productivity, technological adoption, and safety standards, Bangladesh's shipbuilding industry can enhance its global competitiveness and contribute meaningfully to sustainable economic growth and national development.

Notes and References

1. Allied Market Research, (2022), Shipbuilding market by types and end use, available at: <https://www.alliedmarketresearch.com/shipbuilding-market>, accessed on 19 Jun 2025.
2. Banglapedia, (2003), The National Encyclopedia, Banglapedia Trust, Asiatic Society of Bangladesh, available at: en.banglapedia.org, (Accessed on 29 Jun 2022).

3. Business Research Company, (2021), Shipbuilding global market report 2021, Jan 2021, available at: <https://menafn.com/1102455116/The-Shipbuilding-Industry-Takes-On-3D-Printing-Technology-As-A-Latest-Trend>, (Accessed on 09 Jul 2022).
4. Brookings, (2024), The critical infrastructure gap u s port facilities and cyber vulnerabilities, available at: <https://www.brookings.edu/articles/the-critical-infrastructure-gap-u-s-port-facilities-and-cyber-vulnerabilities/>, accessed on 02 May 2024.
5. Chen, Jihong, (2019), "Constructing Governance Framework of a Green and Smart Port" (PDF). *Journal of Marine Science and Engineering*. 7 (4): 83. doi:10.3390/jmse7040083, 27 March 2019.
6. Château J (2014) Trade patterns in the 2060 world economy, OECD economics department working papers, No-1142, OECD Publishing, Dec 2014.
7. Crevier Daniel (1993), *AI: The Tumultuous Search for Artificial Intelligence*. New York, NY: BasicBooks. ISBN 0-465-02997-3, accessed on 07 May 2024.
8. Copeland, J., (2004), *The Essential Turing: the ideas that gave birth to the computer age*. Oxford, England: Clarendon Press. ISBN 0-19-825079-7, accessed on 07 May 2024.
9. Clarksons Research, (2015), *World Shipyard Monitor*, July 2015.
10. Clarksons Research, (2021), *Shipping Review Outlook*, June 2021.
11. ClarksonsResearch, (2024), *Shipping Sector Reports*, March, 2024, Clarksons Research.
12. Danish Ship Finance, (2024), *Shipping Market Review*. May 2024.
13. Deng L, et al, (2014), "Deep Learning: Methods and Applications" (PDF), *Foundations and Trends in Signal Processing*, 7 (3–4): 1–199, doi:10.1561/20000000039, accessed on 03 May 2024.
14. IMF, (2021), *Equity and defeating the pandemic*, 1 June 2021, available at: <https://www.imf.org/en/Home> (Accessed on 26 Jul 2022).

15. Hossain K A, et al, (2010), SWOT analysis of shipbuilding industries in Bangladesh and its challenges to become potential ship exporting nation, *Journal of Ship Technology India*, Volume 6, Issue 2, July 2010.
16. Hossain K A, (2015a), Leadership qualities for 21st century leaders, *Journal of Management, Social Science and Humanities*, Published on 19 May 2015, (Accessed on 11 Jul 2022).
17. Hossain K A, (2015b), Future of energy resources, *International Journal of Renewable Energy Technology Research (IJRETR)*, Volume 4, Issue 5, Nov 2015.
18. Hossain K A et al, (2017), A Study of global shipbuilding growth trend and future forecast, *Procedia Engineering*, Elsevier, Jul 2017, available at: <https://www.sciencedirect.com/science/article/pii/S1877705817332927>, (30 Jun 2022).
19. Hossain K A, (2018), SWOT analysis of China shipbuilding industry in the third eyes, *Journal of Recent Advancement of Petrochemical Science*, Volume 4, Issue 2, 22 Jan 2018, available at: <https://juniperpublishers.com/rapsci/pdf/RAPSCI.MS.ID.555632.pdf>, (Accessed on 13 Jul 2022).
20. Hossain K A, (2018), Analysis of important steering factors which give success to global shipbuilding leaders, *Journal of Recent Advancement of Petrochemical Science*, Volume 4, Issue 5, 10 Apr 2018, available at: <https://juniperpublishers.com/rapsci/pdf>, (Accessed on 13 May 2022).
21. Hossain K A, (2018), Proposed viable ship recycling process for South East Asian recycling yards specially for Bangladesh, *Procedia Engineering*, Elsevier, Published on 27-07-2018, available at: https://www.mtc-utm.my/wp-content/uploads/MARTEC_2018_Paper/I2.pdf, (Accessed on 30 Jun 2022).
22. Hossain K A, (2021), Strength Weakness Opportunity, Threat (SWOT) analysis of Bangladesh shipbuilding industry, *Technical Paper: NAME, MIST*, 16 Dec 2021, available at: <https://www.mist.ac.bd/storage/files/name/TECHNICAL>, (Accessed on 02 Jul 2022).
23. Hossain K A, (2023a), Challenges of development and operation of port in 21st century, *IJNRD (www.ijnrd.org)* ISSN 2456-4184, Volume 8 Issue 5, 23 May 2023.

24. Hossain K A, (2023b), Evaluation of global and local shipbuilding market, SciencePG, Science, Technology & Public Policy, US, 2023; 7(2): 52-68, doi: 10.11648/j.stpp.20230702.12, ISSN: 2640-4613, ISSN: 2640-4621, (Accessed on 02 Jun 2025).
25. Hossain K A, (2023c), An Overview of Merchant Ships, IJNRD (www.ijnrd.org) ISSN 2456-4184, Volume 8 Issue 6, 23 June 2023.
26. Hossain et al, (2023), Analysis of present global ship recycling status and challenges for Bangladesh, GSJ: Volume 11, Issue 4, April 2023, Online: ISSN 2320-9186, April 2023.
27. Hino, M.et al, (2018), "Machine learning for environmental monitoring". Nature Sustainability. 1 (10): 583–588. Bibcode:2018 NatSu...1..583H. doi:10.1038/s41893-018-0142-9, October 2018, accessed on 03 May 2024.
28. Hossain K A, (2025a), Artificial Intelligence (AI), ISBN-13, 979-8328010290, 2025, Amazon, US.
29. Hossain K A, (2025b), Evaluation of Internet of Things (IoT), ISBN-13, 979-8306216980, Jan 2025, Amazon, US.
30. Hossain K A, (2024a), An Overview of Merchant Ships, ISBN-13, 979-8324932374, May 2024, Amazon, US.
31. Hossain K A, (2024b), Warship Construction Idea, ISBN-13, 979-8327525443, June 2024, Amazon, US.
32. Hossain K A, (2024c), Analysis of ship recycling, ISBN-13, 979-8343259971, Oct 2024, Amazon, US.
33. Hossain K A, (2024d), Artificial Intelligence and Robot, ISBN-13, 979-8332453625, Sep 2024, Amazon, US.
34. Hossain K A, (2024e), AI is the smart solution for ocean resources preservation and maritime industry operation in modern era, Scientific Research Journal (SCIRJ), Volume XII, Issue X, October 2024 ISSN 2201-2796, available at: <https://www.scirj.org/papers-1024/scirj-P10241001.pdf>, accessed on 11 June 2024.
35. IMO, (2021), Report of the Maritime Safety Committee on its 103rd session, MSC 103/21, London, 25 May 2021.

36. IHS Markit, (2022), Maritime and trade research and analysis, Feb 2022, available at: <https://ihsmarkit.com/research-analysis/shipbuilding>, (Accessed on 20 Jun 2022).
37. IHSSeaweb, (2016), The world's largest maritime ships database, Jul 2016, available at: <https://onlinebilgi.com.tr/ihs-sea-web>, (Accessed on 11 Jul 2022).
38. JOE, (2024), Costs found outweigh port automation benefits, available at: https://www.joc.com/technology/costs-found-outweigh-port-automation-benefits_20181213.html,%20technology/costs-found-outweigh-port-automation-benefits_20181213.html, accessed on 08 May 2024.
39. Lixing Z, (2009), Development oriented finance and economy in China: A historical review and prognostic assessment, Printed in Blooming Ton, Indiana, USA, July 2009.
40. Lloyds Register, (2022), World ships statistics, Archive and library, Jan 2022, (Accessed: 17 May 2022).
41. Markets and markets, (2022), Global digital shipyard market by region (in million USD), Jul 2022.
42. Mordor Intelligence, (2022), Shipbuilding market growth, trends, COVID-19 impact, and forecasts 2022-2027, available at: <https://www.mordorintelligence.com/industry-reports/ship-building-market>, (Accessed on 16 May 2022).
43. MSc Thesis, (2010), Evaluation of potential prospect and challenge of Bangladeshi shipbuilding in light of global contest by khandakar Akhter Hossain, Dept of NAME, BUET, 10 Jan 2010, available at: <https://docplayer.net/64761793-Khandakar-akhter-hossain.html>, (accessed on 20 Jul 2022).
44. Michael D, (2010), China: A modern history, I B Tauris and Co Ltd, London, UK, May 2010.
45. Manik Tanwar, (2024), The AI Revolution in Shipping: Efficiency, Advantages, and Challenges, March 4, 2024, available at: <https://www.linkedin.com/pulse/ai-revolution-shipping-efficiency-advantages-challenges-manik-t-ijh9c/>, accessed on 12 June 2025.
46. McCorduck Pamela, (2004), Machines Who Think (2nd ed.), Natick, MA: A. K. Peters, Ltd., ISBN 1-56881-205-1, accessed on 06 May 2024.

47. Noordstrand A, (2018), Experience with robotic underwater hull cleaning in Dutch Ports, Hull PIC 18 (pp 4-9), Redworth, 3rd Hull Performance and Insight Conference, Jun 2018.
48. OECD, (2011), International trade and capital movements in OECD, 11 Mar 2011, available at: <http://www.theworldeconomy.org/advances>, (Accessed on 23 Jul 2022).
49. OECD, (2015), Peer review of the German shipbuilding industry, OECD Publishing, Paris, Dec 2015, (Accessed on 23 Jul 2022).
50. OECD, (2017), Council working party on shipbuilding, imbalances in the shipbuilding industry and assessment of policy responses, Economics Department Working Papers on Shipbuilding , Paris, 18-19 Apr 2017.
51. OECD, (2021), Shipbuilding market development, May 2021, available at: <http://www.oecd.org/sti/ind/shipbuilding-market-developments>, (Accessed on 23 Mar 2022).
52. Roussanoglou N, (2021b), Ship owners order more container ships and LNG carriers, Hellenic Shipping News Worldwide, 29 July 2021, (Accessed on 27 Jul 2022).
53. Research and Market, (2022), Shipbuilding market by type and end use: Global opportunity analysis and industry forecast, 2021-2030 Report, Jan 2022.
54. SAJ Forecasts, (2015), New-building requirement forecast (SAJ2014), Presentation by Takeo Suzuki of Japan Ship Centre, JETRO London, on behalf of Shipbuilders Association of Japan (SAJ) held at the OECD Council Working Party on Shipbuilding, 11-12 June 2015.
55. Sea Europe, (2015), Memorandum and data on seaborne trade by Ms. Jenny Braat and Ms. Sarai Blanc, Aug 2015. Stopford M, (2009), Maritime Economics, Routledge, New York, USA, Nov 2009.
56. Stanford News, (2021), AI empowers environmental regulators". Stanford News. Stanford University. 19 April 2021. Retrieved 29 May 2022, accessed on 11 May 2025.
57. Seaweb ships, (2022), The ultimate maritime reference tools, Feb 2022, available at: https://maritime.ihs.com/EntitlementPortal/Home/Information/Seaweb_ (Accessed on 10 Jul 2022).
58. UNCTAD, (2021), Global Trade Update. World trade rebounds to record high in Q1 2021, May 2021, available at: https://unctad.org/system/files/official-document/ditcinf2021d2_en.pdf, (Accessed on 31 Aug 2022).
59. UNCTAD, (2021), Estimates of global e-commerce 2019 and preliminary assessment of COVID-19 impact on online retail 2020, Geneva, 3 May 2021.

60. UNCTAD, (2021), Trade and Development Report 2021, available at: <https://unctad.org/webflyer/trade-and-development-report-2021> (Accessed on 04 Jul 2022).
61. UNCTAD, (2024), Review maritime transport, 2024, available at: <https://unctad.org/publication/review-maritime-transport-2024#>, (Accessed on 04 Jun 2025).
62. WTO, (2021), World trade primed for strong but uneven recovery after COVID-19 pandemic shock, World Trade Organization Press/876, 31 March 2021.
63. Wikipedia, (2022), 4th Industrial Revolution, 4IR or Industry 4.0, Feb 2022, available at: https://en.wikipedia.org/wiki/Fourth_Industrial_Revolution, (Accessed on 01 Sep 2022).
64. Zakaria et al, (2012), Underlying problem of ship recycling industries of Bangladesh, Journal of Naval Architecture and Marine Engineering, Published on 13 Nov 2012.
65. Yang Chen, (2025), The World's Top 10 Shipyards Ranked by 2024 New Orders, Xinde Marine News, Managing Director/Chief Editor, available at: <https://www.linkedin.com/posts/yang-chen>, (Accessed on 09 Jun 2025).

Biography of the Writer



Rear Admiral Khandakar Akhter Hossain, NBP, NUP, ndc, psc, PhD joined the Bangladesh Navy as a cadet and was commissioned into the Engineering Branch on 1 January 1991. He earned his BSc and MSc in Naval Architecture and Marine Engineering with distinction from the Bangladesh University of Engineering and Technology (BUET) and later obtained a PhD from the same university. During his naval career, he served as an Engineer Officer onboard several Bangladesh Navy warships, including BNS UMAR FAROOQ, BNS ALI HAIDER, and BNS SHADHINOTA. He also served as Deputy Director and Director at Naval Headquarters and participated in a United Nations peacekeeping mission in Sudan. He played a key role as Project Chief (Naval Architecture/Engineering) for the Shadhinota Class Missile Corvette Project in China. Rear Admiral Hossain later held senior management roles in Bangladesh Navy-run shipbuilding industries, serving as Managing Director of Chittagong Dry Dock Limited, Dockyard and Engineering Works Limited, and Khulna Shipyard Limited, contributing significantly to Bangladesh's shipbuilding sector. He also served as Member (Engineering) at the Chittagong Port Authority and as Commodore Superintendent of Dockyard. He performed instructional duties at the Bangladesh Naval Academy, Bangladesh Marine Academy, and Military Institute of Science and Technology (MIST), where he served as Dean/Head of the Naval Architecture and Marine Engineering Department. Before joining Bangladesh Maritime University as Vice Chancellor, he served as Assistant Chief of Naval Staff (Materiel). A Fellow of the Institution of Engineers Bangladesh, Royal Institution of Naval Architects (UK), and International Association of Maritime and Shipping Professionals (USA), he has authored over 200 international publications on advanced technologies. He is married to Sharmin Hasan and has two daughters and two sons.

MATARBARI DEEP SEAPORT AS A REGIONAL SHIPPING HUB: OPPORTUNITIES AND CHALLENGES

Commodore Md Shafiul Bari, (ND), OSP, ndc, psc, BN

Abstract

Bangladesh is making notable progress in both economic and social development and is on track to achieve developed nation status by 2041, which requires double-digit GDP growth. The Government of Bangladesh (GoB) is developing the Matarbari Deep Sea Port (MDSP) which has the potential to contribute 2-3% to the country's GDP growth. Recognizing this, the researcher has initiated a study on the MDSP to evaluate its opportunities and challenges to transform the port into a regional shipping hub. A literature review identifies six key factors crucial for this transformation: strategic location, strong connectivity, operational efficiency, high cargo volume, competitive port costs, and a positive economic impact. Through focus group discussions, surveys, and interviews with stakeholders and academia, the researcher reveals that MDSP holds significant potential to become a regional shipping hub, despite several challenges. Located at a strategic position in the Bay of Bengal, the port offers deep-sea access to India's northeastern region, Nepal, Bhutan, and China's Yunnan Province provided hinterland connectivity is improved to international standard. Increasing cargo volume to meet the critical mass requirement of mother vessels and attracting international shipping lines through competitive port costs are also vital for success. Major shipping lines prioritize ports with high operational efficiency and quick vessel turnaround times. To attract these liners to MDSP, the port authority must increase cargo volume by redirecting regional shipments, adopt automation to reduce turnaround times, and ensure competitive port costs relative to other regional hubs.

Background

Bangladesh is at a critical juncture in its journey from a lower middle-income to an upper middle income country, but recent economic challenges have slowed the progress. Consequently, the government urgently needs to stimulate economic growth using available resources. The Matarbari Deep Seaport (MDSP) is expected to play a key role, potentially contributing 2-3% to GDP

and becoming a vital asset in the Bay of Bengal (Sinha, 2023). Bangladesh aims to sustain rapid growth through strategic infrastructure investments, requiring a consistent 10% GDP growth rate over the next 24 years, along with a 1% population growth rate from 2021 (Al-Amin, 2021). Initiatives like SDG 2030 and the Delta Plan 2100 support this growth strategy. The Bay of Bengal's importance increased with Japan's 2014 Bay of Bengal Industrial Growth (BIG-B) plan, which invested \$5 billion over four years to enhance port infrastructure and energy development, improving connectivity with Bhutan, Nepal, and India's Northeastern Region (NER) (Datta, 2016). As part of this initiative, JICA financed an 18.5-meter-deep, 14.3-kilometer-long navigation channel with a \$4 billion ODA loan for the coal power plant (Shinha, 2023). In 2023, Bangladesh launched the first phase of MDSP, including a 460-meter container jetty and a 300-meter multipurpose jetty. The port is set to be fully operational by 2027, enhancing sea connectivity for landlocked areas like India's NER, Nepal, and Bhutan. International organizations, including UNESCAP, are also supporting the efforts to establish integrated road and rail networks, aiming to transform the port into a regional hub (Iqbal, 2023).

Figure 1: Matarbari Deep Seaport and Bay of Bengal Industrial Growth Belt



Source: Presentation by the Ambassador of Japan to Bangladesh on 14 July 2024 at NDC

Bangladesh has three main ports, with the Chittagong Port Authority (CPA) handling 97% of all seaborne cargo and 92% of containerized cargo, while the other two ports mainly handle non-containerized bulk cargo. One major issue for Bangladeshi ports is the draft restriction for Panama ships, as larger ships cannot navigate the narrow and shallow channels. Consequently,

smaller vessels (less than 200 meters long) perform feeder services to and from hub ports like Singapore and Colombo, where cargo is then transferred to larger mother vessels. The high number of smaller vessels conducting feeder services from Chittagong to Singapore and Colombo causes congestion at CPA and extra cost for feeder services. Additionally, limited tidal window complicates ships movement inside the port. The development of the Matarbari Deep Seaport (MDSP) which is independent of tidal restrictions, will allow larger ships to dock directly, reducing congestion by consolidating large consignments of containers into single shipments, thereby saving feeder service cost for the traders. And the deep seaport is expected to play a vital role by fostering maritime-related business and contributing to economic growth.

Developing a deep seaport will not bring required economic dividend but transforming it to a regional shipping hub, will contribute immensely to the economic gain. The Chittagong Port bears the testimony of regional connectivity for transshipping cargo coming from Assam and West Bengal through Bangladesh's river route when the Chittagong Port Commissioners Act 1887 was enacted (Khaleque, 2023). Reestablishing historical connectivity routes with the Northeastern Region (NER) and creating new road links with Nepal and Bhutan will notably shorten the distance from the origin to the transshipment or transit port (Khaleque, 2023). Should the Matarbari port evolve into a regional shipping hub, landlocked areas like NER of India, Bhutan, Nepal and Yunnan province of China would benefit from a significantly shorter distance—approximately one-third of the current distance to Kolkata port used for third-party cargo shipments. This research focuses on identifying the critical features of a regional hub port and the optimal strategies for implementing these features in the development process of the upcoming Matarbari Deep Seaport (MDSP).

Regional Hub Port

A regional hub port is a strategically positioned seaport that serves as a central point for maritime trade within a particular geographic area. These ports are equipped with advanced infrastructures and modern facilities to efficiently handle various types of cargo, including containerized goods, bulk commodities, and liquid cargo. They play a vital role in connecting their regions

to global trade networks, facilitating the movement of goods between ships, trucks, and trains, and reducing both connection time and cost (Liu & Wang, 2023). Regional hub ports often drive economic growth, commerce, and industrial development in their vicinity. They offer value-added services such as warehousing, distribution, and logistics to support regional goods flow. These ports benefit from economies of scale, as handling larger volumes of cargo leads to more efficient operations and lower transportation costs per unit. This can result in cost savings for shippers and lower prices for consumers. Additionally, they attract ancillary industries and services, such as logistics providers, shipping agencies, and manufacturing firms, which benefit from proximity to efficient transportation networks. This concentration of economic activity can stimulate local employment and economic growth.

Objectives of the Research

Primary Objective

The primary objective of this research is to identify the essential characteristics of a regional hub port and determine how these features can be effectively integrated into the Matarbari Deep Seaport (MDSP) to enable it to function as a regional hub, considering the projected maritime trade demands of Bangladesh and the surrounding regions.

Specific Objectives

The study aims to achieve the following specific objectives:

- To conduct a comprehensive literature review to identify the key characteristics of a regional hub port and establish an analytical framework for the research.
- To review the current states of the ports of Bangladesh in relation to the established analytical framework.
- To carry out a specific evaluation of the MDSP, considering the challenges and opportunities involved in developing the essential features as defined by the analytical framework, from the following perspectives:

- Analysis derived from reports, literature, studies, and academic papers.
 - Insights gained from surveys, interviews, and focused group discussions.
- To recommend policy and operational strategies for developing the MDSP as a regional shipping hub, based on the overall findings of the study.

Research Methodology

Due to the nature of the subject, a non-experimental research design with an exploratory approach was implemented. The study focuses mainly on qualitative research, supplemented by quantitative methods to gather information from a variety of sources. The primary data sources will be secondary materials, while efforts will be made to collect primary data through surveys and interviews. Additionally, statistical data on pertinent issues will be gathered from relevant organizations to assess the current state of maritime ports and the anticipated needs for maritime trade.

Analytical Approach

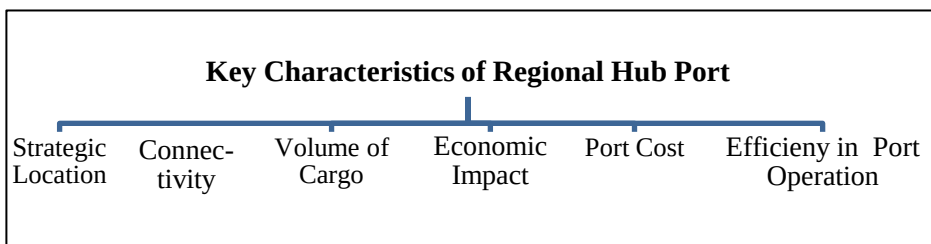
The researcher adopted a descriptive approach, combining both qualitative and quantitative analyses to achieve the research objectives. The qualitative analysis incorporates various research tools, including a literature review, Key Informant Interviews (KII), Focus Group Discussions (FGD), field surveys, and information/data obtained from seminars, lectures, and interviews. The researcher performed a mixed-method analysis of available documents, official reports, journal, articles, periodicals, and statistical data to project the maritime trade of Bangladesh and targeted regions. FGDs, KIIs, and interviews with professionals, academics, senior port officials, port users, and current and former port chairmen, as well as ambassadors in Bangladesh, helped identify challenges and opportunities involved in infrastructure development, hinterland connectivity, port efficiency, bringing mother vessels and cargo from the target regions, logistics, and other factors essential for developing the MDSP as a regional shipping hub. This approach helps determine whether the MDSP qualifies to become a regional hub port, identify key features of such a hub, and

explore the prospects and challenges of transforming the MDSP into a regional shipping hub.

Findings of the Literature Review

The researcher carried out a thematic literature review sourced from various journals, periodicals, books, case studies, articles in newspapers and reports that are directly relevant to seaport selection by shipping liners and traders. Through a comprehensive analysis of the literature, a broad set of criteria that a regional shipping hub should possess is uncovered. These key factors are then used to establish an analytical framework that will guide the development of the standard characteristics for the upcoming port at Matarbari. The reviewed literature highlights various criteria essential for a port to function as a regional shipping hub, with geostrategic location-specifically its proximity to international shipping routes and its linear distance from landlocked regions-being the most critical factors (Kawasaki & Hanaoka, 2023). Many researchers emphasize that multimodal hinterland connectivity, which attracts maritime cargo from landlocked areas, plays a key role in transforming a port into a regional hub (Iqbal, 2023). Most previous studies also stress the importance of port operation efficiency, economic impact, cargo volume, and the adoption of advanced technology as key criteria for a regional hub port (Sohini, 2023). The researcher has developed an analytical framework (Fig. 2) from the above findings to outline the key features of a regional shipping hub, which are then evaluated in the context of Matarbari Deep Seaport.

Figure 2: Analytical Framework

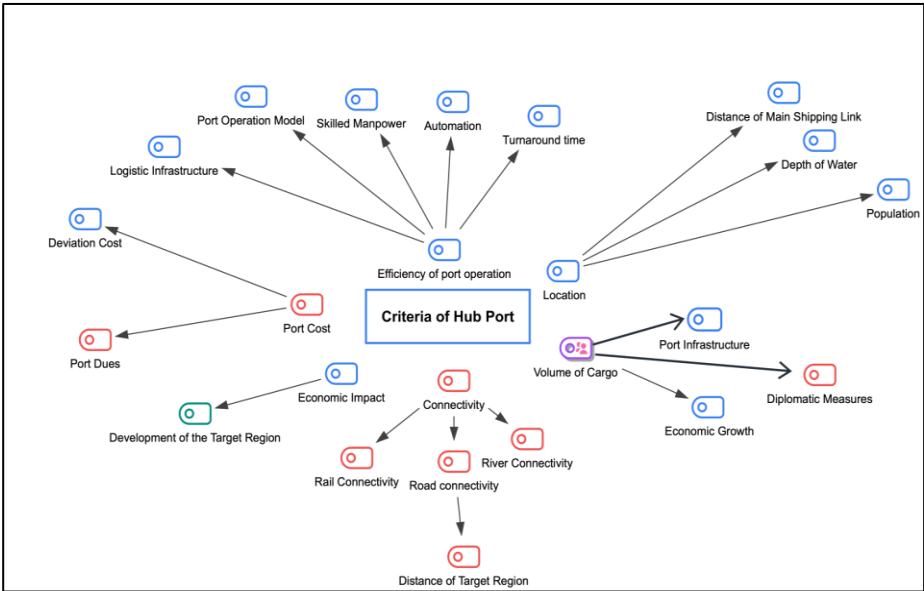


Source: Author's Own Construct from the Literature Review

Challenges and Opportunities for Transforming MDSP into a regional Shipping Hub- Key Findings

A grounded theory approach was used to analyze the qualitative data through inductive process and develop a conceptual framework (Fig.3), which is based purely on literature reviews, interviews, and FGDs. The framework highlights the critical macro-level features necessary for MDSP to become a regional shipping hub: geographical location, hinterland connectivity, cargo volume, port cost, efficiency of port and economic impact.

Figure 3: Key Criteria of Hub Port



Source: Author's Own Construct

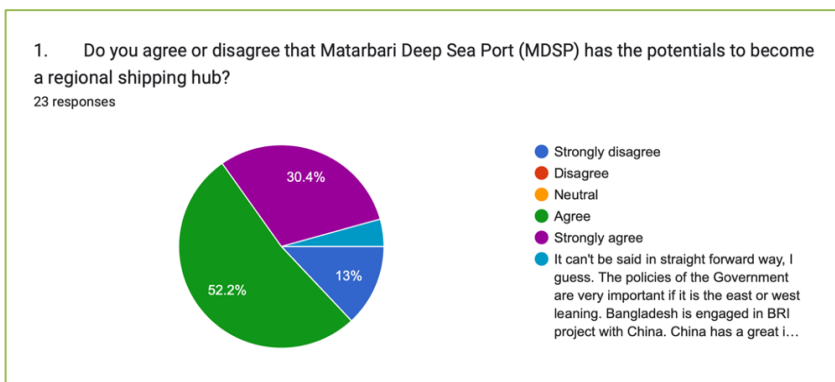
Macro-Level Factors

The geographical positioning of a hub port is vital, providing significant opportunities to access large regional markets for export and import, and to maintain low costs for container repositioning. The extent of connected markets and the integration of seamless supply and value chains are also essential. Maximizing the productivity of a regional port relies on the volume of cargo handled and the efficiency of cargo operations. Additionally, the selection criteria used by shipping liners play a significant role in the success and growth of a regional hub port.

Geographical Location

The geographical location of a port, particularly its proximity to the international shipping trunk, the available water depth for accommodating large vessels, and the population size involved in trading with the port, is crucial. The closeness of a shipping lane directly impacts the important factors of time and cost. Higher operational and diversion costs at the port can discourage shipping liners from docking there. The Matarbari Deep Seaport (MDSP) is strategically situated at the peak of the Bay of Bengal, acting as a gateway for about 2.4 billion people from South and East Asia, roughly 35% of the global population (Farid, 2024). This port offers vital sea access to the Northeastern Region of India, Nepal, Bhutan, and the Yunnan Province of China, significantly reducing the distance to the nearest seaport. A survey among academics and port users found that 82% believe MDSP is ideally positioned to become a regional shipping hub. However, 13% of respondents noted that ships arriving at MDSP would need to detour approximately 650 nautical miles from the main East-West international shipping route, presenting a geographical challenge.

Figure 4: Survey on MDSP as Regional Hub



Source: Survey Report, Conducted on the Port Users, 22 June 2024

This detour could add about 2.5 days to a ship's journey, costing around \$500,000 for vessels 330 meters in length. Interviews suggest that if these additional costs could be offset through reduced port dues and tax incentives, MDSP might become a more attractive destination for transshipment cargo.

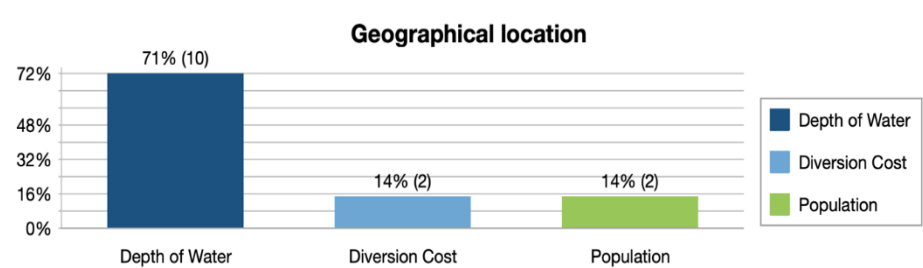
Table 1: Critical Factors of Geographical Location

Criteria	Description	Matarbari Deep Seaport
Distance of detour	The distance of the hub port from the main international shipping link	Approximately 650 nm and it involve extra 2.5 days' voyage
Population	The population size of the targeted regions and their potential maritime trade volume	Target size of population is approx 75 million
Depth of water	The depth of the navigational channel and the basin of the MDSP allowing ships 330 meters	Maintain channel depth 16 meters (CD)

Source: Author’s Own Construct

Another critical factor is the depth of water, unique to this location. MDSP boasts a deep navigation channel of 18.5 meters (msl), a hydraulic advantage unavailable on the West coast of Bangladesh and Myanmar. Maintaining this depth requires annual dredging of 5 million cubic meters, costing over Tk 250 crore (Hakim, 2024). The financial burden of this dredging must be covered either by raising port dues and charges or by government subsidies from Bangladesh. Interviews revealed that 71% of participants support maintaining the channel depth, even if it requires government funding.

Figure 5: Factors of Geographical Location Affecting MDSP



Source: Interviews, FGDs (MAXQDA Data Analysis Software)

Hinterland Connectivity

Road Link

Developing road networks involves several complex challenges, which can significantly impact the overall success and efficiency of the port functions. Constructing new roads requires substantial investment. Bangladesh is a land scares country, acquiring suitable land for infrastructure development is very chaotic and time consuming due to high costs, legal issues and resistance from landowners. Interviews revealed that the Roads and Highways Department (RHD) is yet to begin construction of the 27.2 km Matarbari Port Access Road, which would connect the port to the Asian Highway network (AH1). The delay is due to JAICA's disagreement with the RHD about starting construction before completing land acquisition (Patwary, 2024). The RHD expects to complete the road construction by 2029 (Mamun, 2024). But the Matarbari Port Development Project would be completed by 2027. The delay in access road construction would result in the delaying of port operations by two years which is considered to be the most critical factor for the port to commence its operation.

River Route

The interview reveals the river route might be utilized at a lower scale for the transportation of both domestic and transshipment cargo via Pangaon ICD. However, the sea condition during monsoon may render the cargo transportation venture impractical. However, according to interview data, 38% of respondents prefer road connectivity (Fig.5) over the river route for cargo transportation from MDSP to land lock regions.

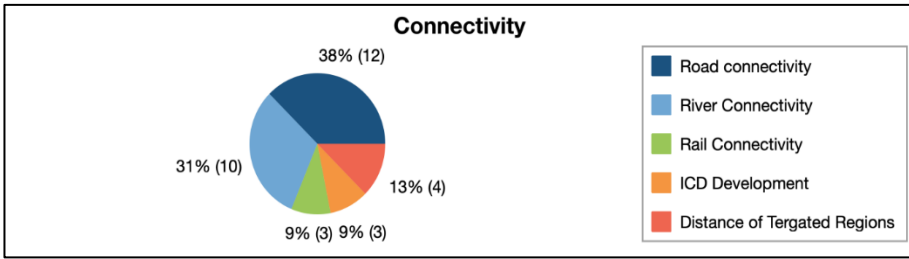
Railway Link.

Another mode of hinterland connectivity is railway link which is also in a planning phase poised to add to the factor of connectivity. The Matarbari-Chakaria DG rail link project aims to connect the MDSP with the Dhaka-Cox's Bazar rail network, ultimately linking to the Asian Railways network. The concerned ministry has developed a Detailed Project Proposal (DPP) for constructing the Matarbari-Chakaria DG rail link, currently awaiting approval from the GoB. Major preparatory work, such as land acquisition and community resettlement, cannot start until funding is available (Gin, 2024).

Table 2: Criteria Related to Connectivity

Criteria	Description	Matarbari Deep Seaport
Road link	The seamless road network connecting MDSP with the targeted regions of this study	Crucial for receiving regional cargo
Rail link	The DG rail link connecting MDSP with the targeted regions of this study	Crucial for receiving regional cargo
River route	The connection between hub port and targeted regions	Provides flexibility
Distance of target region	The distance of target region i.e. NER of India, Nepal and Bhutan, Yunan province of China from MDSP	The distance of MDSP is shortest from any other sea port
Development of ICD	Inland Container Depot where containers are to be inspected by NBR officers	To be developed

Figure 6: Factors of Hinterland Connectivity



Source: Interviews, FGDs (MAXQDA Quantitative Data Analysis Software)

Efficiency of Port Operation.

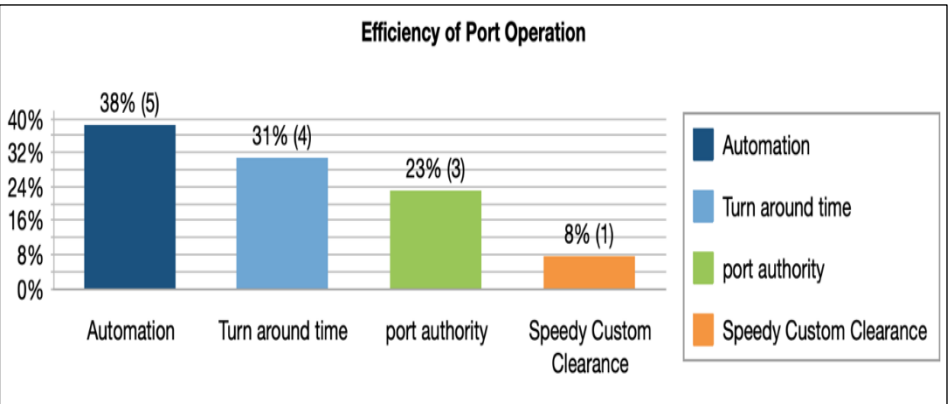
Machines

Automation in mechanical equipments is crucial for MDSP to achieve its goal of becoming a regional shipping hub (Musa, 2024). This macro-level component is made up of several efficiency and time-related parameters that are displayed in the Table 3 and are important for the shipping lines' hub port selection procedure. Automation is considered the main ingredient for efficient port operations, with 38% of respondents identifying it as the main ingredient. Improving vessel turnaround, container delivery, customs clearance and reducing ship's 2.5-day diversion time for the MDSP are very crucial. Automation in port operations can shorten turnaround times, boost productivity, and enhance efficiency. A survey of CPA port officials found that automation and advanced logistic infrastructure in port operation increases efficiency by 70-90% if skilled manpower are employed. MDSP will be free of tidal restriction, so there is no waiting for berthing. Thus, vessel turnaround time at the quayside will be core issue of port's efficiency. The field survey indicate that the turnaround time could be minimized up to 90% by utilizing advanced IT in logistic system. To become a leading smart port, MDSP must offer top-tier services, including automated operation systems for transshipment.

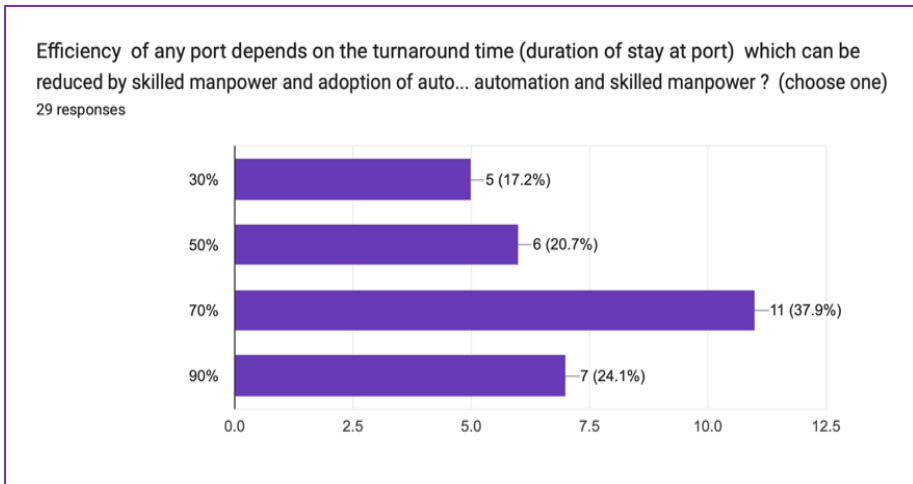
Table 3: Criteria Related to Port Operational Efficiency

Criteria	Description	MDSP
Port operation model	It is the system of operating the port, there are various system of operating port such as Land lord and tool port models.	Land lord model is efficient
Vessel turnaround time	The time taken at the port to complete the entire loading/unloading operation	To be reduced
Skilled manpower	The presence of well educated professional personnel	Important features of hub port
Automation	The availability of advanced IT and robust logistic system	Add to port efficiency
Logistic infrastructure	Capability of providing advanced logistic facilities for multi country usage	Essential for Transshipment

Figure 7: Criteria Related to Port Operational Efficiency



Source: Interviews, FGDs (MAXQDA Data Analysis Software)

Figure 8: Improvement of Efficiency by Turnaround Time

Source: Interviews, FGDs (MAXQDA Data Analysis Software)

Manpower. Another essential factor for successful automation is the development of human resources. While BMU produces educated and skilled graduates for the port sector, a flawed recruitment system poses challenges. According to a professor during a focus group discussion, many graduates face difficulties securing jobs due to the system's heavy emphasis on Bengali language proficiency, which disadvantages those primarily educated in English. This recruitment practice significantly limits the entry of port management graduates into the industry.

Volume of Cargo

Container Throughput

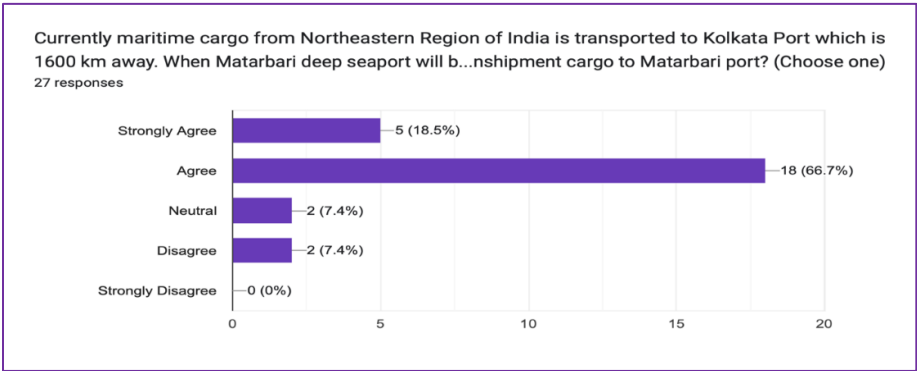
It is the most critical macro-level factor in the hub port selection process for shipping liners. As ships follow trade, increasing maritime trade volume is essential for any hub port to attract large vessels. Maximizing container throughput can be achieved by improving connectivity, port efficiency, and trade relations with target regions. In a survey, 75.9% of port users believed that offering financial incentives to shipping liners could increase cargo throughput. These incentives might include subsidies on port dues or waivers

on storage rent. The overall cost of port services must be lower than that of regional competitors, such as Colombo and Singapore (Farid, 2024). Additionally, a general survey of port users and administrators revealed that the traders from Northeast India will choose MDSP as their transshipment port due to its shorter distance. The GoB and neighboring countries need to develop road and rail networks to enhance seamless connectivity through sub-regional initiatives. However, 45% of the interview respondents are of the opinion that the economic growth of the target region is crucial to get the maritime cargo from land locked regions and also the KII suggests to engage the traders of land locked regions diplomatically for increasing the volume of cargo in MDSP.

Table 4: Criteria Related to Container Throughput

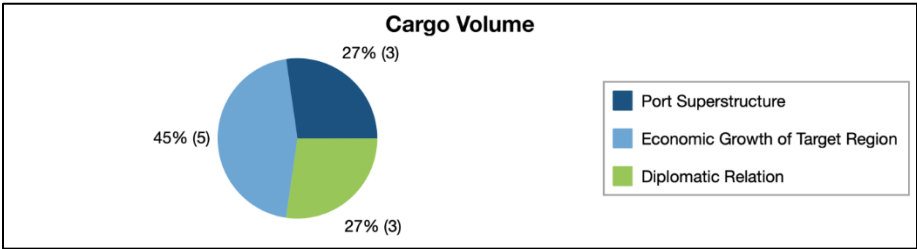
Criteria	Description	Matarbari Deep Seaport
Economic Growth of Target Region	The economic growth is related to the maritime cargo growth of the country i.e more growth means more maritime cargo	Affect the development
Port Infrastructure	Availability of adequate and advanced facilities for cargo handling	Affect the container throughput
Diplomatic Relation	The mutual trade relation between hub port country and targeted countries or region	Important for increasing cargo volume

Figure 9: MDSP- A Regional Shipping Hub



Source: Survey Report, 2024

Figure 10: Cargo Throughput Dependency



Source: MAXQDA Analysis of Interview, 2024

Port Cost/ Significance of Shipping Liners

This category includes the primary criteria directly linked to the costs incurred by shipping lines during the transshipment process, as outlined in Table 6. Regarding port-related expenses, this factor is closely tied to other micro-level elements such as turnaround time, proximity to major shipping routes, and overall port costs. Interviews with shipping industry experts highlighted that major shipping lines serving South Asian ports prioritize factors like vessel waiting and turnaround times, availability of a critical mass of cargo, and the diversion costs of port calls. Similarly, a survey indicated that 75.9% of respondents believe competitive port costs could attract major shipping lines to MDSP. Furthermore, the port's operational efficiency and

logistical infrastructure will be key in drawing large vessels to the emerging hub port.

Port Tariff

To establish MDSP as a regional shipping hub when it commences its operation in 2027, it must offer competitive port tariffs. Interviews indicate that attractive pricing and potential tax holidays will be necessary to draw large vessels away from ports like Singapore, Colombo, and JNPT. Given MDSP's location, which adds two days of travel for ships, lower freight costs compared to other regional hubs will be essential. Implementing competitive pricing and incentives can help attract cargo volumes and position MDSP as a key player in the region.

Table 5: The Criteria Related to the Cost Incurred by a Mother Vessel

Criteria	Description	MDSP
Deviation cost	The journey cost incurred by shipping lines when deviating from international shipping trunk to access to hub port	2.5 days for accessing to hub port
Port Dues	The cost associated with the operation at the hub port. The cost includes container handling charges; port dues, such as navigation, dues, pilotage, towage, and so on	Port tariff is to determined the GoB when the port starts functioning
Cost in feeder link	The cost associated with transporting cargo between hub and feeder ports.	Depends on the distance between hub port and origin
Waiting time	The vessel waiting at the anchorage before entering the port	Nil

Time spent to come to hub port	The time taken for transporting cargo between hub and feeder port or hub port to target region	Only for coastal shipping 3-4 days by sea and by road 12 hours (target region)
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Economic Impact

Bangladesh faces economic challenges, including declining tax revenue, rising debt, and a growing fiscal deficit, putting its credibility at risk (*Mansur, 2024*). Slowing GDP growth, now at 5.6% instead of the projected 7%, has reduced investment and maritime trade. Chittagong Port faced a decline in cargo handling as the government cut spending to preserve foreign reserves. To meet MDSP’s cargo needs, the port must attract shipments from neighboring regions like Northeast India, Nepal, Bhutan, Myanmar, and China's Yunnan Province, which could generate up to 6.8 million TEUs. While domestic downturns may not heavily impact MDSP, securing regional cargo will be crucial for its success.

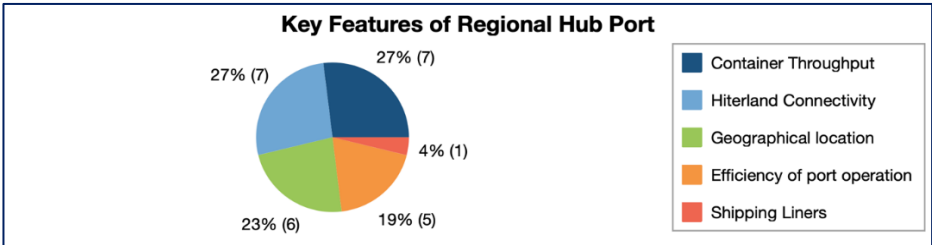


Figure 11: Macro- Level Factors of MDSP

The country is facing multifarious challenges in attaining SDG goals in economic sectors. Maritime trade requirements originate from the result of foreign and internal investments. The investment has shrunk in the country. In this uncertainty of economic growth, the MDSP is to look for maritime cargo of the landlocked countries and regions instead of only relying on domestic cargo.

Way Forward

Based on the findings, the researcher recommends the following:

Infrastructure Development

The following structural development activities may be undertaken to initiate port operations as soon as possible, or the golden opportunity for MDSP to become a regional hub may be lost:

- The Government of Bangladesh (GoB) may launch diplomatic efforts to secure funding from JAICA for the immediate construction of the Matarbari Port Access Road.
- The Roads and Highways Department may aim to complete the Matarbari Port Access Road Project by 2027.
- The Chittagong Port Authority are to complete the Matarbari Port Development Project, including the construction of 360 x 460-meter container and multipurpose jetties and the procurement of necessary equipment, by 2026.
- The Roads and Highways Department may complete the 1.4 km Matarbari North-South Connecting Road by 2027.
- The MDSP Port Authority may enhance operational efficiency by establishing a robust logistics network and constructing warehouses and Inland Container Depots (ICDs) near the port.
- Bangladesh Railways may complete the Matarbari-Chakoria DG Railway Link Project by 2029, connecting Matarbari to the Trans-Asian Rail Network.
- The MDSP Port Authority may ensure regular maintenance of the channel depth at 18.5 meters (msl), as it is crucial for the port's success as a regional shipping hub.

Policy Measures

The GoB may prioritize the completion of international and regional projects like the Trans-Asian Railway (TAR), Asian Highways, BBIN, and BMIC to ensure the Matarbari Deep Seaport (MDSP) is well-connected to key regions such as Northeast India, Nepal, Bhutan, and China's Yunnan Province. The GoB may implement competitive yet sustainable tariff regulations for MDSP, offering incentives on port dues and storage rent for mother vessels during the first two years to offset extra detour costs. Further research on port tariff structures may be needed.

- Efforts may be initiated by the GoB to secure funding from international organizations like the World Bank (WB) and Asian Development Bank (ADB), highlighting MDSP's potential as a regional shipping hub.
- Diplomatic efforts may continue to convince Bhutan to sign a Memorandum of Understanding (MoU) for being connected with the BBIN Economic Corridor (EC).
- The GoB may introduce financial incentives to attract national and international companies to establish industries at the Moheshkhali Special Economic Zone.
- The GoB may declare a Land lord PPP model for the operation of the MDSP.

Human Resource Development

- The MDSP Port Authority may prioritize the recruitment of graduates from maritime universities for port management positions to improve efficiency.
- Short courses on various aspects of port management should be initiated by the Chittagong Port Authority (CPA) to develop a skilled workforce for MDSP.

Miscellaneous

- The port authority of MDSP is to maintain an 18.5-meter depth throughout the navigable channel and harbor through regular dredging to accommodate ships with a 16-meter draft.
- During the first phase of port development, efforts are to be made for incorporating automation in equipment procurement, such as Maritime Autonomous Surface Systems (MASS) for port operations and security.
- The current development plan may include modern port facilities such as Automated Guided Vehicles (AGVs), automated cranes for container handling, and advanced logistics management systems.
- After the completion of MDSP terminals and the procurement of equipment by 2027, the port authority is to begin its operations, initially using river routes, if the road construction is not completed in due time.

Table 6 : Action Plan for Commencing Operation of MDSP as a Regional Shipping Hub

Term	Project	Organi- zations	Target to Complete
Immedi- ately	Commence construction of Matarbari Port Access Road	RHD	2027
	Commence construction of 460x300 meters jetties	CPA	2026
	Commence construction of Matarbari North South Connecting Road	CPA	2026
Short Term	Promulgation of new Tariff for MDSP	CPA	2025
	Procurement of advanced hi-tech equipment for automation	CPA	2026
	Recruitment of fresh graduates from Maritime University	CPA	2026

Long Term	Commence Matarbari-Chakoria DG Railway Link Project	BR	2029
	Construction of ICD	CPA	2029
	Establish industries at the Moheshkhali Special Economic Zone	CPA	2030
	Collect Funding from WB/ADB for commencing the project	MOFA	2028
	Initiate diplomatic efforts to start international and regional project like Asian Highways, TAR, BBIN, BCIM for connecting MDSP	MOFA	2030

Conclusion

A regional port's success hinges on efficient operations, low costs, and high-quality services. Therefore, the Government of Bangladesh (GoB) must effectively implement its plans to capitalize on the opportunity to make MDSP a regional shipping hub. Given the port's developmental stage, infrastructure projects cannot be executed in isolation; a coordinated regional approach targeting specific areas is essential. Initiatives like the Asian Highway, BBIN, and BMIC, which aim to connect MDSP, need prompt implementation. National projects such as the Matarbari Port Access Road, North-South Port Connecting Road, and Matarbari-Chakoria DG Rail Link require careful attention, especially regarding funding and land acquisition. Port authorities must focus on improving operational efficiency, including reducing turnaround times, refining the port management model, and developing a skilled workforce to attract shipping lines and global traders. Additionally, port costs—like dues, deviation expenses, and feeder service charges—must stay competitive with regional hubs such as Colombo and Singapore. While further research is needed to determine optimal tariffs, offering competitive port dues could help offset additional deviation costs, encouraging major shipping lines to use MDSP.

Notes and References

1. Al-Amin, 2021. Bangladesh to be developed nation by 2041: what will be lacking and what needs to be done. SSRN, p. p13.
2. Sinha, S., 2023. The Development of Matarbari Port and its Significance for the Region. National Maritime Foundation, p. p.5.
3. Datta, G., 2016. Japan and the BIG-B Plan for Bangladesh: An assessment. National Maritime Foundation, p. p.6.
4. Shinha, S., 2023. The development of matarbari port and its significance to the region. National Maritime foundation, Issue available at www.maritimeindia.org, p. p.3.
5. Iqbal, M. K., 2023. Prospect of port led Regional Maritime connectivity in the Bay of Bengal: Way Ahead. BMJ, 06(1), p. p.3.
6. Liu, T. & Wang, H., 2023. Evaluating the Service Capacity of Port Centric Intermodal Transshipment Hub. MDPI, 11(7).
7. Khan, M., 1993. History of the Port of Chittagong. Dhaka: Dana Printers Limited.
8. Khaleque, A., 2023. Cost and Benefit of Regional Connectivity: An Analysis from Bangladesh Perspective. South Asian Journal of Social Studies and Economics, 20(3), pp. Pp.138-154.
9. I. Kurt, E. B. a. O. T., 2015. AN AHP DECISION SUPPORT MODEL FOR THE HUB PORT CHOICE OF THE SHIPPING LINERS ON THE MEDITERRANEAN REGION. s.l.:Researchgate.
10. Dyke, G. C. V., 2015. Multi-Criteria Evaluation of Port Competitiveness in West Africa Using Analytic Hierarchy Process (AHP). American Journal of Industrial and Business Management, 5(6).
11. TAI, H.-H. & Hwang, C.-C., 2005. ANALYSIS OF HUB PORT CHOICE FOR CONTAINER TRUNK LINES IN EAST ASIA. Journal of the Eastern Asia Society for Transportation Studies, Volume 6, pp. Pp. 907-919.

12. Wang, L., 2011. Container seaport selection criteria for shipping lines in a global supply chain perspective: implications for regional port competition.. Erasmus University Rotterdam.
13. Rahman, Z., 2023. Development of Maritime Ports of Bangladesh: Prospect and Challenge. NDC Journal, 22(1), pp. Pp.89-92.
14. List, L., 2023. One Hundred Container Port 2023. [Online] Available at: <https://lloydslist.com:one-hundred-container-port-2023> [Accessed 19 Apr 2024].
15. Islam, C. F., 2024. Limitation and Obstacles of CPA [Interview] (7 June 2024).
16. Haque, E., 2024. Obstacles to reduce turn around time in CPA [Interview] (15 Aug 2024).
17. ADB, 2015. Strategic Master Plan for Chittagong Port, Hamburg: HPC.
18. Kibria, C., 2024. The limitation and obstacles of MPA [Interview] (09 Aug 2024).
19. Rashid, H. & Hossain, N., 2022. Rabnabad Channel Dredging Project: Challenges and Prospects. Bangladesh Maritime Journal, 01 January, 6(1), pp. Pp.102-105.
20. UNCTAD, 2022. Review of Maritime transportation. [Online] Available at: https://unctad.org/system/files/official-document/rmt2022_en.pdf [Accessed 09 September 2024].
21. Haque, E., 2024. Difficulties Faced by CPA in Unloading Goods for Custom Inspection [Interview] (25 July 2024).
22. Siddique, A. H., 2022. Matarbari Deep Seaport Project: Future Regional Transshipment hub and gateway to the Country's Trade. Marine Surveyors Association of Bangladesh, 1(1), p. P.6.
23. Hakim, A., 2024. Cargo handling prospect of Matarbari Deep Seaport [Interview] (26 June 2024).
24. Saif, S. & Rahman, Y. O., 2024. Asian High Way: A pipe dream on paper. Business Standard, 24 June.

25. Feller, G., 2021. A massive highways development programme is being planned in Bangladesh. *World High Ways*, 2 August, p. p.5.
26. Venkatesh, M., 2021. India Narrative. [Online] Available at: www.indianarrative.com [Accessed 24 July 2024].
27. Nora, E., 2022. What will it take to connect the Bangladesh, Bhutan, India, Nepal (BBIN) sub-region?. *World Bank Blogs*, 24 January.
28. Goel, P. K., 2023. Assessing the state of BBIN Transport Connectivity. [Online] Available at: <https://www.unescap.org> [Accessed 20 May 2024].
29. Islam, K., 2018. Bangladesh-China-India-Myanmar (BCIM) Economic Corridor: Challenges and prospect. *Worl Fish*, 30(2), pp. Pp.283-302.
30. Shawon, A. A., 2024. Dhaka Tribun. [Online] Available at: <https://www.dhakatribune.com> [Accessed 06 July 2024].
31. Islam, A., 2024. The Daily Sun. [Online] [Accessed 29 June 2024].
32. Ahmed, F., 2023. The Business Standard. [Online] Available at: <https://www.tbsnews.net/bangladesh/infrastructure/asian-highway-pipe-dream-paper-308839> [Accessed 2024 June 2024].
33. Ahmed, F., 2023. Matarbari access road work begins in July. *The Business Standard*, 12 March.
34. Patwary, M. A. H., 2024. Matarbari Deep Seaport Road Project [Interview] (26 June 2024).
35. Azad, H., 2021. Fund for Matarbari power plant's link road project blocked. *Business Insider*, 10 June.
36. Anon., 2024. India Shipping news. [Online] Available at: www.indiashippingnews.com [Accessed 24 July 2024].
37. Gunsekara, R., 2014. Automotive Logistics. [Online] Available at: <http://www.automotivelogistics.media/shipping-focus-the-unexpected-rise-of-humbantota-port/12068.article> [Accessed 4 July 2024].
38. Brook, M. R. & Schellinck, T., 2011. A Systematic Approach for Evaluating Port Effectiveness. *Maritime Policy and Management*, 38(3), pp. Pp.331-332.
39. Ibrahim, J., 2024. *Visiwise*. [Online], Available at: <http://www.visiwise.co> [Accessed 20 Aug 2024].

40. Munim, Z. H., 2018. The impacts of port infrastructure and logistics performance on economic growth: the mediating role of seaborne trade. *Springer Open*, 3(1).
41. Chowdhury, J. R., 2020. India Bangladesh Launch New Initiative to Connect Landlock North east. *The Economic Times*, 03 September, p. P.1.
42. Wing, L. C. A., 2024. *Matarbari Deep Sea Port: Unlocking the Economic Potential of Bangladesh*. [Online], Available at: www.lightcastle.bd [Accessed 22 Aug 2024].
43. Chowdhury, K. R. & Islam, E., 2023. Matarbari Deep Sea Port: A vista of economic development in the Bay of Bengal Region. *The Business Standard*, 26 October.
44. Anon., 2023. *The Business Standard*. [Online] Available at: <https://www.tbsnews.net/bangladesh/infrastructure/construction-matarbari-port-progressing-full-pace-594486> [Accessed 7 August 2024].
45. Matarbari, G.p.t.c.C.B.r.l.t., 2023. *The Financial Express*. [Online] Available at: <https://thefinancialexpress.com.bd/national/govt-plans-to-connect-coxs-bazar-rail-link-to-matarbari-port> [Accessed 7 July 2024].
46. Gin, S., 2024. *Matarbari Railway Connectivity* [Interview] (08 July 2024).
47. Musa, R. A. M., 2024. *Matarbari Deep Sea port as a regional shipping hub* [Interview] (9 May 2024).
48. Mansur, A., 2024. *Dhaka Tribune*. [Online] Available at: www.dhakatribune.com [Accessed 01 May 2024].
49. (JICA), J. I. C. A., 2018. *Preparatory Survey on the Matarbari Port Development in People's Republic of Bangladesh Final Report*, Dhaka: People's Republic of Bangladesh Ministry of Shipping.
50. Basu, P. & Bose, S., 2021. In Search of the Sea: Opening India's Northeast to the Bay of Bengal. *Observer Research Foundation*, 21 June, p. p.1.
51. Basu, A. & Chowdhury, R., 2021. Connectivity and Sub-regional cooperation in the East of South Asia: Importance of India's North-East Revisited,. *Observer Research Foundation*, 30 June, p. p.1.
52. Ahmed, F., 2023. *Matarbari Deep Seaport Channel Set to be Inagurated on 11 Nov 2023*. [Online] Available at: <https://www.tbsnews.net> [Accessed 29 April 2024].

53. Hossain, S., 2022. *Business Inspection*. [Online] [Accessed 01 May 2024].
54. Reza, K. & Islam, E., 2023. Matarbari Deep Seaport: A Vista of Economic Development in the Bay of Bengal Region. 26 October, p. p.5.
55. Sohini, B., 2023. *Bangladesh's sea port: securig domestic and regional interest*. New Delhi: ORF.
56. Corey, J., 2022. Container Transshipment via Regional Hub Port: A case of the Caribbean Region. *Science Direct*, Volume 217, p. p.2.
57. Karim, S. & Hassan, Q., 2015. Motor vehicle Agreement between Bangladesh Bhutan India and Nepal: Implication s and Challenges. *BIISS Journal*, 36(02), pp. Pp. 165-180.
58. Islam, S., 2023. Rail Based trade connectivity in BBIN region Ahead. *WB Spreadsheet*, 15 November, p. Accessed on 24 May 2024.
59. SATO, S. & MOTONO, I., 2023. The economic effects of Matarbari Port in Bangladesh under different without case setting. *OCDI*, XX(XX), p. Accessed on 24 May 2024.
60. MediaCentre>HotTopic>pages, 2023. *Initial IMO GHG Strategy*. [Online] Available at: <https://www.imo.org> [Accessed 22 June 2024].
61. Zaman, D. R. U., 2024. *Geopolitics* [Interview] (25 June 2024).
62. Anon., 2023. *Dohazari Cox's Bazar Railway Project*. [Online] Available at: <https://dhz-coxb-railway.com/trans-asian-railway-network/> [Accessed 28 June 2024].
63. Mahmud, F. & Satoh, R., 2023. *News in Asia*. [Online] Available at: <https://newsin.asia/bangladesh-deep-sea-matarbari-port-promises-a-strategic-anchor-for-japan-and-india/> [Accessed 29 June 2024].
64. Musa, M., 2024. *MDAS as regional shipping hub* [Interview] (7 May 2024).
65. Ferdous, J., 2020. Politics and Possibilities of Deep Sea Port in Bangladesh: A specialfocus on Matarbari Port Project. 01 October, p. p.6.
66. Khan, M., 1993. *History of Chittagong Port*. 1st ed. Dhaka: Dana Publisher.
67. Shaha, R. C., 2023. Inland Container Terminal Development to Increase Seaport's Competitiveness in Bangladesh. *JMR*, 20(1), p. p.13.

68. Colombage, J., 2018. Maritime Trade Dependence of Bangladesh Myanmar and Srilanka: Implication and Way Forward. *National Maritime Foundation*, p. p.7.
69. Anderson, J. B., 2011. What are Innovation Ecosystem and how to build and use them. p. 5.
70. Amin, a., n.d.
71. Rahmatullah, M., 2009. Regional Connectivity: Opportunities for Bangladesh to be a Transport Hub. *Bangladesh Institutes of Planners*, Volume 2, pp. Pp. 13-29.
72. Kawasaki, T. & Hanaoka, S., 2023. Geospital Transition of port hinterland considering intermodal service frequency: A case Study of Bangladesh. *Science Direct*, Volume 108, p. p.5.
73. Datta, G., 2016. Japan and BIG_B plan for Bangladesh: An Assessment. *National Maritime Foundation*, pp. Pp.1-5 Accessed on 25 march 2024.
74. Sato, S., Monto, I. & Ichio, M., 2020. The Economic Effect of Matarbari Port in Bangladesh under Different Without Case Settings.
75. Akram, W. & Zafor, A., 2019. The Prospect of Sustainable Biofuel in Bangladesh: Challenges and Solution. *Scientific Research*, 9(3).
76. IMO, 2023. *IMO's work to cut GHG emissions from ships*. [Online] Available at: www.imo.org [Accessed 21 July 2024].
77. Islam, A., 2024. Prospect of BCIM-EC. *Daily Observer*, 25 April.
78. Kavirathna, C. & Kawasaki, T., 2018. Transshipment hub portselection criteria by shipping lines: the case of hub port around the bay of bengal. *Springer Open*, 4(3), p. p.5.
79. The Ocean Policy Research Institute, t. S. P. F., 2024. Bangladesh's First Deep Seaport: Matarbari Heralds a New Vista in the Bay of Bengal Region. *The Ocean Policy Research Institute, the Sasakawa Peace Foundation* , 2024 June.
80. Anon., 2024. *Hellenic Shipping News Worldwide*. [Online] Available at: <https://www.hellenicshippingnews.com> [Accessed 01 Aug 2024].
81. Nath, S. S., 2023. Matarbari Deep Sea Port Becoming a Regional Hub: A Game Changer in the Region?. *The Centre*, 24 February, Volume 110.

82. Anon., 2023. *Matarbari Deep Sea Port: It'll boost GDP, create 9 lakh jobs..* [Online] Available at: <https://www.thedailystar.net> • [Accessed 01 Aug 2024].

83. Anon., n.d.

84. Farid, C., 2024. *Economic benefit of CPA* [Interview] (7 June 2024).

85. (JICA), R. J. I. C. A., 2023. *MIDI Strategic Vision Development and Economic Impact Analysis Final Report*, Dhaka: Peoples Republic of Bangladesh MIDI Cell.

Biography of the Writer



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FROM COAST TO COMMERCE: EXPLORING THE ECONOMIC POTENTIALS OF BANGLADESH'S MARITIME DOMAIN

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Abstract

The Bay of Bengal has become the heart of Bangladesh's future economic and strategic development, following the delimitation of its sea boundary. The nation boasts enormous blue resources, such as fisheries, hydrocarbons, shipbuilding, maritime trade, tourism, etc. The country's national development is increasingly reliant on the sustainable exploitation of these resources. Maritime Domain Awareness (MDA) is crucial for maintaining various opportunities that encompass safety, security, environmental protection, and economic activities at sea. The effective MDA needs constant surveillance, data exchange, interagency cooperation and regional collaboration. Despite setting policy initiatives and identification of priority sectors within the blue economy, progress has been impeded by limited infrastructure, investment, institutional capabilities and technological prowess. Therefore, it is imperative to enhance the capabilities of ports, facilitate offshore energy exploration, optimize fishery management, advance renewable energy initiatives, promote shipbuilding and develop marine tourism, etc. By implementing comprehensive maritime governance, harmonized policies, strategic planning and international collaboration, Bangladesh's maritime domain can become a key element of sustainable economic development.

Introduction

The delimitation of the maritime boundary has expanded Bangladesh's economic horizons and placed its maritime domain at the centre of future growth prospects. Bangladesh possesses vast and largely untapped oceanic resources, with sovereign rights on over 118,813 square kilometres of maritime territory in the Bay of Bengal and a coastline extending over 700 km. This expansive maritime area holds significant promise in sectors such as fisheries, maritime trade, offshore energy, shipbuilding, ship breaking, coastal/ marine tourism, various minerals, salt, shipping and port facilities, renewable/ non-

renewable energy, aquaculture and various environmental resources. As global focus shifts toward the sustainable use of the marine resources, generally known as blue resources, Bangladesh also stands at a pivotal moment to harness its maritime potential for national development.

Over the years, the dependency of our economy has shifted from land to the maritime sector. It makes the Maritime Domain Awareness (MDA) so important for Bangladesh in the present context. MDA is not only limited to the improvement of general awareness of the people. It also includes several systematic approaches, which include safety, security, economy and environment. Again, the economic aspect of MDA is directly related to the safety and security of the maritime trade and commerce. Economic aspect of MDA is also dependent on exploration, exploitation, conservation and management of resources, and the protection of maritime environment for intergeneration sustainability.

However, constant surveillance, information sharing and rapid response to the crisis are necessary to ensure the security of the maritime domain. It also demands interagency, regional and global cooperation because one agency/organisation or a particular country may not have all the required assets. Specially, to counter trans-border crimes like IUU fishing, piracy, human and drug trafficking need legal cooperation and understanding between the concerned countries. This makes the MDA a complex but an essential area of study in the present context for a maritime nation like Bangladesh.

The concept of the Blue Economy refers to the sustainable use of ocean/marine resources for the economic prosperity, better livelihoods and the well-being of the marine ecosystem. The maritime domain of Bangladesh can contribute significantly to the GDP, if managed strategically. This paper aims to explore the economic and geopolitical implications of the maritime domain of Bangladesh, identifying different opportunities for maximizing its long-term growth.

Maritime Culture and Tradition of The Bay of Bengal

The Bay of Bengal has a cradle of long tradition and rich maritime culture. The maritime culture of the Bay of Bengal is a distinct blend of ancient

navigation, trade legacy, fishing, religious tradition and indigenous sea faring knowledge. Bengal Sultanates used the Bay of Bengal for trade. Bangladesh has been a maritime country for centuries. The historic port of Chattogram was a vital node of ancient maritime silk routes. Seafaring community like Maimalis of Sylhet area used distinct boat-construction, traditional fishing and navigation. Use of indigenous boats like sampan or dinghy reflected the deep local knowledge on currents and tide of the Bay of Bengal. The landing of Portuguese, British, Dutch and French in the Bay of Bengal coast changed many maritime systems. They introduced western navigational method. Despite those modernizations, many traditional practices survived in craftsmanship, coastal oral histories and seasonal fishing cycle. However, coastal livelihoods and maritime festivals maintained this cultural identity alive.

The name and fame of the Bengal seafarers, specially shipbuilders, merchantmen and artisans, once spread to the entire world. Over the years, the scarcity of land resources has become the main constraint for the economic prosperity of the country. Gradually, the dependency of the economy of Bangladesh has shifted from agriculture to the industry and to the service sector. However, our long maritime tradition and style of governance also support pro-people use of the sea. Coastal people always made their fortune by exploring the sea resources. Many people also had to sacrifice their lives in natural disasters due to their lack of awareness of the environment. The owner of a boat could venture to the sea without adhering to all the rules. The traditions continue, and even today, thousands of boats operate at sea without proper documents. Some of them take chances with the rules and get involved in numerous illicit activities. As the concept of security changes with time and space, so does the economic activities' priority. The Bay of Bengal is not an exception to this. It makes the MDA so crucial for Bangladesh in the present context.

Geo-Economic Significance of The Bay of Bengal

The peaceful settlement of the international maritime boundary has opened a new prospect of development with the expansion of Bangladesh's territorial area and establishing sovereign rights over a sizable maritime area of about

118,813 square kilometers in the Bay of Bengal, giving it the ability to exploit mineral resources and ushering in new prospects in the Blue Economy. As the land resources are fast disappearing, it is apparent that our future generation's life will be dependent on the sea resources. As a maritime nation, the Exclusive Economic Zone of Bangladesh can contribute significantly to the national economy of the country and future generations' well-being. As a result, we need to get detailed information on the seafloor, subsoil and anything else on and above it to effectively utilize those resources.



Figure 1: The Sea Area of Bangladesh after Settlement (Source: PCA Verdict)

The significance and importance of the Bay of Bengal are enormous for the South Asia and the Southeast Asian region. The Bay of Bengal covers far more than the Indian Ocean's eastern reaches. The coastal countries' marine zone has long maintained a vibrant relationship through trade, people, religious, cultural and political missions, giving the region an autonomous character. The multiple rising effects will continue to converge due to their centrality. They will be further stimulated by strategic sea lines and the importance of a volatile and unpredictable region due to extra-territorial countries and non-state entities.

Due to its extensive inland penetration and geographical position, the Bay of Bengal also has a significant historical role.

The Bay of Bengal is a vital source of our natural resources. It is well-known for being a key source of the oil and the natural gas. It is home to a variety of energy. Various minerals abound in the vast coastal areas of the Bay of Bengal. The principal shipping route via the Bay of Bengal extends to the south of Sri Lanka and into the Straits of Malacca that connects key Asian economies such as China, India, South Korea and Japan. It is the crucial maritime path between the Pacific and Indian Oceans. Approximately, one-quarter of the world's commercial goods, including Chinese manufactured goods, Indonesian coffee, and oil, transit through the strait every year (Freeman, Donald B., 2003).

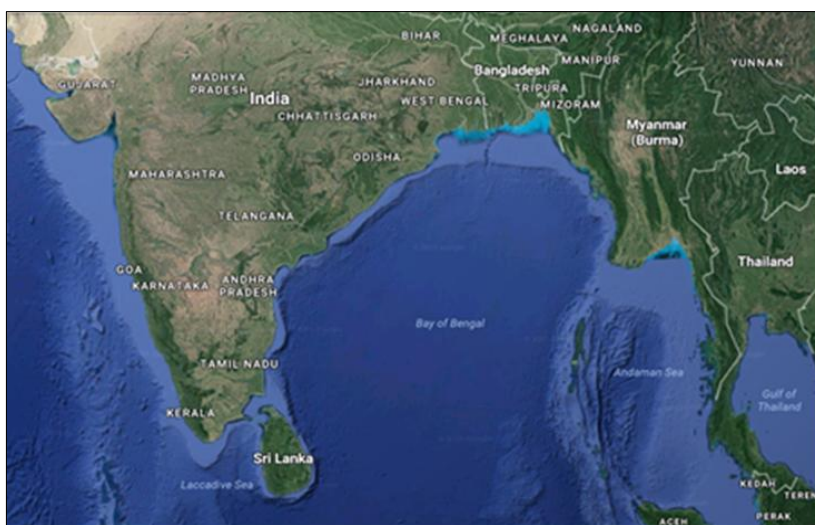


Figure 2: Bay of Bengal - The Big Source of Natural Resources

South Asia and Asia are becoming more important in international politics. Bangladesh's relevance is also growing due to its geopolitical location. Bangladesh's geopolitical position is of significance not only to India, but also to countries such as Nepal, Bhutan, China and the United States of America. Australia and Japan also have interest in Bangladesh. The US prefers to use the Bay of Bengal to improve its strategic influence in the region, given its importance in global affairs. Moreover, the Bay of Bengal is also crucial to two nuclear powers of Asia, India and China who are becoming superpowers in the

global system rapidly. Japan and Australia maintain strong relations with Bangladesh for their national interests, where Australia has many projects and provides significant assistance in the Chittagong Hill Tracts.

However, the maritime area of Bangladesh lacks reliable regional maritime domain awareness institutions. Physical structures cannot separate maritime areas. It is a world common where everyone has access at the same time, directly linked with all other waters and seas. After achieving the huge amount of maritime space, it is still covered by almost a previous limited capacity. High quality operational intelligence is also very important for maritime law enforcement. An efficient information flow enables a faster reaction to maritime issues like piracy, human and drug trafficking, or other maritime emergencies. In such cases, coordination and information sharing between government agencies, regional and international entities and the marine industry is critical.

Prospects of The Blue Economy In Bangladesh

Various maritime resources are available in the maritime zones of Bangladesh. Oil, gas, various minerals, shipping and port facilities, shipbuilding, ship breaking, salt production, marine fisheries, aquaculture, renewable blue energy, coastal tourism, etc are the major marine resources, which support the Blue Economy of Bangladesh. In the Bay of Bengal, there is a massive hydrocarbon reservoir and marine minerals worth billions of dollars. Our marine fisheries account for around 20% of the overall fish production of the country (DOF, 2023). The fisheries sector employs about 18 million people directly and indirectly and contributes around 3.5% to our GDP (DOF, 2023). Fresh and brackish water resources are abundant along the shore. The Bay of Bengal is the home to the world's largest mangrove forest Sunderban. Sandy beaches have a lot of potential for tourism. A coral colony of St Martins Island is also a good tourist destination.

Bangladesh has a more significant stake in developing a sustainable Blue Economy than any other littoral of the Bay of Bengal. The economy of Bangladesh is based heavily on exports, demanding vibrant maritime shipping. Therefore, the future growth of Bangladesh relies on the potential of sea

resources and maritime trade and commerce. Bangladesh is a regional leader in the Blue Economy because of the need to look at the maritime area for its growth. The Blue Economy will contribute considerably to the GDP for the sustainable development of the country. The government prioritized the growth of maritime trade, establishing a national coordinator for the Blue Economy in 2017.

The Ministry of Foreign Affairs (MOFA) organized two workshops at the national level in 2014 and 2017 and designated 26 industries to harness the potential of the Blue Economy in Bangladesh (MOFA, 2018). However, practically all industries remained almost untapped due to a lack of adequate measures (Rahman, et. al., 2017). Shipping, seaport facilities, coastal trade, inland water transports, passenger ferry, shipbuilding, ship breaking yard, fishery, marine acquaintance products, marine aquaculture, marine biotechnology, sea salt, oil, gas, tidal energy, renewable energy, blue energy (osmosis) and biomass, marine mineral mining, aggregate mining, recreational water sports, coastal tourism, cruise tourism, human resource development, maritime surveillance, artificial islands-greening coastal belts, and sound marine planning are among these sectors. Thus, the government is attempting to formulate policies that would assist Bangladesh in achieving the UN Sustainable Development Goals (SDGs) (Hassan et al., 2014).

There are a number of challenges in our maritime domain. As our maritime area has expanded after the maritime delimitation, we must be more aware of our maritime domain. Limited offshore exploration and investment, maritime pollution, unregulated use of resources, climate change, rising sea levels and inadequate legal and institutional frameworks are some of the challenges. In addition, the possible use of sea routes by criminals and the ingress of FDMNs through our maritime areas represent considerable maritime threats to the country. Piracy and armed robbery, narco-trafficking, drug smuggling, etc., are some of the other security challenges in Bangladesh's maritime area. Bangladesh needs to maintain good maritime capabilities and should have capabilities to deal with these security threats and safeguard the enormous untapped blue resources.

Bangladesh has not fully utilized the deep-sea fishing due to limited infrastructure and policy limitations. Protection of marine biodiversity and modernizing the sector can boost exports of fish and seafood, ensure food security and create jobs in processing and logistics with 90% of our trade conducted by sea, the development of port infrastructure is crucial. Modernization of Chattogram, Mongla and Payra ports is essential for enhancing trade efficiency, attracting foreign direct investment and supporting regional connectivity. Bangladesh's maritime area holds potential for offshore gas and oil exploration. However, the exploration has been slow. International collaborations could reduce dependency on energy imports, promote energy security and create high-value jobs in marine geosciences.

Moreover, offshore wind and tidal energy offer a sustainable, long-term energy solution.

Developing eco-tourism can diversify local economies, create employment and earn foreign exchange. However, it must be balanced with marine conservation and climate resilience measures. Bangladesh has an emerging capability in shipbuilding, repair and marine services. Investment in this sector can create skilled jobs, reduce dependence on foreign vessels and strengthen maritime capabilities. Now it is the high time to formulate a vibrant policy and effective strategy for Maritime Spatial Planning at the national level (Hossain et al, 2014). Sooner, an initiative should be taken to form a body under the auspices of the office of the Head of the Government for sectorial planning of the Blue Economy of the country.

Promoting The Blue Economy In Regional and Global Forums

Bangladesh make use of all the opportunities to promote the agenda of its Blue Economy in regional and global forums. It is urged for broader regional cooperation on Blue Economy through group like BIMSTEC. In September 2019, Bangladesh hosted a high-level seminar of IORA Officials, helping to promote the Blue Economy agenda in the IORA. The creation of a sustainable Blue Economy in Bangladesh faces numerous obstacles. Marine pollution, lack of indigenous technical skills and port facilities are a few mentionable major obstacles. If assisted by enough infrastructural and financial support as well as human capital investments, maritime businesses such as tourism, fisheries,

offshore hydrocarbons and other minerals can help Bangladesh in meeting its economic needs.

BIMSTEC has designated 14 Blue Economic priority areas for cooperation, including energy, transportation and communication, commerce and investment, tourism and fisheries. Each member state has been assigned to lead at least one priority area. Member countries could work together to improve people-to-people communication. As a result of shifting geopolitical dynamics in Asia and the Pacific, leaders must recognize the significance of the Bay of Bengal. They also need to realise the role that regional economic incorporation among the BIMSTEC nations can play in achieving security and strategic goals. Our strong leadership in the Bay of Bengal region, built on trade and investment cooperation, will help those better secure strategic items like oil and gas. It will also help them to take a more proactive role in the South Asia-Pacific region.

As our maritime domain is close to the vital sea routes, it positions Bangladesh as a strategic link in the Indo-Pacific. The development of maritime economic zones and naval presence can boost maritime diplomacy, secure trade routes, and attract regional and sub-regional partnerships. Development of a global partnership for harnessing the potential of the Blue Economy may be considered as an important concern.

Conclusion

Bangladesh has significantly expanded its marine jurisdiction in the Bay of Bengal since resolving maritime boundary disputes with Myanmar and India in 2012 and 2014 respectively. The future of the country is linked with the exploitation of our resources from this expanded maritime domain. The Blue Economy will contribute immensely to her economy. It conceptualizes sustainable use and conservation of living resources, marine transport, mineral resources extraction, renewable energy production and marine tourism. Thus, the safety and security of these resources and sea-based activities are also important. It is equally important to protect them using all possible surveillance, on-ground enforcement and interagency information exchange.

Now, it is the time to employ a multi-sectorial approach and coordination to harness the resources rationally. It should also include international diplomacy. Addressing the issues related to maritime security needs political will, a policy framework and the presence of a credible security force along with the government initiative. It also requires cooperation amongst the stakeholders, a positive mindset and sharing of information. Additionally, it also needs strong infrastructure, adequate funds and trained human resources. The economic growth and the prosperity of Bangladesh mostly lie in the Blue Economic activities, that demands effective Maritime Domain Awareness.

Bangladesh's maritime domain is not merely a natural asset but also a geopolitical and economic opportunity. By sustainably investing in maritime sectors, Bangladesh can unlock its future potential, discover new sources of growth, ensure energy and food security and enhance regional influence. With a coordinated and synchronized policy framework aligning with International Maritime Organization, ensuring good maritime governance and maintaining international collaboration, the Bay of Bengal can really become a cornerstone for the economic future and national growth of Bangladesh.

Recommendations

A few recommendations on the economic implications of Bangladesh's maritime domain are as follows:

- Formulate a comprehensive Blue Economy Policy by aligning our National Maritime Strategy to integrate the Blue Economy with maritime security.
- Strengthen maritime governance by establishing legal frameworks and enhance inter-agency coordination, and ensuring surveillance to secure maritime zones.
- Invest in Ports to modernize them and logistics infrastructure by establishing deep-sea ports and multimodal transport hubs to boost trade.

- Strengthen Marine Fisheries Management by regulating deep-sea fishing and preventing IUU fishing.
- Expand Offshore Energy Exploration by accelerating oil, gas and renewable energy exploration through public-private partnerships.
- Boost Shipbuilding, Marine Services and Ship Recycling Industry.
- Promote Marine Tourism and Coastal Development with eco-friendly tourism zones by ensuring climate resilience and biodiversity conservation.
- Develop R&D and promote marine education to support skills development and innovation.

Notes and References

1. Ahmed, Md. Kawser. (2018). Blue Economy of Bangladesh: New Investment Horizon Needs Foreign Investment.
2. DOF, 2023. Yearbook of Fisheries Statistics of Bangladesh, 2022-23. Fisheries Resources Survey System (FRSS), Department of Fisheries and Livestocks, 2023. Volume 40, 138p.
3. Freeman, Donald B. (2003). The Straits of Malacca: Gateway or Gauntlet?. McGill-Queen's University Press. ISBN O-7735-2515-7. A Book review at University of Toronto Quarterly, Volume 74, Number 1, Winter 2004/5, pp.528-530.MOFA (2018). Press Release: Press Statement of the Hon'ble Foreign Minister on the Potential of Blue Economy.
4. Hassan, S. R., Hassan, M. K., & Islam, M. S. (2014). Tourist-group consideration in tourism carrying capacity assessment: A new approach for the Saint Martin's Island, Bangladesh. Journal of Economics and Sustainable Development, 5(19), 150-158.

5. Hossain, M. S., Chowdhury, S. R., Navera, U. K., Hossain, M. A. R., Imam, B. and Sharifuzzaman, S. M. 2014. Opportunities and Strategies for Ocean and River Resources Management. FAO, Bangladesh Country Office, Dhaka, Bangladesh.
6. Kislú, M. N. K., (2016), MARITIME DOMAIN AWARENESS FOR ECONOMIC DEVELOPMENT OF BANGLADESH, NDC E-Journal, 15(1),77-98,Retrived from <https://ndcjournal.ndc.gov.bd/ndcj/index.php/ndcj/article/view/169>.
7. Rahman, M. S., Saha, N., Islam, A. T., Shen, S., & Bodrud-Doza, M. (2017). Evaluation of water quality for sustainable agriculture in Bangladesh. Water, Air, & Soil Pollution, 228(10), 385.

Biography of the Writer



Captain Mohammad Mizanur Rahman, (G), NPP, afwc, psc, MPhil, BN was commissioned in the Bangladesh Navy on 01 July 1998 in the Executive Branch. He completed the Gunnery Specialization Course at BNS ISSA KHAN. In 2003, Captain Mizan became the Honor Graduate of the International Surface Warfare Officers' Course at International Surface Warfare Officers School (ISWOS) in San Diego, United States. Throughout his career, he has served onboard various ships and naval establishments of the Bangladesh Navy in different capacities. His notable appointments include Gunnery Officer at BNS ISSA KHAN, Staff Officer (Operations) to COMKHUL, Executive Officer of the Bangladesh Naval Academy, and Executive Officer of BNS SOMUDRA AVIJAN. He also commanded several ships and establishments, including BCGS TOWHEED, BCGS PORTE GRANDE, BNS JAMUNA, BNS MADHUMATI, BNS SOMUDRA JOY, and the naval base BNS ULKA. He served as Gunnery Officer and First Lieutenant of BNS OSMAN from 07 June 2010 to 09 June 2011 while the ship was deployed under the United Nations Interim Force in Lebanon (UNIFIL) Maritime Task Force. In 2021, he also served as Chief of Naval Operations Centre at UNIFIL Headquarters. At present, he is serving as Chief Staff Officer to Commander Dhaka Naval Area. During his career, he has visited many countries, including the United States, Spain, China, Vietnam, Malaysia, Saudi Arabia, Cyprus, Turkey, Lebanon, and India. In his personal life, Captain Mizan is happily married and blessed with three sons.

INFORMATION FUSION CENTRE: PAVING THE WAY FOR MARITIME DOMAIN AWARENESS

Captain Mohammad Farhad Hossain, (ND), NPP, afwc, psc, BN

Abstract

Maritime Domain Awareness (MDA) has become increasingly vital for protecting and safeguarding national maritime interests at sea to address both conventional and non-traditional threats. Since Bangladesh's trade and strategic outlook heavily depend on the Bay of Bengal, the ability to monitor and manage its maritime space at sea is essential. This paper examines the current challenges facing Bangladesh's maritime security framework and considers the potential of an Information Fusion Centre (IFC) as a pragmatic solution. The study draws on regional experiences to analyze the existing gaps in surveillance, coordination, and data fusion within Bangladesh's maritime domain. It argues that a centralized IFC, supported by modern technologies, institutional frameworks, and international best practices, could significantly enhance situational awareness, operational coordination, and strategic decision-making. Additionally, the paper identifies legal, institutional, and technological barriers to implementation and proposes a comprehensive roadmap for integrating the IFC into Bangladesh's broader maritime security strategy. By combining comparative analysis with policy-oriented recommendations, this study contributes to ongoing discussions aimed at transforming the Bangladesh Navy (BN) into a more effective force capable of addressing contemporary maritime challenges.

Key Words: *Maritime Domain Awareness, Information Fusion Centre, Bangladesh Navy, Maritime Security, Bay of Bengal, Regional Cooperation, Non-Traditional Threats*

Introduction

Unlike land territory, which can be secured through physical presence and occupation, the maritime environment poses unique challenges for governance. At sea, maintaining continuous occupation or surveillance over vast areas is often neither feasible nor practical. Therefore, MDA is essential for effectively

controlling maritime spaces (International Maritime Organization [IMO], 2013; US Department of Defense, 2015). In general, MDA refers to the ability to understand activities occurring within the maritime environment through the systematic collection, integration, and analysis of data. This capability enables responsible authorities to make informed decisions in addressing various threats and challenges (Bueger, 2015). Historically, coastal states have been attempting to maintain awareness of their maritime domains ever since ships and boats first put to sea. In the early days, this depended on visual line of sight or what could be gleaned from intelligence ashore. Today, much more data has become available from sensors and technologies such as Global Positioning Systems (GPS), Automatic Identification Systems (AIS), satellite technology, and other types of surveillance, reporting, and communications systems (Rahman, 2020). Even though no single state can achieve comprehensive MDA independently, it requires international cooperation in information sharing, intelligence exchange, and coordinated responses at both bilateral and multilateral levels, as maritime space is fluidly connecting states and allows trespassing for innocent passages of foreign flags even with its own territorial waters (Bateman & Bergin, 2011). Moreover, the rise in maritime traffic and non-traditional security threats underscores the importance of IFCs for global ocean governance. Innovations such as Digital 3.0, nano satellite technologies, and Artificial Intelligence (AI) have enhanced the analysis and management of large datasets, thereby improving MDA (Lee, 2021). Recognizing the need, Southeast Asian countries are gradually upgrading their Operations Rooms into advanced fusion centers, showcasing the application of cutting-edge technology in maritime operations. For BN, integrating such advanced technologies through a national IFC is no longer optional but essential for ensuring effective coordination and strengthening responses to pave the way for MDA among maritime stakeholders.

Aim

This paper aims to identify the challenges of MDA and explore the feasibility of IFC for Bangladesh.

Literature Review and Theoretical Context

Conceptual Foundations of MDA

The IMO defines MDA as the “effective understanding of anything associated with the maritime domain that could impact security, safety, the economy or the marine environment” (IMO, 2013). The United States Government further expands the concept of the maritime domain as encompassing “all areas and things of, on, under, relating to, adjacent to, or bordering on a sea, ocean, or other navigable waterway, including all maritime-related activities, infrastructure, people, cargo, and vessels and other conveyances” (U.S. Department of Homeland Security [DHS], 2010). While MDA is often primarily associated with governance of oceanic spaces distant from shore, the U.S. definition underscores that it also extends to navigable inland waterways. This dimension is particularly relevant for Bangladesh, where deltaic coastal geography creates a fluid interface between rivers and the sea, making distinctions between fluvial and maritime spaces difficult to demarcate (BIMRAD, 2024).

Genesis of IFC

The emergence of IFCs stems from two interrelated factors. The first is the rapid advancement of information and communication technologies, which created a need for mechanisms to process and integrate large volumes of maritime data to enhance situational awareness and security (Rahman, 2021; BIMRAD, 2024). The second was the surge in Somali piracy between 2007 and 2008, when attacks escalated into a transnational criminal enterprise. During this period, over 175 ships were hijacked, more than 400 attacked, and thousands of crew members from more than 40 nations taken hostage (Chalk, 2009; Oceans Beyond Piracy, 2012). These developments prompted collaborative action among the United States, United Kingdom, NATO, the European Union, and private stakeholders, leading to the establishment of IFCs as hubs for real-time information sharing (Bueger, 2015; IMO, 2013). This effort contributed to a 75 percent decline in piracy incidents within five years (World Bank, 2013), and the IFC model has since been adopted by several states at national and regional levels (Bateman, 2017).



Figure-1: IFC - Regional Information Sharing Hub of IFC at Singapore

Theory and Global Practice of IFC

The exact number of IFCs existing worldwide is challenging to determine due to varying definitions and functions among countries. It is estimated that several hundred IFCs operate globally, mainly in coastal and strategic maritime regions. The Regional Maritime Information System (RMIS) Centers, established by the IMO, are located in key areas like Singapore, Jeddah, and Mumbai, promoting regional collaboration. Singapore’s IFC, established in 2009, integrates maritime data for the eastern Indian Ocean and Bay of Bengal, supporting multilateral engagement with over 20 liaison delegations (NSC, 2024). India’s Information Fusion Centre–Indian Ocean Region (IFC- IOR), launched in December 2018, extends its Area of Interest across the entire Indian Ocean. It currently hosts 12 International Liaison Officers (ILOs) and engages with over 65 international working-level linkages (Wikipedia, 2025). These regional IFCs rely on “white shipping agreements” to exchange data on non-military commercial vessels but often lack comprehensive data-sharing on naval or fishing-related information (NSC, 2024).



Figure-2: The Information Fusion Centre-Singapore and Indian Ocean Region

Technologies and Data Sources Underpinning MDA

Recent technological innovations have expanded the toolkit for MDA. Satellite-based platforms like SeaVision and SkyLight, with the incorporation of AI and high-resolution imaging, are now capable of tracking “dark ships” that disable AIS. Even integrating the US satellite-based HawkEye 360 RF detection system, “dark ships” is further correlated passively. Other efforts involve space-based assets (e.g., Synthetic Aperture Radar, meteorological satellites) and advanced analytics that enrich surveillance beyond surface-level observations (Narayanan et al., 2025).

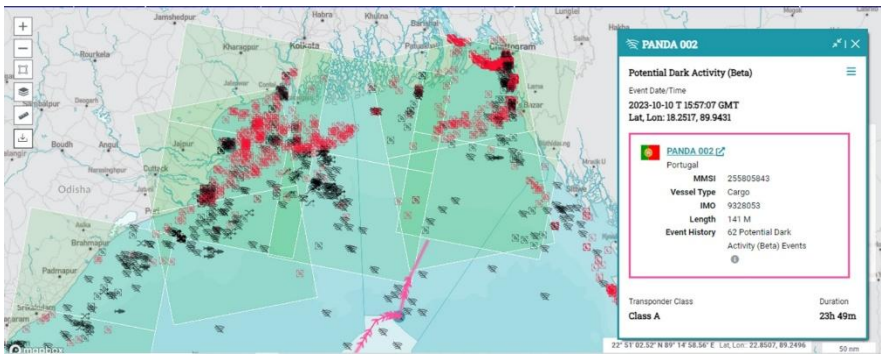


Figure-3: COP of Skylight Software

Regional and Global Policy Frameworks for MDA

Political–institutional forums such as the Indian Ocean Rim Association (IORA), BIMSTEC, and IONS provide formal platforms for maritime cooperation. IORA, for instance, includes a maritime working group, while

BIMSTEC offers potential regional coordination despite institutional limitations (NSC, 2024). The Quadrilateral (QUAD) and Indo-Pacific frameworks, such as the Indo-Pacific Maritime Domain Awareness (IPMDA) initiative, advocate for multi-center data exchange and strategic interoperability (Narayanan et al., 2025). In the Western Indian Ocean, platforms such as SeaVision and IORIS emphasize multinational MDA collaboration within trusted frameworks, striking a balance between information-sharing benefits and sovereignty concerns (IDSA, 2025).

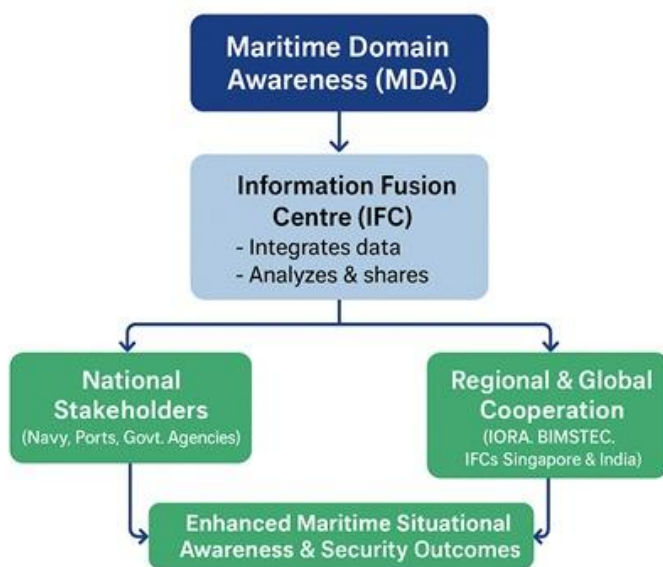


Figure-4: MDA Through IFC

Research Methodology

Research Significance

While generic aspects of MDA and maritime security have been widely studied, there is limited empirical research on practical mechanisms for information sharing in the context of Bangladesh. Specifically, there is a need to explore how the IFC can address institutional, technological, and resource challenges to effectively enhance MDA. In Bangladesh, the IFC at Naval Headquarters currently operates as a pilot project. This highlights the necessity for research into organizational structure, inter-agency collaboration, and

technology integration to strengthen maritime security and resource management (DKI APCSS, 2021; NSC, 2024).

Research Objectives

Assess MDA status, identify IFC challenges, evaluate regional/global best practices, and propose strategies for enhancement.

Research Method

This study employs a qualitative, exploratory approach to examine MDA in Bangladesh, focusing on the IFC.

Limitations

Limited access to classified data and evolving technologies may affect comprehensiveness.

Maritime Security Challenges for Bangladesh

Bangladesh needs offshore oceanic areas and internal riverine spaces, creating strong links between waterborne interests and threats. This shapes the country's strategic outlook, as most non-traditional security (NTS) threats in the ocean originate from or affect land. An analysis of NTS incidents in Bangladesh (shown in Figure 5) indicates that coastal and territorial waters serve as buffer zones, with most incidents beginning or ending on land. While most incidents occur in these coastal waters, only a few are directed exclusively toward them. Improved monitoring of these areas can enhance the management of sovereign rights and jurisdiction. Bangladesh's maritime search and rescue region, as defined by the International Convention on Maritime Search and Rescue, overlaps with its Exclusive Economic Zone (EEZ) and extends toward Myanmar, covering an area of 170,627 square kilometers. In contrast, its flight information region for offshore areas is significantly smaller.

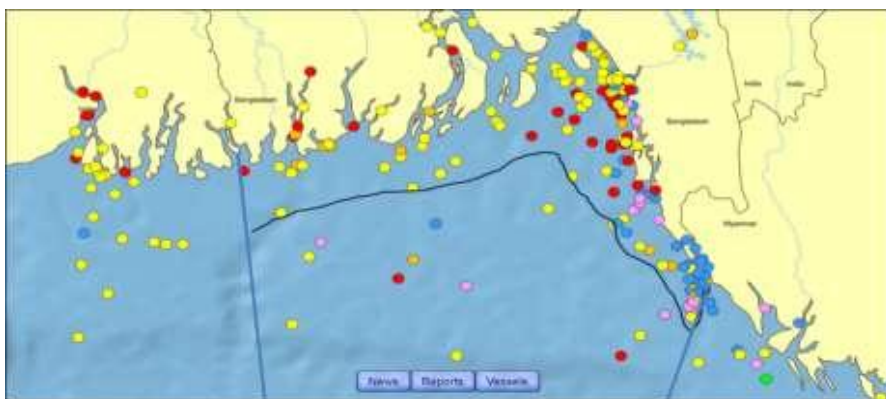


Figure-5: Overview of Maritime Incidents in Bay of Bengal

Traditional Security Threats

Transnational Crime, Piracy, Smuggling, and Illegal Fishing

Bangladesh faces some non-traditional maritime threats, including piracy, armed robbery at sea, smuggling of arms, drugs, and human trafficking, as well as illegal fishing and poaching (Islam, 2019). The Bay of Bengal's porous maritime boundaries and dense small-boat traffic complicate enforcement (Brewster et al., 2024).

Piracy Beyond the Bay of Bengal

Bangladesh-flagged vessels have been targets of piracy beyond Bangladeshi waters. A notable example occurred in March 2024 when a Bangladesh-flagged bulk carrier was boarded off the coast of Somalia, signaling regional vulnerabilities in international shipping lanes.

Environmental and Humanitarian Challenges

High Maritime Accident Rates & Inland Waterway Hazards

Bangladesh has high frequencies of marine accidents worldwide, particularly along coastal and inland waterways, due to congested routes and small, low-tech vessels (Brewster et al., 2024).

Severe Weather Events & Disaster Management

The maritime sector faces challenges from frequent cyclones and extreme weather events. For example, in November 2023, Cyclone Midhili affected port

operations. Similarly, Cyclone Mocha, which struck in May 2023, caused significant destruction along the coast and necessitated operational diversions.

Existing Maritime Infrastructure

Bangladesh has made noteworthy progress in strengthening its maritime capabilities and blue economy activities, particularly since the delimitation of its maritime boundaries with India (2014) and Myanmar (2012). Several initiatives reflect Bangladesh's growing attention to maritime security and governance.

Bangladesh Navy

BN has expanded its fleet under Forces Goal 2030, inducting submarines, frigates, and offshore patrol vessels. Naval aviation has also been strengthened with maritime patrol aircraft and helicopters, providing valuable airborne surveillance.

Bangladesh Coast Guard

BCG is undergoing modernization under Coast Guard Goal 2030, acquiring large patrol vessels, hovercraft, and coastal surveillance radars. Plans are underway for establishing a dedicated aviation wing to enhance law enforcement and search-and-rescue (SAR) capacity (Brewster, 2024).

Vessel Traffic Management Information System (VTMIS)

VTMIS is operational at Chattogram and Mongla ports, for effective monitoring of shipping traffic, with a system that includes control stations, radar, and CCTV connected via microwave links for sharing MDA information. The VTMIS at Payra Port is still under construction, presenting an opportunity for it to integrate with Chattogram and Mongla's VTMIS into their new setup for a comprehensive MDA overview across all port areas.



Figure-6: Data Collection and Sharing Process of DoF

Fisheries Vessel Monitoring System (FVMS)

The government has invested in FVMS for real-time fishing management by Bangladesh's Department of Fisheries (DoF) which has also created a Joint Monitoring Cell (JMC) to enhance marine fisheries monitoring through the Sustainable Coastal and Marine Fisheries Project. It was planned that 10,000 vessels will be equipped with AIS, with 1,500 vessels participating in a pilot project. It installed GSM devices on 8,000 of the 30,000 registered country boats, with plans to outfit all boats. Currently, only five trawlers have VMS installed due to the high costs, but the installation may soon become mandatory for registration (Brewster, 2024).

Maritime Rescue Coordination Centre (MRCC)

MRCC is being developed to coordinate Search and Rescue (SAR) operations in Bangladesh's EEZ. With support from South Korea, the Enhanced Global Maritime Distress and Safety System and Integrated Maritime Navigation System (EGIMNS) project is nearing completion under the Directorate General of Shipping. This project includes a Command and Control (C2) Center in Dhaka and seven Coastal Radio Stations (CRS) in locations like Kutubdia, Cox's Bazar, St. Martin's, and more.



Figure-7: Conceptual Diagram of GMDSS and IMNS System in Bangladesh

Strategic Implications

The need for unified system leaves Bangladesh vulnerable to security, economic, and humanitarian risks. While the hardware (ships, radars, and port systems) is gradually improving, the lack of integration prevents Bangladesh from achieving the benefits of scale and synergy. Without an institutional mechanism like IFC, Bangladesh may face difficulties in translating these scattered assets into a cohesive maritime security framework.

Development of IFC for Bangladesh

The 2018 draft defence policy of Bangladesh emphasizes the role of the Navy in protecting maritime interests, deterring aggression at sea, and coordinating with other maritime agencies. The government gazettes of 1975 also specifically tasked BN for protecting the Fishing Fleet, conducting SAR at sea, and patrolling the country's rivers. Therefore, integrating the surveillance capacities of multiple agencies into a unified network and implementing the "Hub and Spoke" method could enhance monitoring efforts. The AOI of IFC for BN may be as given in the figure below:



Figure-8: AOI of BN IFC

Existing Capabilities to Generate Information

It is impractical for a single agency to generate all the required information/data. Instead, the agency should focus on its core competency and generate data according to its capabilities, which will be integrated through a common framework for sharing with all relevant agencies on a need-to-know basis. Information generation capabilities of maritime agencies through existing infrastructure are given in the table below:

Table-1: Information Generation Capabilities of Maritime Agencies

Organization/ Agencies	Information/ Data Generation Capability
Port Authorities	Incoming and outgoing merchant ships.
DG Shipping	Registered fishing trawlers, craft/boats etc. AIS data of the AOR with CRS.
Civil Aviation Authority of Bangladesh (CAAB)	Aircrafts flying within the designated sector.
DoF/Fish Owners’ association	Fishing trawlers (registered/ unregistered), boats etc plying at sea and their positions/ area of activities.

BSC	Ships deployed at sea along with their updated positions.
BN/BCG	Deployed Ships with their updated position.

Conceptual Framework

In the IFC system, maritime information from multiple sources is collected, processed, and disseminated through the creation of a reliable COP on a centralized platform. This system enables the monitoring and communication of vessels and other entities with authorities via IFC. However, some individuals may seek to remain hidden for unlawful reasons, such as involvement in illegal, unreported, and unregulated (IUU) fishing, drug and arms smuggling, human trafficking, and other criminal activities. The challenge for IFC is to detect both those who wish to be noticed and those who do not. Detection methods include Synthetic Aperture Radar (SAT-SAR), Automatic Identification System (AIS), various web applications and software, coastal surveillance radars, and ship borne radar at sea. These methods are complemented by sector sweeps using Electro-Optical (EO) systems or drones for close inspections of small contacts. After detection, the identification process is enhanced through electronic means, such as Identification of Friend or Foe (IFF), in conjunction with visual identification. Communication is initiated as necessary, and contact data is periodically compared with merchant vessel information from sources like the Port Authority or IFC Sub-Centre. Contacts that cannot be classified may be categorized as "Orange" or "Red," depending on the situation and observed behaviours, which may prompt investigations by local Maritime Interdiction Operations (MIO) teams. A consistent flow of information is maintained between local Command, Control, and Communications (C3) systems and ships, with the IFC coordinating further MIO efforts, particularly for potential threats designated as "Red." For better understanding, a comprehensive flow chart illustrating the operation of the IFC is attached.

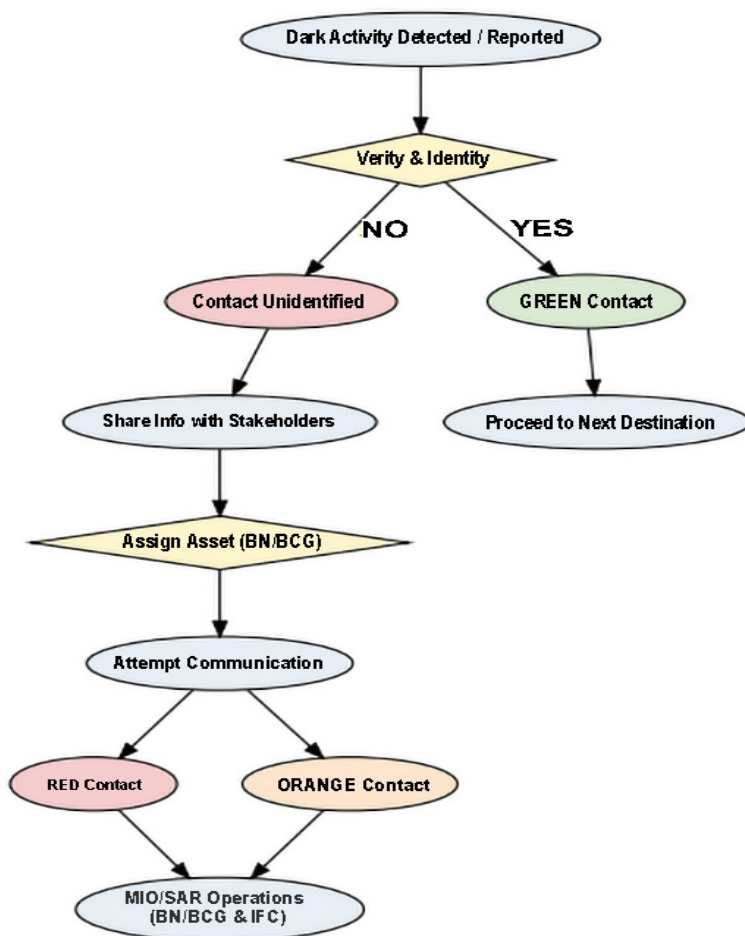


Figure - 9: Operational Function of IFC

Strategic Benefits of an IFC for Bangladesh

National Security and Operational Effectiveness

IFC will enhance the speed and quality of decision-making by integrating various sensor and reporting feeds into a unified COP. This leads to faster detection, quicker cueing, and a more rapid operational response. Empirical regional experience demonstrates that the IFC-style integration reduces incident response times and improves the success rate of interdictions. (Bateman, 2017; Bueger, 2015). For Bangladesh, this will benefit in the following way:

- **Improved Maritime Deterrence** : Better situational awareness makes maritime incursions, smuggling, and organized criminal operations riskier and less attractive, increasing the cost for illicit actors (Rahman, 2021). Moreover, having a robust MDA system serves as a significant deterrent, and illegal actors tend to avoid well-monitored maritime areas, instead targeting regions that are effectively "dark."
- **Enhanced SAR and Crisis Response** : Integrated COP and predictive analytics support faster SAR responses and better allocation of scarce platforms during storms, capsizes, or refugee boat disasters (UNHCR, 2025). BN may even task at free of cost to various agencies for information like satellite tasking as given in the following figure:

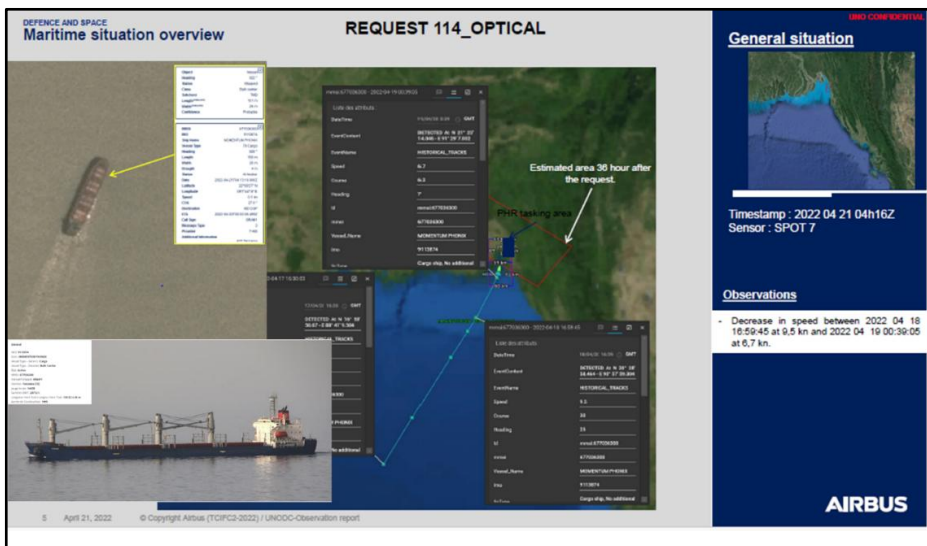


Figure-10: Satellite Tasking for MDA in Bangladesh Water by UNODC

- **Force-multiplication** : By reducing uncertainty, IFC will enable more effective use of existing maritime assets (patrol craft, aircraft, and small units), stretching limited defense budgets further (Brewster, 2024).

Economic benefits and protection of the blue economy

Maritime security is directly linked to economic performance for a port-dependent economy like Bangladesh. IFCs reduce risk in ways that have measurable economic effects:

- **Reduction in losses from IUU fishing :** IUU fishing has been estimated to cost Bangladesh and regional actors large sums annually (World Bank, 2024). Better detection and coordinated enforcement through an IFC would reduce illegal harvests and help restore the value of fish stocks.
- **Lower shipping/insurance premiums and improved trade reliability :** Stronger MDA reduces perceived risk for shipping companies and insurers, which can lower premiums and attract shipping traffic—directly benefiting Chattogram, Mongla and Payra ports (Bateman, 2017).
- **Investor confidence for offshore development :** More transparent maritime governance supports investment in offshore resources (fisheries, wind/energy, ports), accelerating blue- economy returns (Rahman & Hossain, 2023).

Humanitarian and Disaster-Response Benefits

Bangladesh is highly exposed to cyclones, maritime accidents, and refugee flows. An IFC can markedly improve humanitarian outcomes:

- **Faster detection of distressed vessels :** The integration of AIS, satellite tasking, and coastal reporting reduces the time between incident occurrence and rescue initiation, saving lives in high-casualty events such as refugee boat sinkings (UNHCR, 2025).
- **Better disaster coordination :** Linking meteorological feeds with vessel and port data enables more effective pre-positioning of resources and the coordination of evacuation plans during cyclones (Brewster, 2024).
- **Improved post-disaster logistics :** A COP streamlines relief routing and port prioritization, reducing time to recovery.

Environmental protection and resource sustainability

An IFC provides capabilities beyond security-particularly in environmental monitoring and response:

- **Pollution detection and rapid containment :** The timely fusion of satellite EO/SAR imagery and ship tracks enables the early identification of oil spills and illegal dumping.
- **Monitoring and enforcement for sustainable fisheries :** By

combining VMS, AIS, and satellite analytics (including “dark ship” detection), authorities can better enforce exclusive fishing zones and conservation measures (Narayanan et al., 2025).

- **Scientific and policy benefits :** A central data archive enables marine research, ecosystem monitoring, and evidence-based policy for climate adaptation and coastal resilience.

Diplomatic and regional benefits

IFCs are inherently cooperative institutions and thus carry diplomatic value:

- **Platform for regional engagement :** Hosting liaison officers, exchanging de-conflicted information, and participating in joint products enhances Bangladesh’s role in IORA, BIMSTEC, and other regional fora (NSC, 2024).
- **Trust building and soft power :** Contributing timely and trustworthy information to regional responses (e.g., HADR or piracy interdiction) enhances Bangladesh’s diplomatic standing.
- **Leveraging partnerships for capacity building :** IFCs attract partner assistance-technical, training, and satellite tasking-which reduces the national cost of capability acquisition (Bateman, 2017).

Measurable Operational Returns and Precedent Evidence

Regional precedents provide rough, operationally meaningful benchmarks. Coordinated anti-piracy efforts and the fusion of multinational data contributed to a nearly 75% decline in Somali piracy over five years after the crisis peak, demonstrating how information sharing and coordinated operations pay off (World Bank, 2013). Similarly, Singapore and India’s fusion models have produced observable gains in incident cueing, SAR outcomes, and multilateral exercises (Bueger, 2015; NSC, 2024).

Synthesis: Strategic Multiplier for Bangladesh

An IFC is not merely a technical system; it is a strategic multiplier that converts existing platforms, limited budgets, and regional goodwill into amplified security and economic outcomes. The center’s value is greatest when

it is: (a) integrated across civil-military lines, (b) embedded in a legal/data governance framework, and (c) phased to match domestic capacity while linking to external partners for scale and expertise (Brewster, 2024; Rahman, 2021).

Challenges and Constraints

While the establishment of an IFC offers Bangladesh significant security, economic, and diplomatic benefits, the pathway is uptight with structural, technological, institutional, and human resource constraints. Unless systematically addressed, these challenges could undermine the IFC's effectiveness and sustainability.

Institutional and Organizational Barriers

One of the most pressing challenges is the fragmented nature of maritime governance in Bangladesh. Multiple institutions—including the BN, BCG, DoF, Department of Shipping, Ministry of Home Affairs, and Ministry of Disaster Management—exercise overlapping jurisdiction in the maritime domain. This results in duplication of effort, limited information flow and coordination (BIMRAD, 2024). Similar obstacles were observed in India's IFC-IOR, where reluctance to share sensitive naval data restricted the IFC largely to commercial “white shipping” information (Brewster, 2024).

Technological and Infrastructure Limitations

Bangladesh's maritime surveillance architecture is still evolving, and several technical gaps remain:

- **Radar and AIS Coverage :** If coastal radar systems do not cover the full EEZ and AIS compliance is limited to larger commercial vessels, small boats and artisanal fishing fleets will remain invisible to surveillance networks (World Bank, 2024).
- **Satellite Access :** Relying on commercial satellite images can be costly and may not always be available quickly. Without special agreements in place, Bangladesh might find itself relying on outside partners for vital situational awareness (Narayanan et al., 2025).
- **Data Interoperability :** Port VTMS, fisheries VMS, and naval

surveillance systems operate independently, making it hard to build a seamless, integrated system COP.

Legal and Policy Gaps

A significant obstacle is the absence of a national legal framework for the sharing of maritime data. Currently, there are no laws specifying which agencies may share what type of data, under what conditions, and with which partners. This creates uncertainty, both domestically and internationally (Bateman, 2017). Furthermore, the absence of a national maritime policy leaves priorities for data integration undefined. Unlike Singapore, which codified IFC functions under ReCAAP, or India, which institutionalized IFC-IOR through its National Security Council, Bangladesh's approach remains piecemeal (NSC, 2024).

Human Resource and Capacity Constraints

The establishment of an IFC requires specialized expertise in big data analytics, artificial intelligence, and cybersecurity. Bangladesh needs trained professionals in these fields. Maritime operators are proficient in traditional naval and coast guard tasks but often lack the technical skills required for data fusion and predictive analytics (BIMRAD, 2024). Retention of skilled personnel is another issue.

Cybersecurity and Data Integrity Risks

As IFCs rely heavily on digital platforms, they become targets for cyberattacks. Compromising an IFC could cripple decision-making, expose sensitive data, or allow manipulation of vessel-tracking information. Countries such as Singapore have invested heavily in cybersecurity protocols for their IFC, recognizing this vulnerability (Bueger, 2015). Bangladesh will need similar safeguards, yet cybersecurity remains underdeveloped in national defense planning.

Resource and Funding Limitations

Although Bangladesh has expanded defense spending under Forces Goal 2030, its financial resources are constrained compared to larger regional powers. Establishing and maintaining an IFC requires sustained investment in technology, training, and infrastructure. Without external assistance-whether

through partnerships with other countries or international organizations like IMO or UNODC - Bangladesh risks creating an underfunded IFC that cannot fulfil its mandate (Rahman, 2021).

Policy Recommendations and Roadmap

Establishing a full-fledged IFC for Bangladesh requires a phased and pragmatic approach. The success of this initiative not only depends on technology but also on governance, legal clarity, and sustained political commitment. The policy recommendations that identify challenges are listed below:

Governance and Legal Framework

- **National Coordination Body** : Formation of a National Maritime Coordination Committee with representation from the BN, BCG, DoF, Shipping and civil ministries. As the government is also promoting Blue economic development, this may be done under the Prime Minister's office.
- **Data-Sharing Policy** : Introduce a Maritime Data-Sharing Regulation with tiered classifications (public, restricted, confidential, defense-only) beside the government policy on information record policy.
- **Civil–Military Integration** : BN may operate the IFC under naval leadership, like the regional models, with civilian participation to balance security and legitimacy.

Phased Implementation

- **Short Term (0–18 months)** : BN already launched a pilot IFC co-located with Naval Headquarters. Integration may be completed by developing an own COP with AIS and port VTMS data, subscribing to basic satellite services, and drafting legal frameworks.
- **Medium Term (15–60 months)** : Expand coastal radars and DoF FVMS; develop AI-enabled anomaly detection; host liaison officers from key partners and conduct training for analysts and cybersecurity staff.

- **Long Term (61–120 months)** : Evolve into a regional hub, integrating advanced satellite and RF data, underwater domain awareness (UDA), and robust links with international IFCs and multilateral bodies.

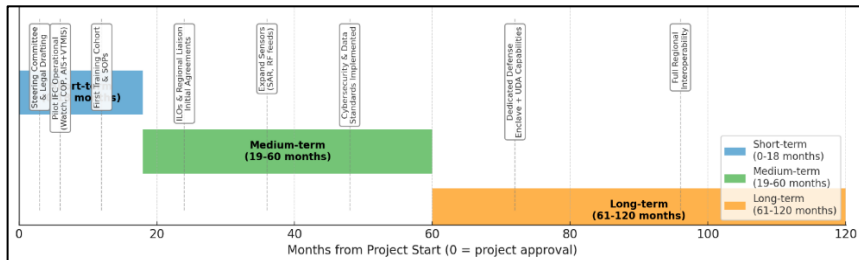


Figure-11: Phased Roadmap for Bangladesh IFC Implementation

Capacity Building

- **Human Resources** : BN may develop specialized training in data analytics and cybersecurity, supported by scholarships and joint programs with universities and partner navies.
- **Retention** : Provide career incentives to prevent loss of skilled personnel to the private sector.

Financing and Partnerships

- **Funding Mix** : Use a combination of national defence budgets, blue economy revenues, and partner assistance (e.g., technical aid from Singapore, and the EU).
- **International Cooperation** : Engage with regional forums like IORA and BIMSTEC and participate in multilateral exercises to build credibility.

Risk Mitigation

- **Sovereignty Concerns** : BN may adopt strict data classification to protect sensitive naval information.
- **Cybersecurity** : Establish strong defenses, including encryption, regular audits, and a maritime-focused incident response team through indigenous means.

- **Geopolitics** : Maintain balanced partnerships to avoid overdependence on any single external power.

Conclusion

Bangladesh's strategic location in the heart of the Bay of Bengal highlights the vital importance of maritime security for the nation. This vast and vibrant body of water offers significant opportunities for trade, bountiful fisheries, and vital energy development, making it a tantalizing prospect for economic growth. However, it also presents a range of threats, including piracy, illegal fishing, smuggling, and the potential devastation from natural disasters. While the current surveillance assets and institutional frameworks aimed at ensuring maritime safety are on the rise, they still suffer from fragmentation and inadequacies that hinder their effectiveness. The establishment of an IFC serves as a holistic solution, integrating data from diverse sources to create a comprehensive operational picture. This initiative fosters greater coordination among civil authorities, military forces, and regional stakeholders, driving collective maritime security efforts.

Insights from successful implementations in countries like Singapore and India demonstrate that IFCs can significantly enhance deterrence and foster cooperation. However, these successes underscore the need for clear legal frameworks and dedicated resources to support their effectiveness. For Bangladesh, the implementation of an IFC could yield multiple advantages, including bolstered national sovereignty, protection of fisheries, improved maritime safety, and enhanced disaster response capabilities. Nevertheless, to reap these benefits, the nation must confront challenges such as fragmented institutions and existing technological gaps.

A pragmatic approach could involve developing a phased roadmap that begins with a low-cost pilot project, leading to the creation of a regional hub for maritime collaboration. The key to this initiative's success will rely not solely on physical infrastructure but rather on unwavering political commitment, robust institutional cooperation, and significant investments in human resources. If executed thoughtfully, the IFC could emerge as an

indispensable element of the Bangladesh Navy's strategy, fostering a culture of regional maritime security cooperation that benefits all stakeholders in the Bay of Bengal.

Notes and References

1. Afrad, H. R. (2014). Maritime security in the Indian Ocean and the role of key Southeast and South Asian navies: A Bangladesh Navy perspective. Dhaka: National Defence College, Mirpur.
2. Alam, M. K. (2004). Bangladesh's maritime challenges in the 21st century (1st ed.). Dhaka, Bangladesh: Pathak Shamabesh.
3. Azad, A. K. (2003). Security in the 21st century: A Bangladesh perspective. Dhaka: Academic Press and Publishers Ltd.
4. Azad, A. K. (2006). Degradation of maritime environment in Southeast Asia: A study of conflict and cooperation and lessons for South Asia. BIIS Papers, 27(02), April.
5. Azad, A. K. (2009). Maritime security of Bangladesh: Facing the challenges of non-traditional threats. Dhaka: BIIS.
6. Bateman, S. (2017). Information sharing in maritime security: A South East Asian perspective. *Journal of the Indian Ocean Region*, 13(3), 273–289. <https://doi.org/10.1080/19480881.2017.1373514>
7. BIMRAD. (2024). Maritime Security and Domain Awareness in the Bay of Bengal. *BIMRAD Journal*, 12(2), 45-67.
8. Bose, R. (2024). Blue Economy and Maritime Governance in South Asia. *Indian Ocean Review*, 8(1), 14-29.
9. Brewster, D. (2018). Give light, and the darkness will disappear: Australia's quest for maritime domain awareness in the Indian Ocean. *Journal of the Indian Ocean Region*, 14(3), 297.
10. Brewster, D. (2024). India's evolving maritime domain awareness architecture: Regional implications. *Australian Journal of International Affairs*, 78(2), 145–163. <https://doi.org/10.1080/10357718.2024.2298745>
11. Brewster, D., et al. (2024). Information Fusion Centres in the Indo-Pacific: Lessons and Challenges. *Indo-Pacific Defence Forum*, 11(3), 55-72.

12. Bueger, C. (2015). *Learning from piracy: Future challenges of maritime security governance*. *Global Affairs*, 1(1), 33–42. <https://doi.org/10.1080/23340460.2015.960181>
13. Chalk, P. (2008). *The maritime dimension of international security: Terrorism, piracy, and challenges for the United States*. Pittsburgh: RAND.
14. Chalk, P. (2009). *Piracy off the Horn of Africa: Scope, dimensions, causes, and responses*. RAND Corporation. https://www.rand.org/pubs/occasional_papers/OP335.html
15. Chatterjee, A. (2014). *Climate change in the IOR: The irreversible threat looming large*. Maritime Perspective.
16. Chew, F. (2016). *Information sharing among the IONS littorals*. Dhaka: Bangladesh Navy.
17. Department of Homeland Security (DHS). (2010). *National plan to achieve maritime domain awareness for the National Strategy for Maritime Security*. U.S. Government. <https://www.dhs.gov>
18. Galdorisi, G., Hsieh, S., & McKearney, T. (2012). *Networking the global maritime partnership*. ICCRTS, 13.
19. Guan, K. C., & Skogan, J. K. (2007). *Maritime security in Southeast Asia*. New York: Routledge Taylor & Francis Group.
20. Habib, M. F. (2006). *The non-conventional aspects of maritime security: A Bangladesh perspective*. Dhaka: NDC, Mirpur.
21. Hossain, A. K. M. (2017). *Enhancing maritime security through multinational information sharing: Way ahead for Bangladesh*.
22. Hoque, M. S. (2015). *Non-traditional security challenges in the Bay of Bengal: Mitigation through subregional cooperation*. Dhaka: National Defence College, Mirpur.
23. Ho, J. (2012). *Sea power and the Asia Pacific*. New York: Routledge.
24. Iqbal, R. A. M. K. (2015). *Challenges in protection of maritime trade in Indian Ocean*. Dhaka: s.n.
25. International Maritime Organization. (2013). *Djibouti Code of Conduct: Report on the implementation of the Code of Conduct concerning the repression of piracy and armed robbery against ships in the Western Indian Ocean and the Gulf of Aden*. IMO.

26. Kaplan, R. D. (2010). *The Indian Ocean and future of the American power*. New York: Random House Publishing.
27. Kaushiva, P., & Singh, A. (Eds.). (2013). *Indian Ocean challenges: A quest for cooperative solutions*. New Delhi: KW Publishers Pvt Ltd.
28. Kislu, (M. N. K. 2016). MARITIME DOMAIN AWARENESS FOR ECONOMIC DEVELOPMENT OF BANGLADESH. *NDC E-JOURNAL*, 15(1), 77-98.
29. Kohli, S. N. (1981). *Sea power and the Indian Ocean*. New Delhi: Tata McGraw Hill Publishing Co Ltd.
30. Lawrence, W., & Prabhakar, S. (2006). **ecuring India's littorals in the twenty-first century: Issues and challenges*.
31. Lim, A. (2023). Singapore's Experience in Maritime Domain Awareness. *Maritime Security Quarterly*, 5(4), 101-119.
32. Lim, L. N. (2011). The Information Fusion Centre: A case for information sharing to enforce security in the maritime domain. *Pointer*, 1.
33. Mahan, A. T. (2013). *The influence of sea power upon history, 1660–1783*. Dover Publications. (Original work published 1890)
34. Mollick, M. M. U. (2008). Prospect of interoperability and information sharing amongst the South Asian littorals. Dhaka: DSCSC, Mirpur.
35. Narayanan, R., Singh, P., & Lee, C. (2025). Emerging technologies and maritime domain awareness in the Indo-Pacific. *Journal of Indo-Pacific Affairs*, 8(1), 55–72.
36. Narayanan, P., et al. (2025). Regional Security Architectures in the Indian Ocean. *Journal of Maritime Affairs*, 19(1), 1-22.
37. National Security Council Secretariat (NSC). (2024). *IFC–IOR annual report 2023*. Government of India.
38. Oceans Beyond Piracy. (2012). *The economic cost of Somali piracy 2011*. One Earth Future Foundation. <https://oceansbeyondpiracy.org>
39. Panikkar, K. M. (1999). *India and the Indian Ocean: An essay on the influence of sea power on Indian history*. Oxford University Press. (Original work published 1945)
40. Rahman, C. (2008). The global maritime partnership initiative: Implications for the Royal Australian Navy. *Australian Maritime Affairs*, 24, 4.

41. Rahman, C. (2021). *Maritime security in the Indian Ocean: Regional priorities and global imperatives*. Australian Journal of Maritime & Ocean Affairs, 13(1), 1–18. <https://doi.org/10.1080/18366503.2021.1887193>
42. Rahman, M. F., & Hossain, M. S. (2023). Prospects of the blue economy for Bangladesh: Policy challenges and opportunities. *Bangladesh Journal of Maritime Studies*, 12(2), 99–118.
43. Rahman, M. R. (2013). Regional cooperation in maritime security: A view from Bay of Bengal.
44. Sakhuja, V. (2014). *Blue economy: Who takes the stewardship in the Bay of Bengal*. New Delhi: National Maritime Foundation.
45. Shoieb, M. J., & Rahman, M. M. (2014). Emerging strategic landscape in the Bay of Bengal and maritime capability building of Bangladesh. *BISS Journal*, 35(1).
46. Singh, K. R. (2012). *Coastal security maritime dimensions of India's homeland security*. New Delhi: Vij Books India Pvt Ltd.
47. Soto, A. A. (2010). Maritime information sharing strategy. *Naval War College Review*, 63(Summer).
48. Tanaka, Y. (2012). *The international law of the sea*. Cambridge: Cambridge University Press.
49. UNHCR. (2025). *Rohingya crisis update: Maritime risks and displacement*. United Nations High Commissioner for Refugees. <https://www.unhcr.org>
50. UNODC. (2023). *Transnational Maritime Threats and Regional Cooperation*. United Nations Office on Drugs and Crime Report.
51. World Bank. (2013). *The pirates of Somalia: Ending the threat, rebuilding a nation*. The World Bank. <https://doi.org/10.1596/978-0-8213-9741> World Bank. (2024). *Illegal, unreported, and unregulated fishing in South Asia: Economic impacts and governance solutions*. World Bank.

Biography of the Writer



Captain Mohammad Farhad Hossain, (ND), NPP, afwc, psc, BN was commissioned in the Executive Branch of the Bangladesh Navy on 1 July 1999. He specialized in Navigation and Direction (ND) and Nuclear, Biological, and Chemical Defence (NBCD) in India. Throughout his career, he has completed several professional courses, including Maritime Warfare and Tactics, Electronic Warfare Instruction, Combat System Management, and Game Development for Wargames. He completed the Junior Staff Course at the Defence Services Command and Staff College, Mirpur, and later attended the Staff Course at the U.S. Naval War College. He also graduated from the Armed Forces War Course (AFWC) at the National Defence College. During his training and professional education, he received the Sword of Honour, two Gold Medals, and the Chief of Naval Staff Trophy for outstanding performance. Captain Hossain has served in various operational, command, and staff roles across ships and naval establishments. He was the maiden Navigator of a Corvette during its delivery voyage from the United Kingdom to Chattogram. He later commanded missile boats, patrol craft, and large patrol craft (missile) and served as Executive Officer of both a Training Base and a Training Ship. He also served with the Bangladesh Coast Guard, commanding an Offshore Patrol Vessel (OPV), and held staff appointments at Area Headquarters, Fleet Headquarters, and Naval Headquarters. He contributed to naval education as an instructor at the School of Maritime Warfare and Tactics (SMWT) and as Directing Staff for the Junior Staff Course. Currently, he serves as a Faculty Member in the AFWC Wing at the National Defence College.

SMALL DEVICES, BIG THREATS: THE HIDDEN RISK OF ELECTRONICS USED IN ARMED FORCES

Captain Md Nur Hasan, (E), PCGMS, psc, BN

Abstract

Today's warfare is heavily dependent on electronic devices. Electronic circuits have become more important than bullets. If even a single component of an electronic system is compromised by malicious actors, it can pose a serious threat to security. Personal electronic gadgets like smart phones and USB drives can also become security risks if not properly controlled. Electronic devices are increasingly becoming vulnerable to hidden dangers such as explosions, sabotage, information leakage, and unexpected failures. After the pager and walkie-talkie explosions in Lebanon, electronic safety has become a growing concern for national security. This issue is especially critical for countries that rely heavily on foreign sources for their electronics. This article explores how risks enter the supply chain and how even the smallest component can become a threat if it is compromised. It also highlights key steps to mitigate the threats related to military and personal electronic devices.

Introduction

We are currently living in an era where electronic circuits and systems have become more important to warfare than bullets. The increasing dependence on digital systems and electronic hardware has fundamentally transformed the nature of modern conflict. In this regard, world has seen a mentionable example in recent past. In September 2024 a series of explosions occurred by compromised communication devices allegedly used by the members of Hezbollah. The incidence resulted at least 32 death and injuries to thousands more. Although no official confirmation has been provided but, it is widely speculated that a particular intelligence agency was involved in the incident. This event serves as a sobering reminder of the catastrophic consequences that can arise from vulnerabilities embedded within electronic components used by the armed forces.

This incident highlights serious concern regarding the vulnerability of the smallest hardware components to exploitation. A single microchip may seem

unimportant. But, if it is compromised, it can cause serious harm. It can get around normal security systems, create secret access points, and help with spying or sabotage. Such breaches underscore a broader systemic issue to the security risks associated with the sourcing of electronic components used in military hardware. Contemporary military operations and national defence systems rely heavily on complex electronic infrastructures. These systems are composed of countless hardware components. Many of which are sourced through global supply chains that are often opaque, inadequately regulated, and sometimes overly dependent on single-source suppliers. As a result, ensuring the integrity of each individual component, no matter how small, has become a matter of paramount strategic importance.

The risk is not confined solely to the electronic hardware deployed in combat scenarios. It also includes devices used by military personnel in their day to day life like, USB flash drives, smartphones, smartwatches, and other personal electronics. These devices are often overlooked in security assessments. They can serve as the medium of physical sabotage if it is sourced from unreliable or malicious suppliers. In an increasingly interconnected and technologically driven battlefield, where the line between digital and physical warfare continues to blur, even the smallest electronic device can represent a disproportionate threat. Thus, safeguarding the supply chain of military electronics is no longer a peripheral concern, rather it is a strategic imperative.

This article examines the hidden threats posed by compromised electronic components and the vulnerabilities within modern electronics. It investigates how inadequately monitored sourcing processes can serve as gateways for adversaries to undermine national security. Furthermore, it emphasizes the critical need for robust control, stringent monitoring, and rigorous security protocols in the procurement of electronic components destined for military use.

Global Supply Chain

The defence Electronics Market is estimated to be USD 166.7 Billion in 2023 and is projected to reach USD 213.2 Billion by 2028. War between countries and arms races between the nations are fostering defence budgets as well as expanding defence electronics market. Modern militaries rely on fast and efficient supply chains to deliver everything from basic equipment to

advanced weapons. However, many of these systems are now depended on parts and materials made in foreign factories. Even the superpower like the USA is also reliant on Chinese production lines for many essentials of military hardware and munitions. While this global sourcing lowers costs, it also creates serious risks. In recent years, global events have shown how easily supply chains can be disrupted or manipulated. Key materials, technologies, and components can be delayed, restricted, or even withheld putting military readiness and national security at risk. Many defence systems depend on foreign-made parts without a clear understanding of where they come from or how vulnerable they are. Without strong oversight, even critical items like sensors, electronics, or raw materials can become weak points to breach securities.

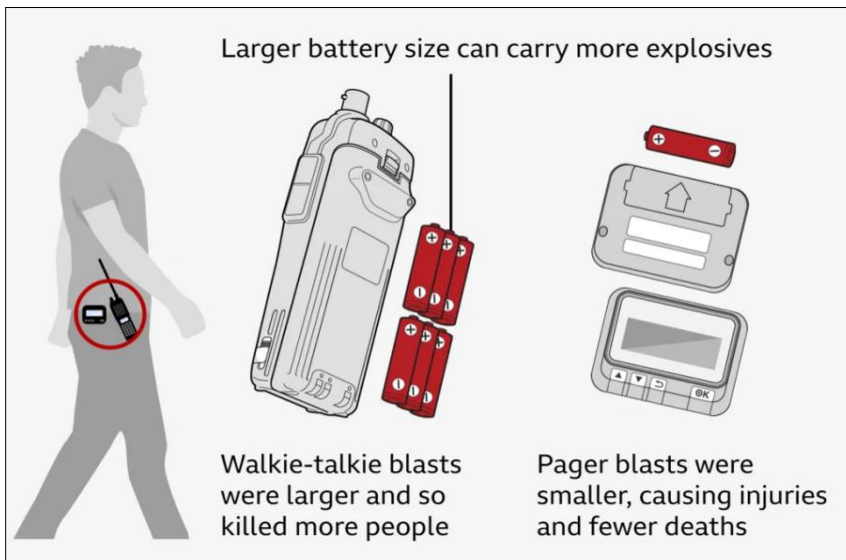
Top key market players in the world for defence electronics are Curtiss-Wright Corporation (US), Aselsan AS (Turkey), Lockheed Martin Corporation (US), Indra Sistemas SA (Spain), Hensoldt (Germany), Thales Group (France) etc. They are the renowned electronics manufacturers in the world and comparatively safe because they operate under strict rules and regulation. They have market reputation and they always try to maintain it. Purchasing any system from a renowned company by G2G (Government-to-Government) contract is comparatively safe. However, sometimes state linked big companies also pose big threats through commercial products. For example, Huawei and ZTE were banned in some countries due to the fear of backdoor access by the Chinese Government. Side by side if any third party is engaged in the purchasing process, risk of sabotage and temptation increases gradually. Another important concern is, generally Defence grade electronics costs are high. So low cost purchasing from untraceable sources contain more risk.

Danger of Small Electronics

Small devices in the military may pose danger in different forms. These devices may steal vulnerable information, hack important system, cause explosion etc. Some devices are directly used in military operations like military radios, tactical GPS units, battlefield sensors, signal jammers, drones, etc. Some devices are used by military personnel in their day to day life like smart phone, smart watch, pen drive etc. The devices which use battery as

power source and operate through electromagnetic frequency are more vulnerable to cause explosion. An explosive device requires five major components: A container, a battery, a triggering device, a detonator and an explosive charge. Most of the communication devices have three of those already. Additional requirements are only a detonator and a charge.

Figure-1: Size of Devices That May Carry Explosives



Source: BBC News (2024)

Hardware level tempering is difficult to detect and it can remain hidden for long time. Question may arise how a small electronic component can cause danger. For explosions, larger sizes of the device causes more damage. Figure-1 shows the size of pager and walkie-talkie compared to human body size which caused explosion and killed more than 30 people and injured thousands in Lebanon. Moreover, the impact of small explosions can be more if it takes place inside ammunition or chemical store. Similarly, Figure-2 is the cover page of Bloomberg Businessweek magazine where the size of a microchip was compared to a human finger. This type of microchip can be used in electrical circuit without proper knowledge of the user to collect sensitive information.

Figure-2: Size of Microchip



Source: Cover Page of Bloomberg Businessweek Magazine (2018)

The risk related to tempted or sabotaged electronics doesn't only lie with explosion or information leakage, there is also operational risk. Counterfeit components of an important system may start malfunctioning unexpectedly during a real time operation, which ultimately results in failure of operation and loss of life also. Modern combat systems are integrated with each other. So the failure of one system causes total failure of fighting efficiency.

Case Study

Few case studies related to the topic are given below:

- a. **Case study 1: Communication Devices Explosion.** At least 32 people, including two children, were killed and thousands were injured in Lebanon after communication devices suddenly exploded on September 2024. The devices, like walkie-talkies and pagers, were used by the members of Hezbollah. The explosion of walkie-talkies killed 20 people and injured around 450 more during a funeral gathering. The day before, pager explosions had killed 12 people and injured nearly 3,000. The blasts caused panic across the country. Ambulances struggled to reach the injured, and people grew afraid of anyone using electronic devices. Hezbollah blamed Israel for the attacks, but Israeli officials did not comment. Two companies from

Taiwan and Hungary were accused of making the devices, but both denied any responsibility. Total incidence of pager explosion can be shown in Figure-3.

Figure-3: Incidence Flow Diagram of Pager Explosion



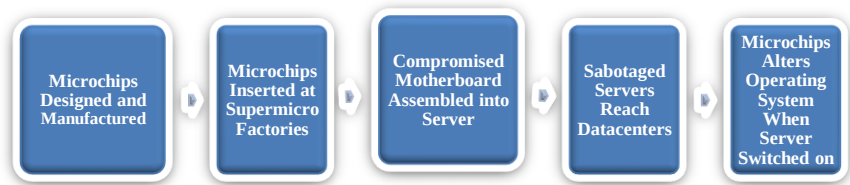
Source: Author's Self-Construct

Takeaways. A longer and more complex production process increases the chances of sabotage. It also causes delays and raises production costs. Complicated supply chains also creates favorable environment to tamper the products. For every extra step and involvement of extra company adds more risk. It becomes easier for someone with harmful intentions to interfere and turn the product into a threat. A strong vetting process for the devices can help to find these problems.

b. Case Study 2: Microchip Espionage Allegation. In 2018, Bloomberg reported that Chinese agents had secretly placed spy chips in motherboards made by Supermicro. These motherboards were used in different important data centers of U.S. like, defence contractors, major tech companies, and even inside the military. Although the claim was denied but the report sparked a major debate about the risk of hidden backdoors in hardware. The anticipated operation took place according to the steps shown in figure 4.

Takeaways. Hardware tampering is very difficult to spot and can go unnoticed for years. Even powerful countries are at risk of spying because they rely on global supply chains for electronic parts. To stay safe, nations must carefully check and verify every component from the time of manufacturing to the time of finally using it.

Figure-4: Incidence Flow Diagram of Microchip Espionage



Source: Author’s Self-Construct

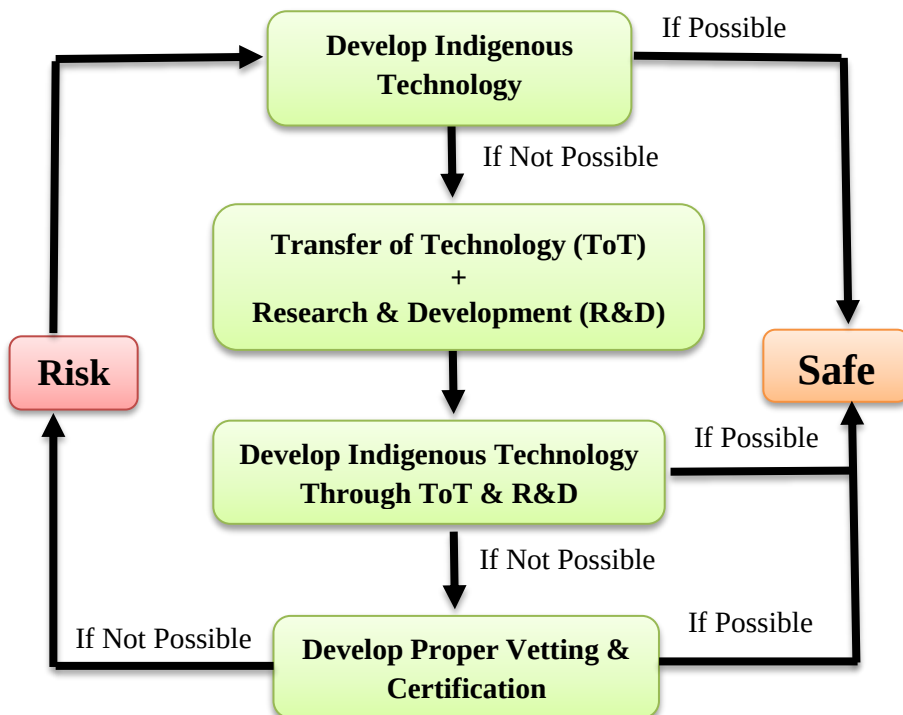
c. **Case Study 3: Communication Device Vulnerabilities in Ukraine-Russia War.** Russian government backed hackers have increasingly targeted Signal messenger accounts, particularly those used by Ukraine’s military, government officials, and activists to steal sensitive information. According to Google’s security team, Signal has become a prime target due to its widespread use among soldiers, politicians, and civil society members. Other messaging apps like WhatsApp and Telegram have also come under attack. The hackers primarily rely on phishing tactics, often using fake QR codes to exploit Signal’s “linked devices” feature. When unsuspecting users scan these codes, their accounts are secretly linked to devices controlled by the attackers, granting them real-time access to private messages.

Takeaways. Personal gadgets like smart phones are also a medium to sabotage. Messaging apps like Signal, WhatsApp, Telegram are top targets for hackers, especially in war zones. Hackers use phishing tricks, like fake QR codes, to spy on users. Even secure apps can be vulnerable if users aren’t careful.

Mitigation Strategy

Developing Indigenous Technologies. One of the most effective ways to reduce hardware-related risks is to develop indigenous technology. When a nation manufactures its own electronic equipment, it is much easier to monitor and control production. However, developing indigenous technology is challenging and it demands time, investment, and skilled personnel. Therefore, at the beginning a country might focus on modest military electronics, such as communication sets. To materialize that, the country can utilize the expertise of its top domestic manufacturers. For instance, in Bangladesh, Walton Group is a leading consumer electronics producer. Armed forces can come to an agreement with Walton to gain the know-how needed to build military-grade communication devices. Starting with a single product line can lay a strong foundation and foster capabilities to expand over time. For the technologies that remain beyond immediate reach, Transfer of Technology (ToT) agreements and collaborative Research and Development (R&D) with trusted partners can help bridge the gap and foster indigenous innovation.

Figure-5: Risk Mitigation



Source: Author's Self-Construct

Vetting and Certification. When it's not possible to produce electronics within the country, proper vetting and certification of imported components becomes critical for national security. Every part of a system, especially those used in sensitive systems, should be thoroughly checked by certified labs before being integrated. For example, replacing the motherboard or PCB in a key control system might seem routine, but even a tiny microchip can be dangerous. Hidden chips can leak sensitive information or even reveal the location of high-value assets. Case Study 1 shows that if proper security checks had been done on pagers and walkie-talkies before deployment, many lives could have been saved. This proves how essential it is to verify every component. The vetting process should include physical inspections, firmware code verification, supply chain tracing, and testing for malware or backdoors. Importantly, this should not be a one-time check; rather it must be part of an ongoing security and compliance program. To ensure this, a dedicated unit made up of both civilian and military experts should be established within the armed forces. This team would be responsible for verifying and certifying all electronics used in defense systems.

Never Trust, Always Verify Procurement. When the question of security comes, the principal should be "Never trust, always verify". This is especially important in the procurement of electronic hardware, where a Zero Trust approach must be followed. Whether the supplier is local or international, no source should be automatically trusted. In the case of the Bangladesh Armed Forces, procurements are done through internal service systems and the Directorate General of Defense Procurement (DGDP). While local suppliers are registered and somewhat traceable, foreign purchases often hide the actual manufacturer or originator behind layers of intermediaries. This makes it difficult to monitor how and where the product was made. By applying Zero Trust principles to procurement policies, organizations can shift away from blind trust. Instead, if every product and supplier is verified, it will help to detect and prevent threats from counterfeit or malicious hardware before they reach critical systems.

Strengthen Reliable Global Alliances. No country can meet all of its technological needs on its own. In this field, every nation relies on others to some extent. Building strong and reliable partnerships with trusted countries

can help reduce the burden of research and development and make it easier to share advanced technologies. However, for successful partnerships, all countries involved must have the capability to develop technology and must operate with trust, transparency, and shared standards.

Safety of Personal Gadgets. The safety of personal gadgets is just as important as the safety of large systems. Military personnel use mobile phones, laptops, smart watches, pen drives and other electronic devices in their daily lives. However, these everyday gadgets can also be turned into tools for sabotage. In many countries, smart devices are not allowed inside military areas for this reason. Sometimes, we receive gadgets like smart watches, phones, or pen drives as gifts from others. Without knowing their true source, we risk other systems by using compromised devices. We must remember that attackers today have many ways to misguide the user of electronic devices without owner's knowledge. Many devices have hidden weaknesses that make them easy to hack. Because of this, even trusted employees with access to sensitive information can cause harm without knowing anything. Their devices might record private conversations, leak important data, or allow harmful software into the system. These risks can seriously harm national security.

Policy Recommendation

Formulating Electronics Security Standard. Formulating effective Electronic Security Standard for both the nation and Armed Forces are very important. The standard should outline minimum requirement of safety and activities important for national security. The standard should provide a clear framework for acceptable components, secure design practices, tamper resistance, and cyber security protocols. The standard should also describe which electronics will be manufactured indigenously and which will be imported? This will ensure strategic control over sensitive technologies while maintaining flexibility where appropriate. If a nation can set clear guidelines, the nation will be able to safeguard from both internal and external threats.

Centralized Authority for Vetting and Certification. A centralized authority can be formed for vetting and certification of electronics related to armed forces and national security. There must be a policy mentioning duties

and responsibilities of the authority. This authority may also be empowered to monitor and recommend purchasing process basing on the sensitivity of the equipment. However, this authority should also conduct regular audits. Audits should cover supply chain integrity, firmware and software analysis, physical inspection, and operational behavior under different conditions. These tests will help to identify any hidden functions, backdoors or performance anomalies that may not have been evident during initial procurement. Continuous testing ensures that equipment remains secure throughout its lifecycle, not just at the point of entry.

Policy on Personal Gadget. It is not possible to restrict all personnel from using electronic gadget, but it is very much possible to restrict using personal gadget in unauthorized area. During war time use of unencrypted personal gadgets easily reveal location and sensitive information to enemies. At the beginning of the Russian invasion of Ukraine, Russian troops used unencrypted devices including their mobile to communicate with their unit and family members. That has made them vulnerable to Ukrainian forces by exposing what they're saying and pinpoints their locations. Use of social media in mobile, laptop, computer by the military personnel is also become dangerous if the user falls in a trap. However, considering the moral issue, it is not possible to impose restriction on the use of personal gadgets. But, an effective policy on the use of personal gadgets of military personnel will reduce the risk.

Policy on Procurement System. There are policies that explain how procurement should be carried out. However, we also need a policy to ensure the security of the procurement process. This policy should describe how to carry out procurement through a secure network of trusted vendors and foreign partners. It should be designed in a way that keeps the entire supply chain under the control of the purchaser.

Conclusion

Modern military operations heavily rely on complex electronic systems and those systems are built using thousands of tiny components. No matter how small they are, these parts can pose serious threats if they are compromised. As

discussed in the earlier case studies, even a single faulty or counterfeit component can lead to unexpected failures or security breaches. Though there are not too much examples, but it is assumed that lot of incidence remain unnoticed or never disclosed.

For countries like Bangladesh which depend on foreign sources for military-grade electronics, the risk is even higher. This dependence makes it crucial to develop strong local capabilities in both electronics manufacturing and quality control. Achieving full self-reliance may not be possible, but gaining greater control over the sourcing and inspection of critical components is essential to safeguard national security. We have to remember that, with rapid technological advancements and the increasing use of Artificial Intelligence, threats are becoming delicate and harder to detect. Besides, personal gadgets like smart phones used by military personnel can also be exploited. A simple unauthorized USB drive can be used to steal sensitive data or infect systems with malicious software.

Obtaining self-sufficiency is the best way to eliminate the risk. However, obtaining self-sufficiency is not possible for all countries. Therefore, the ability to detect counterfeit parts or sabotage is the most important strategy. Implementing strict policies on sourcing electronics only from trusted vendors, and regulating the use of personal gadgets within the Armed Forces are also important to mitigate the risk. The size of electronic devices may be small but the risks associated with them are very high. It is time to take necessary steps. The sooner we will act, the safer we will be.

Notes and References

1. Bloomberg. (2018, October 4). The Big Hack: How China used a tiny chip to infiltrate U.S. companies. Available at <https://www.bloomberg.com/news/features/2018-10-04/the-big-hack-how-china-used-a-tiny-chip-to-infiltrate-america-s-top-companies> (Accessed 02 May 2025).

2. Business Standard. (2024, September 23). Lethal explosion of pagers, walkie-talkies deliver supply chain warning. Available at https://www.business-standard.com/world-news/lethal-explosion-of-pagers-walkie-talkies-deliver-supply-chain-warning-124092300003_1.html (Accessed 05 May 2025).
3. Harper, J. (2022, May 31). Ukraine-Russia war teaching US military a lesson about secure communications. Fedscoop. Available at <https://fedscoop.com/ukraine-russia-war-teaching-us-military-a-lesson-about-secure-communications%E2%80%9C/> (Accessed 30 April 2025).
4. Markets and Markets. Defense electronics market by vertical, platform, and region – Global forecast to 2028. Available at <https://www.marketsandmarkets.com/Market-Reports/defense-electronics-market-183642563.html> (Accessed 25 April 2025).
5. Murphy, M., & Tidy, J. (2024, September 20). What we know about the Hezbollah device explosions. BBC News. Available at <https://www.bbc.com/news/articles/cz04m913m49o> (Accessed 24 April 2025).
6. BBC News. (2021, May 5). Huawei and ZTE left out of India's 5G trials. Available at <https://www.bbc.com/news/business-56990236> (Accessed 29 April 2025).
7. Antoniuk, D. (2025, February 19). Russian state hackers spy on Ukrainian military through Signal app. The Record. Available at <https://therecord.media/russian-state-hackers-spy-on-ukraine-military-signal> (Accessed 26 April 2025).
8. Philips, W. G., et al, (2024, September 19). What to know about the two waves of deadly explosions that hit Lebanon and Syria. AP News. Available at <https://apnews.com/article/lebanon-israel-hezbollah-pager-explosion9493409a0648b846fdcadffdb02d71e> (Accessed 29 April 2025).
9. Walkenhorst, B. (2024, November 25). New security standards for electronic device detection: Are military and federal facilities ready?. Military Embedded Systems. Available at <https://militaryembedded.com/cyber/cybersecurity/new-security-standards-for-electronic-device-detection-are-military-and-federal-facilities-ready> (Accessed 03 May 2025).

Biography of the Writer



Captain Md Nur Hasan, (E), PCGMS, psc, BN was commissioned in the Bangladesh Navy on 21 December 2001 in the Engineering Branch. He completed his BSc in Mechanical Engineering from the Chittagong University of Engineering and Technology (CUET). He completed the Missile Airframe and Engine Engineer Course at the Naval Aeronautical Engineering Academy, China. He also obtained a Postgraduate Diploma in Project Planning, Development and Management from the National Academy for Planning and Development (NAPD). In addition, he earned an MSc in Defence Studies from the Bangladesh University of Professionals (BUP). Throughout his career, he has served in various important appointments, including the Rapid Action Battalion (RAB), Bangladesh Coast Guard Headquarters, Bangladesh Navy Headquarters, the Mongla Port Authority, onboard different ships, and at Bangladesh Navy Dockyard. In recognition of his service, he was awarded the President Coast Guard Medal Seba (PCGMS). He also participated in a United Nations peacekeeping mission in the Democratic Republic of the Congo under the United Nations Organization Stabilization Mission in the Democratic Republic of the Congo (MONUSCO). Presently, he is serving as General Manager (Planning & Design) at Dockyard and Engineering Works Limited, Narayanganj.

SEAWEED FARMING AQUACULTURE-POTENTIAL COASTAL CONSERVANCY UNDER BLUE ECONOMY

Ex-Commander Mohammad Mehadi Amin Miah, (G), psc, BN

Abstract

This paper explores the alternative food security and the ever-growing population of Bangladesh. By the year 2050 the world will face tremendous challenges of producing 50% additional food for almost 10 billion people. As the resource of land will be exhausted, sea remains the only option to explore for mankind under blue economy. Tropical maritime nations are already exploring the aspects of seaweed aquaculture under blue economy for future food security and sustainability. Coastal maritime security will be threatened if coastal population are not engaged in economic activities concerning food security. Policy implementation needed to support small coastal entrepreneurs engaged in seaweed farming by financial authority of local government. Feasibility of seaweed cultivation in Saint Martin's lagoon area assessed in 2018-2020 through secondary data analysis under exploratory research. Local and international investment can be assured on building storage facilities, food processing plants, hydrocolloid extraction plants including technical training and sustainable marine spatial planning center. The result of the feasibility assessment found five other acceptable areas including Saint Martins. Importance of seaweed aquaculture can enhance security of coastal area, change the coastal economy with local awareness building about the potential of coastal conservancy in the case of maritime Security of Bangladesh.

Key Words: Coastal Conservancy, Blue Economy, Aquaculture, Sea weed, Marine Pollution.

Introduction

Since prehistoric times the sea has played a crucial role in sustaining human populations by providing significant sources of food and livelihood. A sustainable marine environment is vital for economic development, food security, and the well-being of communities. Food security can only be achieved when a large segment of the population has economic access to

nutritious and sufficient food for their dietary requirements. The impact of climate change poses a significant threat to food security for an estimated 10 billion people globally, including 200 million in Bangladesh. Given the depletion of land resources, aquaculture within the framework of a blue economy emerges as a viable solution for ensuring food and forms the background of this study. The question remains whether, harnessing the potential of the blue economy aquaculture can enhance the security of coastal dwellers during fishing restriction seasons and offer economic opportunity or not. Currently, aquaculture is the fastest-growing sector worldwide, encompassing fish farming, aquatic plant cultivation, algae, seaweed, mollusks, crustaceans, and other organisms, contributing 47% of the nutrients in the global food supply¹. Promoting aquaculture can significantly increase the economic value of marine resources in a sustainable manner.

As a maritime nation, the Bay of Bengal serves as a crucial pillar of food security for the people of Bangladesh. The region's three extensive fishing zones, favorable water temperatures for breeding, appropriate salinity levels, and gentle gradient of alluvial silt, have transformed the bay into a largely untapped fertile area. Bangladesh Navy is responsible for safeguarding maritime zones including blue economy. Illegal coastal activities may reduce if local communities are engaged in economic activities by cultivating seaweed and contribute maritime economy. After successful delimitation of maritime boundaries with both neighbors in 2014 through ITLOS/PCA attained control over a sea area of 1,18,813 sq km². This huge sea area is same as the land area of Bangladesh is the responsibility of Navy which has opened a wider horizon to develop maritime economy and develop living standard of coastal dwellers.

The purpose of this paper is to explore the concept of blue economy for future food security challenges, engaging coastal community in economic activities and refraining them from illegal coastal activities. However, major argument remains on the prospects of seaweed farming, and feasibility of conservancy management in the coastal regions of Bangladesh.

Concept of Blue Economy and Significance of the Research

The concept of Blue Economy was first introduced during the 1992 Earth Summit in Rio de Janeiro. The primary focus of this conference was the green economy, which addressed issues of land scarcity and exploration of marine economy prioritizing environmental sustainability. However, Small Island Developing States (SIDS) in the Caribbean, Pacific, and Indian Oceans began to advocate for ocean economy, emphasizing marine economic development. This idea contributed to the development of Blue Economy supported by Professor Gunter Pauli's book, 'The Blue Economy: 10 Years, 100 Innovations, 100 million Jobs,' mentioned the global shift from traditional economic models to a more human-centric approach to development. The fundamental principle of Blue Economy is to decouple socio-economic development from environmental degradation. In this context, the efficient and optimal use of natural marine resources within ecological limits can enhance the economic value ensuring environmental sustainability.

Thus, Blue Economy refers to the conservation and sustainable use of marine resources, extraction of oil and minerals, bioprospecting, renewable energy production, and maritime transport, conceptualizing oceans and development Spaces. This paradigm shift moves away from conventional economic development towards a human-ocean-centric model that emphasizes sustainability. It encompasses all activities that take place in coastal regions, seas, and oceans, with a focus on exploring and utilizing seabed and oceanic resources while reducing carbon emissions. To achieve these sustainability goals, environmentally friendly seaweed farming or kelp cultivation in coastal areas can provide a natural remedy for coastal pollution. Significance of this research focuses on the coastal protection part of blue economy. As kelp can absorb five times more carbon than land-based plants, filter nitrogen from the water, create artificial reefs. Besides, it serves as storm surge barrier protection for coastlines from storm and pollution to combat environmental degradation which is very pertinent for Bangladesh coastal region³. This research is significant for Bangladesh Navy (BN) because most of the illegal activities along the coastal region will drastically reduce if the coastal community remains engaged in maritime economic activities like kelp farming. Involvement of BN in such task and feasibility of specific type of seaweed was not found in all the publications assessed on references forms the Research Gap.

Benefits of Seaweed Production and Significance of the Research.

Maritime nations with the potential for a Blue Economy are committed to enhancing the development of renewable resources derived from biomass. These nations aim to transform these resources into products such as food, animal feed, and bioenergy to achieve carbon emission reduction targets. In the future, characterized by a decline in fossil fuel reliance, an increasing share of plastics, chemicals, textiles, fuels, and electricity will need to be sourced from biomass. Given the trend of a rising global population, food production must increase by at least 50% to 70% by the year 2050, all while addressing environmental challenges such as drought, flooding, and soil toxicity. To enhance soil fertility organically, the development of biomass is essential. Developing countries are promoting a green economy, with safe food production as a primary objective. According to the European Bioenergy Policy, biomass production is expected to rise significantly by 2030, with imports projected to triple by 2021⁴. A significant shift in food security can be achieved through the large-scale production of animal feed, biofuels, and seaweed, which could serve as a cornerstone for transforming marine exploration into a means of ensuring food security.

Since 2012, seaweed farming has been expanding at an annual rate of 9% among maritime nations, with projections indicating an increase to 14% per annum by 2050, potentially generating 500 million tons of dry weight⁵. The growing practice of seaweed cultivation ensures safe food production in a clean environment and creates new job opportunities to generates government revenue. Oceans cover one-third of the Earth's surface, yet economic activities in these areas are largely limited to fishing and mineral extraction. Seaweed farming in coastal regions presents a significant opportunity for revenue generation for maritime nations. A well-managed modern farm can yield approximately 1,000 dry metric tons per square kilometer, with the Bay of Bengal potentially producing a substantial harvest in a designated sea area of 40,000 square kilometers out of a total of 118,813 square kilometers which covers just 0.3% of the sea area⁶. Due to siltation most of the coastal area are not suitable for commercial farming of seaweed. However, Table 1 shows how limited seaweed farming can support our ecosystem and assures our future food

security. The feasibility study of this coastal seaweed farming in Bangladesh and the involvement of BN to develop coastal security is the significance of the research.

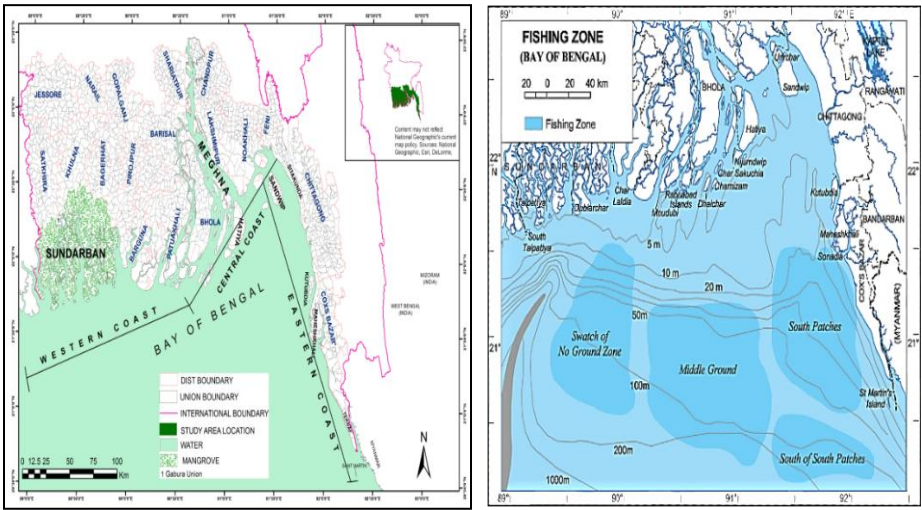


Figure 1. Coastal Regions and Fishing Zones of Bangladesh, Coastal and Marine Conservation Strategy for Bangladesh, September 2018⁷.

Table 1. Area Designated for Seaweed Cultivation along with Ecosystem Benefits Derived from 500 Metric Tons of Seaweeds⁸

Area/ Weight	Event	Outcome
500,000 km ²	Ocean area required	Only 0.03% of the ocean's surface area can guarantee a seaweed yield of 1,000 tons per square kilometer.
50,000,000 tons	Protein for people and animals	A total of \$28 billion can be generated from 10% dry weight protein, which has the potential to replace fishmeal and animal feed.
15,000,000 tons	Algal oil for people and animals	The lipid content, valued at \$23 billion, represents 3% dry weight and can serve as a substitute for fish oil and animal feed.

10,000,000 tons	Removal of Nitrogen	Fertilizer contributes 18% nitrogen, equivalent to 2% of the dry weight of farmed seaweed.
1,000,000 tons	Phosphorous removal	Additionally, 2% of the dry weight of seaweed contains phosphorus that can replace 61% of the phosphorus found in fertilizers.
135,000,000 tons	Carbon assimilation	Annually, 6% of the carbon added to the ocean due to the greenhouse effect corresponds to 27% of the dry weight carbon content.
1,250,000,000 MWH	Bio-energy potential	Furthermore, 1% of global energy consumption is equivalent to 50% of the carbohydrate content derived from energy.
1,000,000 km ²	Land sparing	Lastly, 6% of global cropland yields an average of 5 tons per hectare.
500 km ³	Freshwater sparing	Annually, 14% of global freshwater extraction corresponds to 1 cubic meter per kilogram of agricultural biomass utilized.

Dried seaweed, which appears reddish, comprises 1%-5% of its dry matter, containing 3% lipids and 19% protein, with a total weight of approximately 500 million dry tons. In its wet form, seaweed exhibits a greenish hue and contains 10%-30% protein. This substantial quantity of seaweed yields around 15 million tons of algae oil and 150 million tons of algae protein. Algae oils are a source of omega-3 fatty acids, providing nutritional value comparable to that of fish oil for human consumption⁹.



Figure 2. Notable Varieties of Red, Green, and Brown Seaweed, Accompanied by a Practical Depiction of Cultivation Practices at Moheshkhali Island.

The comparison between algae protein and soybean meal reveals that a total of 500 million tons of seaweed is equivalent to 20% of the protein derived from soy. Furthermore, the cultivation of seaweed could lead to a remarkable 750% increase in fish oil production. Algae oils, which are rich in long-chain omega-3 fatty acids, can effectively meet the demand for fish oil, thereby reducing the reliance on fish oil in aquaculture and animal feed. Currently, the price of soybean meals is approximately \$550 per ton, with the protein fraction valued at around \$28 billion. Additionally, the oil component is estimated to be worth \$15 billion, which is comparable to the production of fish oil from seaweed priced at \$1,500 per ton. It is noteworthy that the production of 10 dry tons of seaweed could directly generate 50 million jobs¹⁰. Consequently, the seafood industry has the potential to double job opportunities. The current workforce in marine fishing industries, both at sea and on land, could see an increase of 100 million job opportunities if a basic processing plant infrastructure is established.

Methodology and Pollution Remediation

In 2018, global fertilizer usage amounted to 114 metric tons of nitrogen, with 30% of this quantity being lost to coastal waters and 50% remaining unutilized by plants. Such losses have led to the formation of approximately

245,000 square kilometers of dead zones¹¹. The cultivation of seaweed offers a sustainable approach to mitigate the absorption of a substantial portion of these excess nutrients. It is projected that 245 million tons of dry seaweed could be harvested, assuming a yield of 1,000 tons per square kilometer¹². Eucheuma type green weed has been harvested in the south-east bay of Saint-Martins Island as project work from October-December 2019. Number of data collected from farmers and coastal dwellers along the coast of Bangladesh and incorporated in this paper for assessment of feasibility study.

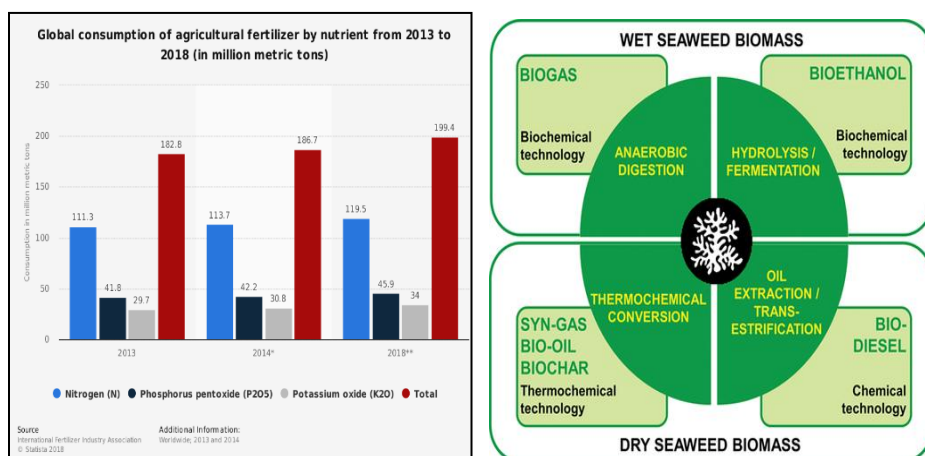


Figure 3: Worldwide Fertilizer Usage Incorporating Both Dry and Wet Seaweed Biomass¹³.

Dry seaweed can contain up to 3% nitrogen and has the capacity to absorb as much as 20 tons of nitrogen per square kilometer¹⁴. In coastal areas or open sea sanctuaries, it is estimated that approximately 10 million tons of nitrogen could be captured through the cultivation of 500 million tons of seaweed, which represents 30% of the nitrogen that is likely to be released from oceanic phosphorus. This phosphorus plays a crucial role in mitigating environmental disturbances and reducing dead zones in coral ecosystems. In 2018, the total global output of phosphorus fertilizer was merely 48 million tons¹⁵. A farmer can generate an income of 12,000 to 14,000 Tk in a single season with an investment of only 1,200 Tk. Utilizing the method shown below, Bangladesh Fish Research Institute has successfully harvested between 14 and 31 kg of seaweed per square meter. Around thirty thousand farms in the nineteen coastal districts of Bangladesh rely on aquaculture for their livelihoods. Commercial

viability of Bangladesh grown seaweeds has not been achieved yet. However, the application of modern technology and sinker float or long line method may be adopted for improving seaweed aquaculture to achieve commercial export standard.

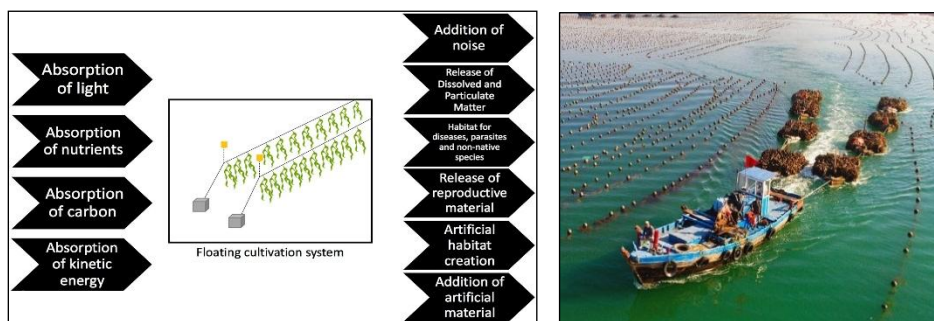


Figure 4. Environmental Benefits Associated with the Cultivation of Seaweed Farms¹⁶.

Carbon Sequestration

The increase in atmospheric carbon dioxide, coupled with rising temperatures, is a consequence of ocean acidification, which is severely impacting marine ecosystems. Ocean acidification has led to a decrease in the pH levels of seawater, thereby diminishing the availability of essential shell-forming minerals needed by corals, mollusks, and various microorganisms. In 2018, anthropogenic carbon emissions reached approximately 8,182 teragrams (Tg), while 500 million tons of seaweed have the capacity to absorb around 135 million tons of carbon. This absorption represents roughly 3.2% of the carbon introduced into seawater annually due to greenhouse gas emissions¹⁷. Consequently, this greenhouse gas emission presents an opportunity for utilizing carbon credits within the seaweed industry. Along with carbon absorption coastal sea weed farms can act as a natural barrier for marine pollution conservancy management.

Dry Seaweed as Biofuel

Seaweed comprises nearly fifty percent carbohydrates, making it a significant potential source of biofuel under dry conditions. It can convert complex carbohydrates and methane into sugars for ethanol production. With

its carbohydrate content, seaweed can generate approximately 1.25 billion megawatt-hours of methane as liquid fuel annually. The energy produced from seaweed is equivalent to 85 billion megawatt-hours derived from fossil fuels, accounting for 1.5% of total energy consumption in 2016¹⁸. The cultivation of seaweed can be conducted in coastal waters without depleting freshwater resources. It is clear that large-scale seaweed farming initiatives are essential for enhancing future food security. Such initiatives can contribute to environmental sustainability and alleviate the burden on terrestrial resources. However, it is crucial to foster a culture of seaweed consumption to facilitate marketing, processing, and production in response to demand. Seaweed production technologies are well-established in the coastal regions of Southeast Asia. Nevertheless, major companies should promote the culture and popularity of seaweed consumption to restore ecological balance. Significant efforts must be made to diversify the range of products derived from seaweeds. Therefore, ongoing research and development are vital to fully realize the potential of seaweed production for commercial use in Business industries.

Table 2: Dry Weight Composition Percentages of Fat, Carbohydrate, Protein and Minerals¹⁹.

Composition (Dwt)	Gracilaria % (<i>Gracilaria verrucosa</i>)	Solieriaceae% (<i>Kappaphycus alvarezii</i>)	Kombu% (<i>Saccharina japonica</i>)	Nori% (<i>Porphyra yezoensis</i>)	Wakame% (<i>Undaria pinnatifida</i>)
Fat	0.3	0.2	1–2	2	1–5
Carbohydrate	74	63–67	52	44	45–51
Protein	12	5–6	7–8	31–44	12–23
Minerals	6	23–26	27–33	8	26–40

Composition and Use of Seaweeds

There are three primary categories of seaweed recognized globally: red, brown, and green (Figure 2). Dark brown and red seaweed are primarily utilized to produce hydrocolloids. Brown and green seaweed are consumed as food, while agar, carrageenan, and alginate serve as industrial thickeners. In 2018, approximately 40% of seaweed was consumed by individuals, with over 40% of industrially processed seafood containing seaweed, and the remaining 20%

being employed in medicinal and industrial applications²⁰. The principal component of seaweed is carbohydrate, which functions as a clear and flavorless thickening agent. Gelling agents can be extracted from colored seaweed such as carrageenan and agar. The most significant red seaweed is utilized for thickening and stabilizing various products, including pharmaceuticals, food items, and cosmetics such as shampoos, body lotions, toothpaste, soaps, air fresheners, hair gels, and other consumer goods. Brown seaweed is regarded as industrial raw materials, with alginates extracted from them being used to create thickeners for dye-containing pastes in the textile industry. Green alginate-type seaweeds are particularly employed in the food and beverage sector, especially in sauces and ice creams. Agar-type seaweed is also commercially utilized as a fuel-oil separator and as a sponge agent in the bakery industry. Alginate and carrageenan types of seaweed are commonly used as stabilizing agents for various biocatalysts in commercial production and adaptation reactions within the chemical and pharmaceutical sectors. Additionally, alginate finds application in the paper industry for surface sizing and the creation of a continuous glossy film surface. It provides an oil-resistant layer on paper and equipment, enhancing grease resistance. Other commercial uses of alginate include welding rod coatings and binders for fish feed.

The Seaweed Aquaculture Industry

Globally, 99% of seaweed is cultivated in the coastal waters of Asia, particularly in countries such as Japan, the Philippines, China, Taiwan, and Indonesia. In 2016, the leading nations in seaweed harvesting were China (55%), Indonesia (25%), the Philippines (9%), Japan (6%), and South Korea (3%). The primary commercial types of seaweed observed in these major producing countries are red and brown varieties (Figure 2). Red algae typically thrive in tropical regions characterized by intertidal zones with sandy substrates. In tropical nations with coral reefs, brown algae spores are primarily cultivated in hatcheries using rope lines, and these are subsequently suspended on floats during the autumn season²¹. While there are over 30 species of seaweed that hold commercial value, only six species account for most of the production:

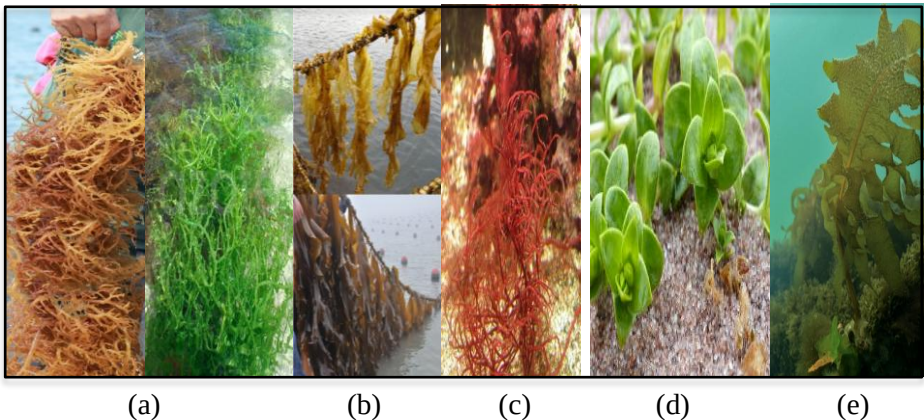


Figure 5: a. Kappa Phycus Algie and Eucheuma Denti Culatum (33%), b. Saccharina Japonica Kombu (25%), c. Glacilaria Verrucosa (11%), d. Poriphyra Supponori (8%), and e. Undaria Pinnatifida (8%).

Table 3. Global Production and Market Values of Commercial Seaweeds²².

Seaweed Category	Global Production (MT/year)	Unit Price (US\$/Kg)	Gross Market Value (US\$ million/year)
Agars	10,600	18	191+
Alginates	30,000	12	339
Carraqueenan	60,000	10.4	626

Seaweed Farming Prospect and Challenges

The consumption of seaweed remains relatively uncommon among the population of Bangladesh. With a coastline extending 716 kilometers and a coastal area of 25,000 square kilometers, this densely populated nation of 180 million people presents significant market potential for seaweed. The coastal regions, characterized by sandy, muddy, coral, and mangrove substrates, are conducive to seaweed cultivation. Approximately 133 species of seaweed have been identified in Bangladeshi waters, of which nine are deemed commercially viable²³. Large-scale commercial production of these nine species is feasible within the coastal zones of Bangladesh. Seaweed can be utilized in various

ways, including salt, natural fertilizer, and dairy ingredients, which presents significant opportunities for establishing small-scale marine-based industries. Additionally, the textile, pharmaceutical, and paper industries utilize seaweed as a raw material. Research conducted in the Moheshkhali and Teknaf regions indicates that the period from November to April is the most favorable for *Hypnea* cultivation. Since seaweed does not require fertilizers, pesticides, or herbicides, its cultivation is considerably more cost-effective compared to other crops. A modest investment of 1,200 Tk over four square meters can yield 60 kg of seaweed within just two weeks²⁴. The high mineral content, including iodine, calcium, copper, and iron, enhances the nutritional value of seaweed, making it appealing to consumers. Seaweed is also abundant in vitamin K, protein, fiber, and folic acid, while being low in calories and fat. Traditionally regarded as a highly nutritious food, seaweed holds significant potential to meet the dietary needs of the Bangladeshi population.

Bangladesh Navy always supports to develop the living standard of coastal community by supporting their economic activities. Effective engagement of coastal community will refrain them from illegal activities like drug trafficking, gun running, smuggling and petty theft like activities. The viability engaging coastal community in seaweed farming has yet to be confirmed through intense feasibility studies. While the concept of the 'Blue Economy' offers numerous opportunities, not all can be deemed commercially viable without thorough investigation. Challenges such as coastal siltation, adverse weather conditions, the absence of lagoons, the need for stable and clean water, as well as the lack of appropriate techniques, technology, local awareness, and processing industries pose significant obstacles to the successful establishment of seaweed farming. Presently, due to sea surface temperature rise, acidification, pollution and high rate of siltation, seaweed coastal project farming not giving an expected harvest. However, in depth feasibility studies, improvements in harvesting techniques, the creation of artificial habitats, and the seeding of appropriate clean coastal areas may be planned to promote seaweed cultivation.

Among the various species, *Hypnea* has been identified as the most suitable for coastal cultivation, demonstrating commercial viability and a harvest cycle of just 15 days²⁵. *Hypnea* is recognized for its ability to store iodine, which can address iodine deficiency needs. The Bangladesh Fisheries

Research Institute has also evaluated the appropriateness of seaweed in the coastal regions of Sundarbans, Kuakata, Kutubdia, Moheshkhali, Teknaf, and Saint Martins.

Table 4: Commercially Important Seaweeds in Bangladesh

Ser No	Species Class	Category	Area
1.	Caulerpa Caulerpa racemosa	Green Seaweed	Coxs Bazar
2.	Enteromorpha Enteromorpha	Green Seaweed	Kutubdia
3.	Gelidiella Gelidiella tenuissima	Red Seaweed	Moheshkhali
4.	Gelidium Gelidium pusillum	Red Seaweed	Sundarbans
5.	Halymenia Halymenia discoidea	Red Seaweed	Sundarbans
6.	Hypnea Hypnea pannosa	Red Seaweed	Saint Martins
7.	Hydroclathrus Hydroclathrus clathratus	Brown Seaweed	Saint Martins
8.	Sargassum Sargassum sp	Brown Seaweed	Saint Martins
9.	Eucheuma sp	Green Seaweed	Saint Martins

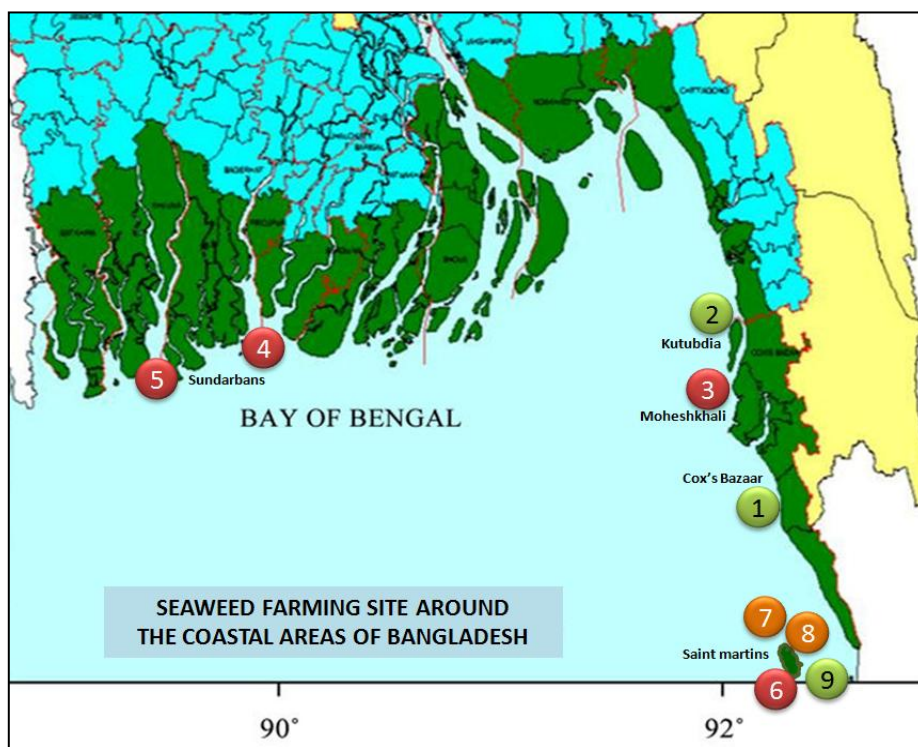


Figure 6. Seaweed Cultivation Sites in Coastal Areas of Bangladesh by BFDI²⁶.

Seaweed Farming Result and Analysis

Seaweed farming plays a pivotal role in coastal conservancy by providing environmental, economic, and ecological benefits. As a nature-based solution, seaweed cultivation helps mitigate coastal pollution by absorbing excess nutrients, such as nitrogen and phosphorus, from the water. This process reduces the likelihood of harmful algal blooms and improves water quality, creating healthier marine ecosystems. Asian countries account for 99.1% of all seaweed cultivated for food which can help reduce the ocean's carbon budget by acting as CO₂ sinks. In the context of climate change mitigation, seaweed cultivation serves as an energy crop and functions as a bio-filter and bio-extractor throughout its life cycle²⁷. In terms of coastal protection, seaweed farms serve as natural barriers, reducing wave energy and protecting shorelines from erosion caused by storm surges and rising sea levels.

The cultivation of seaweed also fosters biodiversity by creating habitats for marine organisms, enhancing the ecological balance in coastal regions. The

cultivation of seaweed does not require fertilizers, pesticides, or freshwater, making it eco-friendly and cost-effective. Seaweed absorbs carbon dioxide and releases oxygen, mitigating ocean acidification caused by oil spills and improving the resilience of marine ecosystems. Additionally, seaweed farming promotes the restoration of degraded habitats by creating artificial reefs, providing shelter and food for marine species affected by oil spills. The coastal waters are home to a diverse array of seaweed species, characterized by various colors, textures, and sizes, all rich in nutrients. To maximize these benefits, strategic planning is needed, including site selection, adoption of sustainable farming methods, and community involvement. Integrating seaweed farming into coastal conservancy plans can ensure environmental sustainability and resilience against climate change impacts.

In the current context, seaweed aquaculture and cultivation present a viable opportunity to improve the living standards of coastal residents. Commercial production of seaweed in the coastal regions of Bangladesh requires further investigation into its economic viability. Nevertheless, large-scale seaweed cultivation has the potential to create new opportunities for Bangladesh in terms of future food security, coastal security monitored by Bangladesh Navy and can contribute significantly to the achievement of national sustainable development goals.

Conclusions and Recommendations

The two oceans, one is sweet and other salty are not alike. From each of them you can eat fresh meat and wear ornaments to use. You see ship sailing their way through them so that you may seek his favor and give him thanks. (Surah Fatir: Verse-12)

The Holy Quran also references the consumption of fresh and tender marine life, highlighting the significance of aquatic organisms for sustenance. Seaweed stands out as a highly nutritious plant that can enhance human health and contribute to future food security. A sustainable marine environment is critical for economic growth, food security, and community well-being. Climate change threatens food security for billions globally, including 200 million in Bangladesh, necessitating sustainable development approaches. In national development process Bangladesh Navy remains as a significant stake holder of

secure maritime commerce. With land resources dwindling, aquaculture within the framework of the blue economy is a viable solution. Aquaculture, encompassing fish farming, seaweed cultivation, and other aquatic production, currently contributes 47% of nutrients to the global food supply and is the fastest-growing food production sector. Promoting sustainable aquaculture can significantly enhance marine resource value. Bangladesh Navy can play a significant role to encourage appropriate seaweed farming amongst coastal community to enhance maritime and coastal security. As terrestrial resources face depletion, coastal and marine resources offer promising avenues for ensuring future food and energy security. Developing aquaculture is essential for producing sufficient biomass and protein to meet the needs of a growing global population without relying on additional land and freshwater resources.

Seaweed offers substantial environmental and commercial benefits, making it a vital resource for sustainable development. Dry seaweed contains up to 3% nitrogen, absorbing up to 20 tons per square kilometer. Cultivating 500 million tons of seaweed could capture 10 million tons of nitrogen, mitigate oceanic phosphorus-related environmental disturbances and reduce coral dead zones. Phosphorus derived from seaweed could supplement costly, conventional fertilizers, which have declining production trends. Additionally, seaweed absorbs significant carbon, approximately 3.2% of oceanic carbon emissions, aiding in greenhouse gas mitigation and carbon credit opportunities. Seaweed is also a potential biofuel source, containing 50% carbohydrates and capable of generating 1.25 billion megawatt-hours of methane annually, equivalent to 1.5% of 2016's global energy consumption. It can be farmed without freshwater depletion, offering environmental and economic benefits while alleviating pressure on terrestrial resources. Its high nutritional value and cost-effective cultivation make it a sustainable option for improving livelihoods and food security. Efforts to promote seaweed consumption, diversify products, and invest in research are essential to unlocking its potential for ecological and commercial applications, restoring balance and advancing sustainability.

Despite its nutrient-rich benefits, seaweed consumption is rare in Bangladesh. The country has identified 133 species of seaweed, with nine commercially viable species. However, for seaweed farming in Bangladesh faces several limitations, including coastal siltation, rising sea surface temperatures,

acidification, and high pollution levels, which affect yield and quality. The absence of lagoons, stable and clean water conditions, and advanced cultivation techniques further hinder its development. Adverse weather conditions, such as cyclones, pose risks to coastal farms. Limited local awareness and insufficient processing and marketing infrastructure restrict the industry's potential. Additionally, challenges in identifying suitable farming sites and the lack of feasibility studies on commercially viable species impede large-scale production. Overcoming these limitations requires investment in research, technology, and awareness campaigns to unlock seaweed farming's potential.

The cultivation of seaweed can address several of the 17 Sustainable Development Goals, particularly the top seven, through green mitigation efforts. Key indicators of these goals, such as poverty reduction, zero hunger, clean energy, climate action, and the preservation of life both below water and on land, can be achieved through seaweed farming where Bangladesh Navy can contribute significantly in developing the living standard of coastal community. By embracing innovative technologies in aquaculture, in depth feasibility studies in coastal region for seaweed production, Bangladesh can achieve sustainable development goals related to a safer coastal environment and food security sooner than anticipated.

Notes and References

1. James H. Tidwell, 'Aquaculture Production Systems,' West Sussex, UK, Oxford Publishers, 2012, p 4.
2. Robert C. Beckman, Millicent McCreath, J. Ashley Roach, Zhen Sun, 'High Seas Governance: Gaps and Challenges,' Leiden, Netherlands, Hoteli Publishing, 2018, p. 195.
3. Bela H. Buck and Richard Langan, 'Aquaculture Perspective of Multi-Use Sites in the Open Ocean', New Hampshire, Springer International Publishing, 2017, p. 8.
4. R Bosch and M. van d Pol & J. Philp. Define biomass sustainability, Nature 523, 2015, pp. 526–527.

5. Kate Johnson, Gordon Dalton, Ian Masters, (ed.), 'Building Industries at Sea - 'Blue Growth' and the New Maritime Economy,' Denmark, River Publishers, 2022, p 310.
6. IUCN Bangladesh Country Office. Bio-ecological Zones of Bangladesh, 2002, p. 97.
7. Ibukun J. Adewumi, Maree E. Fudge, Andrei Polejack, Joanna Vince, (ed.), 'Blue Economy and Ocean Sustainable Development in a Globalised World: Social, Political, Economic and Environmental Issues,' Lausanne, Switzerland, Frontiers Media SA, 2022, p. 111.
8. Ceridwen Fraser, Zi-Min Hu, (ed.), 'Seaweed Phylogeography- Adaptation and Evolution of Seaweeds Under Environmental Change,' Netherlands, Springer Publications, 2016, p. 293.
9. I.H.Pike and A. Jackson, Fish oil: production and use now and in the future, Lipid Technology, Vol. 22(3), 2010, pp.59–61.
10. Anicia Hurtado, Alan T. Critchley, Iain C. Neish (ed.), 'Tropical Seaweed Farming Trends, Problems and Opportunities,' Switzerland, Springer International Publishing, 2017, p 193.
11. World Fertilizer Trends and Outlook to 2018. Food and Agriculture Organization (FAO) of the United Nations, Rome, 2018. P. 18.
12. Diaz, R. J. & R. Rosenberg, 'Spreading dead zones and consequences for marine ecosystems,' Science, Vol. 32(1), 2008, pp. 926–929.
13. Michalak. Izabela, 'Experimental Processing of Seaweeds for Biofuels,' Wires Energy and Environment, Vol. 7(3), June 2018, pp. 336-352, Doi: <https://doi.org/10.1002/wene.288>.
14. L.Misurcova and Se-Kwon Kim, 'Handbook of Marine Macroalgae & Chemical composition of seaweeds,' West Sussex, UK, Wiley-Blackwell, 2012, pp. 173–192.
15. Op Cit, FAO 2018.
16. Sams Research Services Ltd. Report, 'Seaweed Farming Feasibility Study for Argyll and Bute,' Vol. 1(3), Sep 2019, available at: F108-004 SRSL Report Template, accessed on 06 June 2025.
17. J. P Gattuso & L. Hansson, Ocean acidification: background and history, Jester, Vol. 221(89), 2011, pp. 1–20.

18. N. Wei, J.Quartermann, & Y. S. Jin, Marine Macro-algae: an untapped resource for producing fuels and chemicals. *Trends in Biotechnology*, NY, Vol. 31(2), 2013, pp. 70–77.
19. Garcia-Casal (et al), High iron content and bioavailability in humans from four species of marine algae. *The Journal of Nutrition*, Vol. 137(12), 2007, pp. 691–695.
20. IEA, Key World Energy Statistics 2014. International Energy Agency, Paris, 2014, p.37.
21. D.Valderrama (et al), The Economics of Kappaphycus seaweed cultivation in developing countries: a comparative analysis of farming systems, *Aquaculture Economics and Management*, Vol.19(2), 2015, pp. 251–277.
22. Rhein-Knudsen (et al), Seaweed Hydrocolloid Production: An Update on Enzyme Assisted Extraction and Modification Technologies, *Marine Drugs*, Vol. 13(6), 2015, pp. 340–359.
23. M Ali Reza Khan, Sundarban: Rediscovering Sundarban : the Mangrove Beauty of Bangladesh, Dhaka, Nymphaea Publication, 2013, pp. 147-152.
24. Shykh Siraj, Seaweed door to blue economy, *Daily Star*, August 02, 2018, retrieved on 10th Sep 2024, web link <https://www.thedailystar.net/country/seaweed-door-blue-economy-1614625>.
25. Mehedi Al Amin, ‘Seaweed farming: alternative livelihood for coastal people’ *Dhaka Tribune*, 17 April, 2019, retrieved on 16th Feb 2025 also available on webpage <https://www.dhakatribune.com/bangladesh/event/2019/04/17/seaweed-farming-alternative-livelihood-for-coastal-people>.
26. Nesar Ahmed and Wara Taparhudee, Seaweed Cultivation in Bangladesh: Problems and Potentials, *Research gate*, Vol. 28(2005), 2010, pp. 324-336also available at https://www.researchgate.net/publication/47378683_Seaweed_cultivation_in_Bangladesh_Problems_and_potentials.
27. Durga Prasad Behera and Viral Vadodariya (et al.), Seaweeds cultivation methods and their role in climate mitigation and environmental cleanup, *Elsevier*, Volumes 3–4, December 2022, 100016, Pp. 76-89, doi: <https://doi.org/10.1016/j.totert.2022.100016>.

Biography of the Writer



Ex-Commander Mohammad Mehadi Amin Miah, (G), psc, BN was commissioned in the Bangladesh Navy in 1996. He received his basic training from the Royal Malaysian Navy and completed his degree in Maritime Defence and Transportation. During his service, he completed numerous professional and academic courses both at home and abroad. He commanded several small and medium craft vessels and served as Executive Officer of a Training Frigate. He also served as Personal Secretary to the Principal Staff Officer, Armed Forces Division. He completed the EEZ Protection Course in Hampshire, UK, and the Coastal Oil Spill Clearance Beach Master Course at the Oil Spill Training Centre, Southampton, London. Academically, he earned a Postgraduate Diploma in International Humanitarian Law from NALSAR University, Hyderabad, India, a Bachelor of Law from National University, a Masters in Defence Studies from Defence Services Command & Staff College, Mirpur, under the Bangladesh University of Professionals (BUP), and an MPhil from the same institution. He was a dedicated seafarer and served as Training Commander of BNS ISSA KHAN, the Bangladesh Navy's largest training command. The officer passed away on 14 October 2025 (Inna lillahi wa inna ilaihi rajiun).

CONTEMPORARY GLOBAL CONFLICT DYNAMICS: INSIGHTS FOR DEVELOPING NATIONS LIKE BANGLADESH

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Abstract

The 21st century has been characterized by wave of confrontations and revolution in military technologies. Critical analyses of recent engagements such as the ongoing Russia-Ukraine war (2014 to till to date), Iran-Israel 12 days war of June 2025, India-Pakistan skirmish of 07-10 May 2025, Armenia-Azerbaijan war of 2020, and the protracted Middle East crisis reveals a widespread use of cutting-edge technologies. These conflicts accentuate the effective utilization of drones (UAVs/UAS), electronic warfare (EW), cyber warfare, precision weapons, ballistic missiles, proxy concepts, hybrid warfare strategies, sophisticated satellite technology, advanced fighter aircraft, and multi-layer air defense systems. The study of the contemporary conflicts, especially Russia-Ukraine, India-Pakistan, Armenia-Azerbaijan conflicts highlight the potent and effective deployment of UAVs, demonstrating their critical role in modern days battlefield. Furthermore, Iran-Israel and Russia-Ukraine wars have show cased the paramount importance of multi-layered air defense, precision weaponry, robust C4ISR systems, and the growing significance of cyber warfare. Again, the unprecedented example of the threat of Iran in 22 June 2025 to blockade the 'Strait of Hormuz' in retaliation to US B2 bomber attack on Iran Nuclear sites, make one understand how low-cost, asymmetric weapons can also be the perfect deterrent tool. Another major lesson of recent conflicts is hybrid and proxy warfare which continues to rise in prominence. The developing nations need to be alert and ready to protect their sovereignty and territorial integrity by strengthening intelligence, surveillance, reconnaissance. This paper comes up with ways ahead of the leading lessons of conflicts in the modern world and provides a guide on how the Bangladesh armed forces can adapt with the changing dynamics. The roadmap offered is basing on the concept of multidoma in warfare, adoption of cyber, AI and electronic warfare capabilities, incorporation of C4ISR system, and develop multi-layer air defense. The study also suggests the significance of

introducing a collaborative innovation among the military, government, academia, and industry. With the help of appropriate planning, adapting with new technologies, training and capacity building, Bangladesh Armed Forces can transform into a high-tech, robust and future-proof organization that can cope with the challenges of the 21st -century warfare.

Key Words: UAV, C4ISR, EW, Cyber, technology, capacity enhancement.

Introduction

The world is presently affected by widespread conflicts in different regions. After the devastation of World War-I, World War-II, Arab-Israeli wars, Cold War, Syrian conflict and Middle East crisis, international community is now witnessing two major conflicts including the long running Russia-Ukraine war and Iran-Israel conflict. An intense 12-days war between Israel and Iran broke out on 13 June 2025, as Israel carried out the air strikes with nearly 200 fighter aircrafts against Iranian targets, killing key military personals and nuclear scientists¹. In June 2025, the U.S. B2 bunker-busters bomb penetrated Iranian nuclear facilities, underscores the changing face of strategic warfare. A small-scale but intense four days conflict between two nuclear powers, India- Pakistan, broke out between 07-10 May, 2025. Both the parties put into play a heavy fleet of drones, fighter aircrafts, missiles, and electronic warfare, which further testifies to the roaring pace of modern warfare.

Modern war is currently supported by a multitude of factors. Commanders are currently being supported by artificial intelligence in their ability to make rapid decisions, review extensive data, and, in certain instances, operate autonomous weapons. Additionally, hybrid warfare and proxy war strategies are becoming increasingly prevalent in the majority of conflicts. Drones or other unmanned equipment monitor the enemy position, inflict targeted attacks, and even disseminate propagandas to damage the morale or create fear. Cyberspace has become a very potential arena of contemporary conflicts, and in recent Israel-Iran war, cyberwarfare has played a significant role². Again, sea denial through naval mines still remains a potent means for the developing nations. Recently, on retaliation to US attack of 22 June 2025, Iran threatened to close the Strait of Hormuz passage using naval mines, shows how

asymmetric weapons can be a powerful and cost-effective defense-especially for developing countries.

Evolving geopolitical landscape presents a significant challenge for the less developed countries³. The super powers of the world are extending their reach to the Indian Ocean region and militarization of this region has become a great security concern for Bangladesh⁴. Consequently, to safeguard its territorial integrity and sovereignty, Bangladesh needs to have a credible armed forces and foster indigenization in military technologies. In this article, the author examines the key lessons of global conflicts that Bangladesh can exploit to develop a technologically competent, multi-domain enabled, and future-ready Armed Forces.

Evolving Nature of Modern-Day Warfare

The contemporary conflict scenario has surpassed the earlier era of warfare, during which tanks, vessels, and fighter aircraft were the sole factors that determined the outcome of a battle⁵. The ongoing Russia- Ukraine war offers significant lessons to be drawn for the world militaries⁶. The following table as developed by researcher Osama Qatrani, presents the key global forces shaping modern conflicts, showing how each becomes weaponized, categorized by type of tools used and the regions where this dynamics is most visible.

Table 1: Evolving Conflict Dynamics and Weaponization of Global Forces

Global Force	Primary Conflict Trigger	Weaponized Effect	Type of Tool	Geographical Arena
Arms Industry	Militarization and arms races	Prolonging wars through weapons supply	Hard Power	Middle East, Ukraine

AI & Algorithms	Algorithmic targeting, cyber warfare	Autonomous weapons, data-driven strikes	Hybrid	USA, China, Iran
Weather & Climate	Climate-induced migration and disasters	Weaponization of climate shocks	Hybrid	Africa. South Asia. Latin America
Water Scarcity	Resource wars over rivers/aquifers	Using water access as leverage	Hard Power	Ethiopia, Egypt, Central Asia
Energy	Pipeline disputes. fuel embargoes	Energy blackmail, oil as weapon	Hybrid	Russia, Gulf. Venezuela
Media	Narrative control, psychological warfare	Propaganda, disinformation campaigns	Soft Power	Global networks, social platforms
International Sanctions	Economic Destabilization, Indirect war	Trade restrictions as coercive tools	Soft Power	Iran. Russia, North Korea
Geopolitical Conflicts	Border and ethnic/political disputes	Conventional and hybrid military interventions	Hard Power	Ukraine, Syria, Yemen

Source: Osama Qatrani, Global Crisis Case Study: The Iran-Israel War, Vol 2 – 2025, page 20
 Sunday, 22 June 2025 ⁷

In light of the above findings, the lessons for a developing nation like Bangladesh's defence strategists and combat forces is to adapt with new technologies and strategies. Conflicts in recent times have seen the following shifts in strategy and innovations in military technology:

Hybrid and Proxy War Concept

Proxy war is evident in the ongoing global confrontation⁸. Again, the conflict in Russia and Ukraine is often described as a "hybrid war" where traditional war is intertwined with proxy war, cyber warfare and information operations. Ukraine is receiving assistance from the United States and the European Union in this conflict, while Russia is receiving assistance from China, Iran, and North Korea. The world has also seen how private military organizations have been involved in furthering Russia's goals in the crisis in Ukraine. Furthermore, the concept of hybrid war and proxy war is common in many Middle Eastern wars. The Syrian crisis of the last decade can be classified as a classical example of hybrid war due to the complexity of the combination of conventional warfare, asymmetric warfare, proxy war and unconventional warfare involving many states. Proxy warfare, which involves state-sponsored non-state groups, adds uncertainty and complicates conflict resolution. Developing countries are vulnerable to proxy conflicts because of their strategic location and other interests of the superpowers. Wars are more about narratives and media in the 21st century rather than about arsenals. Media and algorithms are applied by powerful nations that want to influence the mass opinion and give reasons to their deeds⁹. Developing countries, such as Bangladesh, must strengthen intelligence, surveillance and reconnaissance capability to detect and resist external influence or proxy groups working within their borders.

The Ubiquitous Influence of Drones, UAVs, UAS, UCAS

Drones have had an ever-present influence on warfare, as shown most notably in the ongoing Russia-Ukraine War, in the India-Pakistan 04 days battle of 07-10 May 2025, in the 2020 Nagorno-Karabakh War, and the ongoing Israel-Iran Conflict, etc. Azerbaijan could effectively use Turkish made 'Bayraktar TB2' drones in the 2020 conflict with Armenia. The 07-10 May 2025 India-Pakistan conflict brought to the fore the use of drones as a decisive means of war in the present times. Quadcopters, long-range munitions, and other drones were sent to strike and spy, in hundreds. It marked the first time that the complete-scale drone war involved probing, spoofing, and interceptions constant between the two nations¹⁰. In Russia- Ukraine ongoing conflict,

Ukraine has been using ‘First-Person-View (FPV)’, AQ-400 Scythe and Liutyi AI guided drones against Russia while Russia has been using Iranian origin ‘Shahed’ drones, FPV, Fiber optic swarm drones and various ISR drones¹¹.

Hypersonic Ballistic Missile

In April 2024, an Israeli strike on an Iranian diplomatic facility in Damascus killed several senior IRGC officers. In response, Iran launched a direct and large-scale aerial assault on Israel, unveiling its most advanced military capabilities-ballistic missiles, and cruise missiles¹². Recent tensions between Israel and Iran in 2025 have shown both the effectiveness and vulnerabilities of missiles and air defense systems. Iran is said to be using hypersonic missiles called the Fattah 1, which can reach speeds of more than Mach 5. Since the beginning of the Israel conflict, Iran has launched some 550 ballistic missiles and around 1,000 drones targeting Israel¹³. On the contrary, Israeli Air Force is known to use advanced fighter air craft like F-35, F-15, F-16 to deliver precision-guided missiles and munitions. The most serious military crisis between the nuclear armed rivals in decades was the India-Pakistan conflict of May 2025 triggered by the April 22nd Pahalgam terrorist attack and consequent India’s Operation Sindoor of May 7th-10th. During this four-day standoff, India deployed its cruise missile such as BrahMos and SCALP-EG against Pakistan that responded with conventional versions of short-range ballistic missiles¹⁴.

Air Warfare and Air Defense Systems

Recent India-Pakistan conflict of May 2025 climaxed in one of the longest and largest dogfights in the history of global aviation on the 6th and 7th of May with more than 100 fighter jets on either side actively engaged with missile exchanges taking place at very high altitudes¹⁵. There were unprecedented drone wars by the two countries with the objective of damaging and there was also a massive deployment of air defense systems. The recent war between Israel and Iran has highlighted the significance of an effective air defense system which is a good lesson for Bangladesh. Bangladesh also needs to develop formidable air defense system. Responding to the threats and harnessed by the support of its allies, Israel has built a multi layered air defense system that can detect and destroy a great variety of Missile threat. Israeli air defense

system basically comprises of Iron dome (short range defense against rockets, artillery, drones), David's Sling (Mid-range interceptor for ballistic and cruise missile up to 200 km and arrow 2/Arrow 3 (which can intercept medium-long range ballistic missiles, with Arrow 3 operating above the atmospheric level)¹⁶. The system of Israel, though advanced, is not infallible and can surely be overrun in case too many projectiles are unleashed at it concurrently. The interception cost is also the other major issue. To counter this problem, Israel is endeavouring to develop the Iron Beam air defense system with an aim to ensure cost effectiveness of the air defense system¹⁷. The experience of the Iran-Israel conflict shows that it is not enough to have only one air-defense system when facing a wide variety of threats in a broad modern battlefield, starting rockets and drones, passing different ballistic missile types, and may be hypersonic as well. Multilayered approach is necessary to ensure different systems cover different ranges and profiles of threat to create resilience.

Figure 1: Israeli Air Defence Against Iranian Ballistic Missile Attack



Source: <https://www.timesofisrael.com/the-israel-iran-war-by-the-numbers-after-12-days-of-fighting>¹⁸

AI's Transformative Role in Military Operations

Artificial intelligence (AI) is revolutionising the military decision-making process. AI accelerates the processing of combat information by utilising deep-learning algorithms that extract relevant information from extensive datasets, including satellite imagery, surveillance, and reconnaissance. The automatic

identification and recognition of facts liberates military leaders from the necessity of focusing on plan implementation, allowing them to avoid the wasting time in revisiting extensive data. Throughout the Russia-Ukraine war, both sides have utilised disinformation facilitated by artificial intelligence. This also entails the utilisation of generative AI to produce deepfake videos, counterfeit social media profiles, and propaganda aimed at altering public perception and undermining the adversary¹⁹. The Israeli military has pioneered the application of AI in its operations, particularly in precision strikes and intelligence gathering against entities such as Iran, Hezbollah, Houthi, etc. The deployment of completely autonomous deadly weapons remains a contentious issue, however there are indications of the partial AI-enhanced autonomy in targeted strikes. The demise of Iranian nuclear scientist Mohsen Fakhrizadeh in 2020 reportedly featured an AI-enabled, remotely operated gun²⁰.

Deep Penetration Strikes-Bunker Buster

On 22 June 2025, the United States initiated Operation "Midnight Hammer," deploying B-2 spirit stealth bombers to strike three critical Iranian nuclear facilities: Fordow, Natanz, and Isfahan²¹. The exercise showcased the novel data-absorptive and precision accuracy weaponry, highlighting the growing significance of space-based technologies in modern warfare. The U.S. military is presently the sole force capable of deploying the Massive Ordnance Penetrator (MOP), a 30,000-pound (13,600 kg) laser-guided bomb designed to obliterate heavily fortified underground facilities, including bunkers and tunnels. The MOP is said to be capable of penetrating up to 200 feet (61 meters) of soil or 60 feet of reinforced concrete before detonation. The B-2 Spirit is currently the sole U.S. arsenal aircraft capable of transporting the MOP, with the capacity to carry two units in a single mission. It possesses exceptional stealth characteristics, making it challenging to detect on radar, hence enabling it to execute high-risk, deep penetration missions successfully within hostile territory²².

Cyber Warfare

Cyber warfare has emerged as a crucial element in contemporary conflicts, as evidenced by the ongoing Russia-Ukraine war, Israel – Iran war, and the broader Middle East crisis. The Russia-Ukraine war has seen significant cyber

activities, with both sides targeting infrastructure, disseminating disinformation, and compromising government and military networks. Russia's prominence is attributed to its vastness, sophistication, and state-backed resources. The campaigns often involve the utilisation of customised malware, including the damaging AcidPour wiper, alongside extensive espionage operations aimed at acquiring vital information and employing disruptive malware such as WhisperGate against essential infrastructure²³. Conversely, although Ukrainian cyber operations lack the centralisation characteristic of Russia's, they have effectively incapacitated governmental and military functions and significantly compromised essential systems, leveraging hacktivist collectives. The ongoing confrontation between Israel and Iran, along with the Middle East crises, has a protracted history of digital disputes in the online realm. Both nations and their proxies have engaged in cyber espionage, sabotage, and influence activities.

Electronic warfare (EW)

Electronic Warfare (EW) has emerged as an important aspect in contemporary conflicts, impacting the outcome of engagements by occupying the electromagnetic spectrum. EW is a force multiplier which operates on multiple levels of a conflict, from self-protection to operational attack plans²⁴. Historically, Israel had substantial effectiveness using EW during the 1973 Yom Kippur War, when it used it to suppress Arab air defence. During the ongoing Russia-Ukraine conflict, EW has played a major role in interrupting navigation, jamming drones, and disrupting command and control networks. Russia's R-330Zh Zhitel, Krasukha-4, and Borisoglebsk-2 systems performed critical roles in stopping long-distance Ukrainian drone strikes and disrupting satellite communications²⁵. Meanwhile, Ukraine has developed EW-enabled vehicles, such as the SHARK UAV, to counter Russian drones. For developing nations like Bangladesh, adopting EW capabilities is no longer an option; it is now the essential method to defend critical military infrastructure, ensure operational independence, and remain

Table 2: Key Technologies and Their Observed Effectiveness Across Conflicts

Technology Category	Iran-Israel Conflict (Observed Effectiveness/Role)	Russia-Ukraine War (Observed Effectiveness /Role)	Nagorno-Karabakh Conflict (Observed Effectivness/ Role)	Key Takeaways/Limitations
Drones/UAVs	Iran used drones in barrages, few intercepted by Israel's Iron Dome.	Pervasive for ISR, precision strike, FPV attacks, logistics, EW; commercial drones adapted; battlefield saturation; long-range capabilities.	Pivotal force multiplier; suppressed Armenian air defenses; enabled precision strikes on artillery/tanks; enhanced propaganda.	Cost-effectiveness and high impact; "democratization of lethality" for non-state actors; necessitate robust anti-drone measures.
Artificial Intelligence (AI)	AI-based precision attack mentioned (killing nuclear scientist)	Used for reconnaissance, target identification, automated decision-making; AI-enhanced autonomous drones.	Used by Russia to impede Ukrainian drone AI from target identification .	Enhances intelligence, situational awareness, precision targeting, and decision-making speed; enables autonomous systems.

Cyber Warfare	Used by both side	Critical for disrupting infrastructure, data theft, spreading disinformation, attacks on government/ military networks; sophisticated state-backed operations vs. decentralized hacktivism.	Not applicable	Essential for modern conflict; protects critical infrastructure; requires strong defensive and potentially offensive capabilities.
Electronic Warfare (EW)	Used by both side	Extensive use by Russia (jamming, spoofing, C-UAV systems); affects civilian navigation; Ukraine acquiring EW aircraft for anti-drone missions.	Jamming/spoofing signals can override drone controls.	Control of EM spectrum is a new frontier; crucial for protecting communications, disrupting enemy C2, and countering drones.

Hypersonic Missiles	limited maneuverability led to >95% interception for most; some penetration by advanced types (Kheibar Shekan).	Russia uses long-range missiles	Not Applicable	Speed vs. maneuverability crucial; challenge to traditional defenses; reduced warning times increase escalation risk.
Air Defense Systems	Multi-layered; high interception rates (>95%) but not foolproof; vulnerable to saturation; high cost per interception.	Ukraine's air defenses strained by mass drone/missile attacks; US anti-air supplies halted.	Armenian air defenses vulnerable to drone exploitation; failed to adapt.	Multi-layered, integrated systems are imperative; cost-effectiveness of countermeasures (e.g., lasers) is critical for sustained defense.
Satellite Assistance	U.S. B-2 attack on Iran used	Unprecedented integration of dual-use commercial	Not Applicable	Provides strategic dominance through ISR, precision

	satellite assistance	space capabilities; critical tactical enablers for intelligence.		strike, early warning, and EW support; enhances situational awareness.
Deep Penetrating Munitions	U.S. used B-2 with GBU-57 MOP on Iranian nuclear sites.	Not applicable	Not applicable.	Unique capability for neutralizing hardened, deeply buried targets; requires specialized stealth platforms.

Source: Author's Construct

Lessons for the Developing Countries such as Bangladesh

Modern warfare is ever changing and is now more complicated and unpredictable than ever. These changes have major implications for developing countries such as Bangladesh. The most important lesson is that the future will not always be the domain of the conventional state-on-state threats. Rather, in the future warfare, hybrid warfare, proxy war, asymmetric warfare, and the role of non-state actors will dominate more. Bangladesh armed forces have to adapt with these changes in warfare and develop its capability accordingly. Mentionable that, beside conventional roles, Bangladesh Armed Forces are being called upon more and more to support civil authorities in unconventional roles like combatting terrorism, human trafficking, organized crime, cybercrime, and natural disasters including floods, cyclones, earthquakes, pandemics, etc²⁶. As a result, the development of armed forces should be such that it can perform both peace time and war time role. Bangladesh should have a long-term and comprehensive approach to mitigate those new forms of threats and new military technologies.

Strategic Foresight

Proactive strategy, which is supported by the constant research and planning, is the key to safeguarding national interests. The developing countries need to devise suitable strategy against new security challenges. Periodical research of the trends in the global conflicts and new technologies in the military sphere will help such country as Bangladesh to develop robust defense policies.

Adaptation with the Technological Transformation

To remain prepared in the contemporary warfare environment, Bangladesh needs to pursue technological change in military domain. This transformation must be participatory and integrative- involving the military, academia, industry and the policy-makers. Although there are already some initiatives in progress, there is a need to have a structured and collaborative approach.

Capacity Enhancement Strategy

In developing countries, the issue of military modernization is restricted by the financial and geopolitical factors. The investments ought to be made in less expensive but high-payoff technology such as UAVs, electronic warfare systems, cyber defense systems, and artificial intelligence. Capacity enhancement strategy should encompass the strategy of joint venture initiative, technology transfer, etc. Native talent pool will provide a massive boost in national defense capability and will also contribute to sovereignty and territorial integrity.

Establishing Strong C4ISR Capabilities

Modern warfare exists in several domain, which necessitates a smooth connection between all theaters. A good C4ISR network is a must which allows real-time situational awareness, quicker decision-making, and synchronized action. Combination of drones, satellites, radars, and other sensors with AI-enhanced C4ISR tools will go a long way to enhance the effectiveness of operations as such the developing nations need to focus on C4ISR through meticulous planning and execution.

Hybrid and Proxy Warfare

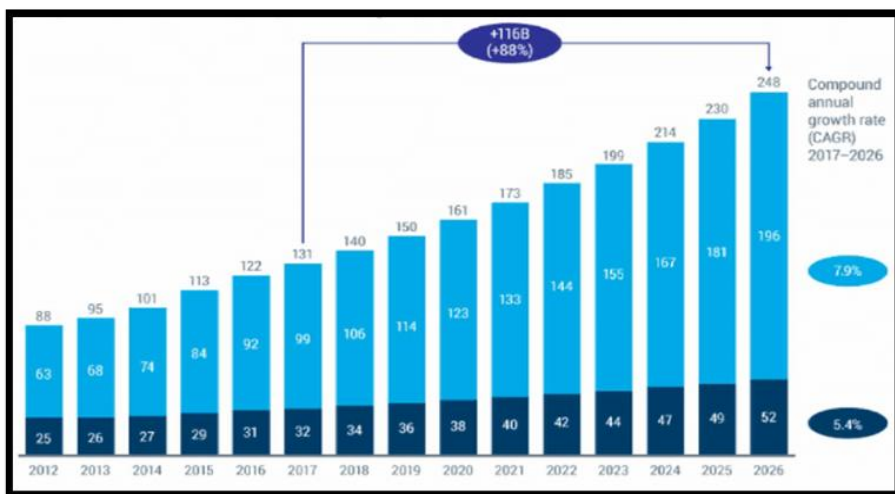
The increasing cases of hybrid and proxy war as witnessed in the Russia-Ukraine war and Middle-East crisis are serious issues to the developing nations. The big powers tend to manipulate the internal differences or support the non-state actors to serve their interests. Bangladesh needs to be cautious of such hybrid and proxy war. Intelligence collection, counter-insurgency and strategic diplomacy are the key elements in identifying and countering external influence and internal subversion.

Developing Electronic Warfare Capability

Modern military platforms like ships, aircraft, and armored vehicles need to utilize the electromagnetic spectrum in communication, navigation, and targeting. To prevent such systems from jamming and spoofing, among other things, the EW capabilities must be effective. Offensive EW can interfere with the enemy sensors and communications and defensive EW protects the integrity of friendly systems.

Cyber Warfare Capability

As technology advances, so do the potential threats in cyberspace. the cyberspace is currently considered as the fifth realm of warfare after land, sea, air, and space²⁷. Cyber security is seen as one of the most important national security challenges of present time, and it is increasingly being presented as a strategic-military concern. Major nations are creating new and more advanced military technology to maintain strategic superiority in areas like outer space and cyberspace²⁸. Cyber defense should be given the due emphasis taking the example of its devastating effect in recent Russia- Ukraine warfare since 2014 to till date. New York - Rome lab incident of 1994, Kosovo war (1995), Estonian crisis (2007) bear the example of prominent cyber-attack in the early 90's which continues in manifold in the current decade too²⁹. In the absence of strong cyber skills, the existence of critical systems remain at risk of being spied upon, losing information, and being incapacitated. The following graphical representation may help to comprehend the increase in global spending for cybersecurity:

Figure 1: Increasing Trend of Budget in Cyber Security

Source: <https://www.researchgate.net>³⁰

Developing Research and Indigenization

Bangladesh needs to focus on its own research and development, develop locally based manufacturing and seek technology transfer by forging international alliances. This will be encouraged by promoting innovation, counter-adaptation and self-reliance in order to reduce dependency and develop long-term resilience. New doctrines are needed to focus on the multi domains operations and unconventional warfare capabilities rather than following the obsolete, conventional doctrines by based on the lessons learned in the global conflicts in the recent past. In this fourth industrial revolution era, the establishment of specialized research organization is an imperative for country like Bangladesh³¹.

Jointness

Modern warfare is inherently joint in nature and demands seamless coordination and integration among the services. The norm of jointness has gained prominence from the 1980s onwards³². The jointness has been dogmatic and disoriented in principle and practice in Bangladesh Armed Forces. Consequently, concept of the jointness among members of the Armed Forces

needs more engagement, more joint training, more joint exercises, more social activities, and more confidence building measures.

Table 3: Suggested Domain for Military Technological Adaptation

Area of Adaptation	Specific Recommendations	Rationale/ Lesson Learned (from conflicts)	Potential Challenges/Considerations
UAVs/Drone	Invest in persistently UAVs to support surveillance and reconnaissance.	UAVs offer cost-effective, persistent ISR; satellites provide wide-area, real-time situational awareness.	Financial restrictions, information security, integration with the existing systems, training of operators.
Electronic Warfare	Establish high-level EW suites (EA, EP, ES) and put them on all significant military assets.	EW plays important roles in the control of the EM spectrum, own system defense, and interference with enemy communication /drones.	Expense of costly hi-tech EW systems poor and intensive technical manpower requirements, and high rate of obsolescence.
Cyber Defense	Develop indigenous capability to defend C2 systems, and major military infrastructure. Set	Prevents distraction, theft of data and hacking of key military	Lack of competent cyber specialists, constant changes in threats, protection of

	up cyber defense units.	information and system.	secure supply chains.
Unmanned Systems Integration (USVs/UUVs)	Acquisition of USVs and UUVs for maritime patrol, mine countermeasures, ASW, and potential swarm applications for Navy.	USVs/UUVs are comparatively affordable to build and improve maritime operations, minimize human exposure and provide asymmetrical uses.	Technological complexity, high development/acquisition cost, ethical /legal frameworks of autonomous systems.
Anti-Drone Capabilities	Equip key military platforms/ships/installations with multi-layered anti-drone systems (EW jamming/spoofing, kinetic, laser-based defenses).	Improves the high-profile and low-cost drone threat to military assets.	Drone technological development, the identification of friendly/enemy drones
C4ISR Modernization	Invest into secure, redundant and jointly functional C4ISR systems. Explore AI/ML opportunity to integrate to make better decisions, prioritize the	Enables data-driven warfare and augment in rapid response and multi-domain asset smooth integration	Challenges in critical integration issues, high infrastructure cost of investing, and data integrity and security.

	threats, and identify the target.		
Training & Doctrine Adaptation	Revisit the military doctrine to include multi-domain and hybrid warfare concepts. Implement comprehensive training programs on cyber security, EW tactics, AI-assisted decision-making and UAV operation.	Flexible doctrine and skilled personnel are critical for changing nature of warfare.	Change resistance, investments in constant training of resources, recruitment and retention of talent.

Conclusion

The lessons brought about by the conflicts in the modern world make it clear beyond any doubt that what is needed at the moment to have a better way to eliminate potential conflicts is the establishment of an entirely different paradigm both in terms of military thinking and capabilities by the military forces, such as the Bangladesh Armed Forces. The omnipresence of the new technologies, including smart drones and multi-layered air defense, smart cyber, and electronic warfare capability development, requires a holistic solution to its response. Bangladesh should then enact a relevant military doctrine that should integrate multi domain and the hybrid war concept fully since warfare in the future is going to be fought on physical, digital and electromagnetic spectrums. Most importantly, it implies extensive training on the use of UAVs, conducting cyber defense, the development of advanced EW techniques, and AI-supported decision-making of the entire personnel, to the culture of perpetual learning and evolution.

As a possible measure to combat the change in threat environment, Bangladesh Armed Forces would be required to develop and build-up dedicated organizations with well-developed EW units and well-built cyber defence units. One of the most basic measures is to equip all the major military assets like warships, army tanks/assets, military aircraft with advanced EW packages. In addition to this, long-term national security will require developing both defensive and offensive cyber capabilities. It is also important to make sure that the military key platform, assets, and installations are augmented with the multi-layered anti-drone framework, which incorporates EW capabilities, kinetic, and to be able to counter the broad range of UAV threats. Another significant lesson from the conflicts is to develop a secure C4ISR system. Specifically, this should aim at seeking the possible integration of AI and Machine Learning (ML) to assist in the military command with better decision-making, dynamic threats sorting, and enhanced target recognition. It is imperative for Bangladesh and the developing nations to design focused research and development taking all stakeholders, i.e., government, military, academia, industrialists, friendly nations, etc. onboard. Through selective investment in these key spheres and by cultivating a culture of innovation and flexibility, Bangladesh Armed Forces will be able to create a modern force, technologically advanced, robust, and highly operational unit, prepared to defend the national interests and perpetuate the stability in various regions of the constantly evolving security landscape of the 21st century.

Notes and References

1. Chughtai, A., (2025). Visualizing 12 days of the Israel-Iran Conflict. Aljazeera. <https://www.aljazeera.com/news/2025/6/26/visualising-12-days-of-the-israel-iran-conflict>.
2. Laila, R., (2025). A Cyber War of Iran-Israel: A Geopolitical Rivalry. University of Indonesia, Jakarta. P 54.
3. Mahmud,W., (2023). Evolving global order brings risks, opportunities for Bangladesh ,TBS Report, 09 December, 2023.
4. Rahman, Z., (2021). Bangladesh's geopolitical position provides for unique opportunities, Thursday November 4, 2021.

5. Crombe, K., John A. Nagl (2024). Introduction: Lessons from Ukraine for the Future Force.
6. Mykhaylo, Z., (2022). Preliminary Lessons in Conventional War fighting from Russia's Invasion of Ukraine: February-July 2022.
7. Qatrani, O., (2025). Global Crisis Case Study: The Iran-Israel War, Vol 2 – 2025, page 20, Sunday, June 22, 2025.
8. Qatrani 2025, Opcit.
9. *ibid.*
10. Joshua T. White (2025). Lessons for the next India-Pakistan war. May 14, 2025.
11. Mykhaylo, Z. 2022 Opcit.
12. Tarzi, A. (October 2024). MEs Insights, Volume 15, Issue 5, Israel–Iran Conflict: A Change in Iran's Strategic Assessment.
13. www.timesofisrael.com/the-israel-iran-war-by-the-numbers-after-12-days-of-fighting.
14. Christopher, C., (2025). Four Days in May: The India-Pakistan Crisis of 2025. <https://www.stimson.org/research/pivotal-places/asia-indopac/south-asia/> May 28, 2025.
15. *ibid.*
16. Johnson, R., (2025). Israel's Missiles Defense Systems: What you need to Know.<https://nationalsecurityjournal.org/israels-missile-defense-systems-what-you-need-to-know>. Published on 13 June 2025.
17. *ibid.*
18. www.timesofisrael.com/the-israel-iran-war-by-the-numbers-after-12-days-of-fighting.
19. Majchrzak, A.,(2023). Russian disinformation and the use of images generated by artificial intelligence (deepfake) in the first year of the invasion of Ukraine. University of Gdansk. Media BiznesKultura nr 1 (14) 2023 / Vol. 1 (14) 2023.
20. Mizokami, K., (30 September 2021). Everything We Know About Israel's Robotic Machine Gun. <https://www.popularmechanics.com/military/weapons/a37708762/robotic-machine-gun-kills-iranian-nuclear-scientist>.

21. D'Urso, S., (2025). Operation Midnight Hammer: How U.S. B-2 Bombers Struck Iran Undetected. <https://theaviationist.com/2025/06/22/operation-midnight-hammer/>.
22. Martinez, L.,(2025). How bunker-busters and B-2 stealth bombers struck at the heart of Iran's nuclear program. <https://abcnews.go.com/US/bunker-busters-2-stealth-bombers-struck-heart-irans/story?id=123090581>.
23. Andres, J., (2022). AcidRain -A Modem Wiper Rains Down on Europe. <https://www.sentinelone.com/labs/acidrain-a-modem-wiper-rains-down-on-europe>.
24. George, L., (2016). Electronic Warfare: Rethinking the Importance of Its Role in Military Operations. Virginia: National Defence University.
25. Harvey, J., (2025). The Russo-Ukrainian war's expansion into the High North poses electronic warfare challenges for NATO. <https://www.thebarentsobserver.com/opinion/the-russoukrainian-wars-expansion-into-the-high-north-poses-electronic-warfare-challenges-for-nato>
26. Chowdhury, A., (2015). Bangladesh Armed Forces: Challenges for the Future. The Daily Star, Sun Mar 8, 2015.
27. Shamsuddin, L., (2023). Director General, Defence Cyber and Electro Magnetic Division, 'An Interview with Asian Defence Journal', October 2023, ISSN 0126-6403, pp. 7-8.
28. Dunn,M., (2012). 'The Militarisation of Cyberspace', Conference: Cyber Conflict (CYCON), 2012 4th International Conference, January 2012.
29. Sharma, K., (2011). Cyber Warfare- The Power of the Unseen, New Delhi, KW Publishers Ltd, India, 2011, p.4 (19-21),
30. <https://www.researchgate.net/figure/Global-increase-in-cybersecurity-spending-from-2012-to-2026-Source-AustCyber-nd>.
31. Elahee, N., (2022). Defence Research and Development for Bangladesh: A Requirement Analysis. NDC Journal, Volume 21, Number 1, June 2022, ISSN: 1683-8475.
32. <https://www.idsa.in/system/files>.

Biography of the Writer



Commander K M Nazrul Islam, (E), NGP, afwc, psc, BN commissioned into the Bangladesh Navy in 2002, is a seasoned naval officer known for his technical expertise and operational leadership. He has completed key professional courses, including the Officers Bomb and IED Course (Bangladesh Army, 2009), Junior Staff Course (Bangladesh Naval Academy, 2011), Marine Engineering Specialization (BNS SHAHEED MOAZZAM, 2012), Staff Course (Defence Services Command and Staff College, Mirpur, 2018-19), and the Armed Forces War Course at the National Defence College, Bangladesh (2021). Commander Islam has held critical appointments across the fleet and shore establishments, including Deputy Director of Shipbuilding, Staff Officer to the Director of Technical Stores at Naval Headquarters, and Deputy General Manager at BN Dockyard. His extensive sea duty includes service as Engineer Officer aboard warships such as BNS SANGRAM, SHADHINOTA, PROTTOY, DURJOY, NIRMUL, TISTA, KHADEM, and MOHIBULLAH, with international deployments in the UNIFIL mission in Lebanon. Dedicated both to service and family, he is a committed husband and father of two children.

GREY ZONE CHALLENGES AND STRATEGIC CHOICES: REIMAGINING BANGLADESH'S NAVAL POSTURE IN THE CONTEXT OF SOUTHEAST ASIA

Commander Md Siddique Hasan, (C), psc, BN

"Power is not only the ability to strike, but the ability to anticipate and adapt"
Henry Kissinger

Abstract

Grey zone threats are increasingly shaping the strategic environment of the Bay of Bengal, where coercive, ambiguous activities-such as illegal fishing, cyber intrusions, disinformation, and paramilitary maritime operations-are conducted by state and non-state actors to undermine sovereignty without triggering conventional conflict. Positioned at a key maritime crossroads, Bangladesh faces growing pressure from regional rivalries, transnational non-state threats, and hybrid destabilization campaigns emanating from both land and sea. Instability in Myanmar's Rakhine State and intensifying US-China-India competition further complicate the maritime threat landscape. To uphold national sovereignty and maritime stability, BN must evolve beyond traditional sea control to embrace a multidimensional posture incorporating cyber defence, intelligence integration, hybrid threat response, and regional naval diplomacy. Recalibrating naval doctrine, enhancing force structure, and building interoperability with friendly navies are also critical. Therefore, a resilient, adaptive naval posture will enable Bangladesh to counter grey zone coercion and contribute meaningfully to a stable, rules-based Indo-Pacific order.

Key Words: *Grey Zone, Hybrid Threats, Maritime Domain Awareness, Indo-Pacific Strategy, Cyber Security, Non-State Maritime Actors.*

Introduction

In today's rapidly changing security environment, the conflict spectrum has expanded beyond traditional battlefields. One of the most urgent contemporary threats is Grey Zone Warfare, which takes place in the vague space between peace and full-scale war. Unlike conventional warfare, grey

zone activities depend on covert, deniable strategies such as cyberattacks, disinformation, economic pressure, and the exploitation of maritime resources like illegal fishing and other forms (Mazarr, 2015). These actions are intentionally kept below the threshold of open armed conflict, making it challenging for targeted nations to respond decisively without escalating tensions. In the South China Sea (SCS) and Indian Ocean (IO), such tactics are already in use. For instance, China's deployment of maritime militias disguised as fishing vessels, large-scale cyber espionage campaigns, and state-backed media influence efforts have altered the strategic landscape without a single shot being fired (Shuxian Luo, Jonathan G. Panter, 2021).

In this context, Bangladesh, as a littoral state in the Bay of Bengal (BoB), becomes increasingly vulnerable. Situated at the apex of the BoB, Bangladesh occupies a strategic maritime position that serves as a gateway between South and Southeast Asia. While this location provides economic and geopolitical benefits, it also makes the country a focal point among the global powers, where each of the states is eager to expand its influence in the region. Bangladesh Navy (BN), although making progress in its modernization efforts, still has the scope to improve in different aspects to address the multi-dimensional threats that are non-military in appearance yet highly strategic in intent.

The paper will critically examine the grey zone challenges confronting Bangladesh in its maritime domain and assess the readiness and adaptability of its naval forces accordingly. By analyzing real-world examples, identifying vulnerabilities, and considering regional power dynamics, the essay unfolds practical and forward-thinking solutions. These will include enhancing maritime domain awareness, building cyber resilience, forging strategic partnerships, and investing in asymmetric capabilities tailored to grey zone operations. Ultimately, this discussion seeks to reimagine Bangladesh's naval posture considering the persisting security environment of Southeast Asia.

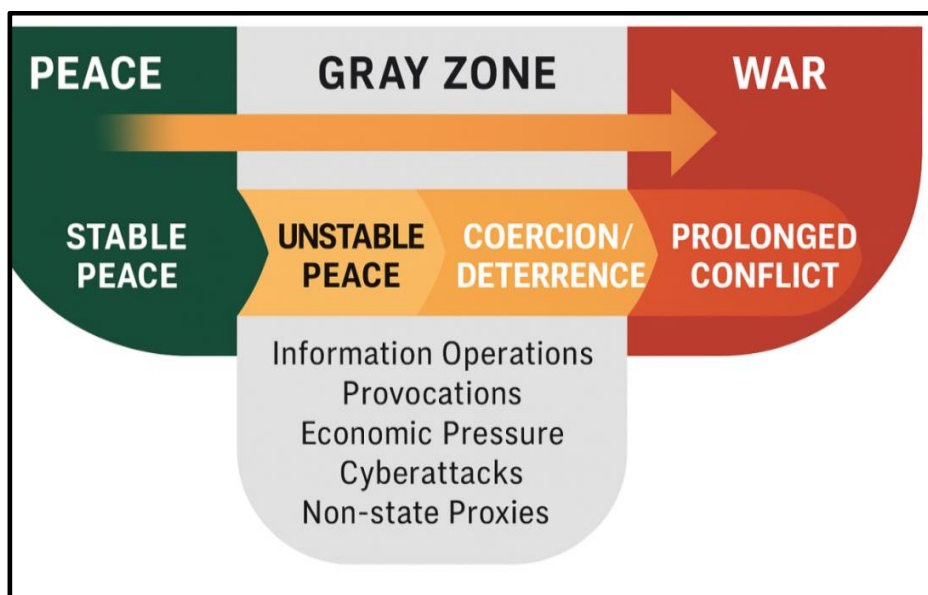
Aim

The paper aims to discuss the basics of the grey zone, the persisting grey zone challenges of Bangladesh in the Southeast Asian geostrategic context, finding threats and suggesting imperatives for recalibrating BN's posture.

Grey Zone Warfare: A Coercive Statecraft between War and Peace

Grey zone warfare refers to a strategic space between peace and open war, where actors employ a blend of military, economic, diplomatic, informational, and cyber tools to achieve objectives without triggering direct armed conflict. These activities are characterized by their ambiguity, deniability, and incremental progression (Brands, 2016).

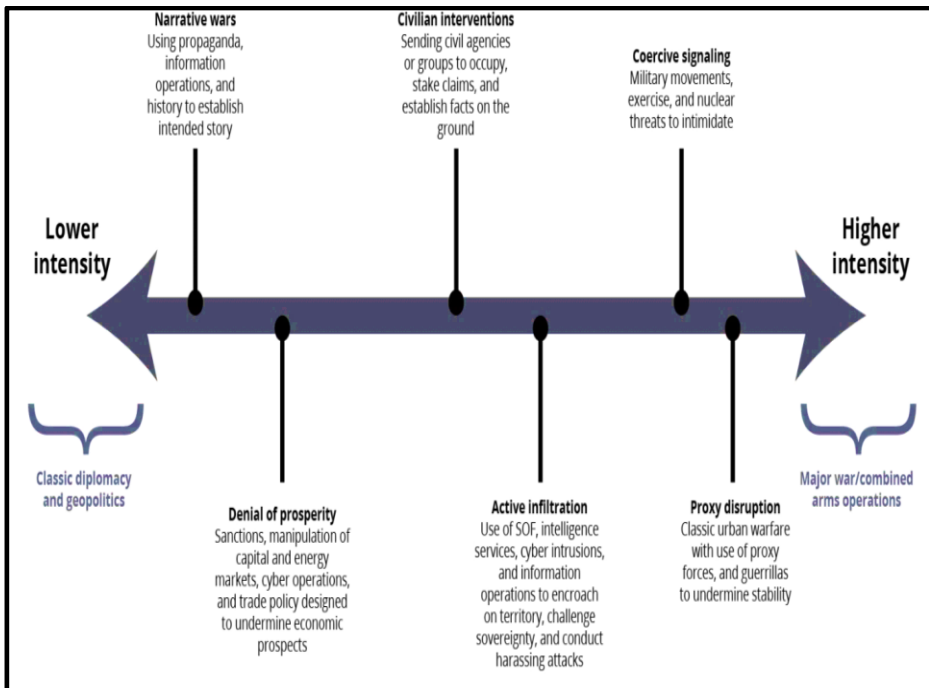
Figure 1: Basic Formation of Grey Zone



Source: Author's Self-Construct

States engaging in grey zone operations seek to exploit legal and normative thresholds to challenge adversaries while avoiding escalation into full-scale war. Key features of grey zone strategies include plausible deniability, use of non-state proxies, hybrid threats, asymmetrical tactics, and layered operations across multiple domains such as cyber, maritime, economic, and information warfare (Mahnken, 2021).

Figure 2: Grey Zone Spectrum



Source: M Mazarr, *Mastering the Grey Zone: Understanding a Changing Era of Conflict*, 2015

Common grey zone tactics vary by region and actor but include cyberattacks, disinformation campaigns, political coercion, economic sabotage, use of paramilitary forces or militias, and exploitation of contested territories etc. These tactics allow states like China, Russia, and Iran to shape their geopolitical realities without overt military aggression. For example, China's actions in the SCS, including the use of maritime militia, artificial island construction, and legal warfare ("lawfare"), exemplify maritime grey zone operations (A. S Erickson & A.P Liff, 2016). Similarly, Russian activities in Ukraine before 2022 involved disinformation, cyber intrusions, and the use of "little green men"¹ (Galeotti, 2016).

¹"Little green men" is a term used to describe Russian soldiers who, during the 2014 annexation of Crimea and the subsequent conflict in eastern Ukraine, were deployed in unmarked uniforms, often green fatigues, and without insignia.

Figure 3: Generalized Phases of Chinese Grey Zone Tactics



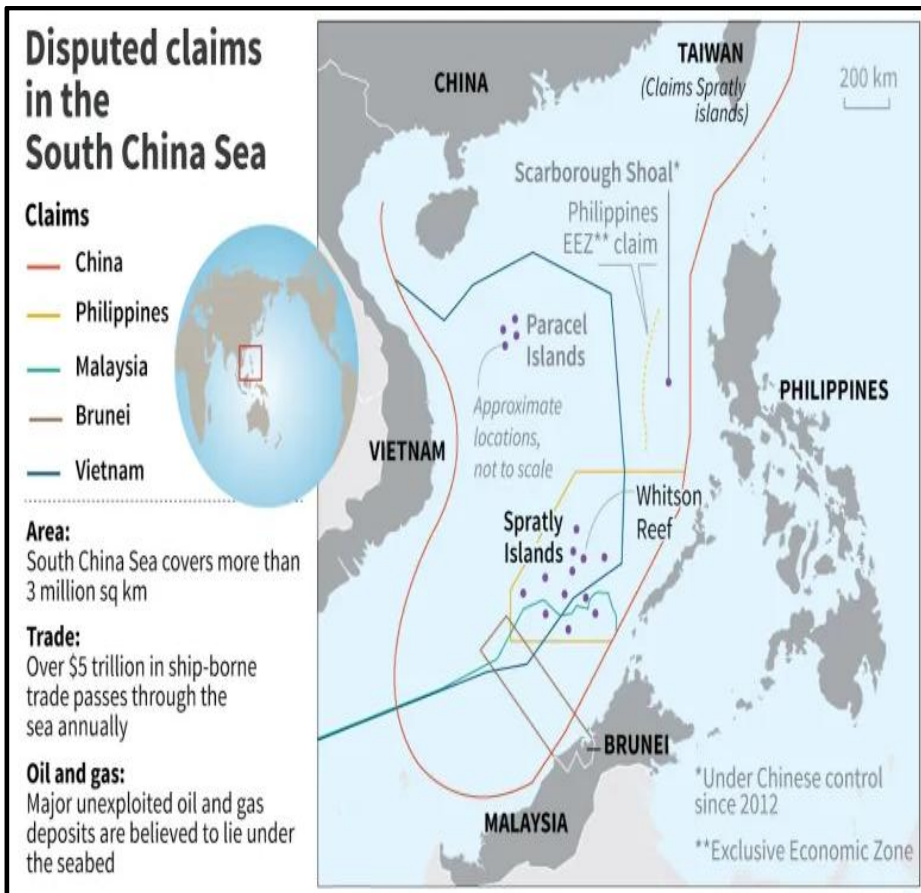
Source: Sze-Fung Lee, Decoding Beijing's Grey Zone Tactics: China Coast Guard Activities and the Redefinition of Conflict in the Taiwan Strait, 2024

Grey zone strategies are prominent in sectors like maritime security, where fishing militias or coast guards are used to assert sovereignty; cyber operations, where state-sponsored hackers steal data or disrupt systems; and in information warfare, where social media is weaponized to influence elections and destabilize societies (M. J. Mazarr, D. M. Gerstein, 2018).

Southeast Asian Geopolitics and Bangladesh's Strategic Position

The strategic geography of Southeast Asia is central to the broader Indo-Pacific security landscape. Flanked by the IO and SCS, the region is a theatre of increasing geopolitical friction driven by great power rivalries, evolving maritime doctrines, and economic interdependence. As an adjacent South Asian state with extensive maritime boundaries in the BoB, Bangladesh is directly affected by the unfolding dynamics in Southeast Asia.

Figure 4: Disputed Claims in the SCS

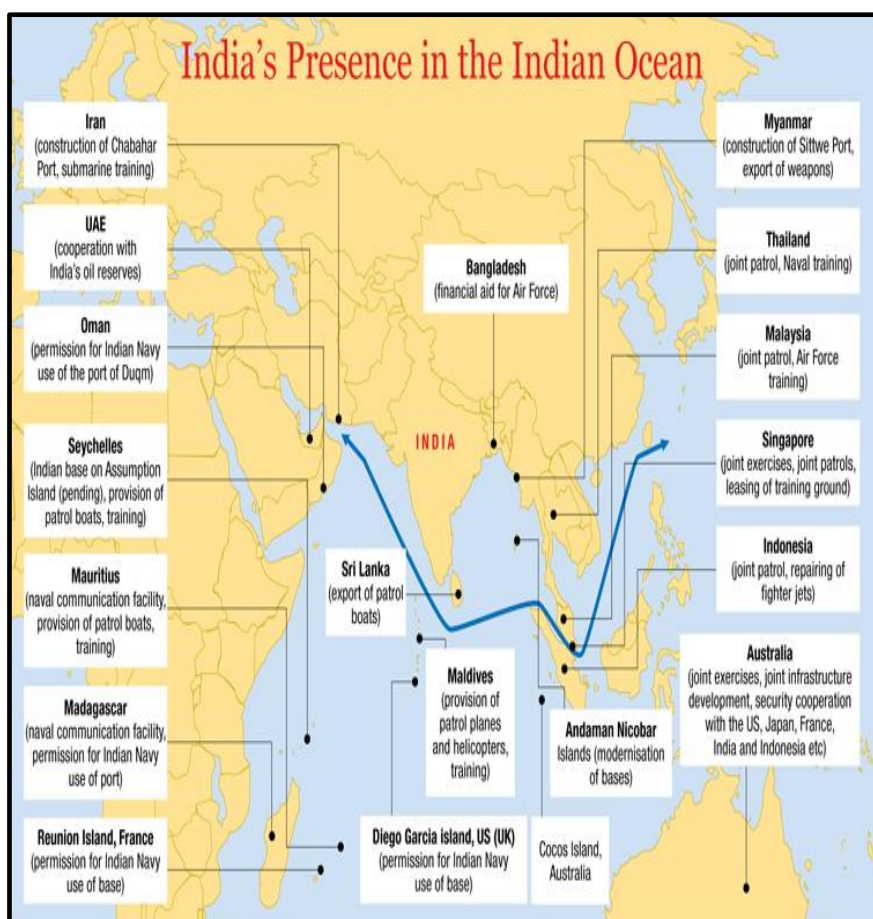


Source: CSIS/AMTI, D. Rosenberg, Middlebury College, Harvard Asia Quarterly, China Maritime Safety Administration

a. **The U.S.-China Rivalry in Maritime Southeast Asia:** The intensification of strategic competition between the US and China is reshaping Southeast Asia's maritime security environment. China's assertiveness in the SCS, characterized by militarized artificial islands, aggressive fishing militia operations, and sovereignty claims within the Nine-Dash Line, challenges the rules-based maritime order (Mastro, 2019). Concurrently, the U.S. has bolstered its presence through the Freedom of Navigation Operations, enhanced bilateral defense

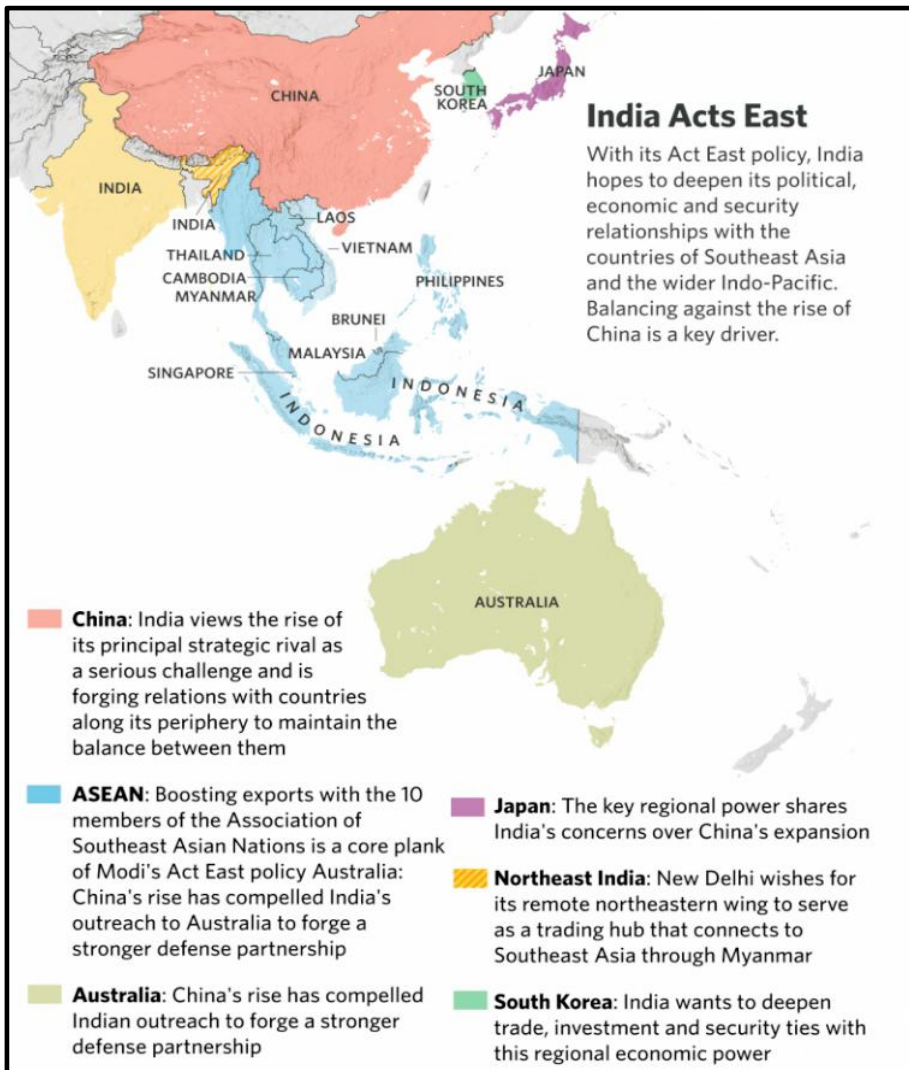
agreements, and its broader Indo-Pacific Strategy (U.S. Indo-Pacific Command, 2023). Although geographically outside the SCS, Bangladesh's maritime interests are increasingly linked to the region's strategic stability due to its location near vital sea lanes and its dependence on maritime trade routes that traverse these contested waters.

Figure 5: India's Presence in the IO Reflecting the Country's Maritime Ambition



Source: ANKASAM Infographic: India's Presence in the IO, Ankara Centre for Crisis and Policy Studies, 2022

Figure 6: Mapping of India's Act East Policy



Source: Dr Jitendra Singh, Connectivity is an Important Element of Act East Policy, Mar 2021

b. India's Maritime Ambitions and Act East Policy: India's geopolitical aspirations, particularly under its "Act East"² and

²The Act East policy is an effort by the Government of India to cultivate extensive economic and strategic relations with the nations of Southeast Asia to bolster its standing as a regional power and a counterweight to the strategic influence of the People's Republic of China.

SAGAR³ doctrines, reflect a desire to increase its maritime footprint in Southeast Asia and beyond (Ministry of External Affairs (India), 2022). The Indian Navy has expanded bilateral and multilateral exercises with ASEAN states, built logistics-sharing agreements with Singapore and Vietnam, and intensified engagement with QUAD⁴ partners. Bangladesh's proximity to India and its access to the BoB place it squarely within New Delhi's strategic periphery. While this has facilitated growing naval collaboration, such as coordinated patrols, port visits, and hydrographic cooperation, India's aspirations for regional primacy sometimes conflict with China's expanding influence in Bangladesh through infrastructure and defence partnerships (Cordesman A. H., Chinese and Indian naval competition: The Indian Ocean and beyond., 2023).

Figure 7: Mapping of China's Belt and Road Strategy



Source: CHEN JIA, 'Belt and Road' Takes New Route, 2015

c. **China's Belt and Road Initiative (BRI) and Maritime Outreach:**

China's BRI, particularly the Maritime Silk Road component, has deep implications for Southeast Asian maritime geopolitics. Port

³Security and Growth for All in the Region (SAGAR) is India's policy or doctrine of maritime cooperation in the Indian Ocean region.

⁴Quadrilateral Security Dialogue (QUAD) is a strategic forum of the USA, Japan, India & Australia.

developments, undersea cable investments, and naval diplomacy under the People's Liberation Army Navy have been central to China's effort to consolidate its presence in the IO and Southeast Asia (Brewster D. (., 2020). Cambodia and Myanmar have received significant Chinese investment, which often includes dual-use infrastructure capable of supporting both commercial and military operations. Bangladesh, not being a Southeast Asian nation, has seen similar investment patterns, such as the Chinese-backed expansion of various ports, communication nodes and modernization of naval hardware. These parallels draw Bangladesh into the strategic calculus of Southeast Asia's power dynamics, particularly as Indian and Western analysts interpret Chinese infrastructure projects as potential military footholds (Mayal, 2024).

d. Multilateral Maritime Forums and ASEAN Engagement:

Bangladesh's interaction with Southeast Asia also occurs through multilateral organizations and regional maritime forums. Although not a member of ASEAN⁵ Bangladesh engages with the ASEAN Regional Forum⁶ activities and maintains diplomatic dialogues with Southeast Asian nations. The Indian Ocean Rim Association (IORA)⁷, where Bangladesh is an active member, facilitates cooperative maritime security initiatives such as joint surveillance, blue economy governance, and capacity-building programs (Indian Ocean Rim Association (IORA), 2023). Moreover, BIMSTEC⁸, offers a platform for naval collaboration, information-sharing, and disaster response exercises. Given the growing

⁵The Association of Southeast Asian Nations, commonly abbreviated as ASEAN, is a regional grouping of 10 states in Southeast Asia, that aims to promote economic and security cooperation among its ten members.

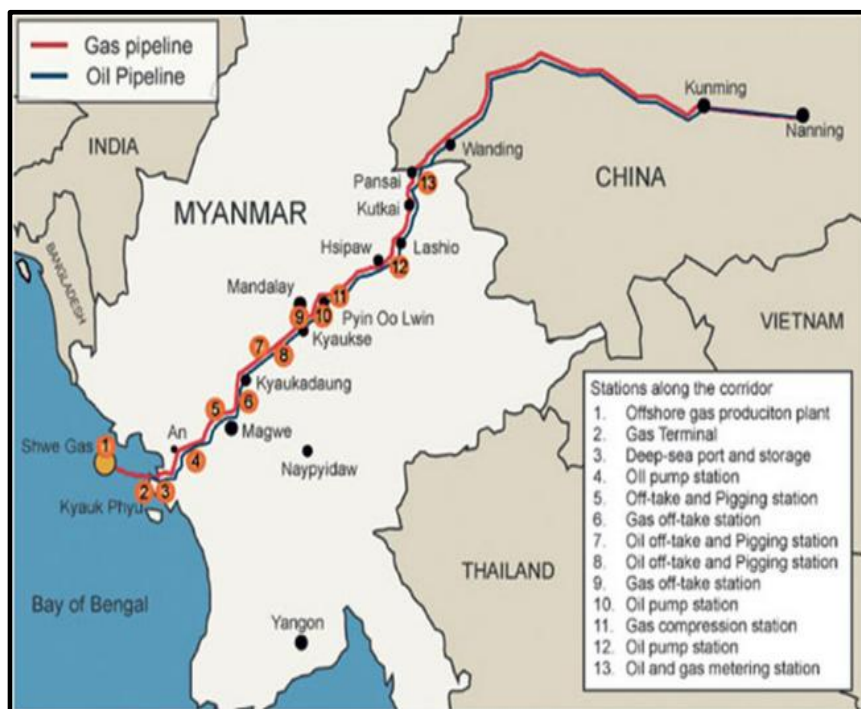
⁶The ASEAN Regional Forum (ARF) is a platform for political and security dialogue in the Asia-Pacific region. Established in 1994, it serves as a multilateral forum for participating countries to build confidence and address security concerns in the region.

⁷The IORA is a regional forum, tripartite in nature, bringing together representatives of Government, Business and Academia, for promoting co-operation and closer interaction among them. It is based on the principles for strengthening Economic Cooperation, particularly on Trade Facilitation and Investment Promotion, as well as Social Development of the region.

⁸BIMSTEC, the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation, is a regional organization comprising seven nations surrounding the Bay of Bengal. The organization's main aim is to foster economic cooperation among its member states.

complexity of maritime threats, ranging from piracy to grey zone incursions, these mechanisms are valuable in building maritime confidence and reducing miscalculation.

Figure 8: China's Gas and Oil Pipeline through Myanmar



Source: John Foster, Myanmar: A Shortcut to China, 2017

e. **Spillover of the Myanmar Crisis:** Since late 2023, escalating conflict between Myanmar's Military Junta and the Arakan Army in Rakhine State has triggered displacement, worsened the unresolved Rohingya crisis, and elevated the risk of grey zone threats such as narcotics business, arms trafficking, abduction, cross-border infiltration, etc. (International Crisis Group. , 2024). Compounding the issue, China's deepening involvement in Rakhine, particularly through the Kyaukpyu deep-sea port under the BRI, enhances its strategic reach into the BoB (Brewster D. , 2023). Meanwhile, increased Myanmar Navy maneuvers near the Naf River have heightened maritime security concerns for adjacent coastal areas (The Diplomat., 2024).

Figure 9: India's Kaladan Multi-Modal Transit Transport Project



Source: The Bay of Bengal, Instability in Myanmar Threatens India's Strategic Kaladan Initiative, July 2025

India also has significant strategic interests in Rakhine, particularly through its Kaladan Multi-Modal Transit Transport Project, which aims to connect India's eastern seaboard to its northeastern states via the Sittwe Port and inland routes across Chin and Rakhine. This project is crucial to India's Act East Policy and regional connectivity goals, but faces serious risks from insurgent groups operating in the same corridors. Multiple armed non-state actors active in the Rakhine-Chin region-including those with links to Indian insurgencies-further complicate security dynamics and pose threats to Indian infrastructure and personnel (Cordesman A. H., Center for Strategic and International Studies (CSIS), 2023).

Grey Zone Threats in the Maritime Domain: Relevance to BN

In the evolving security environment of the BoB and its adjoining waters, BN faces a broadening range of grey zone threats. Amongst many, the main eight key threat vectors, spanning operational, technological, economic, and informational dimensions, directly affect the Navy's mission profile and strategic outlook:

a. **Illegal, Unreported, and Unregulated (IUU) Fishing:** IUU fishing poses a persistent threat to Bangladesh's maritime sovereignty and resource security. Foreign vessels occasionally encroach into Bangladesh's Exclusive Economic Zone (EEZ) using dark vessel tactics⁹, operating beyond patrol reach (Rahman & Hossain, 2022). BN platforms deployed at sea patrol work relentlessly to prevent the IUU fishing.

b. **Cyber Vulnerabilities in Maritime Infrastructure:** With increased digital integration in port operations, naval communications, and logistics systems, cyber attacks pose a growing grey zone risk. Antagonistic cyber actors may target various crucial networks or disrupt operations at major KPs and VPs. (IMO, 2023).

c. **Maritime Militia and Paramilitary Intrusions:** The emergence of state-backed maritime militia—civilian vessels equipped for surveillance, sabotage, or denial operations— is a growing concern. Such vessels often act as advanced scouts, collecting intelligence or asserting presence under the civilian guise (Bergin, 2021), making them difficult to counter under standard Rules of Engagement (ROE).

d. **Strategic Infrastructure Coercion:** Bangladesh's ports, LNG terminals, and undersea cables are increasingly financed by foreign powers, notably China and Japan. These infrastructure nodes are vital to maritime trade and energy security, but also represent potential, grey zone targets— either through debt leverage, cyber sabotage, or embedded surveillance technologies. Strategic overdependence can result in coercive diplomacy or the denial of access during geopolitical standoffs (Cordesman A. H., 2023).

e. **Information and Influence Operations:** BN has already been subjected to coordinated disinformation campaigns intended to weaken public trust, stir political division, and question defence alignments. False narratives surrounding naval modernization, joint exercises, and regional

⁹Dark vessel tactics refer to the methods used by some vessels to conceal their activities and avoid detection, particularly in maritime trade. These tactics often involve disabling or manipulating their Automatic Identification System (AIS) and engaging in deceptive shipping practices.

partnerships have circulated on social platforms, often traced to proxy networks tied to hostile states (Wirtz, 2021).

f. Transnational Criminal Networks: The BoB's porous maritime borders facilitate transnational criminal activities, arms smuggling, narcotics trafficking, and human migration, often linked to hybrid networks operating across land-sea domains. These groups exploit jurisdictional gaps and patrolling gaps in the sea areas by the enforcing agencies. BN is required to support more in constabulary operations in coordination with Coast Guard and Customs agencies. (International Crisis Group, 2024).

g. Humanitarian and Forcibly Displaced Myanmar National (FDMN) Flow Manipulation: Instability in neighbouring Myanmar, particularly Rakhine State, continues to result in large-scale FDMN flows into Bangladesh's southeastern coastal zones. Grey zone actors could manipulate these flows to conceal infiltration, provoke border skirmishes, or destabilize internal cohesion. Mass displacement, particularly by sea, also places operational pressure on BN for maritime interdiction, disaster response, and logistical support functions.

h. Legal and Normative Ambiguity in Maritime Claims: Bangladesh's EEZ, while legally delineated by international arbitration, still faces normative challenges from neighbouring countries. Overlapping fishing rights, unregulated exploitation of seabed resources, and differing interpretations of UNCLOS¹⁰ provisions often lead to confrontations. Without a clear regional maritime governance mechanism, these disputes can be manipulated into prolonged standoffs or "lawfare"- the strategic use of legal processes to delay or deny access.

Imperatives for Recalibrating Bangladesh's Naval Posture

The rapidly evolving threat landscape in the BoB, shaped by great power rivalry, grey zone conflicts, and regional instability, necessitates a recalibration of the BN's posture. As a rising maritime nation, BN need to revamp to appear as a multidimensional force capable of deterring coercive actions in the grey

¹⁰The United Nations Convention on the Law of the Sea (UNCLOS), also called the Law of the Sea Convention or the Law of the Sea Treaty, is an international treaty that establishes a legal framework for all marine and maritime activities.

zone, projecting influence in the regional commons, and contributing to national security. Several imperatives must guide this recalibration:

a. **Strengthening Naval Combat Power and Operational Reach:** The heart of a credible naval posture is the ability to deter aggression and assert sovereignty. BN may continue to invest in acquiring platforms that enhance both conventional deterrence and grey zone responsiveness. This includes multi-role frigates, long-range maritime patrol aircraft, submarines, and unmanned surface and underwater vehicles. The expansion of blue water capabilities may be complemented by the induction of smaller, agile crafts for shallow water and coastal interdiction missions, especially useful for countering IUU fishing, smuggling, and insurgent infiltration. Modernization efforts must be supported by logistical enablers, such as replenishment vessels, forward bases, and ISR platforms. Furthermore, operational reach can be extended by developing island-based infrastructure, which would serve as strategic forward naval bases.

b. **Building Cyber and Information Warfare Capabilities:** In the grey zone, digital infrastructure is as critical as physical presence. BN may institutionalize cyber defence as an operational priority. This includes establishing a dedicated Naval Cyber Command/ Centre with offensive and defensive capabilities to protect networks, disrupt adversary communications, and monitor cyber intrusions into maritime critical infrastructure. Simultaneously, BN may build its capability in information warfare and strategic communications, including open-source intelligence (OSINT), psychological operations (PSYOPS), and counter-disinformation units. These can help neutralize hostile influence operations and false narratives that may target Bangladesh's maritime policies or military engagements. This initiative requires close integration with national cyber agencies, like Directorate General of Forces Intelligence, and other national/ international cyber security cooperation forums.

c. **Enhancing Maritime Domain Awareness (MDA) and Surveillance:** BN may prioritize satellite-based surveillance, radar chain integration along the coast, and use of unmanned aerial vehicles (UAVs) for wide-

area maritime patrols. A Coastal Surveillance Radar System (CSRS) may be linked with regional partners, particularly India and Sri Lanka, for shared situational awareness in the BoB. Integration of Automatic Identification System (AIS), Long-Range Identification and Tracking (LRIT), and other maritime traffic databases may be centralized through a Joint Maritime Coordination Centre (JMCC) under BN command for interagency response.

d. Developing Legal and Diplomatic Instruments: Grey zone challenges often manifest within legal loopholes. BN may support efforts to strengthen maritime law enforcement, both domestically and through regional cooperation. It is vital to revise and harmonize national maritime laws to allow rapid response to IUU fishing, cyber intrusions, and hybrid threats. Bangladesh may also lead regional dialogues under BIMSTEC and IORA to push for multilateral maritime codes of conduct and non-binding rules for grey zone encounters. Additionally, BN must remain engaged in naval diplomacy. Joint exercises, port visits, and naval training exchanges with friendly navies, will enhance both capability and strategic signaling. BN's participation in the Western Pacific Naval Symposium (WPNS)¹¹ and Indian Ocean Naval Symposium (IONS)¹² must evolve beyond symbolic presence to doctrinal convergence.

e. Countering Non-State Actors and Extremism at Sea: Non-state actors, including pirates, narcotics traffickers, and violent extremists, who exploit the gaps of maritime laws and porous sea borders. BN may develop a separate group for maritime interdiction and boarding teams trained in asymmetric and hybrid warfare. The Special Warfare Diving and Salvage (SWADS) unit, already elite in capability, should be further empowered for counter-terrorism missions in littoral and archipelagic environments. Intelligence fusion with the Coast Guard, Police, BGB, and regional

¹¹WPNS refers to the Western Pacific Naval Symposium, a series of biennial meetings between naval forces in the Western Pacific region. It's a platform for discussing maritime security issues and fostering cooperation among participating nations.

¹²The Indian Ocean Naval Symposium (IONS) is a series of biennial meetings for the navies of countries bordering the Indian Ocean. It serves as a platform for maritime security cooperation, regional maritime issue discussions, and fostering friendly relations among member states.

international naval forces is critical. Maritime fusion centers with access to financial intelligence, travel data, and cargo manifests would enhance interdiction capabilities against grey zone actors operating under commercial or humanitarian cover.

f. Border Security and Littoral Resilience: The southeast coastline bordering Myanmar remains a sensitive zone due to ongoing instability in Rakhine State. BN must work with land and air components to secure amphibious access points, chokepoints, and FDMN access routes. Island resilience, including hardened logistics and dual-use naval-civil infrastructure, is key to maintaining control of coastal zones during contingencies. The development of civilian maritime infrastructure, such as fishing harbours and coastal communication towers, along the bordering coastlines should be guided by naval interest to prevent their exploitation by hostile proxies or transnational actors.

g. Leveraging Emerging Technologies for Grey Zone Dominance: To counter threats in the grey zone, the BN must embrace emerging technologies. Integration of Artificial Intelligence (AI), geospatial analytics, and machine learning into maritime surveillance and early warning systems will significantly reduce response latency. Tactical data links, secure cloud-based coordination platforms, and real-time vessel pattern analysis must be part of the next-generation C4ISR ecosystem. Additionally, deploying swarm drones, underwater sensors, and satellite constellations in partnership with allied nations can provide exponential situational awareness without heavy financial burden.

h. Building Strategic Partnerships and Deterrence Credibility: Finally, Bangladesh must recognize that, maritime deterrence today is as much about alliances as it is about armament. BN may aim to create strategic ambiguity through naval exercises, foreign deployments, and capability demonstrations, which deters with adventurism without provoking escalation. This requires maintaining defence diplomacy with neighboring countries, while deepening operational trust with Western navies under frameworks like the Indo-Pacific Partnership, Japan's

FOIP¹³, and US Indo-Pacific Strategy, without undermining Bangladesh's non-aligned foreign policy tradition.

Conclusion

The contemporary maritime security environment of the Indo-Pacific has entered a transitional phase, dominated not by traditional naval confrontation but by hybrid challenges and strategic ambiguity. Grey Zone threats are now central to the competitive strategies of regional and global powers. Bangladesh, positioned at the northeastern rim of the BoB and flanked by major maritime actors such as India, China, and the US, finds itself exposed to these subtler forms of coercion. The country's maritime domain, once regarded solely through the lens of economic potential and regional connectivity, is increasingly being exploited as a means of strategic competition and ambiguity. In this context, BN must assume a pivotal role in preserving national sovereignty, economic interests, and regional credibility.

In recent years, BN has made commendable progress acquiring new war fighting platforms, expanding port infrastructure, and developing indigenous shipbuilding capacity. However, conventional naval strength alone is insufficient to deter or manage grey zone tactics, which often remain legally ambiguous and fall outside the scope of traditional doctrines. BN now faces the challenge of transitioning into a multi-domain force, capable not only of kinetic operations but also of cyber defence, intelligence fusion, legal diplomacy, and narrative control. The operational engagement has also intensified due to geopolitical instability in neighbouring countries, and from increasing transnational crime and extremism along maritime borders. These pressures demand that BN evolve into a force that can simultaneously deter, de-escalate, and dominate across the physical and virtual maritime environments.

Therefore, reimagining Bangladesh's naval posture is not merely about force expansion but about force adaptation. This transformation must

¹³FOIP stands for Free and Open Indo-Pacific Strategy, which consists of three pillars: Firstly, Promotion and establishment of rule of law, freedom of navigation and free trade, etc. Secondly, Pursuit of economic prosperity, Thirdly, Commitment to peace and stability.

internalize strategic resilience at the doctrinal, technological, diplomatic, and psychological levels. BN must emerge as a guardian not only of maritime borders but of national sovereignty in its broadest form, protecting critical infrastructure, countering subversive narratives, managing crisis at sea, and anchoring Bangladesh's role in multilateral maritime coalitions. In doing so, BN will not only ensure freedom of navigation and secure maritime economic assets but will also elevate Bangladesh's strategic standing in an increasingly contested Indo-Pacific order.

Recommendations

- To counter grey zone threats effectively, BN may establish a Joint Maritime Hybrid Threat Response Command integrating surveillance, cyber defence, intelligence, and legal operations. This command may coordinate closely with national agencies to detect and respond to unconventional threats such as cyber intrusions, maritime militias, and illicit trafficking. Investment in unmanned systems and AI-driven early warning tools is also essential.
- Simultaneously, BN may lead a Maritime Security Dialogue under BIMSTEC, promoting cooperation in surveillance, crisis response, and legal harmonization. Clearer rules of engagement and diplomatic initiatives will reinforce Bangladesh's role in shaping a stable maritime order.

Notes and References

1. S Erickson & A.P Liff. (2016). Installing a Fence atop China's Great Wall: New Trends in China's Foreign Policy. *The Washington Quarterly*, 35-53.
2. Bergin, A. (2021). Australian Strategic Policy Institute. The lawless sea: Illegal fishing and how to deter it.
3. Brands, H. (2016). Paradoxes of Grey Zone. Foreign Policy Research Institute.

4. Brewster, D. (. (2020). China's new Indian Ocean strategy. The Interpreter, Lowy Institute.
5. Brewster, D. (2023). The China-Myanmar corridor: Kyaukpyu and the Bay of Bengal. Lowy Institute.
6. Cordesman, A. H. (2023). Center for Strategic and International Studies (CSIS). Chinese and Indian strategic interests in Myanmar: Energy and connectivity.
7. Cordesman, A. H. (2023). Center for Strategic and International Studies (CSIS). Chinese and Indian strategic interests in Myanmar: Energy and connectivity.
8. Cordesman, A. H. (2023). Chinese and Indian naval competition: The Indian Ocean and beyond. Center for Strategic and International Studies (CSIS).
9. Galeotti, M. (2016). Hybrid war or Gibrinaya Voina? Getting Russia's non-linear military challenge right. Mayak Intelligence.
10. IMO. (2023). Maritime cybersecurity awareness in South Asia. Retrieved from <https://www.imo.org>
11. IORA. (2023). Annual report on maritime safety and security cooperation. Retrieved from <https://iora.int>
12. International Crisis Group. (2024). Myanmar's post-coup crisis and Bangladesh's maritime security. Retrieved from <https://www.crisisgroup.org>
13. International Crisis Group. (2024). Myanmar's post-coup conflict in Rakhine State: Escalation risks and regional fallout. Retrieved from <https://www.crisisgroup.org>
14. M. J. Mazarr, D. M. Gerstein. (2018). Understanding the Grey Zone: Countering Competition in the Space Between War and Peace.
15. RAND Mahnken, T. G. (2021). Understanding Grey Zone Conflict. Center for Strategic and Budgetary Assessments.
16. Mastro, O. S. (2019). The stealth superpower: How China hid its global ambitions. Foreign Affairs.

17. Mazarr, M. J. (2015). Mastering the grey zone: Understanding a changing era of conflict. U.S Army War College Press.
18. Ministry of External Affairs (India). (2022). SAGAR and Act East policy: Maritime priorities of India. Government of India.
19. Rahman & Hossain . (2022). Illegal fishing and maritime security in the Bay of Bengal: Policy challenges for Bangladesh. *Journal of Maritime Affairs*, 18(2), 65-79.
20. Shuxian Luo, Jonathan G. Panter. (2021). China's Maritime Militia and Fishing Fleets. Army University Press.
21. The Diplomat. (2024). Myanmar navy maneuvers near Bangladesh border spark concern in Dhaka. Retrieved from <https://thediplomat.com>
22. U.S. Indo-Pacific Command. (2023). Annual posture statement to Congress. Retrieved from <https://www.pacom.mil>
23. Wirtz, J. (2021). *Journal of Strategic Studies*. Information warfare and the grey zone, 701–719.

Biography of the Writer



Commander Md Siddique Hasan, (C), psc, BN was commissioned on 01 June 2008 in the Executive Branch of the Bangladesh Navy. He has attended various professional courses both at home and abroad. He completed the Executive Officer's Basic Course (XOBC) and the Communication Specialization Course at BNS ISSA KHAN, and the Junior Staff Course at the Bangladesh Naval

Academy. In 2022, he earned an MSS in Security Studies from the Defence Services Command and Staff College, Mirpur. His other professional training includes the Ship's Diving Course, Naval Commando Course, and Basic Para Course conducted by the Bangladesh Army. He also completed a Diving Course with the Royal Malaysian Navy, UDT/SEAL training in South Korea, and a Free Fall Course with the Indian Army. Commander Hasan has served onboard various ships of the Bangladesh Navy in different capacities. His key appointments include Navigating Officer of BNS Gomati, Executive Officer of BNS SHAHEED AKHTERUDDIN AND BNS SAGAR, and Commanding Officer of BCGS SHADHIN BANGLA AND BCGS APARAJEYO BANGLA. On deputation, he also served in the Bangladesh Coast Guard. His staff appointment includes Staff Officer (Operations) to COMKHUL. Under the Blue Helmet, he served onboard BNS Nirmul with the United Nations Interim Force in Lebanon (UNIFIL) in Lebanon. Currently, he is serving as the Executive Officer of the Naval Commando Group in Special Warfare Diving and Salvage (SWADS). Commander Hasan is happily married to Mrs. Sanjida Hasan and is blessed with a daughter.

LEGAL RESILIENCE AND OPERATIONAL MINDSET AGAINST LAWFARE AND CONFLICT AT SEA: A BANGLADESH NAVY PERSPECTIVE

Commander Syed Samiul Islam, (G), psc, BN

Abstract

Strategic competition is shifting from classic naval threats to more ambiguous and complex issues like lawfare and gray zone activities in the Bay of Bengal. These mixed threats take advantage of legal gaps and unclear situations to weaken national security without using military force, ranging from tricky legal claims about the sea to government-backed pressure that doesn't involve fighting. In a geopolitically sensitive and resource-rich marine area, Bangladesh Navy needs more than military preparedness to tackle these challenges. Bangladesh Navy needs legal resilience, a solid grasp of international maritime law, and an operational approach that integrates strategic foresight, legal acumen, and interagency collaboration. This essay examines lawfare and grey zone operations in the Bay of Bengal region, maritime forces' legal and doctrinal vulnerabilities, and a Bangladesh Navy legal-operational readiness framework. Recommended actions include improving navy legal advice capacity, integrating legal considerations into operational planning, promoting regional legal interoperability, and creating training modules for grey zone combat. Maritime strategy must prioritize legal resilience to protect Bangladesh's sovereignty and maritime frontier stability.

Key Words: Legal Resilience, Lawfare, Grey Zone Conflict, Operational Mindset.

Introduction

Strategic competition in the marine sector has evolved from overt military maneuvers to subtle, non-traditional measures in the 21st-century security paradigm. Lawfare and grey zone conflict have become powerful influence and coercion instruments for state and non-state entities to achieve strategic goals without war. These approaches exploit legal ambiguity, procedural complexity, and operational uncertainty, endangering marine sovereignty and regional stability. Lawfare is the purposeful use of legal instruments or arguments to

achieve strategic goals, frequently by undermining adversaries' lawful acts or restricting their operations. Grey zone conflict involves coercive activities below the level of armed conflict (A. B. M. Mosquera, 2016). Strategic benefits are achieved while avoiding military escalation and plausible deniability.

Bangladesh, on the northeastern Bay of Bengal rim, borders Indian Ocean and Southeast Asian maritime routes. Bangladesh's geostrategic landscape is changing as it develops its Blue Economy and participates in international maritime security. Geopolitical rivalries, resource competition, and irregular maritime activities are rising. These developments make it more likely that countries will use legal tactics and ambiguous actions to weaken national marine interests, test legal limits, and affect strategic actions without using military force (Krishnan, 2022).

To confront such difficulties, Bangladesh Navy has to maneuver beyond traditional threat perceptions. Legal resilience, institutional capacity to interpret, implement, and defeat adversarial legal techniques, and an operational mindset to foresee and respond to ambiguous, non-kinetic dangers in real time are needed (Sari, 2020). It investigates the growing importance of lawfare and grey zone risks in the Bay of Bengal and their effects on Bangladesh's maritime security. It defines these hybrid threats' operational characteristics, contextualizes their use in regional maritime domains, and identifies navy doctrine and legal preparation vulnerabilities. In addition, the research recommends capabilities development, interagency coordination, legal training, and strategic foresight to improve Bangladesh Navy's legal and operational position.

Understanding Lawfare

Lawfare

Lawfare is a combination of “law” and “warfare,” is the strategic use or misuse of legal instruments and standards for military, political, or strategic goals. One can use law either offensively to restrict an opponent's freedom of activity or defensively to validate planned behavior (Fisher, 2023). Lawfare in marine affairs has become a subtle but powerful tool for molding power, challenging sovereignty, and influencing legal systems like UNCLOS (J. H. G.

Pizarro, 2022). Lawfare has occurred in the South China Sea as states have made competing EEZ claims and used UNCLOS to legitimize their conduct, constraining competitor warships' operational flexibility and justifying their actions (Pramono, 2023).

Conceptual Foundations of Lawfare

Originally introduced in the context of asymmetric warfare, lawfare has expanded to include peacetime actions in which legal mechanisms are employed to:

- a. Undermine an adversary's legitimacy.
- b. Delay, deter, or delegitimize lawful military operations.
- c. Shape international opinion through selective legal narratives.
- d. Institutionalize new interpretations of international law favorable to one party.

Tactics and Methods of Maritime Lawfare

In the maritime domain, where the rule-based order is significantly dependent on interpretation and consensus, lawfare assumes distinct strategic value (Pogies, 2017). In contrast to kinetic warfare, it is non-lethal, cost-effective, and challenging to attribute or challenge directly. Nonetheless, marine lawfare may encompass:

- a. **Excessive Maritime Claims:** States may declare overly broad territorial seas, Exclusive Economic Zones (EEZs), or straight baselines.
- b. **Legal Barrier:** Use of domestic law or administrative measures to disturb or delay foreign naval or commercial vessels under the pretext of legal compliance.
- c. **Selective Treaty Interpretation:** Exploiting legal provisions of international treaties to rationalize aggressive measures, such as unauthorized boarding, naval exclusion zones, or the utilization of civilian boats for military purposes under a legal pretext.
- d. **Information-Legal Fusion:** Integrating legal arguments with public diplomacy and media power to construct narratives of legitimacy,

frequently depicting the opponent as an aggressor contravening international law.

Strategic Objectives of Lawfare: The application of lawfare in maritime operations is frequently directed towards:

- a. **Deterrence through Constraint:** Limiting an adversary's operational choices by imposing legal and political repercussions for military engagement.
- b. **Strategic Ambiguity:** Functioning inside a legal ambiguity that complicates adversarial decision-making and diminishes the clarity of reaction thresholds.
- c. **Legitimacy Engineering:** Establishing advantageous legal precedents and standards over time that facilitate strategic expansion or maritime assertions.
- d. **Delay and Dilution:** Employing procedural legal mechanisms to postpone or mitigate the impact of opposing measures, thus gaining time or opportunity for strategic maneuvering.

Regional Relevance to Bangladesh

Lawfare is especially pertinent for Bangladesh, a UNCLOS signatory in a contentious maritime context. Powerful actors have tried to redraw maritime boundaries, control international sea lanes under the guise of law enforcement, and deploy civil-military fusion methods (Odom, 2019). Bangladesh relies on marine trade, fishing rights, and EEZ energy exploration; therefore, legal manipulations could harm national interests.

Understanding Grey Zone Conflict

Grey Zone Conflict

Grey zone conflict involves coercive tactics between statecraft and open combat. Grey zone techniques involve deniability, progressive escalation, and legal or political ambiguity. These methods are particularly pernicious in the marine sector, using hazy jurisdiction, international legal intricacy, and attribution issues to achieve strategic goals without military retribution. Due to

conflicting territorial claims and unclear war and peace lines, the South China Sea is a perfect gray zone (Xian, 2013).

Grey Zone Activities in the Maritime Sphere

In the maritime environment, grey zone strategies are demonstrated through a range of low-visibility, high-effect measures, including:

- a. **Coercive Presence Operations:** The deployment of marine militia, armed fishing vessels, or coast guards to inundate contested waterways, frighten opposing ships, and establish de facto control over disputed areas (Malekos Smith, 2016).
- b. **Hybrid Naval Tactics:** Utilizing purportedly non-combatant platforms, such as research or fishing vessels, outfitted with intelligence, surveillance, or low-intensity weapon systems to secretly monitor or contest military assets (Xian, 2013).
- c. **Information and Influence Campaigns:** Disseminating incorrect legal narratives or misinformation concerning marine entitlements and operations to influence domestic and international perceptions.
- d. **Cyber Disruption:** Attacking navy command, control, and logistical networks to impede operations or acquire critical information, while concealing attribution through civilian infrastructure (Malekos Smith, 2016).
- e. **Blockade-Like Actions:** Limiting access to maritime regions via strong law enforcement measures or the creation of illegal exclusion zones under civilian justifications.

Strategic Intent of Grey Zone Tactics

These actions frequently constitute a component of a more extensive strategy known as “salami slicing,” which incrementally secures tactical advantages. Nevertheless, actors utilizing grey zone strategies seek to:

- a. **Create Strategic Fait Accompli:** Establish control over maritime space without engaging in direct conflict, forcing others to respond to a new reality (Benjamin E. Bagozzi, 2024).
- b. **Avoid Attribution and Escalation:** Conduct operations that remain below the threshold of war, thus complicating legal and political responses.
- c. **Exploit Gaps in International Law:** Operate in legal grey areas where norms are weak, enforcement mechanisms are limited, and responses are diplomatically constrained.

Relevance to Bangladesh and the Bay of Bengal

As a rising littoral power in the Bay of Bengal, Bangladesh is exposed to grey zone pressures from regional and extra-regional entities attempting to expand influence in this economically and strategically significant area. The Exclusive Economic Zone (EEZ), rich in fisheries, hydrocarbons, and commercial routes, attracts clandestine encroachments, uncontrolled resource exploitation, and coercive legal procedures. The Indo-Pacific is seeing an increasing trend of civilian fishing vessels and law enforcement ships asserting maritime claims as usual operations. Bangladesh's successful international adjudication of maritime boundary disputes requires careful enforcement and strategic presence to prevent grey zone tactics from undermining legal victories. Low surveillance and no hybrid threat doctrines expose the country to slow-onset, non-traditional intrusions that may go undetected until they reach a critical threshold (Pnina Fichman, 2021).

Table 1: Summary of Examples from the South China Sea, Black Sea, and Indo-Pacific.

Region	Lawfare Example	Hybrid Warfare Example	Grey Zone Conflict Example
South China Sea	Legal ambiguity over nine-dash line; PCA ruling denial	Military base construction; economic/diplomatic pressure	Harassment of foreign vessels; ambiguous sovereignty
Black Sea	Legal maneuvering post-Crimea annexation	Power projection with plausible deniability	Double asymmetry tactics; avoidance of direct confrontation
Indo-Pacific	Instrumental use of international law	Synergistic use of non-military and military means	Activities below war threshold; exploitation of ambiguity

Other Conceptual Fundamentals

Legal Resilience

Legal resilience denotes the capacity of a legal system or institution to foresee, endure, and adjust to the strategic exploitation or manipulation of law, termed the instrumentalization of law by opponents. This capability is essential for preserving operational efficacy and legitimacy, particularly in environments characterized by lawfare and grey zone conflicts (Sari, 2020). This notion encompasses three fundamental capacities:

- a. **Anticipation:** The ability to foresee potential legal challenges or manipulations that adversaries might employ.
- b. **Withstanding:** The robustness to resist or absorb legal attacks without compromising core missions or principles.

c. **Adaptation:** The flexibility to modify legal strategies, policies, or operational approaches in response to evolving tactics by adversaries.

Operational Mindset

Personnel of Bangladesh Navy may enhance operational understanding which will combine legal matters with strategic foresight to integrate legal issues into military planning and decision-making, notably in Lawfare and Grey Zone Conflict. Recognizing law as a domain of conflict, using rules of engagement (ROE) and maritime law as operational tools, and framing every operation within the law of the sea, IHL, and national legislation is the foundation of an effective operational mindset in naval doctrine (Yee-Fui Ng, 2023). However, legal inputs must be integrated at strategic, operational, and tactical planning levels.

Table 2: Strategic Payoff of Legal-Integrated Operational Mindset

Legal Consideration	Operational Impact	Strategic Advantage
Clear ROE and legal support	Avoids unintended escalation	Maintains legitimacy
Legal documentation of engagements	Counters propaganda and lawfare	Enhances global credibility
Law-compliant engagement protocols	Prevents misuse of force	Strengthens Bangladesh's legal posture
Legal war-gaming & scenario analysis	Prepares for grey zone conflicts	Ensures readiness and resilience

Threat Landscape in the Bay of Bengal

Overlapping Maritime Claims and Boundary Disputes

The Bay of Bengal is a strategically significant area with several coastal states like Bangladesh, India, and Myanmar asserting conflicting claims over territorial waters, Exclusive Economic Zones (EEZs), and continental shelves. Historically, these issues have resulted in intricate legal actions, including those resolved by the International Tribunal for the Law of the Sea (ITLOS) and arbitral tribunals established under UNCLOS (United Nations Convention on the Law of the Sea) (Elihu Lauterpacht, 2016).

Lawfare and Grey Zone Conflict

The Bay of Bengal lawfare is a major issue (T M Caliskanlar, 2023). Hybrid threats use legal instruments to dispute maritime boundaries, resource rights, and operational independence, blurring peace and conflict. This is especially important when UNCLOS clauses have legal ambiguity or “grey areas” are created or exploited (Elihu Lauterpacht, 2016).

SLOCs and Strategic Vulnerabilities:

The Bay of Bengal holds crucial SLOCs for Bangladesh's trade and energy security. Bangladesh Navy's ability to protect national interests and maintain uninterrupted maritime commerce is challenged by attempts to contest or restrict access to these routes through legal challenges or grey zone techniques (He, 2023).

Operational and Policy Limitations

Even though Bangladesh has resolved key conflicts, it must be cautious against future lawfare. The Navy may need to adjust its doctrine to combat hybrid threats that combine legal, informational, and operational methods. Legal resilience must be developed to ensure strong grasp of international law, proactive engagement in conflict resolution venues, and readiness to fight adversarial use of law as a weapon (ASM M Hasan, 2024).

Challenges in Countering Lawfare and Grey Zone Tactics

Overlapping Authorities

In Bangladesh, similar to numerous coastal states, various governmental agencies have overlapping authorities concerning maritime affairs, security, and legal issues (Roughan, 2013). Nevertheless, the overlapping jurisdictions encompass:

- a. Bangladesh Navy (operational maritime security).
- b. Coast Guard (law enforcement at sea).
- c. Ministry of Foreign Affairs (international legal diplomacy).
- d. Ministry of Home Affairs and Ministry of Shipping (port, customs, and maritime infrastructure).
- e. Department of Fisheries, Department of Environment, and BLPA/CPA/MPA (sector-specific regulatory bodies).

These overlapping authorities have huge impact on:

- a. Jurisdictional confusion during maritime crises (e.g., illegal fishing, survey vessel intrusion, or suspected grey zone operations).
- b. Delays in coordinated response due to unclear lead-agency designation.
- c. Vulnerability to Lawfare, as opponents may leverage jurisdictional ambiguity in international forums or multilateral organizations (e.g., ITLOS, IMO).

Challenges in Legal-Operational Intelligence Sharing

The lack of a secure, interoperable structure for sharing legal, operational, and intelligence data across various stakeholders hinders Bangladesh's legal defense (Shesterinina, 2024). Challenges include:

- a. Different databases and threat assessments between various stakeholders.
- b. No centralized legal incident tracking system to analyze adversary lawfare patterns or recurring grey zone provocations.
- c. Challenges in synchronizing legal interpretations of actions taken at sea (e.g., boardings, arrests, seizures).

Therefore, the challenges in Legal-Operational Intelligence Sharing have impacts on:

- a. Reactive responses to incidents at sea.
- b. Missed opportunities for proactive narrative control in international media and diplomacy.

Table 3: Towards Institutional Synergy: Overcoming Legal Fragmentation

Challenge	Strategic Impact	Recommended Solution
Overlapping authorities	Delayed or uncoordinated responses to legal provocation	Develop a Maritime Unified Legal Response Protocol (MULRP) assigning clear roles
Information silos	Ineffective anticipation and counter-lawfare strategy	Establish a National Maritime Legal Intelligence Fusion Center
Conflicting actions	Loss of legitimacy and narrative control	Formulate Joint Legal Communication Doctrine across Navy, MoFA, and law enforcement

Approach to Building Legal Resilience

National Level Initiatives

In light of escalating maritime disputes and unconventional security concerns, national measures are crucial to develop a sound and vigorous Bangladesh Navy (Fink, 2023). These programs must be institutional, inter-agency, and instructional, targeting both the strategic and operational aspects of lawfare resistance and grey zone response.

Emphasizing Maritime Law Education for Naval Officers

To integrate legal resilience into operations, naval officers need to comprehend domestic and international maritime law. Therefore, all levels must have a structured maritime legal education curriculum. The suggested action may include:

- a. Integration of legal modules (Law of the Sea, Rules of Engagement, Maritime Jurisdiction, IHL, Lawfare Doctrine) in curricula at Bangladesh Naval Academy (BNA), School of Maritime Warfare & Tactics (SMWT), Defence Services Command and Staff College (DSCSC), and National Defence College (NDC).
- b. Implement short-term legal warfare training for mid and senior-level commanders on grey zone combat, lawfare, and deterrence, using case studies from the South China Sea, Black Sea, and Indian Ocean Region.
- c. Legal simulation exercises included into annual naval war drills, encompassing mock tribunals, UNCLOS dispute scenario analyses, and international court simulations.

Institutional Cooperation with MoFA, MoD, and Legal Think Tanks

Bangladesh Navy must develop institutional collaboration frameworks with civilian and diplomatic organizations that shape the country's international legal position to harmonize maritime legal response. The main stakeholders are MoFA, MoD, along with legal think tanks and universities. The engagement with MoFA requires a collaborative legal-diplomatic task force on maritime disputes, frequent briefings on UNCLOS and geopolitical lawfare trends, and Navy legal liaisons in MoFA's legal and ocean affairs offices. The collaboration

with MoD requires a Naval Legal Doctrine Review Board, interagency workshops on hybrid maritime threats, and legal red lines. Finally, partnerships with BIMRAD, BISS, Bangladesh Maritime University, and University of Dhaka (Law Department) are needed to research lawfare tactics, publish policy briefs and white papers on maritime legal strategy, and exchange program or fellowships for naval legal officers.

Development of a "Naval Legal Warfare Manual"

A "Naval Legal Warfare Manual" tailored to Bangladesh Navy's threat environment and jurisdiction is essential to operationalizing legal resilience. The Navy and related agencies will use this as a standard reference during operations, deployments, and legal incidents, training, exercises, and after-action legal evaluations, and to strengthen doctrinal unity.

Regional and International Tools

UNCLOS, ITLOS, and maritime arbitration have helped Bangladesh create legal resilience in maritime disputes and "grey zone" confrontations. Bangladesh's 2012 ITLOS action and 2014 arbitration indicate how these processes may protect national interests, assure fairness, and respect international law.

United Nations Convention on the Law of the Sea (UNCLOS)

UNCLOS is an international convention that delineates the legal framework for maritime activity, encompassing the demarcation of territorial seas, exclusive economic zones, and continental shelf (ASM M Hasan, 2024).

International Tribunal for the Law of the Sea (ITLOS)

ITLOS is a judicial entity established by UNCLOS to adjudicate disputes concerning maritime boundaries, the interpretation of the Convention, and associated matters (Haider, 2022).

Maritime Arbitration

Maritime arbitration pertains to the resolution of disputes via an arbitral tribunal instead of a conventional court. Under UNCLOS, governments may choose for arbitration as a form of dispute resolution (Elihu Lauterpacht, 2016).

Institutional Requirements

Bangladesh Navy must go beyond legal advisory in an era where state and non-state opponents use legal instruments for hybrid warfare. Lawfare detection, deterrence, and defeat require a proactive, institutionalized strategy. Dedicated legal infrastructure, legal intelligence integration into operational cycles, and early warning measures for grey zone provocations are needed.

Establishment of a Naval Lawfare Response Cell (NLRC)

Naval Headquarters may establish an NLRC as the central command node for legal resilience and lawfare counter-strategy. This will coordinate real-time legal response to maritime provocations (e.g., unlawful detentions, maritime harassment, EEZ violations) and provide legal analysis for ROE and strategic communications.

Table 4: Proposed Structure of NLRC

Unit	Function
Legal Strategy Desk	Develops doctrine, maintains database of legal precedents, oversees manual development
Incident Analysis Unit	Conducts forensic legal reviews of incidents at sea (e.g., arrests, boardings)
Litigation & Arbitration Wing	Prepares Bangladesh Navy’s legal briefs for international forums (ITLOS, UNCLOS tribunals)
Liaison Unit	Coordinates with MoFA, MoD, intelligence community, and Coast Guard legal units

Development of a Naval Legal Intelligence Framework

Early, predictive insights into adversarial legal techniques are essential for legal resistance. The NLRC should create a Naval Legal Intelligence Framework (NLIF) to collect, evaluate, and share lawfare and legal manipulation intelligence. This will track regional maritime litigation trends, foreign legal theories, and legal narratives in international forums (UN, IMO) and regional debates (IORA, BIMSTEC).

Early Warning Mechanisms for Lawfare and Grey Zone Conflict

An integrated early warning system must be established to notify naval and civilian authorities of impending lawfare threats and grey zone provocations. This will initiate the joint Legal-Diplomatic Crisis Cell, provide legal posture advice to operational commanders, and deploy pre-prepared legal briefs and media responses.

Fostering an Operational Mindset

In today's strategic context, when adversaries exploit grey zone tactics and weaponize international law as lawfare, Bangladesh Navy must infuse legal awareness into its operations. Legal considerations must now be understood and used by operational commanders, planners, and front-line personnel (Sari, 2020).

Operationalizing Legal Thinking by an Adaptive Mindset

Naval commanders must stop reacting to legal issues and start anticipating them. Operational planning, MIO, Naval Exercises (including legal injects), and Rules of Engagement Formulation (for hybrid environments) should contain legal perspectives. This adaptive attitude allows military leadership to evaluate the lawfare impacts of their decisions, such as how international media or legal platforms may portray force or non-lethal measures like boarding or surveillance operations.

Cultural Shift to Legal Literacy as Combat Multiplication

Promote legal awareness as an operational strength. The U.S. Navy and Japan Maritime Self-Defense Force (JMSDF) use legal literacy to boost

legitimacy, avoid strategic traps, and strengthen national narrative abroad (Takei, 2020). Promoting legal resilience as a “warfighting competency” in BN will make officers intuitively analyze all engagements for legality.

Table 5: Comparison Table for Traditional Ops Planning vs. Legally-Aware Ops Planning

Aspect	Traditional Ops Planning	Legally-Aware Ops Planning
Rules of Engagement (ROE)	Focused on tactical necessity and force protection	Calibrated to lawfare risks, narrative control, and legal framing
Mission Planning	Centered on objective achievement	Integrated with legal analysis of possible international reactions
Training Content	Mostly kinetic, technical, and doctrinal	Includes legal case studies, grey zone scenarios, and simulations
Response to Provocations	Often reactive or force-based	Legally calculated, with strategic communications in mind
Documentation	After-action reports for internal use	Legally robust documentation for diplomatic and legal defense
Support Structure	Tactical advisors and intelligence officers	Includes legal advisors and international law experts

Recommendations

Lawfare and gray zone conflicts are characterized by their unpredictability and the utilization of law as an instrument of conflict. To maintain preparedness for lawfare and gray zone threats, Bangladesh Navy should:

- a. Invest in comprehensive legal resilience strategies that integrate with operational planning at all levels.
- b. Enhance coordination among military, governmental, and legal entities to streamline responses to hybrid threats.
- c. Prioritize ongoing education and scenario-based exercises focused on lawfare tactics and international legal developments.
- d. Promote an organizational culture that values adaptability, continuous learning, and proactive legal engagement.

Conclusion

The integration of legal resilience and operational attitude has transitioned from a strategic luxury to an operational must for contemporary naval forces maneuvering through the complexities of lawfare and grey zone conflict. As maritime threats become hybridized, ambiguous, and legally intricate, Bangladesh Navy must consistently evolve its doctrinal framework and legal readiness. Through covert coercive measures and distorted legal frameworks, opponents are exploiting international law to undermine sovereignty without breaching conventional war parameters.

Addressing these challenges necessitates a dual-track strategy: one that enhances legal strength via proactive legal education, institutional frameworks, and real-time legal intelligence; and the other that refines tactical adaptability, allowing personnel to interpret, respond, and function effectively in contested and legally ambiguous environments. This synergy guarantees that legality transforms from a mere restraint into a force multiplier in asymmetric maritime contexts.

Bangladesh Navy, with its expanding regional presence, developing expeditionary functions, and expertise in international operations like UNIFIL, is distinctly equipped to establish a regional framework for incorporating legal resilience into naval doctrine. By institutionalizing this attitude, the Navy can establish a benchmark for adjacent forces, reinforcing its leadership in developing a South Asian maritime policy that is both operationally agile and legally robust and equipped to confront the multifaceted threats of the future.

Notes and Reference

1. A. B. M. Mosquera, S. D. (2016). Lawfare in Hybrid Wars: The 21st Century Warfare. *Journal of International Humanitarian Legal Studies*, 63-87.
2. ASM M Hasan, M. S. (2024). Analysis of International Legal Frameworks on Maritime Boundary Delimitation: Judicial Case Examples. *Selçuk Üniversitesi Hukuk Fakültesi Dergisi*, 1777-1806.
3. Benjamin E. Bagozzi, R. G.-d.-F.-C. (2024). A Framework for Enhancing Social Media Misinformation Detection with Topical-Tactics. *Digital Threats: Research and Practice*, 1-29.
4. Elihu Lauterpacht, C. G. (2016). Dispute Concerning the Delimitation of the Maritime Boundary between Bangladesh and Myanmar in the Bay of Bengal. *International Law Reports*, 464-722.
5. Fink, M. (2023). Challenges of applying the law of naval warfare in non-international armed conflict at sea. *The Military Law and the Law of War Review*, 39-58.
6. Fisher, B. (2023). The origin of the concept of "lawfare" and the Exploitation of Public International Law. *Scientific Notes of NaUKMA. Legal Sciences*, 100-107.
7. Haider, I. A. (2022). Bangladesh V Myanmar Maritime: Boundary Delomitation Case. *International Journal of Research and Innovation in Social Science (IJRISS)*, 811-814.
8. He, H. (2023). A Study of Bangladesh's Maritime Strategy Options and Its Development Prospects. *Journal of Asia Social Science*, 93-113.
9. J. H. G. Pizarro, F. H. (2022). Lawfare. *EUNOMÍA. Revista en Cultura de la Legalidad*, 267-287.
10. Krishnan, A. (2022). Fifth Generation Warfare, Hybrid Warfare, and Gray Zone Conflict: A Comparison. *Journal of Strategic Security*, 14-31.
11. Malekos Smith, J. (2016). Twilight Zone Conflicts: Employing Gray Tactics in Cyber Operations. *SSRN*.
12. Odom, J. G. (2019). Maritime claims in the South China Sea and freedom of navigation operations. *Building a Normative Order in the South China Sea*, 171-194.

13. Pnina Fichman, M. V. (2021). The relationships between misinformation and outrage trolling tactics on two Yahoo! Answers categories. *Journal of the Association for Information Science and Technology*, 1498-1510.
14. Pogies, C. R. (2017). UNCLOS and the South China Sea Arbitration: Into Lawfare's Abyss? *ASIEN*, 93-105.
15. Pramono, B. (2023). The Indonesia's Strategies For Exclusive Economic Zone (EEZ) Sovereignty With 1982 UNCLOS Provisions: North Natuna Sea. *Journal Defendonesia*, 41-63.
16. Roughan, N. (2013). *Authorities: Conflicts, Cooperation, and Transnational Legal Theory*. Oxford: Oxford Academic.
17. Sari, A. (2020). Legal resilience in an era of grey zone conflicts and hybrid threats. *Cambridge Review of International Affairs*, 846–867.
18. Shesterinina, A. (2024). State-Building as Lawfare: On Conflict, Interpretation, and Ethics. *Nationalities Papers*, 228-231.
19. T M Caliskanlar, C. D. (2023). Hybrid Threat Practices in the Legal Environment: A Typology of Legal Practices as a Conflict Tool. *Journal of Security Strategies*, 213-246.
20. Takei, T. (2020). Gray Zones and Vulnerability in the U.S.-Japan Alliance: Operational and Legal Dimensions. *Asia Policy (National Bureau of Asian Research)*, 19-29.
21. Xian, W. (2013). Research on Tactics of Maritime Police and Non-traditional Threats at Sea. *Journal of China Maritime Police Academy*.
22. Yee-Fui Ng, E. W. (2023). Legal Considerations in Machine-Assisted Decision-Making: Planning and Building as a Case Study. *Bond Law Review*, 143-168.

Biography of the Writer



Commander Syed Samiul Islam, (G), psc, BN was commissioned on 01 June 2010 in the Executive Branch of the Bangladesh Navy. He has attended several professional courses both at home and abroad and is a qualified Gunnery Officer. He completed the Coastal Defence Missile Officers Foundation Course at the Naval Aeronautical Engineering Institute, Yantai, China. He also attended the Torpedo Command and Tactics Course and Missile Command and Tactics Course at FAC School, BNS ISSA KHAN. In addition, he completed the Basic Intelligence Course at the School of Military Intelligence, Comilla Cantonment. He is also a graduate of the Defence Services Command and Staff College, Mirpur. Commander Islam has extensive experience serving on various ships, establishments, and organizations of the Bangladesh Armed Forces. He commanded three ships of the Bangladesh Navy-BNS KUSIYARA, BNS SALAM, and BNS ADOMYA. In addition to his naval appointments, he served at the Armed Forces Division as GSO-2 (Joint and Miscellaneous Training). He also served in a United Nations peacekeeping mission as N71 at the Maritime Task Force Headquarters of the United Nations Interim Force in Lebanon (UNIFIL) in Lebanon.

EVOLVING NEXUS OF SPACE AND NAVAL WARFARE: RETHINKING THE FUTURE OF BANGLADESH NAVY IN THE AGE OF SPACE MILITARISATION

Lieutenant Commander Shourav Kumar Paul, (E), psc, BN

Abstract

The integration of space technologies has transformed naval warfare by enhancing navigation, communication, and surveillance while introducing new vulnerabilities. This qualitative study examines how such advancements impact modern maritime strategy, with a focus on the Bangladesh Navy (BN). It reviews key developments in satellite communications and navigation systems, assessing their military applications through case studies like the Russia-Ukraine war and the 2025 India-Pakistan conflict. The findings highlight the benefits of space-enabled capabilities, including improved maritime domain awareness and operational resilience. However, they also expose risks tied to overreliance on space assets. The study recommends that BN adopt cost-effective space technologies, foster partnerships, and incorporate space-based tools into its doctrine. Emphasis is placed on training for space-denied environments and promoting international space governance. By integrating space-derived intelligence with existing naval systems, BN can enhance strategic effectiveness within resource constraints and navigate the evolving dynamics at the sea-space interface.

Key Words: Space Warfare, Naval Warfare, Bangladesh Navy, Space Militarisation

Introduction

The 21st century has witnessed a fundamental shift in military strategy, where the traditional domains of land, sea, and air are now inextricably linked with space and cyberspace¹. This interconnectedness is encapsulated by the concept of ‘convergence’, a term that has gained prominence in military lexicon to describe the synchronization of multi-echelon and multi-domain effects

1. Sharpe, J., Trichas, M. and Terrill, D. (2024) ‘Culture: a sixth domain and the introduction of the “C6ISRT” framework’, *Defence Studies*, 25(1), pp. 1–25. doi: 10.1080/14702436.2024.2397520.

across time and space². In essence, military effectiveness in any single domain is increasingly reliant on capabilities in others, with space emerging as a particularly critical enabler. As space-based assets become increasingly integral to naval capabilities (navigation, communications, intelligence gathering, early warning, and precision targeting), navies worldwide must reconsider their strategic frameworks to remain operationally effective³. This transformation is particularly critical for emerging naval powers like Bangladesh, which must balance modernization imperatives with resource constraints while navigating an increasingly complex security environment where space dominance directly impacts maritime operations.

The integration of space technologies into naval operations has moved beyond auxiliary support functions to become the spine of modern maritime warfare. It has created opportunities and vulnerabilities which demand comprehensive strategic recalibration⁴. The strategic implications of this integration extend beyond operational capabilities to fundamental questions of naval doctrine and force structure. This perspective demands that naval forces develop integrated approaches that treat space as an operational domain rather than merely a source of supporting services⁵. The democratization of certain space technologies offers pathways to enhanced capabilities that were previously accessible only to major powers. Simultaneously, this creates new vulnerabilities and dependencies that must be carefully managed within constrained defense budgets.

2. Army University Press (2025) 'Convergence', Military Review.

3. Chatham House (2025) 'Securing space-based assets: NATO members and cyberattacks'. <https://www.chathamhouse.org/2025/05/securing-space-based-assets-nato-members-cyberattacks>.

4. Gallagher, T. (2023) 'The Navy's reliance on space operations is growing', Seapower. <https://seapowermagazine.org/the-navys-reliance-on-space-operations-is-growing>.

5. Bowdish, R.G. and Woodyard, B. (1999) 'A Naval Concepts-Based Vision for Space', US Naval Institute. Available at: <https://www.usni.org/magazines/proceedings/1999/january/naval-concepts-based-vision-space>.

This paper examines the latest space technologies and their military uses, surveys the global militarisation of space, and analyses how space power is reshaping naval warfare. Through case studies of the Russia-Ukraine war and a recent India-Pakistan clash, this paper illustrates the impact of space assets on naval and joint operations. Finally, it concludes with strategic recommendations for BN, focusing on how a smaller navy can leverage space-derived capabilities.

Advancements in Space Technologies and Their Military Applications

Space is becoming increasingly important for military operations, leading to a key difference between militarization and weaponization. Militarization simply means using space for military tasks that don't involve weapons. This includes activities like gathering intelligence, communicating, and navigating⁶. The 1967 Outer Space Treaty forbids placing weapons of mass destruction in orbit but allows conventional military uses, creating a blurry legal area for military activities in space⁷. Even though this treaty is a cornerstone, it doesn't cover all modern space-based military actions, giving nations room to expand their capabilities within legal boundaries.

Military use of space technology began in the late 1950s, during the Space Race between the Soviet Union and the United States. In 1957, the Soviet Union launched Sputnik 1, the first artificial satellite. This was a big deal militarily, showing that satellites could be used for reconnaissance and communication⁸. This event truly launched space as a new arena for military strategy. By 1960, the US launched its first Missile Defense Alarm System (MIDAS) satellite, marking the start of space-based early warning systems⁹.

6. Diplo Foundation (2025) 'Militarisation of space'.<https://www.diplomacy.edu/blog/militarisation-of-space>.

7. Boothby, B. (2017) 'Space weapons and the law', *International Law Studies*, 93(1), pp. 179-214.

8. Buchanan, R.A. (2019) 'History of Technology - Transport and Communications', *Encyclopædia Britannica*. <https://www.britannica.com/technology/history-of-technology/Transport-and-communications>.

9. Darling, D. (2016) 'MIDAS', *Daviddarling.info*. <https://www.daviddarling.info/encyclopedia/M/MIDAS.html>.

In 1962, the US launched the first Defense Meteorological Satellite Program (DMSP) satellite, providing crucial weather data for military operations¹⁰. By 1966, the first Defense Satellite Communications System (DSCS) satellite enabled secure global military communications for the US¹¹. A major breakthrough came in 1978 with the launch of the first Global Positioning System (GPS) satellite. The system became fully operational by 1995, completely changing military navigation and targeting, allowing for precision strikes and better situational awareness¹². The other three major Global Navigation Satellite System (GNSS) constellations in space are: GLONASS (Russia), Galileo (European Union), and BeiDou (China). In 1987, the Soviet Union launched the Polyus orbital weapons platform, a prototype designed with nuclear mines and a cannon. Although it failed to reach orbit, it highlighted the ongoing competition in space weaponization¹³.

Figure 1: Major Navigation and Positioning Systems of the World

Name	Country	No of Satellites	Types of Satellites	Operational From	Coverage Area	Precision
GPS		31	Medium Earth Orbit (MEO)	1995	Global	30 cm
GLONASS		24	MEO	1996	Global	2.8 m
Galileo		28 (24 active)	MEO	2016	Global	20 cm
BeiDou (BDS)		28 MEO and 3 IGSO	MEO & IGSO (Inclined Geosynchronous Orbit)	2020	Global	10 cm
IRNSS (NavIC)		7	GEO (Geostationary Earth Orbit) & IGSO	2018	South Asia	5 m
QZSS		7	QZO (Quasi-Zenith Orbit), GEO	2018	Japan and Asia-Oceania	~0.6 m (with GPS)

Source: Mendez, 2024¹⁴

10. Patel, K. (2022) 'Remote Sensing of Ionospheric Irregularities', Elsevier EBooks, pp. 307–324. doi: 10.1016/b978-0-323-99262-6.00003-1.

11. Ellington, T. (1980) 'DSCS III - Becoming an Operational System', IEEE Transactions on Communications, 28(9), pp. 1499–1504. doi: 10.1109/tcom.1980.1094817.

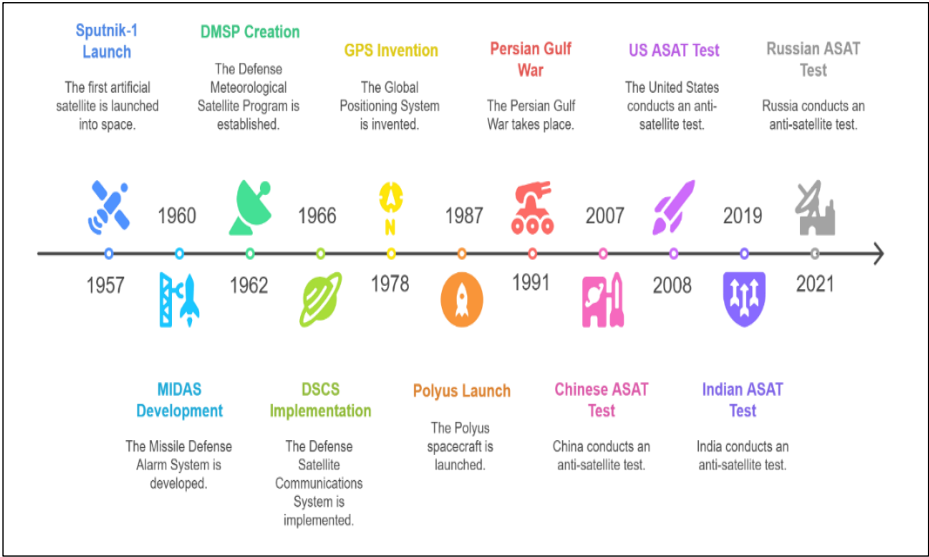
12. Bucher, S. (2005) 'The Evolution of GPS', USC Viterbi School of Engineering. <https://illumin.usc.edu/the-evolution-of-gps>.

13. Gruntman, M. (2015) Soviet Intercept. AIAA (American Institute of Aeronautics & Astronautics).

14. Mendez, M. (2024) 'What are the limitations of GNSS?', Inertial Labs. <https://inertiallabs.com/what-are-the-limitations-of-gnss>.

The Persian Gulf War in 1991 was the first major conflict where military space technology was used on a large scale. The US-led coalition relied heavily on satellites for reconnaissance, communication, and navigation, proving their immense value in modern warfare¹⁵. The 2020s have seen a focus on advanced satellite systems and resilient networks. In 2007, China conducted an Anti-Satellite (ASAT) test, destroying an old satellite with a ground-based missile, ushering in a new era of space weaponization. The US followed in 2008, destroying the malfunctioning USA-193 satellite, citing safety concerns. India then demonstrated its ASAT capability in 2019 by destroying a live satellite, joining the exclusive club of nations with space weaponization potential. Russia conducted a similar test in 2021, destroying the old Kosmos 1408 satellite, further escalating concerns about space debris and the militarization of space¹⁶.

Figure 2: Major Milestones in Space Militarisation



Source: Author's Construct

15. Aerospace (2018) 'A Brief History of Space Exploration', Aerospace.org. <https://aerospace.org/article/brief-history-space-exploration>.

16. Todd, D. (2022) 'One Year After Russian ASAT Test: What Has Changed?', Slingshot Aerospace. <https://www.slingshot.space/news/one-year-after-russian-asat-test>.

Global Landscape of Space Militarization

Outer space has rapidly shifted from a benign sanctuary to a contested military domain¹⁷. In parallel with commercialization, ‘militarization’ of space has accelerated. By one count, there were only about 800 satellites in orbit in 2002. By 2022, that number had surged to over 7000, many carrying military missions¹⁸. Several global actors are at the forefront of this evolving space domain. The United States, with its Space Force established in 2019 and allocated \$1.8 billion Artificial Intelligence (AI)/ Machine Learning (ML) initiatives (2024-2025). They operate 123 military satellites focused on satellite defense, missile warning systems, and counterspace operations¹⁹. Their strategy involves significant investment in space readiness, cutting-edge technologies, and strengthening partnerships with allies²⁰.

The very first Space Force was created back in 1992 by Russia. But it had a short life, being reabsorbed into the Air Forces as a subbranch in 2015²¹. Russia’s Aerospace Forces, operating 74 military satellites, emphasize space control through kinetic ASAT weapons and electronic warfare tools²². China’s People’s Liberation Army (PLA) Strategic Support Force (established in 2015) integrates space, cyber, and electronic warfare, with capabilities such as ASAT weapons²³. China is aiming to establish itself as a world leader in space by 2050 with an annual budget of approximately \$8 billion for acquiring and improving

17. CSIS (2025a) ‘The future of military power: Space power’, Center for Strategic and International Studies. <https://www.csis.org/analysis/future-military-power-space-power>.

18. Rajeev, N. (2025) ‘India-China Outer Space Competition: Implications for Strategic Stability’, RSIS, NTU. <https://rsis.edu.sg/rsis-publication/idss/ip25040-india-china-outer-space-competition-implications-for-strategic-stability>.

19. World Population Review (2025) ‘Military satellites by country’. <https://worldpopulationreview.com/country-rankings/military-satellites-by-country>.

20. Gallagher, Loc Cit.

21. Sanmarti, M. (2023) ‘The rise of Space Commands’, Catalonia Global. <https://cataloniaglobal.cat/en/the-rise-of-space-commands>.

22. World Population Review (2025) ‘Military satellites by country’. <https://worldpopulationreview.com/country-rankings/military-satellites-by-country>.

23. SPF (2020) ‘The militarization of space and its transformation’. https://www.spf.org/iina/en/articles/nagashima_02.html.

its space capabilities²⁴. They are Developing comprehensive counterspace capabilities including kinetic ASAT weapons, directed-energy systems, and the BeiDou navigation system.

Figure 3: Space Capabilities of Different Countries in 2025

	US	RUSSIA	CHINA	INDIA	AUS.	FRANCE	IRAN	ISRAEL	JAPAN	N. KOREA	S. KOREA	UK
LEO Direct Ascent	■	▲	▲	■	●	●	●	●	●	●	●	●
MEO/GEO Direct Ascent	■	■	■	●	●	●	●	●	●	●	●	●
LEO Co-Orbital	■	▲	▲	●	●	■	●	●	●	●	●	●
MEO/GEO Co-Orbital	■	■	■	●	●	■	●	●	●	●	●	●
Directed Energy	■	■	■	●	●	■	●	●	●	●	●	●
Electronic Warfare	▲	▲	▲	■	■	■	■	▲	■	■	●	●
Space Situational Awareness	▲	▲	▲	■	■	■	■	■	■	■	■	■
LEGEND: NONE ● SOME ■ SIGNIFICANT ▲ UNCERTAIN ? NO DATA —												

Source: Secure World Foundation, 2025²⁵

Beyond these major powers, continual progress in High-Altitude Pseudo-Satellites (HAPS), CartoSat-3, Geosynchronous Satellite (GSAT), Indian National Satellite System (INSAT), and Indian Regional Navigation Satellite System (IRNSS), and Navigation with Indian Constellation (NavIC) developed by the Indian Space Research Organization (ISRO) demonstrate their growing capabilities²⁶. In addition, countries like Israel and Pakistan are also gaining influence in space and security matters. Pakistan leverages Chinese Bei Dou for navigation since 2013²⁷. Furthermore, North Korea and Iran are developing Electronic Warfare (EW) capabilities aimed at denying or degrading space-

24. Goswami, N. (2021) ‘Status of Existing and Emerging Asia-Pacific Space Powers Capabilities August 2021’. https://cms.apln.network/wp-content/uploads/2021/08/APLN_Special-Report-1_Namrata-Goswami_V3.pdf

25. Secure World Foundation (2025) ‘Global Counterspace Capabilities Report’, SWFound.org. <https://www.swfound.org/publications-and-reports/2025-global-counterspace-capabilities-report>.

26. Sanjay, B.M. (2019) ‘CARTOSAT-3 Highlights India’s Military Satellite Applications’, Zona Militar. <https://www.zona-militar.com/en/2019/12/02/cartosat-3-highlights-indias-military-satellite-applications/>

27. Amir, S. and Rehman, N.A. (2024) ‘Space Technology and Its Military Application: Options for Pakistan’, Journal of Advanced Military Studies, 15(1), pp. 136–152. doi: 10.21140/mcu.20231501008.

based communications and navigation²⁸. The following figure depicts the space capabilities of different countries in 2025.

Case Studies: Integration of Space Technologies in Recent Conflicts

Russia-Ukraine War

The 2022-2025 conflict in Ukraine provides perhaps the starkest example of space's battlefield role. Ukraine has leveraged commercial satellite imagery from companies like Maxar and Planet Labs to monitor Russian naval movements in the Black Sea²⁹. Additionally, SpaceX's Starlink constellation, with thousands of terminals provided to Ukraine, has ensured resilient communication for Ukrainian forces, even in contested environments³⁰. On the other hand, Russia has employed GPS jamming and cyberattacks, such as the 2022 Via Sat hack, to disrupt Ukraine's space-based capabilities³¹. In addition, Russia employed GLONASS navigation and also attempted to jam Western Satellite Communications (SATCOM) links³² (though with limited success). Overall, this war demonstrated that a small nation (Ukraine) could fight back by tapping space technologies. This ability with satellite-fed ISR and communication in the battlespace is a game-changer.

28. CSIS (2025b) 'Space threat assessment 2025', Center for Strategic and International Studies. <https://www.csis.org/analysis/space-threat-assessment-2025>.

29. CETAS (2024) 'The role of the space domain in the Russia-Ukraine war'. <https://cetas.turing.ac.uk/publications/role-space-domain-russia-ukraine-war>.

30. BBC (2022) 'Space, the unseen frontier in the war in Ukraine'. <https://www.bbc.com/news/technology-63109532>.

31. Atlantic Council (2022) 'The role of space in the Russia-Ukraine war'. <https://www.atlanticcouncil.org/blogs/new-atlanticist/the-role-of-space-in-the-russia-ukraine-war/>.

32. CETAS (2024) 'The role of the space domain in the Russia-Ukraine war'. <https://cetas.turing.ac.uk/publications/role-space-domain-russia-ukraine-war>.

2025 India-Pakistan Conflict

In the recent skirmish along the India-Pakistan border (May 2025), space technologies similarly played a crucial supporting role. India's military brings a significant space arsenal: reconnaissance satellites, the regional Navigation with Indian Constellation (NavIC), and a growing SATCOM infrastructure³³. These were likely used to track troop movements and guide precision strikes on the Pakistani side. Pakistan, by contrast, maintains fewer satellites of its own (notably PAKSAT). China provided real-time satellite imagery of Indian deployments to Pakistan during the conflict³⁴. China's vast constellation (267 satellites) could survey the situation and share data³⁵. In effect, the conflict became a proxy showcase for Sino-Indian space rivalry: India used its space network to target Pakistani positions, while Pakistan leveraged Chinese space-based intelligence.

Key Lessons

Together, these case studies highlight following key lessons:

- Space-enabled ISR and communications are force multipliers. Ukraine's success hinged on adapting commercial satellites, while India demonstrated the reach of its space assets.
- Conflicts in the Bay of Bengal (BoB) would be triangular contests in space, air, and sea (supported by land). For Bangladesh, this means any future crisis in the BoB could involve space support.
- Alliances and commercial ties matter. Ukraine got Starlink from the US, Pakistan got imagery from China. Bangladesh, therefore, consider which space partnerships to cultivate (with friendly space powers or data providers) and how to secure reliable space services.

33. Channa, Z. (2025) 'Indian Acquisition of Emerging Technologies: Exploring Response Options for Pakistan', TDHJ.org, <https://tdhj.org/blog/post/india-pakistan-edt/>.

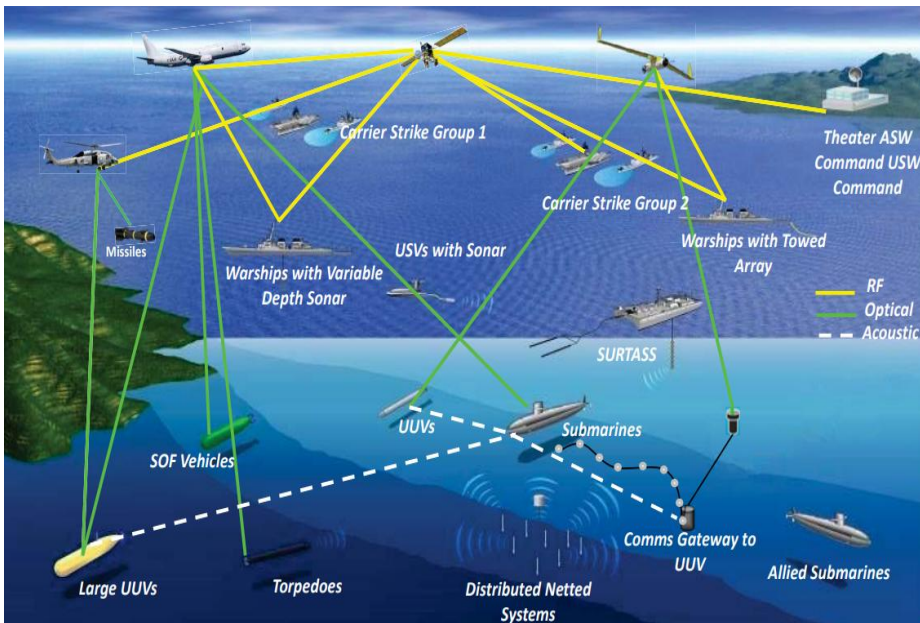
34. Sen, S.R. and Strumpf, D. (2025) 'China Gave Pakistan Satellite Help, India Defense Group Says', Bloomberg. <https://www.bloomberg.com/news/articles/2025-05-18/china-gave-pakistan-satellite-support-indian-defense-group-says>.

35. Torode, G. (2025) 'India-Pakistan conflict offers rich intelligence opportunity for China', Reuters. <https://www.reuters.com/world/asia-pacific/india-pakistan-conflict-offers-rich-intelligence-opportunity-china-2025-05-09>.

Impact of Space Militarization on Naval Warfare Dynamics

The militarization of space has fundamentally altered naval warfare dynamics by creating new domains of competition, vulnerability, and opportunity that extend far beyond traditional maritime boundaries. Naval forces that once operated with relative independence from external support systems now find themselves critically dependent on space-based assets for basic operational functions. The transformation of naval operations through space integration has created what military analysts term ‘space-enabled naval warfare’³⁶.

Figure 4: Space-Enabled Naval Warfare



Source: Filipoff, 2018³⁷

36. Bowdish, R.G. and Woodyard, B. (1999) ‘A Naval Concepts-Based Vision for Space’, US Naval Institute. <https://www.usni.org/magazines/proceedings/1999/january/naval-concepts-based-vision-space>.

37. Filipoff, D. (2018) ‘How the Fleet Forgot to Fight, Pt. 3: Tactics and Doctrine’, Center for International Maritime Security. <https://cimsec.org/how-the-fleet-forgot-to-fight-tactics-and-doctrine>.

The concept of ‘space control’ has therefore become essential to naval operations, requiring capabilities to ‘ensure our freedom of operations in space and, if necessary, deny that freedom to adversaries’. The rise of space power is transforming naval warfare in multiple ways. On the positive side, space systems vastly amplify a navy’s situational awareness and reach. Satellites provide Maritime Domain Awareness (MDA) over the horizon and beyond coastlines. Earth-observation satellites (optical, SAR) can monitor shipping lanes and littoral zones far more persistently than any shipboard radar³⁸. For example, commercial constellations now allow near-real-time tracking of individual vessels worldwide- a capability once limited to only the wealthiest navies³⁹. Satellite communications (including new LEO broadband constellations like Starlink) give ships on patrol a continuous datalink to national C2 networks and international fleets. Satellite navigation ensures precision in navigation and weapons delivery even in poor visibility⁴⁰. Collectively, these systems effectively make navies ‘networked’ which would be able to sense and strike targets at sea from space, coordinate joint forces across oceans, and conduct multi-domain operations. To provide a comprehensive overview of how these space-based capabilities translate into tangible naval applications, the following table illustrates the critical link between various space assets and their direct utility in maritime operations.

38. Maureen and Mike Mansfield Foundation (2023) ‘Policy Recommendations for Maritime Domain Awareness and Space Technology’. <https://mansfieldfdn.org/blog/policy-recommendations-for-maritime-domain-awareness-and-space-technology>.

39. Kuzma, R. and Wester, T. (2018) ‘Persistent Eye in the Sky: How Commercial Satellites Can Help the Navy Achieve Superior Maritime Awareness’, War on the Rocks. <https://warontherocks.com/2018/11/persistent-eye-in-the-sky-how-commercial-satellites-can-help-the-navy-achieve-superior-maritime-awareness>.

40. Jana, S., Biswas, R., Pal, M. and Majumdar, A. (2024) ‘The Critical Role of Satellite Navigation Systems in Modern Defense Strategies’, Research Gate. https://www.researchgate.net/publication/379815598_The_Critical_Role_of_Satellite_Navigation_Systems_in_Modern_Defense_Strategies.

Figure 5: Naval Application of Various Space Enabled Systems/ Capabilities

Space System or Capability	Naval Application	Example / Note
Satellite Communications	Global ship-to-command voice/ data link, ISR relay	Starlink terminals enabling Ukrainian fire-control after ViaSat was disabled
Position, Navigation, and Timing (PNT)	Precise ship navigation; guided weapons targeting	US's GPS and China's BeiDou navigation constellation used for missile accuracy
EO and SAR Satellites	Persistent maritime surveillance; detecting ships/ subs	Commercial SAR (e.g. ICEYE, Capella) helped Ukraine locate enemy vehicles
Space-based ISR (SIGINT/ ELINT)	Monitoring adversary communications, radar signals	China's SIGINT sats listening on regional militaries
AIS / Space-based Radar	Tracking vessel movements, illegal fishing, piracy	AIS receivers on LEO satellites collect ship positions worldwide
Anti-Satellite Weapons	Potential space-based strikes on ships (speculative) or denial of enemy sats	Chinese jammers deployed in SCS indicate use of space EW
Space Weather Forecasting	Naval operations planning (e.g. missile data links)	Helps early planning- used by US and allied nations

Source: Author's Construct

However, this dependence of naval operations on space assets creates a potential single point of failure for numerous critical functions. Hence, space dependence also creates new vulnerabilities. If space assets are jammed, spoofed, or destroyed, the entire operational effectiveness of a navy can be severely crippled⁴¹. A navy that relies on GPS or SatCom can be crippled if those services are degraded or denied. Adversaries may attempt to blind or destroy satellites to blind a fleet's eyes and ears. Military analysts warn that should satellites be 'taken out' by enemy action, forces must be prepared to revert to analogue techniques. Indeed, 21st-century sailors should be trained in celestial navigation by sextant 'in case GPS fails'⁴². Navies thus must harden their space links (anti-jam antennas, cryptography) and develop backups (celestial navigation, terrestrial communication). Future threats in space warfare, therefore, point towards a number of risks in future.

41. CSIS, Loc Cit.

42. Shepherd, T. (2024) 'Space warfare: how the military could be forced to give up GPS and return to navigating by the stars', The Guardian. <https://www.theguardian.com/science/article/2024/jun/01/space-warfare-military-defence-gps-satellites-navigating-by-the-stars>.

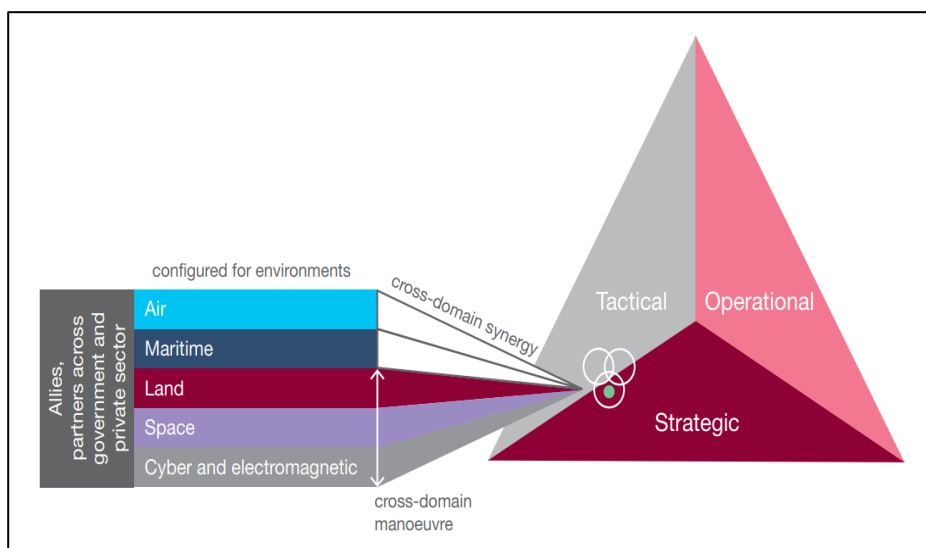
Figure 6: Risks of Future Threats in Space Warfare

Impact/ Likelihood	Minor	Moderate	Major	Severe
Rare	Satellite malfunction	Cyber intrusion attempts	Unintended orbital debris	Nuclear space weapon testing
Unlikely	Non-state actor threats	Supply chain disruptions	Data interception incidents	Planetary protection breaches
Possible	Strategic satellite disruption	Communication jamming	Military escalation in space	Weaponized space technology deployment
Likely	Increased anti-satellite systems	Space-based surveillance expansion	Political conflicts affecting space treaties	Continuous advancement in counterspace capabilities

Source: Author's Construct

Space also affects naval combat doctrine. The first sea battles of tomorrow may be fought with targets spotted from orbit or struck by satellite-guided missiles. Anti-ship missiles and ASW systems can use space-based targeting data to increase accuracy. Conversely, space-based surveillance enables early warning of naval manoeuvres or amphibious assaults far from the coast. Furthermore, space is effectively another layer in anti-access/area-denial (A2/AD)⁴³. A navy might be kept at bay not only by coastal missiles but by threats to its satellites. In essence, naval commanders must now think in 'five domains' (sea, land, air, cyber, space) - planning to use space assets aggressively while protecting their own from enemy counter-space actions.

43. Joshi, S. (2019) 'Demystifying the Anti-Access/Area Denial (A2/AD) Threat', Medium. <https://sameerjoshi73.medium.com/demystifying-the-anti-access-area-denial-a2-ad-threat-d0ed26ae8b9e>.

Figure 7: Blend of Space-Maritime Environment in Cross Domain SynergySource: Ellison & Sweijs, 2024⁴⁴

The profound reliance of modern naval operations on space capabilities, where space is explicitly described as the ‘backbone of maritime warfighting dominance’⁴⁵, exposes a significant vulnerability. This inherent vulnerability means that merely acquiring space-enabled platforms is insufficient; a robust strategy for resilience and redundancy is paramount.

Strategic Recommendations for Bangladesh Navy

In light of these trends, BN must adapt its strategy and investments. Key recommendations include:

- a. **Enhance Maritime Domain Awareness with Space Assets:** BN should fully exploit its space infrastructure for naval C2 and surveillance. The existing Bangladesh Satellite-1 (BS-1) (geostationary satellite) can be

44. Ellison, D. and Sweijs, T. (2024) ‘Empty Promises? A Year Inside the World of Multi-Domain Operations’, War on the Rocks. <https://warontherocks.com/2024/01/empty-promises-a-year-inside-the-world-of-multi-domain-operations/>.

45. Gallagher, Loc Cit.

used for military communications⁴⁶, and another upcoming satellite to be launched for Bangladesh (low earth orbit) will be a valuable Earth-observation asset⁴⁷. The Navy should ensure encrypted, high-bandwidth links on these SATS for ship communications. It should also coordinate data of BS-1 and BS-2 (when in service) with the Information Fusion Centre of BN, Navy's Blue Economy Cell, Bangladesh Coast Guard, facilities of Department of Shipping (DoS, and port authorities to monitor EEZ activities (e.g. illegal fishing, incursion). Beyond its own SATS, BN can subscribe to commercial satellite data and platforms. Analysts advise using low-cost MDA platforms (like Sky Light, Sea Vision, etc.) that fuse Automatic Identification System (AIS) signals with satellite imagery and AI analytics. These services would provide near-real-time tracking of vessels and potential threats in Bangladesh's waters at minimal cost.

b. Build a Resilient Sensor and Communications Network: Relying on a single satellite or sensor is risky. BN should develop redundant systems. For example, deploying a network of shore-based radars and AIS receivers would complement satellite MDA. At sea, ships should carry multi-band communication antennas (Ku/Ka-band, LEO terminals, etc.) so they can switch among SATCOM providers. Given anti-satellite threats, alternative navigation and timing systems are needed. Nevertheless, the Navy should reinvigorate training in celestial navigation and inertial systems (a backup to GNSS). It can also explore emerging solutions to reduce dependence on any one GNSS constellation.

c. Integrate Space into Doctrine and Training: Bangladesh Armed Forces and BN should treat space as an operational domain. Regular information sharing and joint exercise should be conducted in cooperation with Bangladesh Air Force and Bangladesh Army. Space-awareness and counter-space threats must be part of naval exercises and war games. War games could simulate scenarios like satellite jamming or loss of comm, to

46. Daily Sun (2022) 'Armed Forces to use Bangabandhu satellite', Daily Sun. <https://www.daily-sun.com/post/620211/Armed-Forces-to-use-Bangabandhu-satellite>.

47. The Daily Star (2024) 'Deal for Country's Second Satellite in Three Months'. <https://www.thedailystar.net/business/news/deal-countrys-second-satellite-three-months-3608421>.

test the Navy's contingency plans. The Navy might consider Information Fusion Centre (within the Naval HQ Operations branch) to liaise with the Bangladesh Space Research and Remote Sensing Organization (SPARRSO) and with friendly space agencies. Promoting officers to specialize in space and information warfare will build institutional knowledge. Key doctrines should explicitly address space-based ISR and communication security.

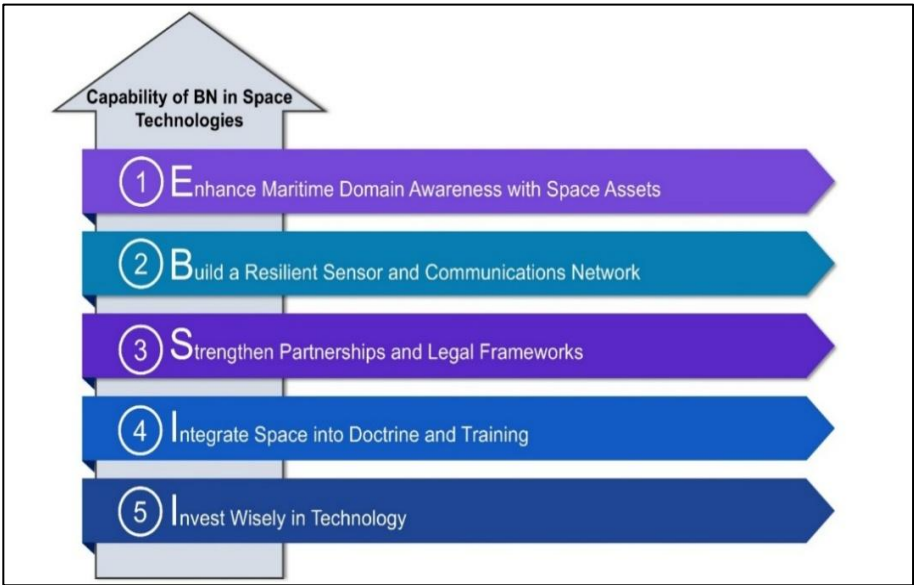
d. Strengthen Partnerships and Legal Frameworks: No small navy can ignore great-power space politics. Bangladesh should deepen defense diplomacy in space. For instance, posting a naval liaison officer at regional fusion centres (e.g. Information Fusion Centre - Indian Ocean Region [IFC-IOR] or IFC Singapore) will improve access to shared maritime intelligence. Bangladesh could seek status as a 'Participating/ Observer State' in multinational space exercises (like the US's Global Sentinel or similar exercises with friendly nations), or join bilateral intelligence sharing (e.g. AIS data with friendly navies). Meanwhile, Bangladesh should advocate for space norms that protect its interests: supporting international law (Outer Space Treaty compliance, rules against debris, etc.) and staying neutral on space arms control debates to avoid entanglements.

e. Invest Wisely in Technology: Given budget constraints, the Navy should leverage cost-effective technologies. Continued investment in UAVs and drones (for reconnaissance) should include ensuring they have reliable satellite datalinks. The Navy could explore fielding small Unmanned Surface or Underwater Vehicles (USV/ UUV) with satellite uplinks for remote monitoring. On the procurement side, Bangladesh should demand SATCOM terminals and GPS jammers/hardeners on new ships and submarines. Finally, Bangladesh should consider partnerships to build indigenous space assets: for example, collaborating with US, Chinese, Russian, or Japanese space agencies on dedicated small ocean-monitoring satellites, or contracting foreign ground stations for real-time data reception.

In implementing these recommendations, the BN must balance ambition with realism. It cannot match superpower space budgets, but it can be savvy: coopting commercial space and regional alliances will give Bangladesh disproportionate leverage. As one study concludes, Bangladesh 'should take

greater advantage’ of free/low-cost satellite data and public-private MDA initiatives. Similarly, ensuring that new assets like BS-2 provides enhanced coverage for maritime surveillance is a clear imperative.

Figure 8: Strategic Recommendations for BN to Enhance Capability in Space Technologies



Source: Author’s Construct

Epilogue

The 21st century marks a big change in military thinking. War is no longer just about land, sea, or air. Space and cyberspace are now deeply connected to all military operations. This connection, often called ‘convergence’, means that being effective in one area often relies on capabilities in others. Space, in particular, has become a vital enabler. Navies around the world, especially those like Bangladesh, must now think differently about their plans. This is because space assets are key for things like navigation, communication, intelligence gathering, early warning, and precise targeting.

The history of military space use ranges from the launch of the first satellites to modern anti-satellite tests. It surveyed how major global powers, such as the United States, China, and Russia, are building their space capabilities. It also highlighted how other nations are gaining influence in this

domain. Important lessons came from studying recent conflicts, like the Russia-Ukraine War and a clash between India and Pakistan. These case studies showed how critical space-enabled intelligence and communication are on the battlefield. They proved that even smaller nations can fight back by using advanced space technologies, often through commercial partnerships.

The impact of space militarization on naval operations is profound. Space systems greatly boost a navy's ability to see and understand its surroundings, even far beyond the horizon. They allow for constant communication and accurate weapon delivery. However, this reliance also creates new dangers. If space assets are jammed, spoofed, or destroyed, a navy's effectiveness can be severely crippled. This means navies must protect their space links and have backup plans if these services fail. Naval commanders must now consider space as a full operational domain, just like sea, land, and air.

Given these trends, BN must adapt its strategy and investments. It needs to improve its ability to monitor its maritime areas using space assets. Building strong and backup communication and sensor networks is also very important. Space must become a key part of naval training and doctrine, preparing forces for scenarios where space links are disrupted. Strengthening international partnerships for intelligence sharing and supporting space norms will also be beneficial.

Finally, smart investment in technology is crucial for BN. This means leveraging cost-effective commercial space solutions and potentially collaborating on indigenous space projects. By combining space-derived information with existing systems, BN can achieve a level of awareness and precision that was once impossible for a smaller force. The future of naval operations is deeply tied to space, and BN must make this connection a core part of its future planning.

Notes and References

1. Army University Press (2025) 'Convergence', Military Review.
2. Aerospace (2018) 'A Brief History of Space Exploration', Aerospace.org, 1 June. Available at: <https://aerospace.org/article/brief-history-space-exploration> (Accessed: 18 May 2025).
3. Amir, S. and Rehman, N.A. (2024) 'Space Technology and Its Military Application: Options for Pakistan', Journal of Advanced Military Studies, 15(1), pp. 136–152. doi: 10.21140/mcu.20231501008.
4. Atlantic Council (2022) 'The role of space in the Russia-Ukraine war'. Available at: <https://www.atlanticcouncil.org/blogs/new-atlanticist/the-role-of-space-in-the-russia-ukraine-war/> (Accessed: 18 May 2025).
5. BBC (2022) 'Space, the unseen frontier in the war in Ukraine'. Available at: <https://www.bbc.com/news/technology-63109532> (Accessed: 18 May 2025).
6. Bueger, C. (2023) 'The six spatial domains of maritime security', KIMS Periscope. Available at: <https://en.kims.or.kr/issubrief/kims-periscope/peri336/> (Accessed: 22 May 2025).
7. Boothby, B. (2017) 'Space weapons and the law', International Law Studies, 93(1), pp. 179-214.
8. Bowdish, R.G. and Wood yard, B. (1999) 'A Naval Concepts-Based Vision for Space', US Naval Institute. Available at: <https://www.usni.org/magazines/proceedings/1999/january/naval-concepts-based-vision-space> (Accessed: 22 May 2025).
9. Buchanan, R.A. (2019) 'History of Technology - Transport and Communications', Encyclopædia Britannica. Available at: <https://www.britannica.com/technology/history-of-technology/Transport-and-communications> (Accessed: 22 June 2025).
10. Bucher, S. (2005) 'The Evolution of GPS', USC Viterbi School of Engineering, 2 May. Available at: <https://illumin.usc.edu/the-evolution-of-gps/> (Accessed: 18 May 2025).
11. CETAS (2024) 'The role of the space domain in the Russia-Ukraine war'. Available at: <https://cetas.turing.ac.uk/publications/role-space-domain-russia-ukraine-war> (Accessed: 18 May 2025).
12. Chatham House (2025) 'Securing space-based assets: NATO members and cyberattacks', 15 May. Available at: <https://www.chathamhouse.org/2025/05/>

securing-space-based-assets-nato-members-cyberattacks (Accessed: 18 May 2025).

13. Channa, Z. (2025) 'Indian Acquisition of Emerging Technologies: Exploring Response Options for Pakistan', TDHJ.org, 8 March. Available at: <https://tdhj.org/blog/post/india-pakistan-edt/> (Accessed: 06 June 2025).

14. CSIS (2025a) 'The future of military power: Space power', Center for Strategic and International Studies, 9 April. Available at: <https://www.csis.org/analysis/future-military-power-space-power> (Accessed: 06 June 2025).

15. CSIS (2025b) 'Space threat assessment 2025', Center for Strategic and International Studies, 25 April. Available at: <https://www.csis.org/analysis/space-threat-assessment-2025> (Accessed: 07 June 2025).

16. Daily Sun (2022) 'Armed Forces to use Bangabandhu satellite', Daily Sun. Available at: <https://www.daily-sun.com/post/620211/Armed-Forces-to-use-Bangabandhu-satellite> (Accessed: 22 June 2025).

17. Darling, D. (2016) 'MIDAS', Daviddarling.info. Available at: <https://www.daviddarling.info/encyclopedia/M/MIDAS.html> (Accessed: 22 June 2025).

18. Diplo Foundation (2025) 'Militarisation of space', 20 January. Available at: <https://www.diplomacy.edu/blog/militarisation-of-space/> (Accessed: 07 June 2025).

19. Ellison, D. and Sweijs, T. (2024) 'Empty Promises? A Year Inside the World of Multi-Domain Operations', War on the Rocks, 22 January. Available at: <https://warontherocks.com/2024/01/empty-promises-a-year-inside-the-world-of-multi-domain-operations/> (Accessed: 07 June 2025).

20. Ellington, T. (1980) 'DSCS III - Becoming an Operational System', IEEE Transactions on Communications, 28(9), pp. 1499–1504. doi: 10.1109/tcom.1980.1094817.

21. ESA (2024) 'Why is space relevant for maritime issues?', European Space Agency. Available at: https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Why_is_space_relevant_for_maritime_issues (Accessed: 18 May 2025).

22. Filipoff, D. (2018) 'How the Fleet Forgot to Fight, Pt. 3: Tactics and Doctrine', Center for International Maritime Security. Available at: <https://cimsec.org/how-the-fleet-forgot-to-fight-tactics-and-doctrine/> (Accessed: 18 May 2025).

23. Gallagher, T. (2023) 'The Navy's reliance on space operations is growing', *Seapower*, 26 April. Available at: <https://seapowermagazine.org/the-navys-reliance-on-space-operations-is-growing/> (Accessed: 18 May 2025).
24. Goswami, N. (2021) 'Status of Existing and Emerging Asia-Pacific Space Powers Capabilities August 2021'. Available at: https://cms.apln.network/wp-content/uploads/2021/08/APLN_Special-Report-1_Namrata-Goswami_V3.pdf (Accessed: 31 May 2025).
25. Gruntman, M. (2015) *Soviet Intercept*. AIAA (American Institute of Aeronautics & Astronautics).
26. Jana, S., Biswas, R., Pal, M. and Majumdar, A. (2024) 'The Critical Role of Satellite Navigation Systems in Modern Defense Strategies', *ResearchGate*, 5 April. Available at: https://www.researchgate.net/publication/379815598_The_Critical_Role_of_Satellite_Navigation_Systems_in_Modern_Defense_Strategies (Accessed: 06 June 2025).
27. Jones, A. (2025) 'China expands counterspace capabilities, new report finds', *Space News*. Available at: <https://spacenews.com/china-expands-counterspace-capabilities-new-report-finds/> (Accessed: 17 June 2025).
28. Joshi, S. (2019) 'Demystifying the Anti-Access/Area Denial (A2/AD) Threat', *Medium*, 10 April. Available at: <https://sameerjoshi73.medium.com/demystifying-the-anti-access-area-denial-a2-ad-threat-d0ed26ae8b9e> (Accessed: 06 June 2025).
29. Levin, S. (2024) 'Navies and multi-band, multi-orbit satellite communication: Enhancing maritime superiority', *Defense Brief*, 13 May. Available at: <https://defense-brief.com/2024/05/13/navies-and-multi-band-multi-orbit-satellite-communication-enhancing-maritime-superiority/> (Accessed: 06 June 2025).
30. Kuzma, R. and Wester, T. (2018) 'Persistent Eye in the Sky: How Commercial Satellites Can Help the Navy Achieve Superior Maritime Awareness', *War on the Rocks*. Available at: <https://warontherocks.com/2018/11/persistent-eye-in-the-sky-how-commercial-satellites-can-help-the-navy-achieve-superior-maritime-awareness/> (Accessed: 12 June 2025).

31. Maureen and Mike Mansfield Foundation (2023) 'Policy Recommendations for Maritime Domain Awareness and Space Technology'. Available at: <https://mansfieldfdn.org/blog/policy-recommendations-for-maritime-domain-awareness-and-space-technology/>
32. Mendez, M. (2024) 'What are the limitations of GNSS?', Inertial Labs. Available at: <https://inertiallabs.com/what-are-the-limitations-of-gnss/> (Accessed: 12 June 2025).
33. Nair, N. (2024) 'Near Space Technologies Gaining Momentum', Defence Research and Studies, 29 October. Available at: <https://dras.in/near-space-technologies-gaining-momentum/> (Accessed: 18 May 2025).
34. Nones, M. (2022) 'The Expanding Nexus between Space and Defence', IAI Istituto Affari Internazionali, 22 February. Available at: <https://www.iai.it/en/pubblicazioni/c04/expanding-nexus-between-space-and-defence> (Accessed: 17 June 2025).
35. Patel, K. (2022) 'Remote Sensing of Ionospheric Irregularities', Elsevier EBooks, pp. 307–324. doi: 10.1016/b978-0-323-99262-6.00003-1.
36. Roza, D. (2025) 'What the US Can Learn From the Ukraine War's Space Front', Air & Space Forces Magazine, 27 May. Available at: <https://www.airandspaceforces.com/ukraine-space-front-lessons-learned/> (Accessed: 07 June 2025).
37. Rajeev, N. (2025) 'India-China Outer Space Competition: Implications for Strategic Stability', RSIS, NTU. Available at: <https://rsis.edu.sg/rsis-publication/idss/ip25040-india-china-outer-space-competition-implications-for-strategic-stability/> (Accessed: 07 June 2025).
38. Sen, S.R. and Strumpf, D. (2025) 'China Gave Pakistan Satellite Help, India Defense Group Says', Bloomberg, 18 May. Available at: <https://www.bloomberg.com/news/articles/2025-05-18/china-gave-pakistan-satellite-support-indian-defense-group-says> (Accessed: 07 June 2025).
39. Sanmarti, M. (2023) 'The rise of Space Commands', Catalonia Global, 20 January. Available at: <https://cataloniaglobal.cat/en/the-rise-of-space-commands/> (Accessed: 06 June 2025).

40. Sanjay, B.M. (2019) 'CARTOSAT-3 Highlights India's Military Satellite Applications', Zona Militar, 2 December. Available at: <https://www.zona-militar.com/en/2019/12/02/cartosat-3-highlights-indias-military-satellite-applications/> (Accessed: 17 May 2025).
41. Secure World Foundation (2025) 'Global Counterspace Capabilities Report', SWFound.org. Available at: <https://www.swfound.org/publications-and-reports/2025-global-counterspace-capabilities-report> (Accessed: 17 May 2025).
42. Sharpe, J., Trichas, M. and Terrill, D. (2024) 'Culture: a sixth domain and the introduction of the "C6ISRT" framework', *Defence Studies*, 25(1), pp. 1–25. doi: 10.1080/14702436.2024.2397520.
43. Shepherd, T. (2024) 'Space warfare: how the military could be forced to give up GPS and return to navigating by the stars', *The Guardian*, 31 May. Available at: <https://www.theguardian.com/science/article/2024/jun/01/space-warfare-military-defence-gps-satellites-navigating-by-the-stars> (Accessed: 15 June 2025).
44. SPF (2020) 'The militarization of space and its transformation'. Available at: https://www.spf.org/iina/en/articles/nagashima_02.html (Accessed: 14 June 2025).
45. The Daily Star (2024) 'Deal for Country's Second Satellite in Three Months'. Available at: <https://www.thedailystar.net/business/news/deal-countrys-second-satellite-three-months-3608421> (Accessed: 17 June 2025).
46. Todd, D. (2022) 'One Year After Russian ASAT Test: What Has Changed?', *Slingshot Aerospace*. Available at: <https://www.slingshot.space/news/one-year-after-russian-asat-test> (Accessed: 06 June 2025).
47. Torode, G. (2025) 'India-Pakistan conflict offers rich intelligence opportunity for China', *Reuters*, 9 May. Available at: <https://www.reuters.com/world/asia-pacific/india-pakistan-conflict-offers-rich-intelligence-opportunity-china-2025-05-09/> (Accessed: 18 June 2025).
48. World Population Review (2025) 'Military satellites by country'. Available at: <https://worldpopulationreview.com/country-rankings/military-satellites-by-country> (Accessed: 20 June 2025).

Biography of the Writer



Lieutenant Commander Shourav Kumar Paul, (E), psc, BN was commissioned in the Bangladesh Navy on 01 June 2013 in the Engineering Branch. He earned his BSc in Mechanical Engineering from Military Institute of Science and Technology (MIST). He completed the 18th Marine Engineering Specialization Course at BNS SHAHEED MOAZZAM and the 141st Administration and Development Course at BPATC, Savar. In 2024, he completed the Staff Course at the Defence Services Command and Staff College (DSCSC), Mirpur. Lt Cdr Paul has served onboard BNS DHALESHWARI and as Engineer Officer of BNS ADOMYA and Squadron Engineer Officer of 26 PCS. He also served as Staff Officer (Engineering) to COMCHIT. His instructional appointments include Instructor at the Engineering School, BNS SHAHEED MOAZZAM. He is currently serving as Senior Engineer Officer at BNS ALI HAIDER. His research interests include Artificial Intelligence, Naval Warfare, Unmanned Technologies, and Thermodynamics. Outside his professional duties, he is a music enthusiast, keen photographer, book lover, and avid traveler. He is married and a proud father of a daughter.

REMAINING USEFUL LIFE ESTIMATION IN NAVAL MAINTENANCE: ENABLING SMART FLEET SUSTAINMENT

Lieutenant Commander Shimanto Nandi Akash, (E), BN

Abstract

The operational readiness of naval fleets relies on dependable machinery, yet traditional time-based maintenance used by third world navies is no longer sufficient. This research proposes integrating Remaining Useful Life (RUL) estimation within Condition-Based Maintenance (CBM) to enable smarter, predictive maintenance. RUL predicts how long equipment will function before failure, allowing data-driven, condition-based decisions. The paper reviews RUL methods, including physics-based, machine learning, and hybrid models. A major hurdle is the lack of sensor data and digital infrastructure. To address this, a phased roadmap is outlined starting from awareness, sensor pilot projects, and data systems to implementing a Computerized Maintenance Management System (CMMS) and predictive analytics. The vision is a smart, continuously monitored fleet where maintenance is optimized for cost, safety, and readiness. The findings offer a model not only for Bangladesh Navy but also for other navies aiming to shift to intelligent, future-proof maintenance systems.

Introduction

Maintenance is the key aspect onboard naval ships to ensure upkeep of machinery. The reliability of naval platforms is paramount to safeguard national interests in maritime domain and to ensure combat readiness. It may be mentioned that, due to operation under complex and harsh conditions these vessels demand high levels of machinery integrity and uptime. Therefore, with the passage of time, modern navies have decided to shift towards condition-based maintenance from traditional corrective and preventive maintenance concepts. If we analyze the mechanical equipments, they require constant monitoring on the way and also at harbor. Their failure can lead to consequences, including unexpected machine downtime, production losses, and even safety hazards [1]. Therefore to mitigate these risks, it is also felt

essential to accurately predict the timeframe through which it can operate. Artificial Intelligence envisions these proactive maintenance strategy on board naval vessels and ensures the reliable operation of machinery.

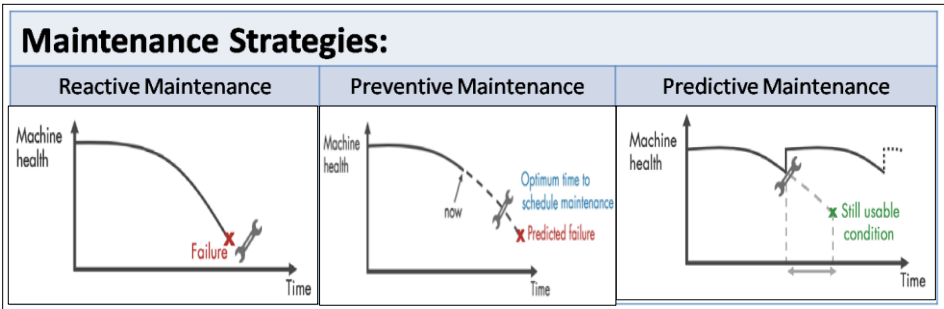
Condition Monitoring concept started in the maritime maintenance domain in post WWII era. Measurable and observable parameters such as oil analysis, vibration analysis, noise monitoring and various sensor measurements were pivoted as indicators of machinery health index. In that trend using these parameters, estimation of equipment Remaining Useful Life (RUL) stood as one of the most important parameters to predict the failure of a component before it effectively occurs [2,3]. Traditional approaches for Remaining Useful Life prediction often rely on physics-based models. However, as the complexity of modern machinery increases, these model-based methods become increasingly challenging to develop and maintain.

In the above context, the need for Artificial Intelligence (AI) was felt for predicting RUL estimation. Sophisticated machine learning approaches can carry out precise and reliable Remaining Useful Life estimations. This approach captures the intricate correlations between sensor data and component degradation. Complex and nonlinear systems can be handled using AI without physical models or specialized knowledge. Therefore, transitioning to AI-enabled smart maintenance, navies can reduce downtime, extend equipment lifespan, and enhance operational efficiency. As Bangladesh Navy is marching toward becoming a Smart Navy, in view that, current maintenance regime demands drastic change.

Naval Maintenance Philosophy

Navies throughout the world adopt their maintenance philosophy to obtain efficiency in time and manpower and to economise the use of money and resources. There are different types of maintenance procedures that are followed on board ships, depending on the needs and preferences of the ship's operational requirements. Some of the common types of maintenance can be classified into different Techniques, and these are demonstrated as follows:

Figure-1: Different Techniques of Maintenance Strategies



Source: <https://uk.mathworks.com/discovery/predictive-maintenance>

Corrective Maintenance: It is the simplest amongst maintenance techniques which is performed only when the equipment has failed. This is also known as unplanned maintenance. It may lead to high equipment downtime and a high risk of secondary faults and thus, create a very large number of defective products in production.

Preventive Maintenance (PM): Scheduled maintenance or time-based maintenance (TBM) which most conventional techniques of naval vessel’s machinery maintenance. PM refers to periodically performed maintenance based on a planned schedule to anticipate the failures as per approved PMS onboard. It sometimes leads to unnecessary maintenance which increases the operating costs. The main aim here is to improve the efficiency of the equipment by minimizing the failures in production.

Predictive Maintenance (PDM): In this type of maintenance methodology maintenance schedules are only taken when needed. It is based on the continuous monitoring of the equipment or the machine, as like CBM. It utilizes prediction tools to measure when such maintenance actions are necessary, hence the maintenance can be scheduled. Furthermore, it allows failure detection at an early stage based on the historical data by utilizing those prediction tools such as machine learning methods, integrity factors (such as visual aspects, coloration different from original, wear), statistical inference approaches, and engineering techniques.

Condition-based Maintenance (CBM): This method of maintenance is based on a constant machine or equipment monitoring or their process health that can be carried out only when they are necessary. The maintenance actions can only be carried out when the actions on the process are taken after one or more conditions of degradation of the process. CBM usually cannot be planned.

Phases of Maintenance Action

Maintenance regime demands a sequence of action to be performed for the upkeep of machinery. This includes:

Detection: Trending a machine's vibration level to detect and quantify any changes from the norm.

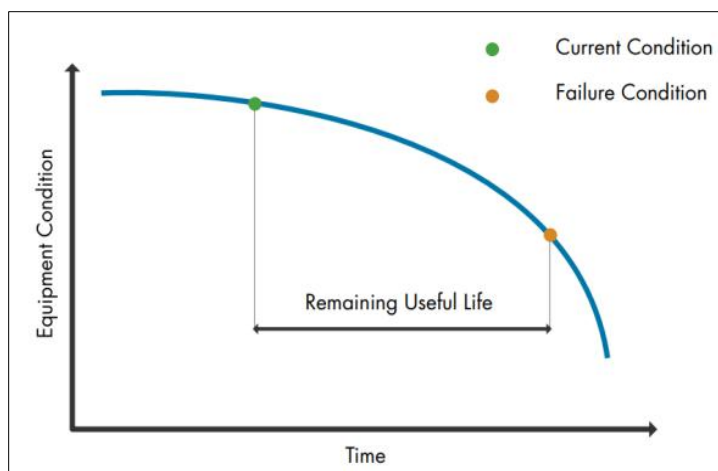
Analysis: When a significant change is detected the vibration is analyzed to determine the nature of the problem.

Correction: The advanced warning provided by the detection and the analysis of the problem allows corrective action to be prepared and scheduled.

Verification: After correction of problem, new readings are obtained (Baseline) to ensure all defects have been eliminated. This also acts as a quality control function when verifying work carried out by external assistance.

Remaining Useful Life (RUL)

Success of predictive maintenance lies in accurate detection of machinery degradation consequently leading to RUL estimation of equipment. RUL is the length of time a machine is likely to operate before it requires repair or replacement. RUL can be expressed in different units, such as days, miles, or cycles, depending on the system. RUL is a subjective estimate based on observations, or average estimates of similar items, or a combination thereof. By taking RUL into account, engineers can schedule maintenance, optimize operating efficiency, and avoid unplanned downtime. For this reason, estimating RUL is a top priority in predictive maintenance programs [5].

Figure-2: Remaining Useful Life (RUL)- Equipment Deterioration Profile

Source: MathWorks. (2018). *Estimating remaining useful life* [Ebook]

Methods of RUL Estimation

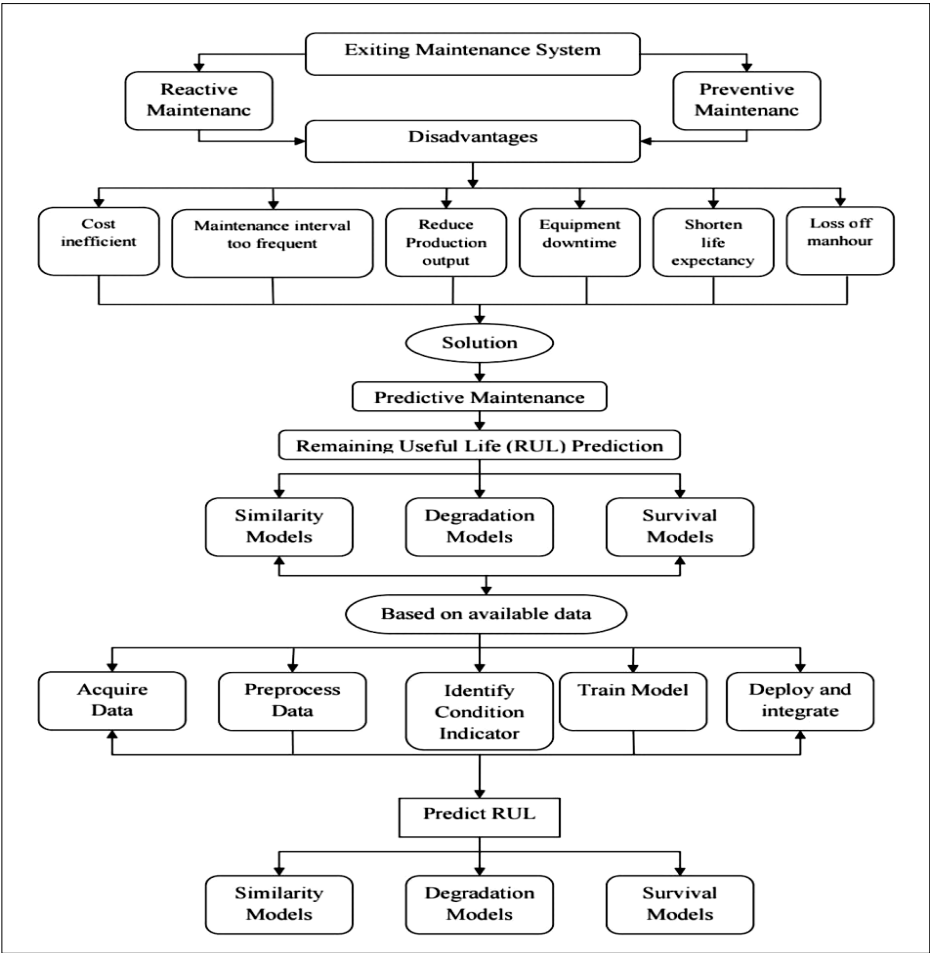
Methods for predicting the RUL of machinery can be broadly categorized into various approaches. These techniques enhance RUL prediction by enabling complex, adaptable, and accurate forecasts across different systems. This improves decision-making in maintenance and asset management. RUL estimation methods leverages historical data, degradation trends, and survival probabilities to forecast the remaining lifespan of assets. In predictive maintenance, these are specifically grouped into three primary model types:

Similarity Models: These rely on comparing data patterns and signal shapes in run-to-failure history to make RUL predictions.

Degradation Models: These use known degradation patterns and thresholds to estimate RUL based on cumulative or non-cumulative damage.

Survival Models: These apply statistical survival analysis, often incorporating lifetime data and covariates.

Figure-3: Flowchart of RUL Estimation



Source: Author's Construct

RUL Predication in Different Domain

Every machinery has its own complex vibration system. During operation, they generate complex vibration signals under the interaction of their parts. Common forms of mechanical failure include wear, plastic deformation, gluing, rust, peeling, fractures and cage damage. The objective of life prediction of equipment is generally its gradual failure. The formation process of gradual failure generally represents the process of mechanical failure due to changes in the output parameters caused by damage, fair wear and tear. The vibration

signal generated by the faulty equipment can be analyzed in three domains. They are as follows

Time Domain Approach: Time domain analysis is the simplest technique for fault detection in bearings. Time domain analysis usually involves scalar indices to determine the bearing condition. In time domain analysis, signal is analyzed through temporal vibrational signal data and based on its value bearing condition can be estimated. The simplest approach in the time domain is to measure the overall root-mean-square (RMS) level and crest factor, i.e., the ratio of peak value to the RMS value of acceleration. The resultant RMS values are compared with recommended values to determine the condition of a bearing. Dyer et al. proposed, kurtosis, a fourth moment, normalized with respect to the fourth power of the standard deviation. The kurtosis is given by the expression.

$$K = \frac{\frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^4}{\sigma^4}$$

Where x_i is the instantaneous amplitude $\bar{x}$ is the mean and σ is the standard deviation of the data 'n' is the sample length. For healthy bearing, value of kurtosis is 3 and a value greater than 3 indicates defective bearings [6].

Frequency Domain Approach: Frequency domain or spectral analysis is the most widely used approach for fault diagnosis in bearings. Frequency-domain techniques convert time-domain vibration signals into discrete frequency components using a fast Fourier transform (FFT). Analysis of raw vibration signal in frequency domain can be done through Discrete Fourier transform (DFT) and Fast Fourier transform (FFT). DFT is a straight mathematical procedure but is inefficient while FFT analyses are an easier and efficient way of obtaining narrow band spectra. Frequency domain technique can detect certain frequency components of interest very easily which is an advantage over time domain technique [6].

Time-Frequency Domain Approach: In rotating machines, bearing vibration signal is a combination of periodic components, dominated by the

machine rotation, with signals of a random nature, dominated by a possible bearing fault or imperfection. This phenomenon is periodic in nature, has time invariance and is non-stationary. This has led to the development of time-frequency analysis methods. The advantage of time-frequency domain techniques over FFT is that it has capability to handle both stationary and nonstationary vibration signals. A number of time-frequency analysis techniques, like the Short Time Fourier Transform (STFT), Wigner-Ville Distribution (WVD) and Wavelet Transform (WT) are the techniques in time-frequency domain [6].

Necessity of RUL Estimation in Naval Maintenance Regime

RUL analysis, at its core, is the estimation of the remaining time a component or system is expected to perform its intended function before it requires repair or replacement. It leverages advanced prognostics and health management (PHM) techniques, integrating real-time sensor data, historical performance logs, operational context, and sophisticated algorithms to predict future degradation trends. This moves maintenance from a prescriptive schedule or reactive response to a truly predictive paradigm. The necessity of RUL analysis for naval vessel maintenance can be dissected across several critical dimensions:

Enhanced Operational Readiness and Availability: Naval operations demand constant readiness. Any unscheduled downtime or a critical equipment failure can compromise a mission, delay deployments, or worse, endanger a vessel in hostile territory. Traditional maintenance, even preventive, can lead to equipment being unavailable when needed, either due to scheduled maintenance periods that remove a perfectly healthy component from service, or unexpected failures. RUL analysis provides a clear forecast of when maintenance will genuinely be required, allowing maintenance windows to be optimized and synchronized with operational schedules. By predicting failures before they occur, RUL analysis enables proactive intervention, ensuring that maintenance actions are performed precisely when needed, minimizing disruptive downtime and maximizing asset availability. This leads to a higher mission success rate and a more agile fleet capable of responding to evolving threats. For

example, in Royal Navy converting the T23 class to Reliability centered Maintenance (RCM) changed 50% of maintenance tasks to "No Scheduled Maintenance," reducing downtime and increasing availability. RCM also minimizes the opportunity for inducing new defects during routine maintenance, further improving availability.

Significant Cost Savings and Resource Optimization: Maintenance is a substantial expenditure in any naval budget. Unnecessary replacements, premature overhauls, and emergency repairs due to unexpected failures contribute heavily to these costs. RUL analysis directly addresses these inefficiencies. By accurately predicting component lifespan, it facilitates:

- a. **Optimized Parts Procurement:** Knowing when a part is truly nearing the end of its life allows for just-in-time procurement, reducing inventory holding costs and the risk of obsolescence.
- b. **Reduced Labor Costs:** Maintenance personnel can be deployed more strategically, focusing on components that truly require attention, rather than performing routine checks on healthy equipment.
- c. **Extended Component Lifespan:** By identifying early degradation, targeted interventions can be performed to extend the useful life of expensive components, delaying capital expenditure on replacements.
- d. **Minimized Secondary Damage:** Predicting a primary component failure can prevent cascading failures in interconnected systems, which can be far more costly and complex to rectify. This leads to substantial savings derived from extending refit period intervals and reducing the quantity of maintenance in the refit package.

Enhanced Safety and Risk Management: Naval vessels carry inherent risks due to their operational environment and the powerful systems they employ. The failure of safety-critical equipment can have catastrophic consequences, including loss of life. RUL analysis provides a powerful tool for proactive risk management.

a. **Mitigate Hazards:** Early warning of impending failure allows for timely corrective actions, preventing the manifestation of hazards. The FMECA methodology used in RCM is a methodical and auditable process that considers the consequences of each failure (including safety and environmental), identifies hazards, and puts appropriate strategies in place to manage them.

b. **Improve Safety Case Compliance:** RCM studies, underpinned by RUL insights, directly support Platform Safety Cases and the overarching 1SL Safety Argument by ensuring that material state complies with design intent and that events are reported and investigated. This structured approach documents how maintenance was derived and why certain decisions were made, making RCM a safe, defensible, and auditable process for generating maintenance.

Inform Operational Decisions: Knowledge of a component's RUL can inform operational decisions, such as whether a vessel can safely undertake a particular mission or if a detour for maintenance is necessary. This minimizes exposure to unacceptable risks.

Learning from Failures: The process of RUL analysis inherently involves continuous data collection and feedback, creating a valuable loop for understanding failure mechanisms and improving future designs and maintenance practices.

Optimized Logistic Support: The global deployment of naval vessels necessitates a robust and responsive logistics chain. Supplying the right parts at the right time to distant locations is a logistical challenge. RUL analysis streamlines this process by more precise forecasts for spare parts demand, allowing for efficient inventory management and reduced lead times instead of stocking generic spares, logistics can be tailored to specific vessel needs based on their equipment's predicted degradation, reducing shipping costs and improving responsiveness. By aligning procurement with actual need, the risk of obsolescence can be minimized.

Implementational Challenges Conventional Maintenance Holders

Developing navies like Bangladesh Navy who are willing to shift their conventional maintenance regime to RCM or CBM are likely to face a lot of challenges in way of implementation. Challenges in Implementing RUL Analysis in Naval Vessels are articulated below:

Data Availability and Quality: Reliable RUL prediction hinges on vast amounts of high-quality sensor data, historical maintenance logs, and operational profiles. Naval vessels often have legacy systems, fragmented data, and challenging data acquisition environments.

Sensor Integration and Reliability: Integrating a comprehensive suite of sensors for continuous data collection can be complex and costly. The sensors themselves must be robust enough to withstand the harsh maritime environment.

Complexity of Naval Systems: Naval vessels are highly integrated and complex systems with intricate interdependencies. Predicting the RUL of individual components in isolation may not be sufficient; a holistic view of system-level RUL is often required.

Model Development and Validation: Developing accurate RUL prognostic models requires expertise in machine learning, signal processing, and domain knowledge. Validating these models in a real-world naval operational context can be time-consuming and challenging.

Cultural Shift: Moving from established time-based or reactive maintenance practices to a predictive RUL-driven approach requires a significant cultural shift within naval organizations, encompassing training, processes, and a willingness to embrace new technologies. As the paper highlights, some benefits of RCM have not been consistently realized due to factors like reliance on asset-based maintenance from OEMs, old maintenance tasks being restored due to lack of training, and OEMs' reluctance to support maintenance reduction. To address these, actions like RCM training and a study refresh program have been put in place.

Security and Cyber Risks: As maintenance systems become more digitized and interconnected for RUL analysis, the cyber security

implications become paramount. Protecting sensitive operational data and ensuring the integrity of prognostic models is crucial.

SWOT Analysis for Bangladesh Navy to Implement RUL Analysis

With a view to implement the RUL estimation process in Bangladesh navy it's required to identify and analyze organization's Strengths, Weaknesses, Opportunities, and Threats. Therefore, the SWOT analysis in this prospect is mentioned below:

Strength

Awareness of BN: The very act of considering RUL analysis indicates an awareness within the BN that current conventional preventive and corrective maintenance methods are not optimal and a desire for improvement.

Established Maintenance Structure: BN already possesses established maintenance protocols, workshops, and personnel, which can serve as a foundation for integrating new technologies and methodologies. This existing infrastructure, though conventional, provides a starting point rather than building from scratch.

Aspiration for Modernization: As the BN continues to modernize and expand its fleet with more sophisticated vessels and equipment, the long-term cost benefits and operational advantages of RUL will become increasingly apparent and pressing. This growing complexity naturally pushes towards more advanced maintenance strategies.

Significant Cost Reduction: Transitioning from time-based or reactive maintenance to RUL driven predictive maintenance promises significant cost reductions in the long run by optimizing parts procurement, reducing unnecessary overhauls, and minimizing emergency repairs. This potential for financial efficiency can be a strong internal driver.

Weaknesses

Current Conventional Maintenance Practices: The BN's reliance on preventive and corrective maintenance means there's a significant gap in

the adoption of predictive technologies like RUL analysis. This forms a foundational barrier to advanced maintenance.

Lack of RUL Analysis Equipment: The absence of specialized RUL analysis equipment is a critical weakness. This includes necessary sensors, data acquisition systems, and prognostic software.

Lack of Skilled Personnel: A significant hurdle is the absence of personnel trained in RUL analysis, prognostics, data science, and the operation of specialized equipment. This skills gap impacts both the implementation and interpretation of RUL data.

Limited Data Infrastructure: Conventional maintenance often doesn't involve the continuous, high-fidelity data collection necessary for RUL analysis. There might be fragmented data, lack of digitized maintenance logs, and an inability to integrate data from various systems.

Potential Resistance to Change: Shifting from long-standing conventional methods to a new, technology-intensive approach can encounter resistance from personnel comfortable with existing practices.

Opportunities

Enhanced Operational Readiness and Availability: Implementing RUL analysis will directly lead to a more effective and available fleet, aligning maintenance precisely with operational needs and reducing unscheduled downtime. This is crucial for mission success and agility.

Significant Cost Reduction: RUL can lead to substantial long-term savings by optimizing spare parts inventory, extending component life spans, and minimizing costly emergency repairs and secondary damage.

Improved Safety and Risk Management: Proactive identification of degrading components through RUL enhances safety by preventing critical failures and informing timely interventions, thereby safeguarding personnel and assets.

Technological Advancement: The rapid global advancements in sensor technology, AI, machine learning, and data analytics provide readily available tools and methodologies that the BN can adopt.

International Collaboration: Opportunities exist to collaborate with more advanced navies or defense organizations that have already implemented RUL analysis, allowing for knowledge transfer, training, and technology sharing.

Strategic Capability Development: Adopting RUL analysis positions the BN as a more modern and technologically advanced naval force, enhancing its regional and international standing.

Threats:

a. **Initial High Investment Costs:** Acquiring RUL equipment, software, and training will require a significant initial financial outlay, which might face budget constraints.

b. **Complexity of Integration:** Integrating new RUL systems with existing vessel infrastructure and diverse legacy equipment can be technically challenging and time-consuming.

c. **Data Security Concerns:** Increased data collection and connectivity for RUL analysis introduce new cyber security risks that need robust mitigation strategies.

d. **Vendor Dependence:** Reliance on external vendors for RUL equipment, software, and specialized training could lead to long-term dependency and associated costs.

e. **Inaccurate Predictions (Early Stages):** Initially, without sufficient historical data or refined models, RUL predictions might be inaccurate, leading to skepticism and hindering adoption if not managed properly.

f. **Sustained Funding and Commitment:** The success of RUL implementation requires not just initial investment but sustained funding, and long-term commitment from leadership.

Ways Ahead toward Smart Maintenance Regime

The necessity of RUL analysis for naval vessel maintenance is not merely a theoretical concept; it is an operational imperative. As naval fleets strive for

greater efficiency, extended operational reach, and enhanced safety, the ability to accurately predict equipment degradation will be a defining factor in achieving these goals. To implement RUL analysis of equipment, a navy need to invest in following aspects:

Robust Data Infrastructure: Data acquisition from machinery, equipment and system is paramount for developing RUL finding methodology. Developing integrated data acquisition systems, secure data storage, and efficient data processing capabilities.

Advanced Analytics and AI: Lever aging machine learning, deep learning, and artificial intelligence to develop sophisticated prognostic models that can learn from vast datasets and adapt to changing operational conditions.

Skilled Workforce Development: Training personnel in data science, prognostics, and the practical application of RUL insights. The paper emphasizes that RCM training courses have been developed and provided to ensure that the fundamental principles of RCM are understood and that RCM studies are undertaken by suitably qualified and experienced personnel.

Collaborative Ecosystems: Fostering collaboration with industry partners, academia, and research institutions to accelerate the development and adoption of RUL technologies. Liaison with industry is being improved by offering training to industry personnel and undertaking RCM studies at OEM sites.

Standardization and Interoperability: Promoting common standards and interoperability for data formats, diagnostic tools, and prognostic models to facilitate seamless integration across different platforms and systems.

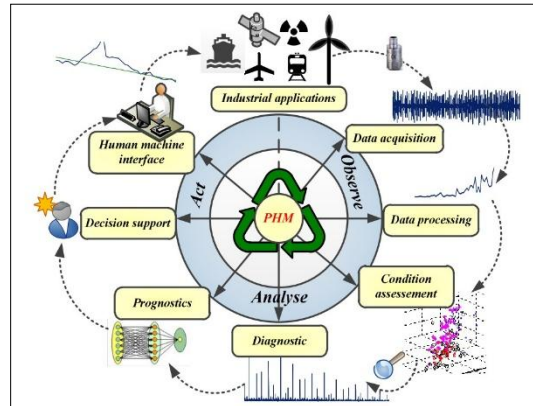


Figure-4: Prognostic Cycle of RUL Estimation

RUL Estimation Roadmap for BN

The implementation of Remaining Useful Life (RUL) analysis concept in the Bangladesh Navy may be carried out in six structured phases, combining both short-term foundational steps and long-term strategic goals. The short-term goals focus on initiating the transition from preventive to condition-based maintenance (CBM), including awareness creation, pilot testing, and digital groundwork. The long-term goals aim to institutionalize RUL-based decision-making, develop internal expertise, and establish continuous improvement cycles. The short and long term goals are described as follows:

Short-Term Goals: The short term goal will extend over a period of 6-12 months and will focus on following steps.

- a. Awareness building & Training on CBM and RUL for technical personnel.
- b. Baseline Assessment to identify critical systems and current maintenance gaps.
- c. Installation of sensors and DAQ systems on select machinery for data collection as a Pilot Project.
- d. Implement a Computerized Maintenance Management System (CMMS) to manage data, link logs, and start building maintenance history.

Long-Term Goals: The long-term goals which may extend over a period of 1-5 years are aimed at institutionalizing RUL analysis across the Navy through model development, scaling, and integration into policy. This involves developing and validating RUL prediction models based on pilot data and gradually expanding the system to other critical assets. Thereby following steps can be considered:

- a. A dedicated CBM unit will be established to oversee predictive maintenance operations and ensure sustainability.
- b. System procurement for full scale implementation.
- c. Collaboration with academic and research institutions for R&D, workforce up skilling.
- d. Formal integration of RUL methodologies into naval maintenance policy.

This roadmap will guide the Bangladesh Navy in evolving toward a data-driven, efficient, and predictive maintenance culture aligned with global naval standards.

Conclusion

Artificial Intelligence enables Condition-Based Maintenance (CBM) and Predictive Maintenance (PDM) by leveraging data from sensors and historical failure records to forecast equipment health. CBM focuses on detecting anomalies or degradation through real-time monitoring, whereas PDM uses prognostic models to estimate when failures are likely to occur. The cornerstone of PDM is the estimation of Remaining Useful Life (RUL), a forward-looking metric that predicts how long a component can operate before requiring repair or replacement. Unlike physics-based models that rely on predefined failure equations, AI methods particularly machine learning can model degradation patterns from raw operational data with minimal prior system knowledge.

The era of reactive and rigidly scheduled naval maintenance is rapidly drawing to a close. The complexities of modern naval warfare, coupled with the relentless pursuit of operational excellence and fiscal prudence, necessitate a paradigm shift towards predictive maintenance empowered by RUL analysis. By embracing this capability, naval forces can transform their maintenance strategies

from a cost center to a strategic enabler, ensuring their vessels remain at peak performance, ready to defend national interests with unwavering reliability and unparalleled safety. The insights gained from RUL analysis will not only save billions in taxpayer money but, more importantly, will safeguard the lives of the brave men and women who serve at sea.

Notes and References

1. A. Qin, Q.Zhang, Q.Hu: Remaining Useful Life Prediction for Rotating Machinery Based on Optimal Degradation Indicator.
2. Cheng Y, Hu K, Wu J, Zhu H, Shao X: A convolutional neural network based degradation indicator construction and health prognosis using bidirectional long short-term memory network for rolling bearings. *Adv Eng Inform* 2021; 48 (June 2020):101247. <https://doi.org/10.1016/j.aei.2021.101247>.
3. Zheng C, et al., A data-driven approach for remaining useful life prediction of aircraft engines. In: *IEEE conf. intel. transp. syst. proceedings, ITSC*, vol. 2018- November; 2018, p. 184–9. <https://doi.org/10.1109/ITSC.2018.8569915>.
4. Çınar, Z.M. et al. (2020): 'Machine Learning in Predictive Maintenance towards Sustainable Smart Manufacturing in Industry 4.0,' *Sustainability*, 12(19).
5. M. Aditya Baru and Rachel Johnson, *Three Ways to Estimate Remaining Useful Life*, USA: MathWorks, 2023.
6. M. K. P. Pankaj Gupta, "Fault detection analysis in rolling element bearing: A review," *ICMPC 2016*, India, 2016.

Biography of the Writer



Lieutenant Commander Shimanto Nandi Akash, (E), BN is a dedicated officer of the Bangladesh Navy, currently serving as Design Engineer Constructive Officer in the ASD Organization. He was commissioned in 2017 after completing his officer cadet training at the Bangladesh Naval Academy. He completed the Marine Engineering System Management Course at PNS JAUHAR, Pakistan, and has represented Bangladesh in several international joint exercises, including DIMDEX (Qatar) and Jeanne d'Arc (BPC Tonnerre). He has operational expertise in Naval Architecture. Beyond engineering, Lt Cdr Akash has served as an Instructor at the Bangladesh Naval Academy, playing a key role in shaping the next generation of naval officers. His commitment, professionalism, and discipline have earned him several commendations, including the ACNS (P) Appreciation, Jatiyo Suddhachar Award, and CNS Gold Medal. He is happily married and is the father of a daughter.

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Notes and References:

1. P.K. Hitti, *Islam A Way of Life*, London, Oxford University Press, 1970, p. 90.
2. Salar Khan et al, *Scientific Indications in the Quran*, Dhaka, Islamic Foundation of Bangladesh, 1995, pp.33-35.
3. Abul Kalam, *Bangladesh in the new Millennium-A University of Dhaka Study*, Dhaka, Dhaka University Press, 2004, Pp.ii+8.
4. Shaikh Maqsood Ali, *From East Bengal to Bangladesh: Dynamics and Perspectives*, Dhaka, University Press Ltd, Second Edition, 2017, p.110.
5. Md Mahfuzur Rahman, *A Study on Drug Proliferation in Bangladesh*, Dhaka, Procholon Prokashan, 2017, p.255.
6. Forces Goal 2030 is a long term modernization program for Bangladesh Armed Forces. Its main purpose is expanding the force size, acquiring modern war weapons and equipments and providing advanced level training. The Goal also stresses on developing indigenous defence industries.

B. Journal/Magazine/Periodical Referencing:

1. Fazilatun Nesa, 'Modern Education in the life of Women,' *Sikha*, Vol 2, 1928, pp. 223-266.
2. A. O. Aldridge, 'The Sources of Franklin's The Ephemera,' *New England Quarterly*, Vol 27, 1954, p.388.
3. Henning Cohen, 'Why Isn't Melville for the Masses,' *Saturday Review*, 16 August 1969, pp.19-21.

C. Visiting website Referencing:

1. 'Turkey,' *CIA World Fact Book*, available at:
www.cia.gov/library/publications/the-world-facebook/goes/tu.html.
accessed on.....(date).....

D. টীকা ও তথ্যনির্দেশ

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- ২। মোহাম্মদ মোশাররফ হোসেন, *আল কুরআনে নারী* (প্রথম খন্ড), ঢাকা, আধুনিক প্রকাশনী, ২০০২।
- ৩। সিরাজুল ইসলাম চৌধুরী, *অর্থনৈতিক ভূগোলঃ বিশ্ব ও বাংলাদেশ*, ঢাকা, ঢাকা বিশ্ববিদ্যালয়, ২০০৩।
- ৪। এ.বি.এম হোসেন, *বাংলাদেশের সাংস্কৃতিক সমীক্ষামালা-২*, ঢাকা, বাংলাদেশ এশিয়াটিক সোসাইটি, ২০০৭।
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