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MESSAGE FROM THE CHIEF ADVISER

I am delighted to be a part of the new multidisciplinary, peer-reviewed journal that publishes original research in the 'Maritime Domain' yearly.

For the last three years, *Bangladesh Maritime Journal* has been a beacon of 'Maritime Research' that maintains a high level of ethical integrity, ensuring consistency and scientific rigor in each of its research articles. My desire for *Bangladesh Maritime Journal* is to continue to excel and insightfully build for the future to provide the greatest value for sharing outstanding science.

There has been a growing appreciation that the world's Oceans and Seas require more in-depth attention and coordinated action. In Bangladesh, certain maritime activities were not well coordinated and thereby suffered from duplication of efforts. It is high time that we established a platform for sustainable development of Bangladesh through 'Maritime Vision'.

Under the visionary leadership of Hon'ble Prime Minister Sheikh Hasina, Bangladesh today has a huge maritime area of 118,813 sq. km. The country is moving towards achieving 'Vision 2041' to become a happy, prosperous and developed Bangladesh. With that aim in view, *Bangladesh Maritime Journal* provides scope for sharing knowledge in maritime issues, challenges, prospects and technology so as to nurture our objectives of 'Blue Economy'. I hope *Bangladesh Maritime Journal* will become the primary platform for maritime professionals, researchers, technologists, academicians, policy makers and stake holders to share findings and publish all aspects of maritime science and technology.

I sincerely hope that all professionals will eagerly access *Bangladesh Maritime Journal*, as both contributors and readers, for the insightful and stimulating science that will shape our future and lead the way towards realizing the dream of 'Maritime Bangladesh'. In that view, I wish to see the Editorial Team continue to expand their horizon even beyond our frontiers so that we are enlightened more with the knowledge and experiences of the reputed academicians and professionals at global level.

I express my deep satisfaction for the good works of the Chief Editor, Reviewers and the Editorial Board, who have really made humble efforts in publishing this important journal.

Rear Admiral M Khaled Iqbal, BSP, ndc, psc
Vice-Chancellor
Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh

EDITOR'S NOTE

Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh is a premier maritime university of Bangladesh, whose motto is to achieve maritime excellence, through sharpening the storm of intellectual passion within maritime community. The BMJ is one of such works that truly embodies the qualitative products of students and faculties of BSMRMU as well as other maritime researchers.

It contains original research works dealing with theory and practice of maritime science and studies. The journal seeks to foster the exchange of new ideas and information. The scope of this journal covers full range of research, analysis, design, operation and support. The constantly growing list of maritime specialised areas is included within the scope. This ranges from the technology and policy to strategic maritime issues. It is hoped that the articles published in this volume will contribute largely to the research on maritime issues and benefit the maritime communities both at home and abroad. The standard of the articles was evaluated on technical quality, relevance and importance of materials, interest of readers and timeliness through peer review. Independent experts have provided the author with critical commentary and suggestions to improve their final papers prior to publication. The authors had to certify that submitted manuscripts had not been published previously or submitted for publication elsewhere, and did not violate any security, proprietary or copyright restrictions.

The Editorial would not be complete if we do not record our gratitude to the Chief Adviser, Rear Admiral M Khaled Iqbal, Vice- Chancellor, BSMRMU, whose invaluable guidance was always with the Editorial Board. We forward our deepest appreciation to the distinguished reviewers for their hard work and relentless support. We also thank the Advisory Board for their valuable guidance and support. Despite all efforts, toils and sincerity, unintentional errors in whatever form may not be unlikely in the appearance of the Journal. We fervently beseech the readers to pardon us of such unnoticed slights. Comments on the journal, articles as well as editorial policy are welcome and will be considered. We hope that the journal will prove its worth to a reader with an investigative mind, an intellectual zeal, assiduous learning and academic yearnings.

Commodore M Ziauddin Alamgir, (L), NGP, fdc, psc, BN
Dean, Faculty of Maritime Governance & Policy and Chief Editor, BMJ

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Ocean Policy for Bangladesh – A Comprehensive Roadmap

Rear Admiral M Khaled Iqbal[1]

Abstract

As Bangladesh is on the course to achieve the objectives of Sustainable Development Goals, she needs to address a few significant ocean-related issues and challenges in order to support her political, economic and security interests. Today, the ocean is regarded as the last major frontier on earth for the exploration, exploitation and development of marine resources to sustain the prosperity of any maritime country and the people in future. The ratification of UNCLOS III has endowed Bangladesh with important rights and responsibilities in her maritime jurisdiction. The architect of the maritime vision of Bangladesh, Bangabandhu Sheikh Mujibur Rahman underscored the importance of endless sea resources and enacted the Territorial Waters and Maritime Zones Act 1974 to establish Bangladesh's sovereign rights over the sea area. The successful delimitation of maritime boundaries with the neighbouring countries in the recent years under the leadership of Honourable Prime Minister Sheikh Hasina, through the verdict of ITLOS and PCA, has opened a new vista of opportunities in the sector of blue economy. That necessitates the formulation of a comprehensive Ocean Policy which should be multi-disciplinary in approach, and in consultation with the government agencies, private maritime industries, the wider community and other stakeholders. The policy should aim to ensure the ecosystem integrity and the conservation of marine biological diversity. It should also indicate specific sectoral measures commensurate with the broader goals of the blue economy set by the government. The overall vision of the Ocean Policy should be to ensure a healthy sustainable ocean; nurtured, understood and harnessed wisely for the benefit of all to achieve vision 2021, vision 2041 and the Delta plan 2100. But truly speaking there is a scope for better managing our maritime interests and resources while the entire gamut of maritime activities needs to be well coordinated.

Key Words: Ocean Policy, Marine Resources, Delta Plan.

Introduction

To meet the new millennium demands, Bangladesh needs to address significant functional and regional Ocean Policy issues to support her political, economic and security interests. Many of these issues are inter-related and therefore, crafting an omnibus Ocean Policy, that effectively deals with her vital maritime interests in a coordinated fashion, poses significant policy challenge. Oceans are the greatest common heritage of mankind that exerts a profound

[1] *Vice Chancellor, Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh.*

influence on all forms of life on earth. Today oceans are regarded as the last major frontier on earth for the exploration and development of resources to sustain mankind in the future. The oceans are considered as unfailing sources of food, minerals, medicine and energy. Yet man has been able to touch only an infinitesimal part of these riches, the main drawback being his incomplete knowledge of the oceans. Sea Lines of Communication (SLOC) comprise the umbilical cord of a state's economy and the arteries of a region's economic health. The sea-based commerce offers a mood of great optimism; hence arises the need for formulating a strategic response towards flourishing the trade and shipping and safeguarding the SLOCs.

The oceans continue to provide a wealth of resources and have the potential to meet the growing demands of a burgeoning worldwide population. The acquisition and conservation of marine resources, therefore, promise to pose daunting policy challenges for Bangladesh. Currently the most commercially significant of these resources are the fishery resources in the Exclusive Economic Zone (EEZ) and petroleum and natural gas on the continental shelf. Approximately, 90% of living marine resources are harvested within 200 miles of EEZ. Marine exploration has revealed the offshore distribution of minerals of economic interest. Nodules of manganese oxide are found in the deeper part of the oceans in high seas, recognised as the common heritage of mankind. Apart from these polymetallic nodules, there are other non-living resources like salt, sulphur, gravel, sand, phosphate and hydrocarbons. It is estimated that the undiscovered oil potential of the continental shelf is more than 60% of the world's total known reserves.

Protection and preservation of the marine environment have become areas of increasing concern for all the Coastal States in formulating Ocean Policy. These environmental concerns were highlighted at the United Nations Conference on Environment and Development (UN CED) in Rio De Janeiro (1992 Earth Summit and other subsequent summits). It is estimated that most marine pollution comes from land-based sources, other major sources include shipping, dumping and offshore mineral production. Hence, this environmental issue deserves special attention in formulating an Ocean Policy.

The traditional perception of the inexhaustibility of marine resources has indeed altered. Maintaining the health and productive capacity of the oceans while seeking to meet the economic aspirations of the growing populations worldwide is a crying need of today. The greater awareness of the value of the ocean has brought about some remarkable changes in jurisdiction over maritime zones in the recent past. A new comprehensive ocean regime created by the 1982 United Nations Convention on Law of the Sea (UNCLOS III) has provided coastal nations with control over vast new ocean areas from where a country can extract resources and build national wealth. By the virtue of this convention, about 35% of water previously recognised as high seas has been enclosed as national zones. The convention established a comprehensive legal order for the ocean which would protect and preserve the marine environment, conserve living resources, facilitate international communication, promote efficient and peaceful uses and management of the oceans and advance the interests of the mankind as a whole. Basically, the UNCLOS III has stopped the so-called creeping and thickening jurisdiction of the Coastal States that used to be a trend in the post-World War II period of emerging nation States. The 1982 convention has formally entered into force on 16 November 1994 and ratified by Bangladesh in 2001. As a developing Littoral State,

Bangladesh has huge stakes in this convention and much of its contents should form the basis of her possible Ocean Policy.

But unfortunately, in the past, the sea used to attract little public interest and attention in Bangladesh. That is symptomatic of a large problem – that of building sufficient community and political awareness about the importance of the sea and marine industries. In fact, Bangladesh's vast oceanic front remained somewhat overlooked, while the country mostly remained "ocean blind". But Bangladesh is endowed with the natural blessings of 710 km of coastline. Recently under the leadership of the government of Honourable Prime Minister Sheikh Hasina, Bangladesh has gained a maritime area of 1,18,813 sq.km through the successful and peaceful maritime boundary delimitation process by the international courts. The discovery of offshore hydrocarbon at the Sangu gas field, the sector added a new dimension to the country's economy. But the follow-up discoveries and extraction of energy from sea blocks are not encouraging. But there is evidence of the bright possibility of having huge energy and mineral resources under our see areas waiting to be explored and exploited. Presently more than 90% trade of Bangladesh is sea-borne. It is therefore imperative for Bangladesh to adopt a "look south" policy by "caring, understanding and using the ocean wisely". To date, marine and ocean affairs of Bangladesh have been characterised by either no policy at all or sectoral approaches by means of few isolated sub-policies. There has been no central body to control various maritime infrastructures, agencies and stakeholders. All these considerations justify the fundamental importance of an "Ocean Policy" to provide a comprehensive, national approach to the protection and management of maritime interests. The Ocean Policy of Bangladesh should set in place as the framework for integrated ecosystem-based planning and management of her marine jurisdictions and resources so that economic benefit exists with sensitive environmental care.

With this backdrop, the objective of this study is to provide a preliminary foundation for an integrated eco-system-based Ocean Policy for Bangladesh in order to ensure coordinated maritime planning and management by the government, marine industries, wider community and other key stakeholders.

Maritime Heritage of Bangladesh: An Overview

Though Bangladesh itself is comparatively a young nation, its maritime heritage is deeply rooted to that of the subcontinent, which in turn can be traced back to the Vedic times. There are enough indications of our seafaring traditions and bondage with the ocean. The mariners of Bengal like their counterparts in the Indian Subcontinent had profound knowledge in the art of seafaring, navigation, communication and shipbuilding. A large number of people living in Bangladesh coastal areas bear the testimony of her close attachment to the sea. Like Columbus and Magellan, Bangladesh also has dream man Chand Saudagar, frequently used in the literature.

Chattogram was the major port of Bengal ever since the Arabs and Yemenis used to come to India for trade since 2nd century BC. The travellers like Ibn Battuta and Barbarossa mentioned the shipbuilding industries of Dhaka, Sonargaon and Chattogram in a high note. The local shipbuilders used to build ships for the Dutch, British, Germans and even the Turks. The image of the Frigate "Deutsch Land" built in Chattogram in 1818 is still preserved in the

Bremerhaven Ship Building Museum of Germany. During the 16th century, the Portuguese named Chattogram port as "Porte Grande" as she offered easy access and safe anchorage to large ships.

Maritime Jurisdiction of Bangladesh and UNCLOS III

The historical trend of attempting to place ocean areas under the State control culminated in 1494 in the Treaty of Tordesillas, approved by Pope Alexander VI when papal Bull divided the oceans between Spain and Portugal. However, the majority of the states realised that they were benefiting more from the free movement of commerce allowed by the "Freedom of the High Seas" or the "Mare Liberum" postulated by the Dutch lawyer Hugo Grotius in 1608.

Development of UNCLOS III: The historic Truman proclamation in 1945 on the continental shelf and fisheries conservation is normally assumed to be the starting point of the contemporary development to the law of the sea. Later on, the creation of the United Nations gave the international community a suitable forum for addressing the contentious and conflicting maritime issues in a comprehensive and coordinated manner. After two partially successful attempts by UNCLOS I of 1958 and UNCLOS II of 1960, the UNCLOS III was opened for signature on 10 December1982 in Jamaica. It took further 12 Years mainly for technical and legal reason for the Convention to come into force on 16 November1994.

The Implication for Ocean Policy: UNCLOS III is in fact, a blend of treaty laws and customary laws. The Convention codified existing practice and established new norms of international law in many areas of Ocean Policy. It sets maximum limits for the different sea areas and clarifies the jurisdictional powers and resource rights of coastal and other states in the areas. The UNCLOS III can be regarded as a legal document which defines legal rights, obligations and responsibilities. Alternatively, it may be considered as a political statement outlining the ways in which the seas may be used and managed in the contemporary world. Some commentators have described it as a combined political and legal blueprint "a constitution of the oceans". Given these implications, the planning and management of ocean call for a coordinated Ocean Policy that treats the UNCLOS III as a beginning, not an end.

Territorial Water and Maritime Zones Act 1974: Bangladesh is, in fact, one of the first countries in the world to enact a law for maritime management. The Father of the Nation Bangabandhu Sheikh Mujibur Rahman enacted Territorial Water and Maritime Zones Act 1974. The Act laid down rules regarding the delineation of maritime zones from the Baseline like Internal Water, Territorial Water, Economic Zone (now EEZ), Continental Shelf and Conservation Zones. Later vide the Territorial Waters and Maritime Zones Rules 1977 the government laid down further rules regarding the conduct of persons and vessels in Bangladesh maritime zones, customs and fiscal laws, reserved area and production of energy from the tide, current, wind and sun.

Growing Maritime Interests of Bangladesh

The maritime interest and concerns of Bangladesh emanate from the necessity to generate more wealth for uplifting the living standard of her impoverished millions and the imperative to enhance her national security. Following are some of the basic maritime interests which

must be preserved while formulating national Ocean Policy:

a. Maritime Security: Security here should be understood in terms of military, economic and environmental dimensions including confidence-building measures, the safety of SLOC, prevention and management of natural disasters and the management of marine pollution.

b. Exploration and Exploitation of Resources: The Bay of Bengal is rich in various renewable resources like fish stock, which not only meets our food demands but also earns a lot of foreign currency for the cash-starved country. The contribution of fishery production was near about 105 million tons which are around 66% of the world total fisheries production in 2012. Moreover, the government is also doing its best to implement its decisions to explore gas and oil found in the offshore areas.

c. Foreign Investment: Bangladesh government is making all-out efforts to attract foreign investors in exploring oil and gas in its offshore zones. The government policy is to involve the private sector in the development of hydrocarbon resources through the participation of international oil companies under the Production Sharing Contract (PSC). Moreover, there is a surge of foreign investment in recent years in the sectors like port, offshore LNG platforms, coastal energy hubs and Special Economic Zones

d. Ensuring Order at Sea: Maritime crimes include poaching, sea piracy, illegal migration, narco-terrorism, smuggling, etc. and shipping accidents like fire, collision, adverse weather, etc. should be decreased. Bangladesh's interest in preventing and minimising these disorders at sea is too obvious.

e. Marine Scientific Research: The safe and economical use of the oceans and the preservation of the same are dependent in every respect on marine scientific research. This will include oceanographic, hydrographic, seismic, geological and geomorphological research including remote sensing. The government has recently established the Bangladesh Oceanographic Research Institute (BORI) for maritime research.

f. Coastal Zone Development: The coastal zone development is an important interest for Bangladesh as regards marine tourism, forestry, maintaining bio-diversity, establishing marine parks and also for aquaculture, hatchery, etc.

g. Trade and Economic Cooperation: It is Bangladesh's interest to deepen her relationship with other regional countries not only bilaterally but also in a collective framework by enhancing trade and economic cooperation. In this respect, the government has emphasised on the need for expanded connectivity with the regional countries.

Concept and Need for Ocean Policy

As the sea would become a bone of contention, it would also offer enormous promises and potential benefits. But in Bangladesh, certain maritime activities are not coordinated whereas other maritime sectors are totally ignored. Various maritime industries are neither centrally controlled nor their performances supervised. Bangladesh is a biologically diverse nation and her maritime environment is a home to spectacular arrays of species, some of which are unique. Her marine area is dynamic in nature and experiences continuous variability of physical, chemical and biological properties ranging from days to decades. But her ocean systems are under increasing

pressure from many uses such as fisheries, shipping, petroleum activities and tourism. Action now is required to put in place a comprehensive system for integrated ocean planning and management which will reduce the risk of a progressive decline and irreversible damage to her marine systems.

Certainly, it may be necessary to provide positive direction to the way in which Bangladesh views the use of the oceans and to the way she regulates those uses both within Bangladesh and perhaps more importantly, in the international milieu. As a nation, Bangladesh must increasingly confront issues requiring the setting of priorities among competing uses and of balancing the distribution of ocean benefits between current and future generations. In the maritime sector, certain individual industries, agencies or maritime infrastructure carry out their responsibilities quite well, but there is hardly any coordination among them or with the government.

A need, therefore, exists for policies that are based on equity and stewardship of the public trust; policies that take into account the functioning of the ocean and its various subsystems; and policies that achieve balance and set priorities that ultimately will determine the success or failure of any ocean management programmes. Clearly, national policy formulation and decision making in ocean development and management raise complex issues, cover a variety of rights and concomitant duties, span a range of governmental and international activity and encompass many diverse disciplines. The approach of maritime issues and the development of a maritime culture has to be inter-disciplinary with historians, lawyers, economists and political scientists working with engineers, biologists, chemists and physicists on common ocean interests. Above all, an Ocean Policy should outline a broad range of commitments that will translate the policy into a programme of activities to help us to achieve blue economy objectives. Building on existing effective sectoral and jurisdictional mechanisms, such coordinated policy should promote ecologically sustainable development of resources, encouragement of internationally competitive marine industries, while protecting the marine biological diversity.

Ocean Policy Issues and Challenges

The use of ocean resources is expected to grow. A primary goal of this policy is, therefore, to ensure that Bangladesh has the management tools in place to avoid potential conflict between ocean users. Ocean Policy would neither be solely an environment protection policy nor solely an economic development policy. It would be a policy for the ecologically sustainable development of the oceanic economy. The policy should establish the broad principles and management approaches necessary to achieve the goal.

Since Bangladesh continues to use the 1982 UNCLOS-III as the foundation for her Ocean Policy, the Convention will serve as a prism that will dispense Ocean Policy into various levels of action and various functional and zonal issue areas. Major Ocean Policy issues that must be coordinated include navigation and overflight, protection and preservation of the marine environment, ocean resources acquisition and conservation, marine scientific research, prevention of piracy, immigration monitoring and control, naval arms control, etc.

All the aforesaid ocean issues have been powerful constituencies at the international, national and local levels, making the crafting of a balanced and effective Ocean Policy as a special challenge.

Vision and Goals of Ocean Policy

Fundamentally, a National Ocean Policy must be a statement of a national vision, a series of goals, principles, strategies and policy guidance. Hence, the Ocean Policy should provide a framework that would outline a broad range of commitments that will translate the policy into a programme of positive actions. The policy should be targeted to give the following early tangible results:

a. The maritime jurisdictions of Bangladesh should be regionalised, based on the large marine ecosystem for the purpose of integrated ocean planning and management.

b. Bangladesh should promote and facilitate the development of marine industries as core components of her economy and drivers of employment growth.

c. Bangladesh should develop a Marine Science and Technology plan, which will improve monitoring and understanding of the global ocean process that influences her marine and territorial environment.

The Vision of Ocean Policy: The vision for Ocean Policy of Bangladesh should be to ensure a healthy sustainable ocean; nurtured, understood and harnessed wisely for the benefit of present and future generations.

The Goal for Ocean Policy: The Ocean Policy should have the following broad goals:

a. To exercise and protect the rights and jurisdiction of Bangladesh over offshore areas and resources.

b. To understand and protect marine biological diversity, the ocean environment and its resources and ensure that ocean uses are ecologically sustainable.

c. To establish integrated ocean planning and management arrangements.

d. To accommodate community needs and aspirations.

e. To promote public awareness and understanding so that people become ocean-minded instead of ocean-blind.

Integrated Ocean Planning: Key Initial Actions

Bangladesh's ocean ecosystem and marine biological diversity are core national assets. If the use of them is well managed, they can meet a broad range of economic, social and cultural aspirations. The collapse of a number of major ecosystems and fisheries resources in other regions like Southern Bluefin Tuna, Southern Sharks etc. with the associated economic damage and social dislocation, is a stark warning of the vulnerability of marine systems.

Conservation of Marine Biological Diversity: The main objective of the Ocean Policy should be to ensure continuing marine ecosystem health and conservation of marine biological diversity, which refers to the variety of living organisms in the estuaries and ocean, their genes and the ecosystem of which they form a part. Tropical hot-humid climate with mild winter, abundance of monsoon rains, surface water and the alluvial rich soils make Bangladesh an ideal place for a high degree of biodiversity. It is said that one square kilometre of the mangrove forests in Bangladesh contains greater biodiversity than that of many countries taken together.

Regional Marine Planning: Integrated and ecosystem-based planning and management should be implemented through the introduction of a major regional marine planning process. For each marine region the plan will broadly identify:

a. Ocean resources, economic and other opportunities.

b. Current and emerging threats to ecosystem health.

c. The community and sectoral interests.

d. Priorities for the industry and economic development of the region.

Maintenance of Ecosystem Integrity: The vision and goals for Bangladesh Ocean Policy should be developed around a national strategy for ecologically sustainable development and multiple ocean uses. The ecological links between the land and ocean, as well as within and between ocean ecosystems, must be taken into account in ocean planning and management. All human uses of the ocean result in a change in ocean ecosystems and there are direct and indirect impacts from a range of land based activities. Hence, the main element in the decision about the maintenance of ecosystem integrity is establishing what the ecosystem characteristics are and understanding the scale and levels of natural variability. The main ecosystem at risk includes mangrove swamps, coral reefs, turtle nurseries, prawn fishing areas and areas used in the production of algae.

Multiple Ocean Use: The priority aim of ocean use management includes the reconciliation of conflicting uses. Manning and management for multiple ocean uses involve the integrated allocation of resource access and should also ensure that such decisions are equitable, objective and transparent.

Marine Protected Areas: A Marine protected area is an area at sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources managed through legal or other effective means. In coasts and estuaries, there is severe competition between human activities and the intricate web of marine life. The delicate mangrove swamps in the Sundarbans are part of a web marine life. While the coral reefs of the St Martin's Island are even more fragile having rich habitats for myriad life forms. This system also provides for the recreational, aesthetic, cultural and economic needs of the people. Bangladesh is a party to the Convention of the world cultural and natural heritage. The Great Barrier Reef of Australia has been referred to as the largest living feature on Earth and was clearly visible from the Moon. It actually consists of 2500 individual reefs and includes some 400 species of coral, 1500 species of fish, making it the world's largest coral reef. Before conservation measures were taken, the Reefs was threatened by recreation, localised populations and other dangers. The Barrier Reef Marine Park is being developed in sections in order to control the impact of human and recreational activities. There are preservation zones designed to conserve ecosystem and protect turtle and bird nesting sites. In scientific research zones, recreation is forbidden. Bangladesh may take the conservation measures of the Great Barrier Reef as a guideline for her marine protected areas.

Conservation of Marine Species and Habitats: Conserving the biological structure of the oceans has become one of the leading issues in ocean use management. The numerous endangered species must be encompassed within management schemes if they are to survive.

Many species have reached critical levels due to overexploitation, damage to or pollution of habitats, competition from other species and the introduction of alien species. The preliminary survey carried out in 1996-97 found abundant coral resources presence of economically important macro-invertebrates (e.g. sponges, gastropods, sea urchins, sea cucumbers) and other rare endangered species. The survey indicated eight species of Tuna and Skipjack and a number of potential species of Mackerels, Shark, Ray, Sardines, Anchovies, Shad, etc. in Bangladesh water. There is a need, therefore, to recognise in legislation "conservation dependent" species and vulnerable ecological communities.

Institutional Arrangement for Implementation of Ocean Policy

All the Maritime infrastructures, agencies and stakeholders are directly or indirectly supporting our maritime economy, in turn the national economy. The maritime infrastructure consists of regulatory bodies, private /public sector commercial operators, repair facilities, education, training and research institutes.

Regulatory Bodies: Numbers of Ministries are concerned with various maritime affairs. They are Ministry of Ports, Shipping & IWT; Ministry of Fisheries & Livestock; Ministry of Energy, Petroleum & Mineral Resources; Ministry of Forest and Environment; Ministry of Defence; Ministry of Home Affairs; Ministry of Industries; Ministry of Foreign Affairs (Maritime Affairs Unit) and Ministry of Finance. Recently the government has established the Blue Economy Cell to coordinate the blue economic activities of different ministries.

Shipping Regulatory Organs: The regulatory organs under the Ministry of Shipping are, Directorate General of Shipping, Mercantile Marine Department and Bangladesh Inland Water Transport Authority.

Commercial Operators: The government-owned public sector commercial operators are Bangladesh Shipping Corporation (BSC), Chattogram, Mongla and Payra Port Authority, Bangladesh Inland Water Transport Corporation (BIWTC) and Bangladesh Fisheries Development Corporation (BFDC). Notable private commercial operators are private shipping and fishing companies, international gas exploration companies and a limited number of tourism and aquaculture companies.

Shipbuilding and Repair Facilities: The major shipbuilding and repair facilities are Chattogram Dry Dock Limited (CDDL), Khulna Shipyard Limited (KSY), Dockyard and Engineering Works Narayanganj, BN Dockyard and other BIWTC dockyards. In private sectors numbers of shipyards are contributing significantly in shipbuilding.

Maritime Education and Training: Following universities, institutes and academies impart training and carry out research in maritime fields:

a. Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh.

b. Bangladesh Marine Academy.

c. Bangladesh Naval Academy.

d. Marine Fisheries Academy

e. National Maritime Institute (NMI).

f. Deck Personnel Training Centre (DPTC)

g. Bangladesh Institute of Marine Technology (BIMT).

h. Some Private Marine Academies/Institutes.

i. Bangladesh Oceanographic Research Institute (BORI)

In addition, some public and private universities conduct some related programmes.

Other Ancillary Organisation: Other ancillary organisations in support of maritime activities are Space Research and Remote sensing Organisation (SPARRSO), Bangladesh Meteorological Department, Department of Hydrography and Survey of Bangladesh.

Enforcing Agencies: The relevant agencies responsible for enforcement of various maritime regulations, monitoring and surveillance are Bangladesh Navy, Bangladesh Air Force, Bangladesh Coastguard Force and Sea Customs.

Institutional Elements for Formulation and Implementation of Ocean Policy

While the government should take the lead in developing Ocean Policy, an effective policy must be shaped by the nation as a whole. The policy should be developed with considerable consultation sharing ideas with the government, the wider community, conservation groups industry and other resource users.

There is no easy, obvious or consensus solution to achieving a coherent and coordinated Ocean Policy. Moreover, the approach may vary from country to country. For example, France is one of the very few countries who has completely re-organised its maritime administration to form a Ministry of the Sea. However, in order to coordinate all the maritime activities and implementation of the Ocean Policy, possible institutional arrangements may be as follows:

a. Department of Ocean Development: In line with our neighbouring country India, Department of Ocean Development (DOD) may be created under the direct control of the Prime Minister's office, providing it considerable importance and prestige. Their activities could mainly involve marine research and development agenda and act as a watchdog for the government's implementation arrangements.

b. National Ocean Ministerial Board: This board could include various key ministries concern with ocean affairs and oversee the implementation, prioritisation, budgetary allocation, regional cooperation and further development of Ocean Policy.

c. National Ocean Advisory Committee: The National Ocean Advisory Committee may be comprised of members with non-government interests, such as industry, science and conservation, selected for expertise in ocean issues. Their main function could be to advise the Ministerial board on cross-sectoral and cross-jurisdictional ocean issues and be a forum for exchanging views between ocean sectors.

d. National Ocean Office: A National Ocean Office may be established to provide secretarial technical support and assist the board in implementation and further development of Ocean Policy. The office could be constituted of governments officers from various ocean-related agencies and act as the main administrative coordination point between the government organisations and other commercial operators.

e. Regional Marine Plan Steering Committees: Regional Marine Plan Steering Committees, including key non-government and government stakeholders, may be established who will oversee the development of regional marine plans, working closely with the National Oceans Office.

Specific Sectoral Measures

Putting Bangladesh's Ocean Policy into actions requires a partnership between all spheres of government, private sectors, scientific and wider communities. The policy itself should be owned by all citizens. The Ocean Policy should also provide guidelines for specific sectoral measures as follows:

a. Fisheries
b. Aquaculture and sea farming
c. Offshore hydrocarbon and minerals
d. Marine environment and pollution
e. Shipping and trade
f. Marine engineering and shipbuilding
g. Port Development
h. Alternative energy source
i. Marine and ecotourism
j. National heritage and marine parks
k. Marine spatial planning

Caring and Understanding the Oceans

People and the Oceans: The main challenges of the Ocean Policy will be to improve the management and technical skills of the marine managers and develop the community understanding of and involvement in marine related issues. Following should be ensured:

a. Professional and skill development of the marine managers.
b. Community participation in ocean-related decision-making.
c. Generate Public awareness and understanding of the role of the Ocean Policy.
d. Develop training courses, seminars, symposium, etc. on integrated marine management.

Understanding the Oceans: The Ocean Policy should highlight the need for greater knowledge and scientific understanding of the marine ecosystem and resources to underpin their conservation and sustainable use. The government should formulate a "Marine Science and Technology Plan" in order to characterise and improve our understanding of the coastal zones, marine jurisdictions, the oceans' interaction with the atmosphere, their biological resources, ecological systems and their underlying geological features. The Ocean Policy should highlight on the following in this regard: Marine Scientific Research, Physical, Chemical and Geological Attributes, Weather and Climate Services and Oceanographic Research. It is, therefore, evident that there is a strong need for ensuring an appropriate scope

for maritime higher education and research. In this view, importance and role of BSMRMU and other universities will always be augmented in future.

Protecting National Interests

Defence Tasks: Oceans are critical to our security. If we are to continue benefiting from the oceans, access and freedom of use must be assured. The strategic policy should advance the need for strategic control, to ensure that potential aggressors are not able to cross our marine jurisdictions. It should be the tasks of the armed forces, particularly the Bangladesh Navy (BN) to safeguard these areas, to control maritime approaches, to exercise and protect the sovereignty and sovereign rights. BN should:

a. Conduct sea exercise programme to maintain readiness and ensure its sustainability in operations.

b. Conduct bilateral and multilateral exercises with regional nations to enhance interoperability and to demonstrate our interests in our commitment to the region.

c. Make a cost-effective investment in the defensive and offensive capabilities of our present fleet. Consolidate towards developing into a credible three dimensional Navy.

Surveillance and Enforcement: Surveillance is required to provide information on illegal activities in our vast marine jurisdictions. It must also be coupled with the capacity for effective enforcement. BN is the major contributor to national maritime surveillance effort while Bangladesh Coastguard Force is entrusted with the task of coastal law enforcement. The government should:

a. Review and rationalise the capacity for surveillance and enforcement, including reform of legislation relating to enforcement.

b. Further develop marine intelligence network.

c. Develop Bangladesh Coastguard Force in taking up the task of coastal surveillance.

d. Develop an integrated system to provide continuous, real-time, all-weather detection and identification of intruding ships and aircraft.

Search and Rescue: With the globalisation of maritime trade and commerce, the safety of the seagoing vessels, fishing fleet and all the seafarers has become a matter of paramount importance. The 1979 International Convention on Maritime Search and Rescue, 1958 Geneva High Sea Convention, 1974 SOLAS Convention and UNCLOS III all require the coastal States to develop National Search and Rescue (SAR) organisation. As per provisional Maritime SAR Plan of IMO, Bangladesh has been delineated with a Maritime Search and Rescue Region (MSRR) where she has to coordinate all SAR efforts for any distressed vessel. Bangladesh also needs to establish an effective Maritime Rescue Coordination Centre (MRCC) to coordinate SAR activities, presently, though DG shipping is the National Coordinating Agency for SAR, her credibility in performing such tasks always remains in question due to her lack of resources and personnel. BN has been entrusted to carry out SAR activities since 1975 and she is presumably in the best position to carry out such coordination task. Following responses are necessary:

a. The government should immediately set up an effective Maritime SAR organisation to make our MSRR safe and acceptable for international shipping. The government may enact appropriate laws in this regard in line with 1979 SAR Convention.

b. Arrangement for Compulsory Ship Reporting System (CSRS). Differential Global Positioning System (DGPS) along the coasts, GMDSS Facilities, etc. should be made for enhancing our security and safety measures at sea.

c. BN may be designated as National SAR Coordinator for the effective monitoring and coordination of SAR activities.

Ocean Policy in Regional and International Context

The world's oceans are interconnected; many of the management concerns are part of a larger regional or global concern that can only be addressed through international cooperation. Ocean affairs are rightly a central part of the broader political and strategic relations in the region. In promoting cooperation, Bangladesh should firstly identify areas of common interest for the sustainable ocean management. The government should take early action in the following areas:

a. Conservation of Maritime Resources: Bangladesh should develop a regional cooperative management regime for straddling and highly migratory fish stocks with a view to ensuring the conservation of living resources.

b. Maritime Safety, SAR and Pollution: Bangladesh should put into effect bilateral/ multilateral arrangement for quick regional response in the prevention of maritime pollution, ensuring standard material state of ships through common port state control measures and effective regional SAR organisation.

c. Regional Marine Protected Areas: Bangladesh should cooperate in developing regional marine protected areas. e.g. jointly managing Sundarbans World Heritage Site.

d. Ocean Observing System: We should actively participate in regional programmes advancing knowledge of the dynamic marine environment, climate prediction and the establishment of a coordinated ocean observing system.

e. Crime Prevention: Joint patrolling, surveillance and exchange of intelligence in the Bay of Bengal would better ensure the prevention of maritime crimes.

f. Hydrographic and Seismic Survey: Joint hydrography and seismic survey can determine the actual reserve of hydrocarbon in the bay and updating our charts and nautical publications.

g. Marine Scientific Research: Regional marine scientific research programme in the field of oceanography, renewable and non-renewable energy resources, weather and climatology, etc. is clearly a major area of regional cooperation.

h. Education, Training and Information Exchange: There is a need for arranging education and training on general maritime management in each other's marine training institutes. Moreover, data collection and exchange, information networks and internet websites will be particularly useful for developing Integrated Coastal Zone and Ocean

Management Strategies at the regional level. In this regard, BSMRMU may undertake joint education and research programmes with other Maritime related universities of the region.

Conclusion

The sea is a major source of food and the sea lanes are the lifelines of all the economics which are heavily dependent on unimpeded access to raw materials, markets and investment opportunities throughout the world. During times of peace, the SLOCs serve as commercial trade routes but during the war, these routes are considered strategic pathways to keep the war machines fully oiled. Throughout the world, there is a significant movement of populations and economic activities to the coastal areas, which have made exploitation of oceanic resources and preservation of the marine environment an increasing priority for all the nations. Man–Land ratio of Bangladesh being the lowest in the world, she can no longer sustain pressures for food, shelter, energy and other necessary commodities. Hence, Bangladesh is bound to show a positive response to her adjacent ocean which is rich in huge untapped living and non-living resources. Bangladesh has to generate maritime awareness among the people and guide them to look south towards the vital maritime interests at stake. Those interests include not only maritime security, law and order at sea, they also cover the exploration and exploitation of marine resources, ensuring foreign investment, marine scientific research and many more. Moreover, the victory over delimitation of the maritime boundary has opened up a new opportunity of maritime jurisdiction for Bangladesh along with rights and responsibilities.

But presently maritime interests and resources of Bangladesh are not well managed, neither the maritime activities well-coordinated. There is a lot of duplication of efforts among the maritime agencies while few sectors are totally ignored. That necessitates the formulation of an overarching Ocean Policy that pertains to the entire assembly of ocean uses and resources and the long term public interest in the ocean as a whole. Such policy should be multi-disciplinary in approach prepared in consultation with the government agencies, private maritime industries, the wider community and other stakeholders. Through the development of Ocean Policy, the government would join in a partnership with the Bangladeshi community to pursue the vision of ensuring a healthy sustainable ocean: nurtured, understood and harnessed wisely for the benefit of all, now and in the future.

As a key initial action, the policy should aim to achieve an integrated eco-system based ocean planning in order to ensure the ecosystem integrity and the conservation of marine biological diversity. While promoting the principle of multiple ocean uses, the policy should afford to divide coastal areas for regional marine planning in order to ensure community and sectoral interests. It should also provide protection to the vulnerable marine species and delineate marine protected areas. In order to implement the Ocean Policy and coordinate the efforts of maritime infrastructure, the institutional arrangement proposes for a National Ocean Ministerial Board who would oversee the implementation of the policy and coordinate budgetary matters. A National Ocean Advisory Committee comprised of members of government and private sectors should advise on the secretarial help. There might also be a Regional Marine Plan Steering Committee to oversee the development of the Regional Marine Planning while the Department of Ocean Development would primarily be an ocean research organ.

The Ocean Policy should also indicate specific sectoral measures commensurate with the broader goals set by the government. These measures should be pursued by all concerned maritime agencies and stakeholders across ocean sectors consistent with the planning and management principles. Hence all the sectors and industries would have to provide positive responses against the challenge. But the main challenge of the Ocean Policy will be to improve the managerial and technical skill of the people to develop community understanding and awareness of the general mass. Finally, the policy should also indicate the particular tasks of the Bangladesh Navy. Bangladesh Coastguard Force and other enforcing agencies in protecting our vital maritime interests. Since Ocean Policy has a strong international connotation, guidelines should also be given in identifying the common areas for regional cooperation with our friendly neighbours. As a matter of fact, the time is right for our government, to be truly forward-looking and put an Ocean Policy in place before the problems of the oceans become intractable, before missed opportunities become serious costs to the national economy.

Recommendations

It is recommended that:

a. The Government should hold a national Ocean Forum with wider participation of public and private maritime sectors, researchers and key stakeholders to promote the importance of formulating an Ocean Policy.

b. Efforts may be made to generate public opinion in favour of the Ocean Policy by growing the maritime awareness of the common people.

c. The government should review the existing shipping and fisheries laws and enact new laws on marine pollution prevention and conservation of eco-system integrity and biological diversity.

d. Surveillance and enforcement capabilities of the BN and Bangladesh Coast Guard Force may be enhanced for better protection of our maritime interests.

e. All out efforts may be made for promoting regional cooperation in various sectors of Ocean Policy and marine management.

f. The Goverment may consider to establish the Institutional Elements proposed in this paper for the formulation and implementation of Ocean Policy.

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Maritime Safety and Security in the Bay of Bengal

Rear Admiral Md. Khurshed Alam[1] (retd)

Abstract

Maritime safety and security is a pre-requisite for stability and growth in the Bay of Bengal (BoB) region to protect the prosperity and security of the region. Maritime security and safety encompasses all the operations which are being carried out to ward off threats from the sea. This region depends on safe, secure and clean seas and oceans for prosperity and peace. Through adequate maritime security, the region can maintain the rule of law in areas beyond national jurisdiction and protect the strategic maritime interests. Issues involved in Maritime safety and security in BoB region includes a developing system, systematic cross check, maritime surveillance, Marine Casualty Information and natural disaster. The study based on content analysis aims to discuss these issues in details and propose the ways ahead.

Keywords: Maritime Safety and Security, Bay of Bengal.

Introduction

Maritime safety and security is a pre-requisite for stability and growth in the Bay of Bengal region. Protecting the prosperity and security of the BoB requires that the region play an active role in tackling challenges such as maritime crimes-terrorism, drug trafficking, acts of piracy, illegal transport of migrants, poverty, conflict and humanitarian disasters through actions to support development, reduce the risk of disasters and conflicts and their adverse impacts, as well as to improve capacities for preparedness and response. Maritime security and safety encompasses all the operations that are being carried out to ward off threats from the sea, defend sovereign rights at sea and control risks relating to maritime activities (fisheries patrol, accidents at sea, pollution, sea rescue/shipwreck and assistance, legacy munitions clearance, etc. This region depends on safe, secure and clean seas and oceans for prosperity and peace. It is through adequate maritime security that we can maintain the rule of law in areas beyond national jurisdiction and protect the strategic maritime interests which include:

- Overall security and peace
- Rule of law and freedom of navigation
- External maritime boundary control

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[1] *Secretary, Maritime Affairs Unit, Ministry of Foreign Affairs*

- Maritime infrastructures: ports and harbours, coastal protection, commercial facilities, underwater pipes and cables, offshore platforms and scientific equipment
- Common natural resources and environmental health
- Climate change preparedness.

Importance of Safety and Security at Sea

Almost 90% of the external freight trade is seaborne, and overall, maritime industries are an important source of employment and income for the economy. Millions of containers travel every year through the ports of the Indian Ocean, transporting the 90% of the world's cargo in maritime containers, but only 2% is physically inspected by customs authorities, opening the possibility for illicit activities. Detecting suspicious shipments from customs fraud (e.g. evasion of import or antidumping duties) or from a safety and security viewpoint are difficult tasks for all the coastal countries involved. There is a need to improve maritime safety and security by developing systems to improve maritime surveillance capabilities and to collect information about maritime accidents and ensure the safety of shipping through enforcement of duties laid under the port, flag and coastal States. The objectives of the coastal countries of the bay should be comprehensive but can be taken up in phases for implementation instead of fragmentary approaches.

Strategy Necessary for Improving Safety and Security

The strategies of the countries of the BoB should aim at supporting regional and global security and stability by enhancing prevention, preparedness and response capabilities to various threats of the coastal countries. The rim countries of the Bay of Bengal should strive for an overarching maritime safety and security strategy against all types of challenges from the global maritime domain that may affect people, activities or free trade. It should be developed upon closer cooperation within the region and at national levels with an ultimate objective to protect the maritime interests of all coastal and hinterland countries and increase maritime domain awareness among all stakeholders of the bay. All maritime security and safety stakeholders from among the rim countries either may be called upon to participate in a cooperative setting or under existing multilateral regional organisations. The issues which could be discussed must seek to ensure that the policy response remains fit for current and future challenges in line with political priorities in a rapidly changing safety and security environment and taking into considerations of the ongoing naval development, national policies and other initiatives.

Following issues could be considered by the countries of the rim of the BoB:

Developing a system that can support coastal countries in the task by improving their situation awareness capacity and providing them with additional risk indicators derived from the actual routes followed by the containers. Today, it is widely believed that the only viable way to control containerised cargo is through information-based risk analysis. In this way, it becomes possible to target high-risk shipments and proceed with physical checks, only where needed.

Capable States in the BoB may be tasked to carry out systematic cross-checks of the origin of goods inside import declarations to detect customs fraud. The second one is dealing with the

systematic analysis of pre-arrival data in near-real-time in combination with container traffic container trips data and aims at developing risk indicators for the safety and security of cargo entering the Indian Ocean Region.

The Automatic Identification System (AIS) is an efficient tool to exchange positioning data among participating naval units and land control centres. The fundamental requirement is maritime domain awareness via identification, tracking and monitoring of vessels within their waters and this is exactly what an AIS could bring. It focuses on how the AIS-derived information could be used for coastal security, maritime traffic management, vessel tracking and monitoring with the help of GIS technology.

Maritime surveillance is essential for creating maritime awareness ('knowing what is happening at the sea'). With its competencies in space technologies and data fusion, the countries can have an action plan strengthening the capabilities in maritime surveillance, by contributing to the development of the surveillance system and the information sharing for the maritime domain, and by investigating maritime surveillance solutions.

Establishing a marine casualty information centre where all marine accidents involving member States ships or occurring in the territorial waters of a country may be registered. Such a data base may allow for the storage, exchange and analysis of data on marine casualties and incidents. The shared use of those data may help to develop the accident investigation capabilities of the member States and contribute to improving maritime safety and the prevention of pollution by ships. Software should be developed for reporting and sharing accident and incident reports.

Every year natural disasters and crises worldwide especially in the Indian Ocean cause fatalities and considerable economic losses. In these situations, the region must aim to get help to those who need it as quickly as possible. Reinforcing the capacity to prevent, prepare and respond to disasters is, therefore, a key priority. Enhancing our resilience to crises as well as our capacity to prepare and respond to acute threats should be amongst the objectives of the region. These objectives call for technologies and approaches that help the member states and its dialogue partners to stay ahead of threats and hazards by improving prevention, preparedness, early warning and response in the domains of disasters and man-made crises. The region can strengthen the resilience to crises and disasters through its action plan in crisis management technologies, satellite image processing and analysis, disaster risk management and internet surveillance systems.

The BoB should be committed to improving its capacity to respond to disasters and supports international cooperation in assessing recovery needs and planning recovery measures in post-disaster situations. It should contribute to this process with the development of a guide to multi-stakeholder needs assessment recovery framework for decision-makers to use during the early phases of disaster recovery planning.

Cyber-attacks constitute one of the main threats to critical infrastructures. An increasing number of vital services depend on digital systems – commercial transactions, health, safety, security and others that contribute to our general well-being. Disruptions to these systems – through deliberate "cyber" attacks, natural disasters or technical failure – could cause major

economic and social damage. Moreover, the lack of users' trust regarding the security of online services and privacy protection jeopardies the exploitation of the full potential of information and communication technologies to foster innovation, economic growth and progress. Cyber-security exercises may be identified and should aim to raise the level of preparedness by confronting participants with artificial events and studying their reactions.

The BoB in due course of time can coordinate the network for critical infrastructure protection which aims at providing a framework for networking and co-operation between experimental installations experts and other stakeholders. Activities include sharing information on threats against critical infrastructures and their vulnerabilities, collaborating on appropriate measures to mitigate risk and boost resilience, carrying out critical infrastructure-related security experiments, agreeing on evaluation, qualification and quality assurance methods and proposing standards.

Document security is high among many coastal countries of the BoB. Security of travel documents as “crucial for establishing the identity of a person” and that we can adopt an action plan on document security to introduce and make identity documents, business travel cards and Emergency Travel Documents (ETD) more secure. For many years, travel documents have been subject to standards and security measures as defined in the ICAO Document 9303. Such security measures work on a double layer: traditional paper security features and electronic security features. Travel documents contain an electronic chip embedded which contains data about the document holder (including biometrics) which are protected using cryptographic measures based on the so-called public key cryptography.

The Chemical, Biological, Radiological and Nuclear (CBRN) risk mitigation centres of Excellence should be set up with an initiative to implement a coordinated strategy at the regional level to address the mitigation of and preparedness against risks, either of an intentional, accidental or natural origin, related to chemical, biological, radiological and nuclear (CBRN) materials or agents.

Monitoring the internet regularly is crucial for the regional security community to detect emerging threats, such as public health outbreaks and various types of instability. Internet surveillance systems are routinely used for early event detection, alerting and tracking of emerging public health threats. The medical information system helps to rapidly identify potential threats to public health. Currently, member States are responsible for different aspects of maritime surveillance such as traffic control, safety and security, fisheries control, customs, environment or defence. They collect data separately and often do not share them with each other. In order to provide these authorities with ways to exchange information and data, a common information sharing mechanism has already been proposed. Such a mechanism should ensure effective data exchange between maritime authorities across sectors and across borders by integrating existing surveillance systems and networks and give all concerned authorities access to the information they need for their missions at sea.

Based on the scientific expertise and competencies within the region as well as on the collaboration with the wider scientific community, we in the region should aim to ensure that the best scientific advice possible informs policy development and scientific rigour is applied

when analysing research conducted elsewhere.

With its competencies in space technologies and data fusion, BoB should help to develop a formulation of an integrated maritime policy, in particular, related to integrated maritime surveillance. Support is provided by responding to the needs of a wide range of maritime policies - irregular migration/border control, maritime security, fisheries control, anti-piracy, oil spill pollution, smuggling etc. Also, the global dimension of these policies is addressed, e.g. to help detecting unlawful activities in international waters. Maritime surveillance-authorities are responsible for maritime surveillance, such as border guards, coast guards, police, customs and navies, to share operational information and cooperate with the border security agency and with neighbouring third countries.

Studied technologies intended to build up maritime awareness for use by authorities in piracy affected regions are now available. A prototype software has been developed to track all the merchant ship traffic in wide ocean areas, for use in regional operations centres. The software has been piloted off East Africa and in the Gulf of Guinea. These activities may be replicated among some of the countries in the region.

Measuring and anticipating the effects of future natural hazards is important in order to implement measures to mitigate the effects of disasters. In all phases of crisis management, satellite-derived information plays an essential role as a synoptic, independent and objective source. We now should focus on the automatic analysis of satellite data to provide information products for more effective disaster risk reduction and conflict prevention, as well as evaluating the needs for post-disaster response, recovery and reconstruction planning.

Characterising and monitoring populations in disaster hot spots, early warning approaches must be accompanied by efforts to assess and ultimately reduce exposure and vulnerability of physical assets and population to disasters. Being able to detect where growing concentrations of population, especially the more vulnerable are located in urban disaster hot spots and being able to characterise physical exposure are fundamental inputs for disaster risk assessments. The BoB should address the gaps in the availability of appropriate and consistent physical exposure data region-wide through, which can detect, characterise and monitor human settlement related parameters in both urban and rural settings.

Piracy, maritime awareness and risk-system for Maritime Situational Awareness, (MSA) including piracy and armed robbery should be developed even if it is in a limited way. The real-time maritime situation in the entire, western Indian Ocean basin is provided to Regional Maritime Rescue Coordination Centre (RMRCC) in Mombasa (DCoC ISC)and IOC Anti-Piracy Unit (APU) in Seychelles. We need to familiarise our operators and decision makers with region-wide maritime surveillance capabilities being used in the western Indian Ocean. And then build capacities of our operators, analysts and IT staff to formulate requirements, getting user feedback - what is useful, what is missing and enable scoping of future operational systems and knowing real-time ship positions.

The BoB should be considering modelling, simulation and response capabilities that could be studied to enhance the security and resilience of physical infrastructures and prevent or respond to cybercrime.

Capacity building activities for customs authorities and research to address terrorist or criminal activity form part of the support to customs policy and fight against fraud through;

a. Ship Security Reporting System: The ship security reporting system is an alerting system, which helps in sending distress signals from the ship now directly to the maritime security centre located at Horn of Africa (MSCHOA) and UK Maritime Trade Operations (UKMTO). The BoB countries may recommend to align with those existing systems or set up new centres.

b. Global Maritime Distress Safety System (GMDSS): GMDSS system uses maritime safety information and a general communication channel to receive distress signals from ships in danger. GMDSS system takes help from various elements like INMARSAT, NAVEX, EPIRB etc. to send and receive signals. According to SOLAS, there are certain requirements for GMDSS which are compulsory for every ship to follow.

c. Long Range Tracking and Identification (LRIT) System: The LRIT system is an international ship tracking and identification system adopted by the International Maritime Organisation under the SOLAS convention to ensure a thorough tracking system for ships across the world.

d. Automated Manifest System (AMS): The AMS is a freight tracking system, which requires ships to enter the details of the cargo carried by them. This system was first adopted by the United States of America in 2004 to increase the security level at maritime ports.

e. Vessel Monitoring System (VMS): VMS or the Ship Tracking System is an important system in the shipping industry to find out the location of ships across the world. It is an essential tool for ship tracking and vessel monitoring system.

f. Automated Mutual Assistance Vessel Rescue System (AMVER): AMVER is a vessel safety system which can provide immediate assistance to vessels which are in the emergency situation. The system helps in finding out the location of the vessel and thus provides better crises management.

g. Vessel Management System: Vessel management system uses various tools to monitor and manage shipping traffic at the sea. With the assistance of the Global Positioning System (GPS), VMS not only helps in pinpointing the location of the ships but also helps in the transfer of important weather and environmental data.

Conclusion

It can be said that the regional approach also needs to find an answer on how to involve all concerned littoral countries. In this context, it is very important to understand the need to better and more widely spread the results and awareness of cooperation within the realm of Bay of Bengal rim countries. This would help support the need for maritime cooperation assisted by the bigger picture. When talking about the topic of maritime safety and security as a kind of ‘umbrella’, it might be seen as very relevant for the days to come. However, if it is understood as something everyone is affected by, hence responsible for, if the focus is

rather on the different elements of maritime safety and security like ‘response’, ‘resilience’ or ‘migration’, then it becomes a very relevant topic. And as maritime safety and security is something affecting everyone, successful cooperation in the field of maritime safety and security is a good way to show the added value of cooperation, to show that BoB actually can make a difference. Sadly enough, the interest in maritime safety and security always gets a boost once some major disaster happens and the added value of maritime cooperation is understood. But to prove the added value of maritime cooperation and how it complements other ways of cooperation as common objectives tell us that many challenges cannot be clearly separated between sea and land.

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Maritime Education and National Economic Growth: Bangladesh Perspective

Commodore M Ziauddin Alamgir[1] and M Mojahid Hossain Chowdhury[2]

Abstract

The concept of blue economy recognises the seas and oceans as main drivers for economic development with great potential for innovation and growth. Bangladesh is blessed with approximately 700 km long coast with nearly 1,18,813 sq. km. of maritime area. Hence it is likely to emerge as an important maritime State. The maritime sector in this country has a huge potential to boost national economic growth and thereby harness the blue economy. To tap the benefits from this sector, among others, there is a need for developing maritime human resources. Competent maritime human resources are considered as the backbone of the blue economy and hence the national economic growth. As such Bangladesh needs to emphasise more on developing human resources in this sector through proper maritime education. Collaboration at national and international level in the area of maritime research and education may be given priority to mitigate the challenges militating against the national economic growth. Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh may play a key role in unlocking the potential of Maritime Education for enhanced national economic growth.

Keywords: Maritime Education, Economic Growth, Blue Economy.

Introduction

Traditionally, Bangladesh is a maritime nation. Her maritime history may be traced back thousands of years. Many nations in the past annexed in this part of Asia to flourish their trade and commerce as well as power. From time immemorial, inhabitants of this region depended on the Bay of Bengal for their livelihood. The scarcity of land resources and the advent of modern technology opened a new era of National Economic Growth (NEG), centred at the blue economy with maritime education as a driving force.

The father of the nation, Bangabandhu Sheikh Mujibur Rahman underscored the importance

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[1]*Dean, Faculty of Maritime Governance & Policy, Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh*

[2]*Lecturer, Department of Port and Shipping Management, Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh*

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of endless sea resources and enacted the 'Territorial Waters and Maritime Zones Act 1974' to establish Bangladesh's sovereign rights over the sea and its resources. Through the victory over the maritime boundary disputes with India (2014) and Myanmar (2012) under the dynamic leadership of Prime Minister Sheikh Hasina plots have been set up for rapid NEG through effective maritime education.

The term maritime means a large sunshade over the international and inland commercial, naval and fishing fleet; maritime administration, consultancy, education and training; port and shipping operations, trade, ship-building, marine environment conservation, sub-sea extraction, ocean research and so on (Chowdhury, 2010). The human civilisation's dependence and attachment to oceans, seas and rivers are so spontaneous that it yields a feeling that world means water: blue planet; anyone directly or indirectly attached to it is a maritime human.

The vast sea area of Bangladesh has huge economic potential. There is no alternative to unlock these potentials for the NEG of the country. To accomplish this task, we need to master the knowledge about the protection, preservation, exploration and extraction of the oceanic resources.

Efforts of maritime human resource development have always been an issue for the government of Bangladesh. Seaman's Training Centre (STC) is one of the first known formal educational institutes primarily dedicated to developing seafarers for the nation (ADB, 1995). In due course of time numbers of institutes and research centres have been established. But none of them was fully maritime in nature and failed to encompass the maritime domain as a whole. To fill up this gap Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh (BSMRMU) was established in 2013 with a mission to be the centre of excellence in maritime education (ME).

With this backdrop, the aim of this paper is to examine the potentials of maritime education (ME) in augmenting the national economic growth (NEG) through analysing its problems and prospects and put forward some recommendations. After a short introduction and conceptual discourse, the paper highlights an overview of NEG and ME in Bangladesh, examines challenges and prospects of ME for enhanced NEG, finally the paper highlights the role of BSMRMU and puts forward some recommendations.

Conceptual Discourse

The maritime education (ME) is a process of knowing maritime affairs from the sea job to shore shipping management, way forward to the legal, logistics, transport and supply chain management (Hussain, 2014). Chowdhury defined ME as a set of interdependent processes such as teaching, learning, researching and resources that function harmoniously to achieve specified educational objectives. ME programmes prepare human resources for a variety of careers in the maritime industrial and service sectors.

NEG is usually brought about by technological innovation and positive external forces. Technological innovation is the outcome of sound education, training and research.

Three foundations for human development (Figure-1) are to live a healthy and creative life,

to be knowledgeable, and to have access to resources needed for a decent standard of living (Economic Intelligence Unit, 2015). Human development aims at directly enhancing human abilities through infusing knowledge among others. Education is the more formal and recognised method of infusing knowledge that leads to a long and healthy life and a decent standard of living thus contribute significantly to NEG.

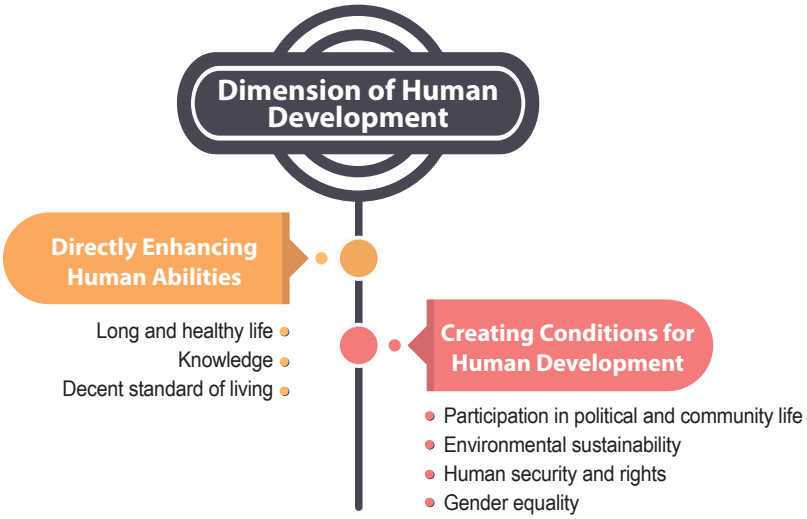

Figure-1: Dimension of Human Development

To the extent that greater freedom and capabilities improve economic performance, human development has an important effect on growth. Similarly, to the extent that increased incomes, increases the range of choices and capabilities enjoyed by households and governments, economic growth enhances human development. Hence education has a direct relationship with NEG (UNCTAD, 2014). The same is true in the case of ME.

Overview of Economic Growth and Maritime Education in Bangladesh

In the last decade, Bangladesh has recorded NEG rates above 5% mainly due to the development of microcredit and garment industry. The market-based economy of Bangladesh is the 46th largest in the world in nominal terms, and 33rd largest by purchasing power parity; it is classified among the next eleven emerging market economies and a frontier market. According to the IMF, Bangladesh's economy was the second fastest growing major economy of 2016, with a rate of 7.1%. Figure-2 shows the national economic growth of Bangladesh from 2007 to 2016.

Since 2004, Bangladesh averaged a NEG of 6.5%, that has been largely driven by its exports of readymade garments, remittances and the domestic agricultural sector. The country has also pursued export-oriented industrialisation and developed self-sufficient industries in pharmaceuticals, steel and food processing. Bangladesh's telecommunication industry has witnessed rapid growth over the years. However, though ocean as a common heritage of humankind, represent in many respects the final frontier for humanity and its quest for

sustainable development. Bangladesh is yet to explore the potential of oceanic resources to the full extent.

The ocean economy has emerged as a significant potential driver of sustainable economic growth in different parts of the world. China's ocean economy contributed 10% of GDP, in 2014, employing 9 million people (World Ocean Review, 2015). The US valued its ocean economy at 1.8% of GDP in 2010. Estimates for Indonesia are about 20% of GDP, a similar

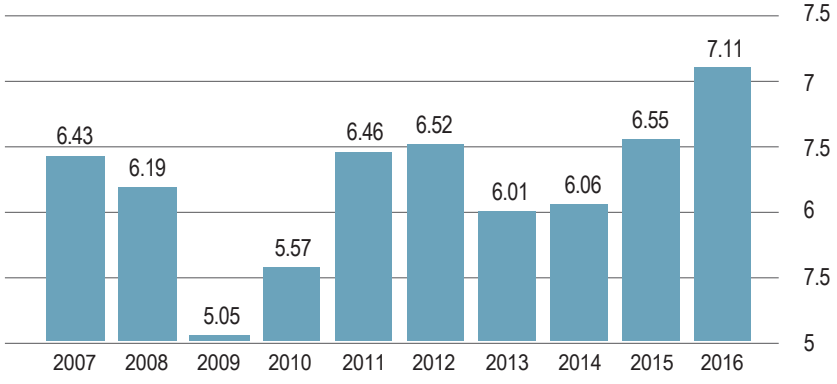

Figure-2: National Economic Growth of Bangladesh (2007-2016)

ratio could be found in other low-middle-income countries with large ocean territories. Unfortunately, in such a mighty industry, the position of Bangladesh is really small. The port sector is doing good. In capturing and culturing fishes, the position of Bangladesh in the world was 4th and 5th respectively in 2012; however, it is the figure of inland water only. In the case of sea fishing, the position is still very insignificant. Fossil fuel exploration is also not up to the mark though it has been discussed long that the Bay of Bengal is a huge source of natural resources.

In Bangladesh, the ocean economy issue has come into the discussion just after the settlement of maritime boundary delimitation dispute with Myanmar and India. This settlement awarded the country a territorial sea covering about 118,000 square kilometres and an Exclusive Economic Zone extending out to 200 nautical miles (Alam, 2014). Exploration of marine resources in this new settled maritime area offers Bangladesh the opportunity to utilise marine resources effectively for sustainable NEG. This warrants a bunch of competent maritime professional in diverse fields.

Till recent past, Bangladesh perceived seafarer as the only maritime professional which hindered the development of multi-skill maritime professional (Kabir, 2014). A close look into the component of ocean economy indicates that the diversity of maritime profession includes legal practitioners, environmentalists, mariners, engineers, oceanographers, hydrographers, researchers, academicians and many more.

Table-1 indicates that the main activities of the ocean economy are harvesting living resources, extraction of non-living resources and commerce and trade. Among these activities other than fishing to some extent, shipping and port services, Bangladesh lacks everywhere mainly due to inadequate ME.

Table-1: Component of Ocean Economy

Activities	Ocean Service	Existing Industries	Emerging Industries	Drivers
Harvesting living resources	Seafood	Fisheries	Aquaculture	Food security
	Marine biotechnology		Pharmaceutical chemicals	Health care
Extraction of non-living resources	Minerals	Seabed mining	Deep seabed mining	Mineral
	Energy	Oil and gas	Renewable	Green energy
	Freshwater		Desalination	Freshwater
Commerce and Trade	Maritime transport	Shipping		Seaborne trade
		Port services		
	Tourism	Tourism	Eco-tourism	Global tourism

Nevertheless, the ME in Bangladesh started in 1952 through the establishment of National Maritime Institute (NMI). It is one of the most modern institutes of "IMO white listed institute" in Bangladesh. It conducts pre-sea training for the ships' ratings. Seafarers produced by NMI earn huge foreign currency and thus contribute significantly to NEG. On the other hand, Bangladesh Marine Academy (BMA) (1962), conducts pre-sea training for the seafarer in nautical and engineering discipline. Presently, BMA conducts 4 years' Bachelor of Maritime Science programme under the umbrella of BSMRMU (Alamgir, 2017). Administrative control of BMA is vested with Ministry of Shipping while academic affiliation is with BSMRMU. The Government has also approved four more marine academies yet to start their function. In addition, there are 18 private marine academies in Bangladesh. However, at present only 4/5 academies are in operation now. These academies very often fail to maintain standard education.

Bangladesh Marine Fishery Academy (1973) aims to create skilled manpower for judicious exploitation and harvesting of marine fisheries resources. Since its inception academy is exploring and pooling the seafaring talents of the country and is training them to become a navigator, engineer and fish processing technologist.

The Bangladesh Navy (BN) Hydrographic and Oceanographic Centre conducts two types of courses: Basic Hydrographic and Survey Recorder. These courses are designed for navy personnel only. Besides, BN also trains personnel in coastal security, navigation, engineering,

naval warfare and logistics management and thus contribute to ME in Bangladesh.

Bangladesh University of Engineering and Technology and Military Institute of Science and Technology conduct undergraduate and postgraduate programmes on Naval Architecture and Marine Engineering. These programmes are designed to produce human resources to contribute various maritime sectors especially shipbuilding industries. Dhaka University started the postgraduate programme in Oceanography in 2013. Patuakhali, Noakhali and Shah Jalal University of Science and Technology have also introduced courses on Oceanography. The University of Chittagong, conducts undergraduate and postgraduate programmes on Marine Science and related disciplines.

BSMRMU only specialised university in the maritime field presently conducts five master programmes and three undergraduate programmes. With a motto "We strive for Maritime Excellence" the university is designed to have seven faculties, 38 departments and four institutes under her umbrella. Within its short span of a journey, the university has established collaboration with a number of universities and organisations both at home and abroad. As a young member, the university is facing challenges in finding qualified faculties.

On the vocational side, Bangladesh Institute of Marine Technology educates and trains the technicians for shipbuilding and repair industries. The institute conducts four years' diploma courses in Marine and Shipbuilding Technology. They also conduct two years' trade courses on marine diesel, fabrication, shipbuilding, welding and mechanical draftsman. Port Authorities of Bangladesh and Bangladesh Inland Water Transport Authority (BIWTA) also conducts some in-house courses pertaining to the maritime field.

Challenges of Militating against ME and NEG in Bangladesh

Lack of Synergy between ME Institutes: The main institutes responsible for ME in Bangladesh are BSMRMU, BMA and BMFA. Administrative controls of these three institutes are vested with three ministries. The BMA is loosely connected with BSMRMU. The plan to collaborate BMFA with BSMRMU is under consideration. As such, there exists a lack of synergy between them. This lack of synergy poses a great challenge for effective ME in Bangladesh and deaccelerate the NEG. The absence of separate ministry for maritime affairs has augmented the problems further.

Maritime Domain Blindness: Though the father of the nation Bangabandhu Sheikh Mujibur Rahman realised the importance of maritime domain as early as 1974, after his assassination till 1990, policymakers remained totally blind to this area. As such sea in particular and maritime domain, in general, did not get due attention. However, the present government of Sheikh Hasina attached paramount importance to maritime affairs. But most of the policymakers are still maritime domain blind. As such maritime awareness drive by BN often fails to obtain the desired result. Moreover, the sea blindness of general mass very often discourages ME and poses challenges against NEG.

The Absence of Central Controlling Body: Till now there is no single controlling body for MET in Bangladesh. To bring all maritime educationists to a common platform, Government of India established Indian Institute of Maritime Studies on 6th June 2002 placing four

government-run maritime institutions within the domain of this institute. In 2008 Indian Maritime University was set up as central university intended to play a key role in the development of trained human resource for the maritime sector. This impacted positively on ME and NEG in India. The absence of a centre controlling body is thus a great challenge militating against unlocking the potential of ME for NEG in Bangladesh.

Shortage of Qualified Faculties: The blue economy agenda includes maritime education in tertiary level. One of the visual outputs of this drive is the establishment of BSMRMU. However, due to the shortage of qualified faculties, it is suffering difficulties to run the programmes. Due to policy restrictions, BSMRMU is unable to offer an attractive entry-level compensation package for qualified teachers and trainers. Therefore, it faces difficulties to enrol qualified faculty members at these initial phases of the establishment. Shortage of qualified faculties is detrimental to the sustainability of ME and NEG in Bangladesh.

Insufficient Capacity of National Fleet: Seafarers are normally expected to complete the shipboard training on-board ships of their own national carrier. At present Bangladesh Shipping Corporation has only 5 vessels and in the process of procuring 6 more. In addition, the private sector in Bangladesh currently owns a total of 54 ocean-going merchant ships. In all these ships about 280 cadets can get their initial training on-board. Since 2013 about 700 to 800 cadets from both public and private marine academies require shipboard training per year on completion of their pre-sea training. Therefore, graduates from both private and public marine academies are facing serious problems to complete their sea training for employment. Moreover, BMA still has to acquire dedicated training ship. This causes an unnecessary delay for the seafarers to get job and nation is deprived of remittance decelerating the NEG.

Prospects of Maritime Education and National Economic Growth in Bangladesh

Victory Over Maritime Boundary Dispute with Myanmar and India: The victory has reaffirmed Bangladesh's legislative right over Exclusive Economic Zone (EEZ) and continental shelf and thus opened windows of opportunities for the exploration of sea resources. Two historical verdicts have established a legitimate right on about 1,18,813 square kilometres of territories at the sea. This undisputed sea area with two important neighbours is expected to generate international and regional cooperation in maritime economic activities. Enhanced international and regional cooperation in trade and resource development would foster maritime industries and offshore activities in Bangladesh. As the maritime industry and offshore activities advances, the required knowledge to cope with the demand also increases, thus ME has become a priority. The verdicts would act as a positive catalyst to convince the government for enhanced budget allocation to ME and could encourage enhanced capacity building in the maritime sector and contribute to the NEG.

The Establishment of BSMRMU: In accordance to its act, BSMRMU is mandated to provide undergraduate and post-graduate studies in all maritime disciplines including maritime strategy, maritime security, shipbuilding engineering, ocean science, maritime legislature etc. Additionally, it will award professional degrees along with vocational maritime diplomas and short courses, that would provide jobs for thousands on-board national and international flag carriers. The BSMRMU has bright prospects to act as a central

body for all levels of ME and as a coordinating body among maritime security organisations like BN, Bangladesh Coastguard, public and private universities, marine academies, institutions etc. (Azad, 2015). Thus BSMRMU is in a position to unlock the potentials of ME for enhanced NEG in Bangladesh.

The Establishment of Maritime Affairs Unit: After winning 118,813 sq. km territorial waters and an EEZ in international arbitrations over the past last few years, the government is now set to form a permanent MAU under MOFA to ensure their maintenance and proper use. This unit shows great prospects to become a full ministry to oversee the maritime activities including ME in Bangladesh and thus augment NEG.

Establishment of BORI: Linkage between academic institutes, research centres and industries is prerequisite for sustainable NEG. This linkage is mostly absent in the maritime domain. BORI can establish the missing linkage and enhance research in the maritime sectors. Thus, the establishment of BORI shows a great prospect for the ME in Bangladesh. This in turn likely to contribute significantly to overall blue economy initiatives of the present democratic government and enhance NEG of Bangladesh.

Strategy to Mitigate the Challenges Militating against ME for NEG of Bangladesh

Establishment of Separate Ministry for Maritime Affairs: Synergy plays a vital role in optimising the efforts of different stakeholders and controlling agencies. Presently the ME is being controlled by the ministry of education, the ministry of shipping, the ministry of fishery & livestock, the ministry of science & technology and to some extent ministry of defence. This hindered ME over years. Very often requirements of different ministries are conflicting. Establishment of a separate ministry would foster ME and enhance NEG.

Acceleration of Maritime Domain Awareness Drive: The maritime domain awareness is defined by IMO as the effective understanding of anything associated with the maritime domain that could impact the security, safety, economy, or environment. Achieving awareness requires that what is seen is properly understood and that visibility and understanding are shared as widely as possible among members of the maritime community. The inclusion of maritime studies in secondary and higher secondary level could enrich the maritime knowledge and unlock the potential of ME for sustainable NEG.

Declaring BSMRMU as Central Body for MET: The cohesion among the universities, academies, institutes offering the course and carry out researches in maritime field is a precondition for effective ME. It could otherwise be better to merge all existing maritime educational and research institutes together to form a single entity like India. However, in the present context, declaring BSMRMU as the central body of MET could foster ME and enhance NEG in Bangladesh.

Introduction of Special Package for Faculties of BSMRMU: The role of competent faculties in any universities need no elaborations. The two-fold problem has been observed in enrolling faculties in BSMRMU: the unwillingness of senior faculties of public universities and government policy for appointment of faculties in respect of experience and pay scale. Introduction of special package for the BSMRMU faculties could attract experienced teacher

both from home and abroad and thus contribute towards the enhancement of ME and NEG in Bangladesh.

Acquisition of Training Ship by BMA: A dedicated training ship could ensure timely completion of sea time for seafarer and foster maritime research. Most of the Maritime Universities like Shanghai Maritime University has dedicated training ship. This has reduced the waiting time for a seafarer to a great extent and ensured the quality of education. The acquisition of a dedicated training ship by BMA could unlock the potential of ME and augment NEG in Bangladesh.

Role of Bangabandhu Sheikh Mujibur Rahman Maritime University

Major Driver of Economic Growth: The role of education as a major driver of economic growth is well established. This role has further been enhanced due to changes in technology, globalisation and demographic impact. To remain competitive in light of these changes, Bangladesh needs to improve productivity and adopt innovative spirit. Higher educational institutes have the capacity, knowledge, and research necessary to achieve these goals. BSMRMU can play this vital role and unlock the potential of ME for enhanced NEG in Bangladesh.

Visible Leadership: Worldwide higher education has historically included economic growth as a part of its core mission. In this respect, BSMRMU may provide strong and visible leadership designed to create quality workforce by growing, training and attracting the finest talent that can support existing maritime business and industry. It can also disseminate research and promote technology transfer in the maritime field through active roles in national, regional and international initiatives.

Economic and Social Research: Research and application-based technology are needed to create sustainable economic growth. BSMRMU may conduct economic and social research and enhance NEG of Bangladesh. Through facilitating technology transfer of basic and applied research BSMRMU may contribute to the commercialisation of the new improved product and even creating new maritime industries and thus enhance NEG.

Services to Stakeholders: The BSMRMU can be valuable to stakeholders by identifying employee skills gaps and providing customised training, technical assistance, customised research and data, conference and meeting facilities among others.

Policy Formulation: The importance of think tank in any fields are recognised worldwide for formulating policy guidelines for enhancement of NEG. BSMRMU may launch a nationwide talent hunt to constitute a ‘maritime think-tank’ and form a national forum with maritime experts, administrators, professional bodies, stakeholders, NGOs, professors, scientists, researchers, environmentalists, journalists and others relevant to the sector to formulate a maritime policy and planning concept on national perspective and ocean economy.

Sustainable Development Goal: Sustainable Development Goal (SDG) 14 underscored the importance of data collection in maritime fields to achieve targets of 2030 agenda. The BSMRMU is well placed to initiate measures to carry out study, fact-finding, consultation, information and data collection, analysis, research to identify potentials and opportunities

along with the risk and threats of the prevention, protection, exploitation and exploration of maritime resources.

Maritime Domain Awareness Drive: Maritime Domain Awareness (MDA) is the key for successful implementation of any economic drive centred at ocean economy. BSMRMU may conduct training, seminars, symposium, and workshop to impart necessary training, education and knowledge relevant to maritime policy, planning and governance to the personals involved with the sector to bring them to a common platform.

Conclusion and Recommendations

Well-trained, skilled and educated human resources are the driving force of the development of an economy, who can participate in the globalisation of business and the accompanying technological revolution. Dynamic and sustainable development is not possible without a skilled workforce. Having assessed the need of world market and local industry, it is found that appropriate ME is essential for sustainable NEG.

A large eligible population places Bangladesh in a suitable position to produce skilled human resources in almost any sector imaginable. A thrust in blue economic growth may come from a large army of skilled coastal and offshore engineers, navigators, merchant mariners, fisheries technologists, biotechnologists, legal experts etc. and in a variety of other professions.

Bangladesh has enormous potential for seafaring job opportunities from its private and public marine academies provided it can arrange on-board practical training facilities for its would be seafarer and also can remain in the white list following The International Convention on Standards of Training, Certification and Watch-keeping for Seafarers (STCW)-95 as amended in 2010. Nevertheless, exploration and exploitation of vast sea resources show a promising future for maritime legal experts, offshore and ocean engineers as well as maritime logisticians. A unified centrally controlled ME can unlock its potential and contribute to NEG of Bangladesh.

Being the only specialised university in maritime field BSMRMU may vital role in unlocking the potentials of ME for enhanced NEG through providing visible leadership to create a quality workforce, carrying out economic and social research in the maritime field. It can also promote maritime domain awareness (MDA), launch maritime talent hunt programme and effectively contribute to attaining sustainable development goals (SDG)-14.

It is recommended that,

a. A separate ministry for maritime affairs may be established.

b. The BSMRMU may be declared as the central body for ME in Bangladesh.

c. The BMA may pursue to acquire dedicated training ship.

d. The attractive entry-level compensation package for faculties for BSMRMU may be introduced.

e. Maritime studies may be included in secondary and higher secondary levels.

f. The BSMRMU may pursue the role as discussed.

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Georesource Potential and Geohazard Status of the Bay of Bengal vis-à-vis Sustainable Development of 'Blue Economy'

Aftab Alam Khan[1]

Abstract

Formation of the Bay of Bengal is linked to the opening of the Indian Ocean and covers an entire off-shore region of Bangladesh wherein the geological processes and tectonic activities in the Bengal Basin have greatly influenced in enriching the Bay of Bengal. Spreading and creation of new seafloor of the Bay of Bengal have continued with the Indian plate motion to the north and northeast. Hence, the Bay of Bengal has been enriched with georesources. 'Blue Economy' is a concept that can significantly contribute to the socio-economic development of the nations situated around the oceans and seas. However, the sustainability of 'Blue Economy' greatly depends on the proper assessment and utilisation of the marine georesources. It is equally important to evaluate the geological hazards of the seas and oceans around the coastal countries in order to better safeguard the development of 'Blue Economy'. Although Bangladesh is situated along the coast of northern Bay of Bengal having the largest continental shelf and the longest deep-sea fan within its legal exclusive economic zone (EEZ), it is the least studied and explored bay in the region that demands much greater attention. The present study is an effort to focus on to the possible geological resources like oil, gas and mineral potentials of the Bay of Bengal within EEZ of Bangladesh. Geological hazards like earthquake, tsunami and other ocean-related geological hazards have also been identified and their probable impact has been assessed for proper planning of development of a sustainable 'Blue Economy'.

Key Words: Georesources, Geohazards, Blue Economy, Bay of Bengal, Bangladesh.

Introduction

The Bay of Bengal, large but relatively shallow embayment of the north-eastern Indian Ocean, occupying an area of about 2,173,000 sq. km. It lies roughly between latitudes 5°N and 22°N and longitudes 80°E and 100°E (Fig. 1). It is bordered by Sri Lanka and India to the west, Bangladesh to the north, and Myanmar (Burma) and the northern part of the Malay Peninsula to the east. According to the definition of the International Hydrographic Bureau, the southern boundary extends from Dondra Head at the southern end of Sri Lanka in the west to the northern tip of the Indonesian island of Sumatra in the east. The bay is about 1,600 km

[1]*Professor, Department of Oceanography and Hydrography, Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh*

wide, with an average depth of more than 2,600 metres. The maximum depth of water reaches to about 4,694 metres at the southern part of the bay (Morgen et al., 2009).

The Bay of Bengal is bordered to the north by a wide continental shelf having water depths ranging between 20m to 200m that narrows to the south and by slopes of varying gradient on the northwest, north, and northeast, all cut by canyons from the rivers. The deep floor of the bay is occupied by a vast abyssal (deep-sea) plain that slopes to the south. The offshore region of Bangladesh that occupy 63,000 sq. km area in waters shallower than 200 m is a southward extension of the Bengal Basin in the Bay of Bengal. The maritime boundary of Bangladesh covers mostly the central part of the northern Bay of Bengal up to approximately 18^{o}N latitude (Fig. 2; Burke, 2014).

The Bay of Bengal is a northern extended arm of the Indian ocean. Bengal Deep-Sea Fan, the largest deep-sea fan in the world and Swatch of No-ground, a deep-sea canyon (Fig. 3) located at the head of the Bay of Bengal are the two main geological features intrinsically related to the present context of the Bay of Bengal (Rogers et al., 2015). Bengal fan is attributed to the deposition of about 4 km thick sediments derived from the Himalaya Range and transported to the Bay of Bengal by the Ganges-Brahmaputra river system forming one of the largest deltas of prograding nature in the continental shelf of Bangladesh. The continental shelf of Bangladesh extends to about 200 km. Swatch of No Ground, on the other hand, is a tectonic element that marks the line of crustal break coinciding with 'down to the basin faults' in the region. Sediments derived from the Himalaya are continuously being supplied to the deep-sea fan through the Swatch of No Ground forming fan turbidites. The

Figure 1: Map illustrates the line depicting the outer limits of the continental shelf of Bangladesh overlying on a gridded bathymetric of the northern Bay of Bengal (Source: https://www.google.com).

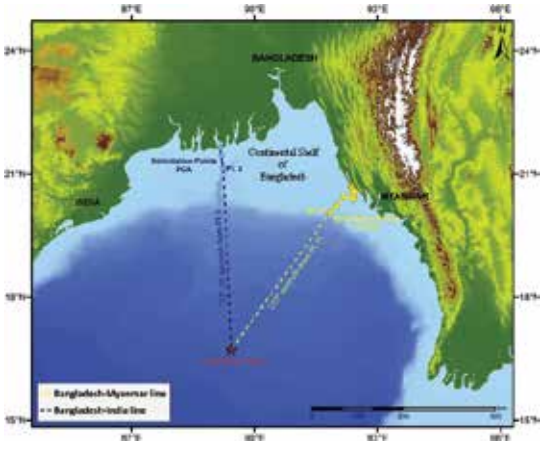

Figure 2: Maritime boundary of Bangladesh declared by UNCLOS covers a large area in the Bay of Bengal (Source: Redrawn from Burke, 2014).

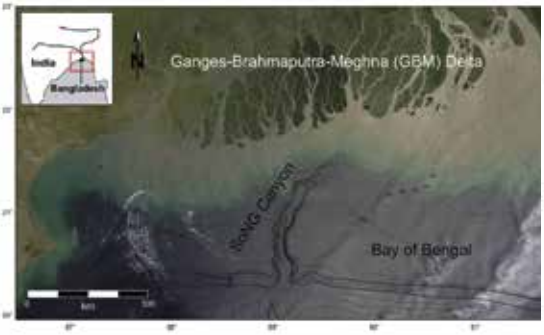

Figure 3: MODIS image of the northern Bay of Bengal and bathymetry illustrating the proximity of the Swatch of No Ground canyon head to shore and to the subaqueous Ganges–Brahmaputra-Meghna delta. The clinoform topset–foreset rollover coincides with the seaward limit of the turbid water in the image (Source: Rogers et al., 2015).

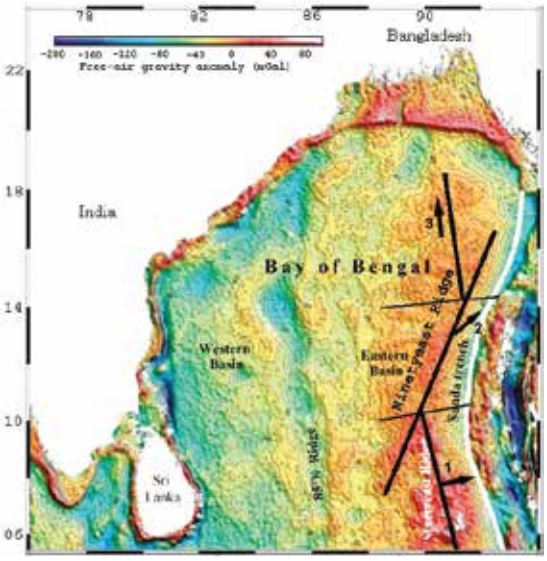

Figure 4: Free air gravity anomaly map of the Bay of Bengal. Two striking features are the gravity responses of the N-S trending buried 85°E and Ninety East Ridges. The buried 85°E Ridge has a negative gravity anomaly with a steep gradient at its eastern edge. The steep gradient is often characteristic of fracture zones. Arrows indicate motions and subduction directions of the crustal segments in the Bay of Bengal (Modified from Talwani et al., 2016).

"Swatch of No Ground" canyon in the Bay of Bengal is a shelf-incising submarine canyon that is actively aggrading in its upper reaches despite regular gravity-driven transport and mass wasting. Although the canyon lies 150 km down drift of its main sediment source, the Ganges–Brahmaputra–Meghna (GBM) river mouth, high sedimentation rates are sustained by both progradation of the subaqueous delta into the canyon head and the conveyance of shelf-generated hyperpycnal flows to the canyon floor (Rogers et al., 2015). Hyperpycnal flow is produced when the density of the river water entering the ocean basin is greater than the density of the standing water in the ocean basin.

Formation of the Bay of Bengal

Formation of the Bay of Bengal is intimately related to the early opening of the Eastern Indian Ocean. Norton and Sclater (1979) have first described the overall evolution of the Indian Ocean, but the evolutionary history of the Bay of Bengal has not yet been unravelled. Talwani et al (2016) have given an elaborate explanation on the opening / spreading of the crust of the Bay of Bengal based on the series of magnetic anomalies in the Western Basin of the Bay of Bengal (Fig. 4) which is correlated with conjugate magnetic anomaly in the western Enderby

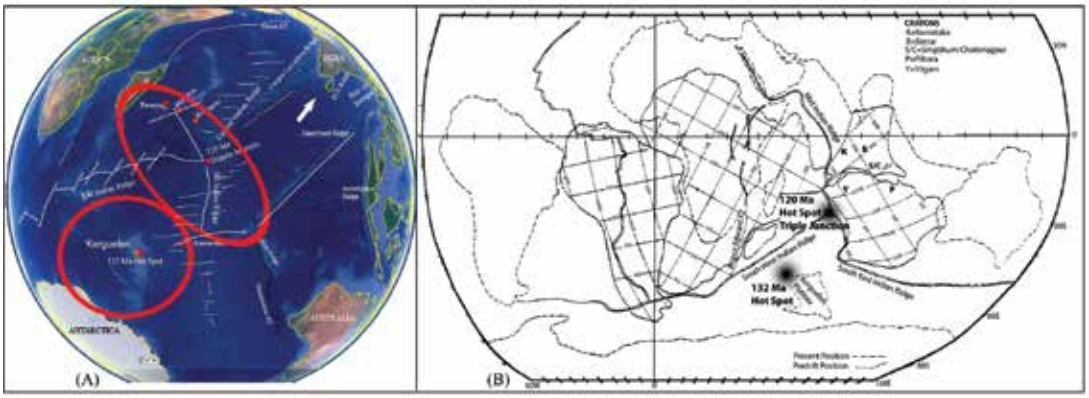

Figure 5: Reconstruction of Gondwanaland. (A) Mega hot spot (mantle plume) at the higher latitude (50^{O}S) of the Southern Ocean around Kerguelen Plateau have been evolved 132 million years ago that helped for the initial separation between Antarctica and India. Hot spot jump from 132 Ma to 120 Ma is evident. (B) Present position of the triple junction (a meeting point of Mid Indian Ridge, SW Indian Ridge and SE Indian Ridge) in the Indian Ocean exhibiting a shift of Kerguelen Hot Spot from an earlier position (132 Ma) to present position (120 Ma). Geological age of 120 million years and the affinity for magma from Kerguelen mantle plume source of both Sylhet and Rajmahal volcanics in the Bengal Basin suggest that these two volcanics were erupted when they were located with the Indian Plate at the position marked by "120 Ma Hot Spot Triple Junction". (after Khan, 1998).

Basin, located off of East Antarctica. This evidence strongly supports that the Western Basin of the Bay of Bengal and western Enderby Basin were together back in 132 million years ago wherein age has been determined from magnetic anomaly number. The present geographic positions of the Western Basin of the Bay of Bengal and the western Enderby Basin strongly support their association back in 132 (Ma) and thereby were separated and drifted from each other due to the seafloor spreading started first in the Indian Ocean.

Since, in general seafloor spreading starts from a triple junction due to the evolving of a hot spot (a mantle plume), it is confidently interpreted that a mega hot spot (mantle plume) in the higher latitudes around 50^{O}S of the Southern Ocean around Kerguelen Plateau must have been evolved 132 million years ago that helped for the initial separation between Antarctica and India (Fig. 5A). However, the present position of the triple junction (a meeting point of Mid Indian Ridge, SW Indian Ridge and SE Indian Ridge) in the Indian Ocean exhibits a definite shift from an earlier one suggesting a jump off the hot spot which is a part of the Kerguelen hot spot (Fig. 5B). Geological age of 120 million years and the affinity for magma from Kerguelen mantle plume source of both Sylhet and Rajmahal volcanics suggest that these two volcanics have erupted when they were located with the Indian Plate at the position marked by "120 Ma Hot Spot Triple Junction" (Khan, 1998; Fig. 5B). Hence an initial opening between 132 Ma and 120 Ma, Indian Ocean floor (oceanic crust) was spreading at a rate between 22 to 30 cm/yr which, in a geological sense, is "Hot Spot Jump". Since then Indian Plate has moved north until it is collided with Eurasia sometime around 55 million years back in the Eocene forming gigantic trans-Himalayan mountain belt. Hence, the Bay of

Figure 6: Magnetic anomaly pattern in the Indian Ocean showing direction of motion of the Indian Plate from triple junction. Dotted lines are the fracture zones with differential movements evident from the shift in the magnetic anomaly numbers. Present crustal motion in the Bay of Bengal is approximately 4-5 cm/yr. (Source: Schlich, 1975).

Bengal has opened-up and enlarged along with the northward motion of the Indian Plate between 120 Ma and 55 Ma at a rate of about 6 cm/yr. Present crustal motion due to the convergence of the oceanic crust in the Bay of Bengal with the Burma microplate is measured to be ~2 cm/yr based on satellite GPS (Steckler et al., 2008). It is inferred that the present crustal motion in the Bay of Bengal is being accommodated for isostatic balancing in the Himalayan orogenic belt and the Bengal Basin. Figure 6 demonstrates magnetic anomaly number in the Indian Ocean with increasing values to the north indicating progressively older crust in the Bay of Bengal to the north from the triple junction of the ridge-ridge-ridge setting of the Indian Ocean. Northward motion of the crust in the Bay of Bengal largely controlled by the Ninety East Ridge which is a mega transform fault, forming several longitudinal shear fractures those show a distinct shift in the magnetic anomaly numbers (Schlich, 1975).

Geological Features of the Bay of Bengal

The continental shelf of Bangladesh offshore is the extension of the Bengal Basin that has evolved largely over the remnant-ocean basin (Graham et al., 1975). The Bay of Bengal is characterised by the geological features those formed principally by the tectonic activities including volcanic and sedimentological processes. Tectonic activities for seafloor spreading started when Gondwanaland broke apart and the continental fragments started drifting. New ocean (mesoTethys) began to form with the emergence of the Indian Ocean about 200 Ma back in the Permo-Triassic period (Metcalfe, 2011). Upwelling of magma forming mantle

plume around Kerguelen Plateau is the main source of all the tectonic activities in the region. The crust of the Gondwanaland eventually had undergone melting, doming, thinning, rifting and finally drifting that initiated seafloor spreading of the Indian Ocean. Seafloor spreading due to the drifting of the crust of the Gondwanaland progressed with the formation of Ninety East Ridge transform and 85oE Ridge transform, both acted as the principal driving lines for the Indian Plate motion (Fig. 4). Crustal segmentation occurred due to the differential motion of the Indian Plate and its variable collision mechanism with the Eurasian plate wherein the southern segment (marked 1 in figure 4) subducted more vertically below the Sunda Trench, central segment (marked 2 in figure 4) subducted obliquely below the Andaman Trench, and northern segment (marked 3 in figure 4)moved dominantly horizontal with major strike-slip component and insignificant thrust component. Hence, crustal segment 3 of the Bay of Bengal is in the state of pull-apart stress component that largely accommodates subsidence bounded by normal faults. Evidence of normal fault and strike-slip fault are derived from the fault plane/focal mechanism solutions and several surface features (Khan and Chouhan, 1996). The oblique convergence and the anti-clockwise rotation of the Indian plate with that of clockwise rotation of Burma plate have resulted in crustal segmentation of the converging plate having a right-slip component to compensate the plate rotation. Further, clockwise rotation and component of convergence of Burmese microplate with respect to Indian Plate can induce vertical derivative of the compressive force which helped in developing younger structures in the segment 3 of the Bay of Bengal. Crustal segmentation also developed several linear mega fractures longitudinally parallel to the Ninety East Ridge and 85^{o}E Ridge. These fractures are extended in the Bay of Bengal associated with the northward shift of the magnetic anomaly numbers (Fig. 6). On the other hand, 85^{o}E Ridge has separated Bay of Bengal into two distinct geologic domains viz., Western Basin and Eastern Basin (Talwani et al., 2016). Free-air gravity anomaly map of the Bay of Bengal (Fig. 4) characterises Western Basin with large negative gravity values suggesting subsided crustal blocks where sediments of greater thickness were deposited. While positive gravity values in the Eastern Basin are due to the high-density materials those must have erupted through the Ninety East Ridge resulting in the elevated crust and less sediments thickness associated with the Ninety East Ridge. The 85^{o}E Ridge is extended from Mahanadi Basin of the eastern margin of India up to the Afanasy Nikitin Seamount in the Central Indian Basin. The ridge is associated with two contrasting gravity anomalies: negative anomaly over the north part (up to 5^{o}N latitude), where the ridge structure is buried under thick Bengal Fan sediments and positive anomaly over the south part, where the structure is intermittently exposed above the seafloor. The ridge is buried by approximately 3 km thick Bengal Fan sediments on its crestal region and about 8 km thick pre- and post-collision sediments on the flanks (Sreejith et al., 2011).

Sedimentation in the Bay of Bengal

Himalaya orogenic belt is the main sediment source for the largest Bengal delta and Bengal deep-sea fan, while, the Ganges and Brahmaputra Rivers drain all the fore-slope and back-slope of the Himalayas. These rivers discharge about 1×10^{9} t / yr of sediment with an appreciable bedload component for the Brahmaputra (Milliman and Syvitski, 1992). River deltas are the main gateway for terrigenous sediment flux to the oceans during transgression

or highstands of the sea level when much river-borne material is trapped at the margin to form thick sediment sequences. The Ganges-Brahmaputra delta is situated in Bangladesh covering the majority of the Bengal Basin which lies in front of the Himalayan foredeep. Since at least the Miocene time (23 Ma), deltaic sediments have prograded from a northeast along undefined tectonic trend paralleling basin-margin fault line accumulating 4 km-thick deposits adjacent to the basin-margin fault zone and increasing to >10 km toward the modern shelf break (Lindsay et al., 1991). About 5×10^5 km^3 of sediment are contained within these deltaic deposits (Johnson, 1994). Beyond the shelf is the world's largest fan deposit, the Bengal Fan, covering 3×10^6 km^2 with a volume of ~1.25×10^7 km^3 (Curray, 1994). According to Goodbred (1999), 1500×10^9 m^3 of sediment fill has been sequestered within the flood plain and delta plain of Bangladesh. This value equates to 0.32×10^9 t/yr or about one-third of the estimated annual load. On the shelf, the subaqueous delta began to form approximately 7000 yr B.P., representing 0.42×10^9 t/yr of sediment storage. Together the flood-plain and subaqueous delta deposits account for ~75% of the estimated fluvial sediment discharge. About 25% of the load remains unaccounted for and apparently escapes the shelf through the Swatch of No Ground canyon. Allison (1998) quantified sediment aggradation between the shoreline and 50 m isobath (topset region) by using a geographic information system–based comparison of current and eighteenth-century British bathymetric charts and suggested that the recent load distribution is similar to the overall Holocene system (7000 Ma). Approximately 30% of the load is sequestered to the floodplains and ~40% is sequestered to the subaqueous delta. The remaining ~30% is presumed to reach the Swatch of No Ground (Kuehl et al., 1997) which is supported by rapid modern sediment accretion of greater than 50 cm/yr in the canyon head (Kudrass et al., 1998). The delta-front foresets are currently prograding seaward at a rate of 15 m/yr (Michels et al., 1998). The seaward progradation of delta front is also a measure of the emergence of new sandy beach in the coastal areas and evidence for relative sea level drop.

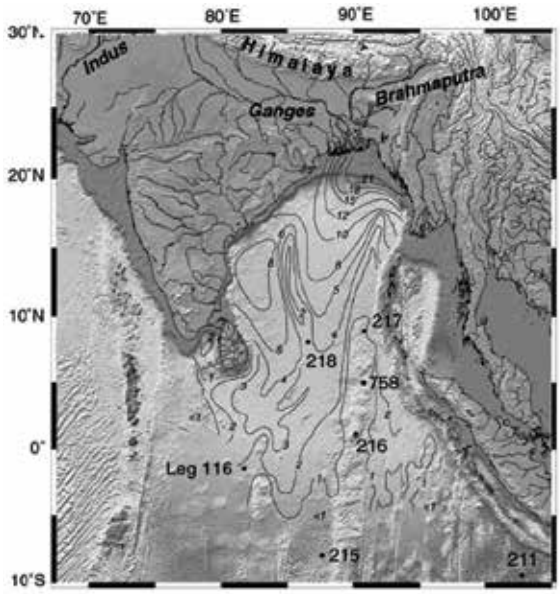

Figure 7: Map showing the position of the different DSDP and ODP Sites documenting the Bengal fan. They represent the total sedimentary and metasedimentary rocks above the oceanic crust, as interpreted from seismic reflection and refraction data. Isopach map of the sediments in the Bay of Bengal that shows maximum sedimentary fan thickness (~21 km) in the continental shelf of Bangladesh and minimum (~4 km) near DSDP 218 in the south. (Source: Curray, 1994).

The Bengal Fan covers the floor of all of the Bay of Bengal from the continental margin of Bangladesh along the west side of the Ninety East Ridge up to about 7˚S. The Bengal Fan was delineated and named by Curray and Moore (1971). Two reflecting seismic horizons pass into unconformities over the exposed and buried hills of folded sediments in the southern part of the fan and over the Ninety East Ridge. The ages of these unconformities were tentatively determined to be uppermost Miocene and upper Paleocene to middle Eocene by DSDP Leg 22 at Sites 218 and 217 respectively (Fig. 7).

Hence, the upper two sedimentary units of the Bengal Fan are associated with the upper Miocene unconformity. Based on the records of Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP), Curray (1994) has prepared an isopach map of the sediments in the Bay of Bengal (Fig. 7) that shows maximum sedimentary fan thickness (~21 km) in the continental shelf of Bangladesh and minimum (~4 km) near DSDP 218 in the south. Depositional processes in a sedimentary fan often reveal a high degree of complexity and lateral, vertical and temporal variability e.g. Amazon Fan (Flood et al., 1997), which limits the continuity of the sedimentary records and stratigraphic resolution. Sediment accumulation in the Bengal Fan is restricted to the currently active channel with a lateral extent of no more than 20-100 km. Maximum sedimentation rates are found on the flanks of the channel-levee system and on internal terraces. Piston coring to the base revealed an age of ~12,800 years and youngest sediment ages of 9700 years (Hübschera et al., 1997; Weber et al., 1997). This means that ~100 meters of sediment accumulated within ~3000 years, corresponding to average sedimentation rates of >30 m/ka in this locality. Figure 8 demonstrates (a) present topography and channel system of the Bengal Fan (redrawn after

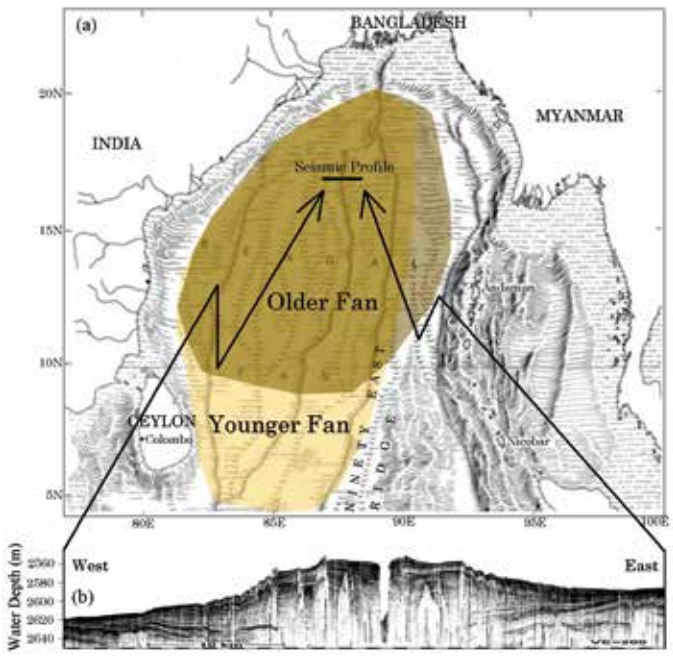

Figure 8: (a) Present topography and channel system of the Bengal Fan. Channel immediately west of Ninety East Ridge is being abandoned today. Extent of older and younger fan is envisaged (redrawn after Curray and Moore, 1974) and (b) segmented channel levee system from the Bengal Fan located at 16°50'N derived from high resolution multi-channel seismic survey (Source: Hübscher et al., 1997).

Curray and Moore, 1974) and (b) segmented channel-levee system from the Bengal Fan located at 16°50'N derived from high resolution multichannel seismic survey (Hübscher et al., 1997). Presumably, this material was deposited in a channel, which rapidly became buried when it was abandoned and a new main channel formed. Turbidites can be expected at the greater distance from the active channel due to the background sedimentation of eventual turbiditic activity. Dasgupta (2004) observed that the lower Bokabil Formation, an important hydrocarbon-bearing formation, exhibits complete Bouma sequence, en-echelon stacking of channels, frequent scouring, the dominance of positive megacycles and interchannel Tbcdturbidites often capped by muddy contourites, high sand-shale ratio and dominance of chaotic facies indicating deposition in a base-of slope to slope environment. The subsequent positions of the progressive sedimentation correlate well with the proto-Bengal fan (Alam, 1989) and the present day Bengal deep-sea fan (Curray and Moore, 1974; Graham et al., 1975).

The offshore stratigraphy is established based on the sedimentary sequence down to the depth of 4598m of BODC-1 well located 20.8^{o}N–91.9^{o}E, as upper and lower well-stratified successions of low energy environment having thickness 1500 m and 1200 m respectively, and about 1200 m thick intermediate sequence characterised by cross-bedding and channel sediments of high energy environment (Maroof Khan, 1980). The paleontologic evidence, primarily the pollen distribution, suggests that the boundary between upper and middle Miocene (base of Echtricolporitesspinosus) in Cox's Bazar well occurs at around 3000m depth (Simpson, 1976). Correlation of seismic sections of Shahbazpur, Sangu, and Kutubdia well sites demonstrate that the sequence characterised by deep-sea channelling during lowstand condition thicken towards Sangu and the same is missing towards Shahbazpur to the north indicate that the region between Kutubdia and Shahbazpur was elevated prior to Mio-Pliocene deep-sea channelling.

Georesources of the Bay of Bengal

Recovery of minerals from the sea bed and our knowledge of new sources of marine minerals like polymetallic nodules, cobalt-rich crust, polymetallic massive sulphides, have developed rapidly during recent decades. Commercial exploitation of solid marine minerals has so far been limited to deposits originating from mechanical and chemical erosion of rocks on continents and transported to the ocean primarily by the rivers. These are found in relatively shallow offshore areas of the territorial sea and the 200-nautical-mile exclusive economic zone. Minerals derived by mechanical erosion from continental rocks are concentrated as placer deposits those are sorted by water motion according to the varying density of the constituent minerals. These minerals contain heavy metallic elements such as barium, chromium, gold, iron, rare earth elements, tin, thorium, tungsten, zirconium, and non-metals like a diamond, lime, siliceous sand, gravel. Sands and gravel are being mined from beaches and shallow offshore accumulations at many sites around the world for construction material and beach restoration. These are the marine materials with the highest annual production value. Of the non-solid minerals beneath the sea, fossil fuel, natural gas and petroleum are being exploited in shallow and deep water. Among the most promising of new fuel sources are methyl hydrates, a mixture of natural gas and water compressed into a solid by the cold and high pressures of the deep ocean floor in undersea basins of the continental margins. The

continuous input of materials dissolved by chemical weathering from continental rocks and transported into the sea by rivers is considered adequate to meet future economic needs of several mineral types. One of these resources is phosphorite, which precipitates in the form of nodules and layers where seawater wells-up from the deep ocean at continental shelves within the belt of the trade winds between 30o latitudes in the north and south of the equator. Phosphorite is used as an agricultural fertiliser by adjacent coastal states. Land supply of phosphorite originally deposited beneath ancient seas fulfils present needs. Two metallic mineral resources of the deep seafloor incorporate dissolved metals from both continental and deep ocean sources. One of these consists of the golf-to-tennis ball-size polymetallic nodules of nickel, cobalt, iron and manganese in varying concentrations. These nodules precipitate from seawater over millions of years on sediment that forms the surface of the vast abyssal plains underlying the deep ocean of water depth 4 to 5 kilometres. Cobalt-rich ferromanganese crusts are the second of the two metallic mineral resources that incorporate metals from both land and sea sources. These precipitate from seawater as thin layers up to 25 centimetres thick on volcanic rocks of seamounts and submerged volcanic mountain ranges at water depths between 400 and 4,000 metres. The richest of these crusts lies within and beyond the exclusive economic zones of the island nations of the western Pacific. It is believed that one seabed mine site could provide up to 25% of the annual global market for cobalt used to make corrosion-resistant, light, strong metal alloys, and paints. In recent time, another important resource has been discovered from the ocean bottom, known as 'oil shale'. Oil shale is a fine-grained sedimentary rock containing organic matter from which shale oil may be produced. The organic matter, derived mainly from aquatic organisms, is called kerogen. Oil shale and tar sands are strategically important domestic energy sources that should be developed to reduce the nation's growing dependence on oil.

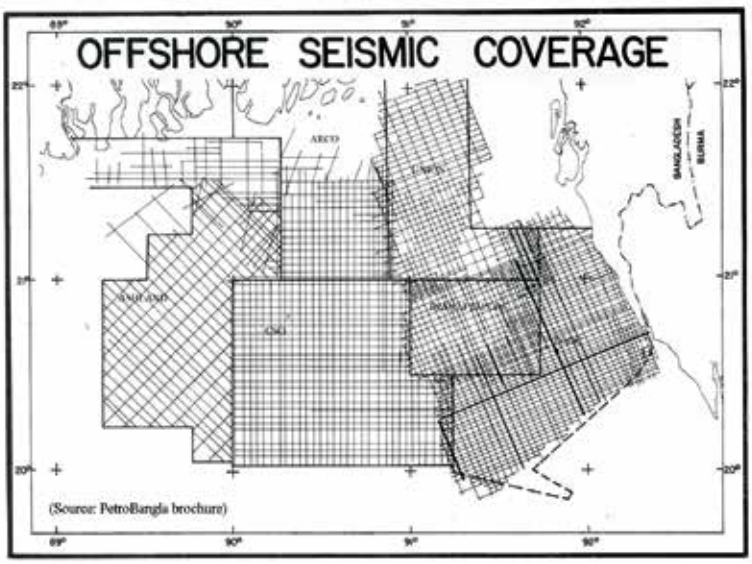

Figure 9: Area in the Bay of Bengal covered by 2D seismic survey by six international oil companies (Petrobangla, 2000).

Continental shelf of Bangladesh is the southward extension of the Bengal Basin which covers a large area of the exclusive economic zone in the Bay of Bengal (Fig. 2). Although the Bengal Basin has been proved to be a potential petroliferous basin, it is ironic that region within the maritime boundary of Bangladesh in the Bay of Bengal has remained as least studied and virgin area. Oil and gas exploration activities in the off-shore region of Bangladesh located between latitudes 20°N–22°N and longitudes 89°E – 92.5°E started in the year 1974 under Bangladesh Petroleum Act 1974 through the participation of six international oil companies such as Ashland, ARCO, CSO, Union, BODC and Ina Naftaplin (Fig. 9). Total coverage of multiple fold 2D seismic data was little over 31000 line-km along with approximately 18000 line-km gravity data (Petrobangla, 2000). Most of the 2D seismic data contain tremendous valuable geological information pertaining to the georesource potentials in the offshore area of Bangladesh. Hafiz (1997) made a geological study of the offshore area between latitudes 20°N-21°N and longitudes 90°E-92°E based on geophysical (seismic and gravity) data and found several prospective structures where hydrocarbon is likely to be trapped. Discovery of gas in Kutubdia and Sangu in the offshore strongly indicate the occurrence of hydrocarbon source rock and suitable structural traps in the continental shelf of Bay of Bengal. Trapping of hydrocarbon in the structures developed at 4-6 km depths is proposed. In addition, mud and sand-filled channels, incised valleys of intense channelling,

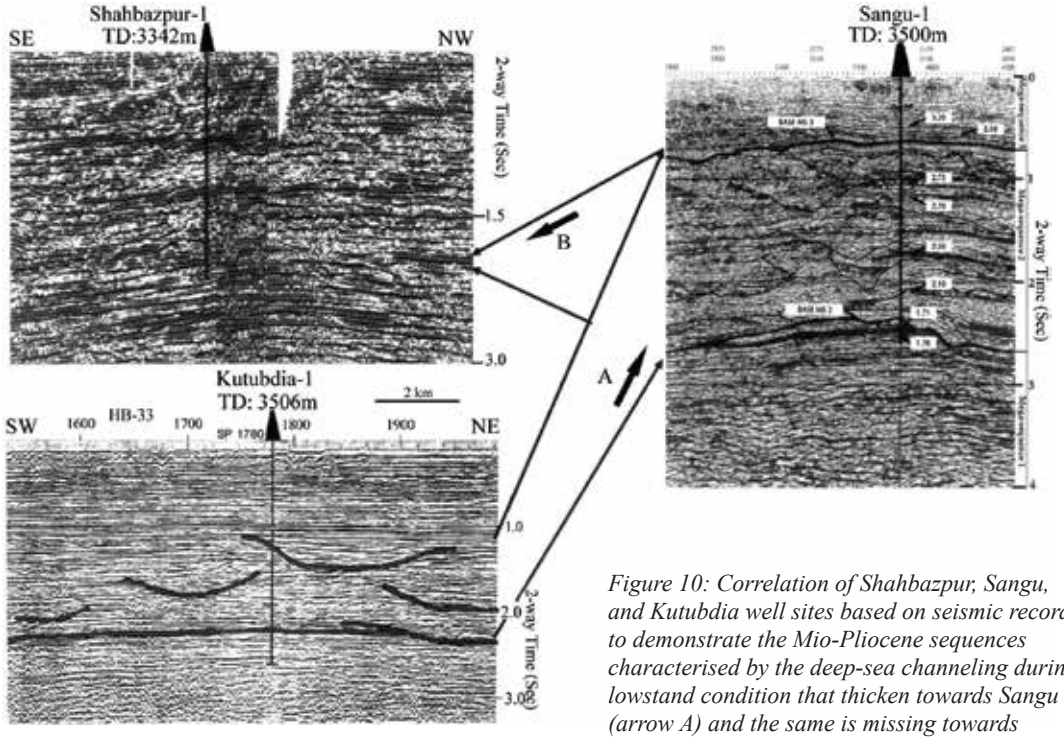

Figure 10: Correlation of Shahbazpur, Sangu, and Kutubdia well sites based on seismic records to demonstrate the Mio-Pliocene sequences characterised by the deep-sea channeling during lowstand condition that thicken towards Sangu (arrow A) and the same is missing towards Shahbazpur (arrow B) indicating that the region between Kutubdia and Shahbazpur was elevated prior to Mio-Pliocene deep-sea channeling.

and pro-delta clays pass up-dip to delta-front sand wedges are considered favourable for developing stratigraphic traps. Based on seismic and well data, the mid-Miocene gas-bearing horizon in Shahbazpur well is observed to occur at about 2600m depth while that in the Sangu well at around 3000m (Petrobangla, 2000).

Crustal segmentation and deformation have resulted in the development of folds and inversion with a variable pattern wherein the young structures are formed on to the older structures. The sediments represent an overall basin-ward progradation from deep marine to coastal marine depositional settings overlain by continental-fluvial type wherein the lower part represents a slope-apron within a migrating accretionary prism complex. Thick mud rock sequence at around 5-6 km depth is considered as upper source rock undergone a high degree of maturation within the oil window. Based on seismic and well data, the mid-Miocene gas-bearing horizon in Shahbazpur well is observed to occur at about 2600m depth while that in Sangu well at around 3000m. The paleontological evidence, primarily the pollen distribution, suggests that the boundary between upper and middle Miocene in Cox's Bazar well occurs at around 3000m depth. Seismic sections of Shahbazpur, Sangu, and Kutubdia well sites have been correlated to demonstrate the sequences characterised by the deep-sea channelling during lowstand condition that thickens towards Sangu and the same is missing towards Shahbazpur indicating that the region between Kutubdia and Shahbazpur was elevated prior to Mio-Pliocene deep-sea channelling (Fig.10). Favourable trapping of hydrocarbon in the structures developed at 4-6 km depths is proposed. In addition, mud and sand-filled channels, incised valleys of intense channelling, and pro-delta clays pass up-dip to delta-front sand wedges are considered as favourable stratigraphic traps. Discoveries include a series of gas fields in the deep-water of Krishna-Godavari Basin of India, new oil and gas fields in the deep-water Krishna-Godavari Basin of India, discovery of gas fields offshore of the Mahanadi Basin of India, and discovery of large deposit of Shwe gas in the Rakhine Basin of Myanmar, all exhibit strong evidence in favour of new future discoveries in the deep-water basins of Bangladesh.

Geohazard Vulnerability

This section deals with the natural hazards occur due to the geological processes. Natural hazards caused by the atmospheric processes are outside the scope of this study. Although Bangladesh coastal belt and the northern Bay of Bengal is highly vulnerable to frequent occurrences of atmospheric hazards like cyclone and storm surge, this study reveals that the vulnerability potentials of the geological hazards are low. Geohazard may be defined as a geological state of the art that may lead to widespread damage or risk. Geohazards are geological and environmental conditions and involve long-term or short-term geological processes. Important offshore geohazards include volcanic activities, mud diapirism and mud volcanism, slope instability, submarine landslide, turbidites, shallow gas, natural gas hydrates, shallow water flows, active fluid seepage, seafloor pockmark formation, seismicity and seismicity induced trans-oceanic tsunami, local tsunami and sea-level rise (Fig. 11). The Bay of Bengal, by and large, is potential for the above-mentioned geohazards. However, the vulnerability of these marine geohazards should properly be addressed and further research is warranted.

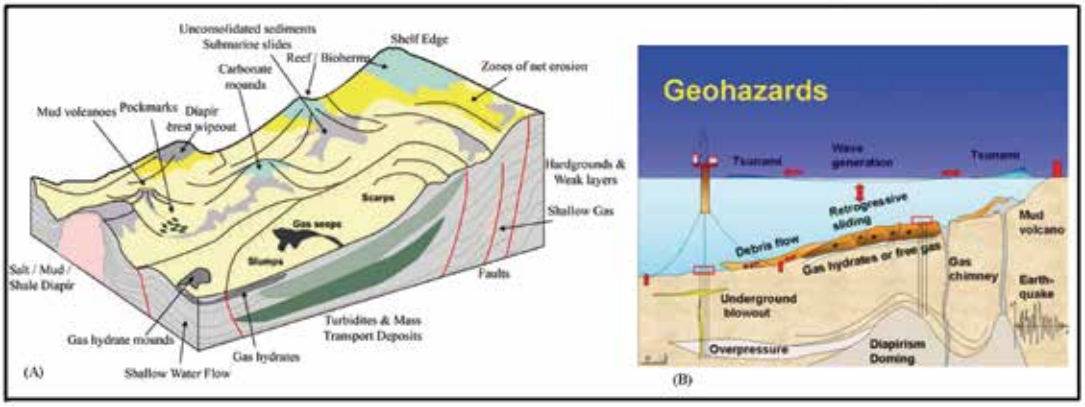

Figure 11: Cartoon of important offshore geohazards those include volcanic activities, mud diapirism and mud volcanism, slope instability, submarine landslide, turbidites, shallow gas, natural gas hydrates, seafloor pockmark formation, seismicity and seismicity induced trans-oceanic hazards.

Although earthquake record of the Bay of Bengal shows 'no to weak' seismicity associated with the region around the Ninety East Ridge and Eighty-Five East Ridge, it is customary to believe that the sources of earthquakes exist in the Bay of Bengal. Ongoing seismic activities is an indication of dynamic crust in the Bay of Bengal, especially in and around Andaman Trench and the Andaman Sea. Barren Island volcanic eruption of 18 April 2001 located south in the Andaman Sea. Eruptions of the Barren Volcano was recorded in 1787 and subsequent eruptions were recorded in 1789, 1795, 1803-04 and 1852 (Raghav, 2011). After nearly one and a half century of dormancy, the island had another eruption in 1991 that lasted six months and caused widespread damage. There were eruptions in 1994-1995 and 2005-07, the latter being considered to link to the 2004 Indian Ocean earthquake that generated a massive trans-oceanic tsunami. All these volcanic eruptions in the Andaman Sea are due to the subduction of the Indian plate in the Bay of Bengal beneath the Burmese plate. The most spectacular feature that has been formed due to the subduction along the Andaman Trench is the Andaman-Nicobar Volcanic Island Arc. Further, the eruptions of the subduction melts in the Andaman Sea can generate large earthquakes inducing back-arc extension in the Andaman Sea. According to Rao et al (2011) 30km thick double oceanic crustal column corresponding to a thickness of about 21km of Burmese crust including a 5km thick sedimentary column, underlain by a thinner Indian crust with an apparent thickness of about 9km modelling. This signifies for the crustal thickness in the Bay of Bengal is 9km. The 2009 August 10 Andaman Earthquake of moment magnitude (Mw) 7.5 and its aftershocks show vertical distribution of the hypocentral depths down to about 50km signify very close proximation of subduction. Rao et al (2011) further opined that there are two crustal groups in the Andaman region, i) normal faulting within 18 km depth, and ii) strike-slip faulting at greater depths down to 26km. This signifies that the Bay of Bengal around Andaman-Nicobar is characterised by extensional tectonics having both horizontal displacement and subsidence which can generate only local tsunami in the Andaman Sea.

In addition, the northern part of the Bay of Bengal especially the continental shelf shows induced seismicity effect from the continental source zone and tectonic trends. Seismicity induced hazards such as mud volcanism, slope instability, submarine landslides are likely to occur. Mud diaper, shallow gas, shallow water flows, high pressure and active fluid seepage are widespread and can pose threat. The Bay of Bengal, by and large, is free from occurrence of the tsunami because of the two fundamental reasons viz., shallow water depth and sea-bed rupture pattern. For tsunami wave, it is essential that due to an earthquake the sea bed rupture must be vertical to near vertical in order to displace vertically the entire water column. However, focal mechanism study revealed that the sea bed rupture pattern is dominantly horizontal i.e., strike-slip. Bangladesh coast is characterised by an added advantage of having wide, approximately 200 km long continental shelf that can act as the barrier as well as plays a key role in flattening the waveform of the tsunami through defocusing process. Any trans-oceanic tsunami like December 2004 Indian Ocean Tsunami due to Sumatra Earthquake, will have an abrupt fall of velocity along the continental shelf break. Decay factor of the tsunami height in dispersive mode resulted from bed configuration and free air anomaly calculated for 2004 Indian Ocean tsunami is equal to 0.324 m/km. This resulted in a total negative height drop of about 13m means a levelling with mean sea level at a distance about 43 km from the coast of Bangladesh. On reaching the coast, the estimated tsunami height would be -3m. Sea-level rise is the most legitimate concern that global warming is likely to induce. However, a recent publication by Khan (2018) revealed that global warming and polar ice-melt will not contribute to sea level rise. Hence, the Bay of Bengal also will not be affected by any so-called predicted sea level rise. Sea level in the Bay of Bengal will rise and fall only due to the subsidence and uplift of the crust. In the present context of prograding Ganges-Brahmaputra delta and deposition of about 40% yearly sediment influx on to the continental shelf of Bangladesh, relative sea-level is likely to drop. Hence, sea-level rise related hazards in the Bay of Bengal is unlikely to occur.

Development of 'Blue Economy'

'Blue Economy' is a term in economics relating to the exploitation and preservation of the marine environment. 'Blue Economy' refers to marine-based sustainable economic development which leads to improved human wellbeing and social equity through significantly reducing environmental risks and ecological scarcities. 'Blue Economy' aims for holistic and sustainable development along with enhancing human welfare. It is a broad concept as it is not only confined to minerals and marine products but also includes even maritime activities like shipping services, trade and business. This concept visualises oceans as the development spaces in which activities like conservation, sustainable energy production, mineral wealth extraction, bio-prospecting, marine transport etc. are integrated. The key elements thus can be summarised as a) optimum and efficient utilisation of resources, b) sustainable, inclusive, harmonious and environment friendly development, c) exploitation of opportunities in emerging marine industries, and, d) creating and streamlining legal and regulatory institutions which govern the access, use and protection of maritime resources.

'Blue Economy' concept is suitable for management and sustainable development of ocean resources. 'Blue Economy' also includes economic benefits that may not be marketed, such as carbon storage, coastal protection, cultural values and biodiversity by measuring variation at the genetic, species, and ecosystem level. A related term of the blue economy is ocean economy. However, these two terms represent different concepts. Ocean economy simply deals with the use of ocean resources and is strictly aimed at empowering the economic system of the ocean. 'Blue Economy' goes beyond viewing the ocean economy solely as a mechanism for economic growth. It focuses on the sustainability of the ocean for economic growth. Therefore, the blue economy encompasses ecological aspects of the ocean along with economic aspects. The World Bank (2017) specifies three challenges that limit the potential to develop a 'Blue Economy': a) current economic trends that have been rapidly degrading ocean resources, b) lack of investment in human capital for employment and development in innovative blue economy sectors, c) inadequate care for marine resources and ecosystem services of the oceans. The strategic and economic significance of the Indian Ocean and its implication for the Bay of Bengal is quite high (Khurshed Alam, 2018). Sustainable 'Blue Economy' Conference held in Nairobi, Kenya in November 2018 to advance a sustainable 'Blue Economy' includes marine protection, plastics and waste management, maritime safety and security, fisheries development, financing, infrastructure, biodiversity and climate change, technical assistance and capacity building, private sector support, and partnerships.

Conclusion

The Bay of Bengal is intimately related to the early opening of the Indian Ocean resulting in the creation of new seafloor overlain by the modern Bengal deep-sea fan at the top 4 km and 12 km thick older sediments at the bottom. The Bay of Bengal has opened-up and enlarged along with the northward motion of the Indian plate between 120 Ma and 55 Ma at a rate of about 6 cm/yr. The Bay of Bengal is characterised by the geological features those formed principally by the tectonic activities including volcanic and sedimentological processes. Evolution history of the Bay of Bengal suggests the occurrence and enrichment of georesource and marine minerals like polymetallic nodules, cobalt-rich crust, polymetallic massive sulphides etc. Oil shale and tar sands are strategically important domestic energy sources that should be developed to reduce the nation's growing dependence on oil. The occurrence of hydrocarbon, gas hydrates and gas shale has been established but a lack of detailed studies and exploration, its reserve estimation has not yet been possible. Favourable trapping of hydrocarbon in the structures developed at 4-6 km depths has been inferred. In addition, mud and sand-filled channels, incised valleys of intense channelling, and pro-delta clays pass up-dip to delta-front sand wedges are considered as favourable stratigraphic traps. Although, Bay of Bengal of Bangladesh is rich in georesources, yet it is quite vulnerable to atmospheric hazards like cyclone and storm surge but geohazards pertaining to earthquake and tsunami are not high except along the north-south trending narrow strip of Andaman-Nicobar Islands. Earthquake-related marine hazards may occur in some tectonically weak zones in the submarine environment. This study further warrants for detailed study and exploration in order to evaluate Bangladesh part of the Bay of Bengal that may ensure the development of the 'Blue Economy'.

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Material Flow Analysis Technique for Material Assessment of Ship Recycling Industry

Commodore Khandakar Akhter Hossain[1]

Abstract

Ship recycling is a viable engineering process of recovering shipbuilding materials by dismantling end-of-life (EOL) ships in a profitable and safe way. There are few dozens of ship-recycling yards existing along coastal belt at Chattogram of Bangladesh. The local ship recycling industry provides the country's main source of steel, recondition equipment and machinery. The industry creates the opportunity of employment, generates revenues for government and contributes to the national shipbuilding industry. This industry promotes economic development for this country. At the same time, the negative image such as environmental pollution, health hazards and few accidents bring major challenges that should be overcome for the constancy of this industry in the long run. There are limited studies that have been found and most were based on preliminary and secondary baseline data analysis. The economic study of the local ship recycling industry particularly the recovery of reusable material and waste material generated from the ship recycling industry was derived on the basis of benchmarks from other countries. As a result, the policy-making decision based on those studies is not technically sound. From this perspective, the paper will discuss the viable economic assessment technique for ship-recycling process by taking help both from existing literature and from other similar industry; justify the sustainability of material flow analysis (MFA) method for calculating the reusable material for local yards; apply the method on actual ground by feeding realistic situation and data. In this research work, more than one dozen shipyards have been selected to accumulate the data for a quite substantial period of time for various types of ships generally handled by the local ship breaking yard in Bangladesh. The study could be helpful for all stakeholder and policymakers who are related with local ship breaking yards of Bangladesh.

Keywords: Shipbreaking, Recycling, Reusable Materials, LDT.

Introduction

Ship recycling is a viable engineering process of recovery shipbuilding material by dismantling end-of-life (EOL) ships in a profitable and safe way. Ship recycling activity was concentrated in industrialised countries mainly USA, UK, Germany, Turkey, etc. until the 1960s. But from the early 1980s, old ships are coming for recycling to India, China, Pakistan,

[1]*Member (Engineering), Chittagong Port Authority, Bangladesh*

Bangladesh and other East Asian yards where health and safety standards are minimal and workers are desperate for work. There are around 150 registers (actually exist around three dozen) along coastal belt at Chattogram of Bangladesh. The local ship recycling industry provides the country's main source of steel, recondition equipment and machinery, it creates the opportunity of employment, generates revenues for government and contributes to the national shipbuilding industry. No doubt this industry promotes economic for this country. At the same time, the negative image such as environmental pollution, health hazards and few accidents bring major challenges that should be overcome for the constancy of this industry in the long run. The restraining nature of the industry is the main problem. As a result, the actual situation, on ground data collection and the actual output of the industry is never assessed extensively. The true fact is that a very few studies have been found so far but mostly those were based on limited preliminary baseline study or secondary data analysis. Even recently, the Ministry of Industries through Safe and Environmentally Sound Ship Recycling in Bangladesh (SENSREC) Project made some studies on economic contribution and hazardous impact assessment and environmental impact on ship breaking industry in Bangladesh. The major limitations of the studies were that they were not based on field data; rather the inventory of hazardous wastes from the ship recycling industry was derived on the basis of benchmarks from other countries. For those, the assessment result is questionable and so any policy-making decision based on the study is not technically sound as it did not follow a standard way and techniques for the vessels that were usually handled by the local ship breaking yards of Bangladesh. On the other hand, Shipbreaking is a global industry and because of the changing socio-economic scenarios of the world, it is necessary to develop the industry in such a way that it is stable in the long run. To fulfil both aspects, extensive study is necessary which will be useful to develop a viable and sustainable recycling method or technique through estimating and calculating reusable and waste material from the different types of EOL ship by achieving both international standards for Health Safety and Environment (HSE) and total quality management (TQM).

It is a research paper and which will discuss the viable economic assessment technique for ship recycling process by taking help both from existing literature and from other similar industry; justify the sustainability of material flow analysis (MFA) method for calculating the reusable material for local yards; apply the method on actual ground by feeding realistic situation and data. In this research work around one dozen recycling yards have been selected to accumulate the data for various types of ships generally handled by the local ship breaking yard in Bangladesh. Data collection format has been designed segregation all the materials from ship breaking into metal and reusable items. After processing all data collected from different shipyards, the amount of actual output of reusable material including component and waste materials have been calculated for different types of ships. Again material flow analysis (MFA) technique has been applied to analyse and plan the ship recycling process so that the ship recycling yards can be managed in a better way by appropriately handling waste and resources. The study could be helpful for both policymakers and stakeholders who can able to assess the actual output in terms of both reusable and waste materials generated by local ship breaking yards of Bangladesh and they can plan to achieve some minimum standard to become stable in the long run.

Outline of the Methodology/Experimental Design

It is a research work to determine viable economic assessment method for ship recycling process and justifies the sustainability of material flow analysis (MFA) technique for calculating the reusable material for local yards and applies the technique on the actual ground by feeding realistic situation and data. Those data have been collected by authors from physical involvement in the local recycling yards since the last six years. For data collection, necessary help has taken from different stakeholders including yard's owners and Bangladesh Ship Breakers Association (BSBA). Output and results will be based on actual and on ground data and take considerable help/guideline from the methodology followed in the available literature. This paper will discuss the viable economic assessment technique for ship recycling process and determine the reusable material calculating sustainable tools of local yards on the basis of on ground situation and data. More than one dozen shipyards have been selected to accumulate the data for a quite substantial period of time for various types of ships generally handled by the local ship breaking yard in Bangladesh. The basic data of this research work are all types of reusable materials and component including hazardous materials of different types and size of more than two dozen of EOL ships dismantle in Bangladesh and shown in table 1. It is to be mentioned here that average complete dismantle time for an EOL ship may vary from 6-9 months in case of many local ship breaking yards in Bangladesh. For data analysis, calculation and determination of numerical values both material flow analysis (MFA) software STAN and Microsoft Excel have been used. However, nuclear waste and other releases, such as emissions of atmospheric pollutants and diffuse emissions of pollutants to the water, will not include in the scope of this research work. In case of missing or unreliable data, benchmarks available in literature will be used for calculations and development of the assessment model.

Table 1: Summarised fact and figure of sample Recycle EOL ships in Bangladeshi yards.

SN	Ship Category/Type	Sample Ships	Range of LDT	Manufacturer /Build Year
1	Bulk Carrier	5	11834 to 21592	1978 to 1986
2	Tanker	5	11182 to 29324	1981 to 1989
3	Cargo	5	5008 to 18302	1984 -1990
4	Container	6	6698 to 16053	1977 to 1992
5	Other Ships	5	5625 to 25997	1966 to 1981

Present Global and Bangladesh Ship Recycling State

Ships are generally removed from the fleet after the end of life (EOL) through a process is known as ship recycling or scrapping. Ship owners and buyers negotiate scrap prices based on few factors; ship's empty weight or LDT and prices in the scrap metal or recycle market. The world-wide ship recycling industry dismantles average 1000 large ocean-going vessels

per year, such as container ships, cargo & bulkers, oil & gas tankers (LNG, LPG), passenger ships and other types of ships, in order to recover steel and other valuable metals or recyclable items. However, at present, almost all ship recycling activities are concentrated in five countries: the three South Asian countries (India, Bangladesh, China and Pakistan), China, and Turkey. Further capacity is available in North America (US, Canada, Mexico) and within the European Union (amongst others Denmark, Belgium and UK). At present, South Asia is undoubtedly the global centre for ship recycling activities. Global major recycling yards are located in India, Bangladesh, Pakistan, China and Turkey. These countries are main ship recycling centres in terms of annual lightweight tonnage (LDT) recycled. The ship recycling yards compliant with either the international standards for HSE management or the ship recycling regulations such as Hong Kong convention and EU ship recycling regulation are considered harmless to the environment, health and safety of the workers. The annual global capacity of green recycling was around 780,000 LDT in 2012.

A total of 933 ships of a combined 44.4 million DWT were scrapped in 2016. In 2016, Bulker and containership recycling activity was very strong and accounted for 65% and 18% of total demolition respectively in terms of DWT. Bangladeshi recycling yards shared 31% of world demolition and that was decreased from 35% of the previous record. In term of DWT, Bangladesh still represented the largest share of demolition activity as they scrapping 199 vessels of a combined 13.6 million DWT in 2016. On the other hand, Indian yards experienced a recovery after a comparatively slow 2015, with 340 ships of a combined 12.5 million DWT recycled in 2016. This led Indian share of total demolition to rise from 20% in 2015 to 28% in 2016 in DWT. Other potential shipbreaking countries are Pakistan, Turkey, China, Denmark and Belgium. Major shipbreaking countries and their share in no of EOL ships and year of built of scrap ships recycle in 2016 have been shown in fig 1 and 2 respectively below.

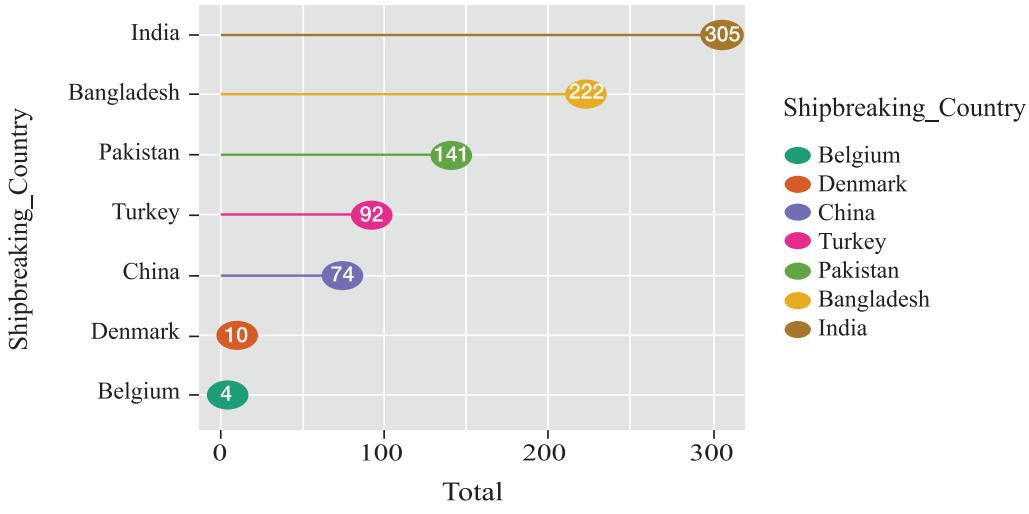


Figure 1: Major ship recycling countries of the world in 2016.

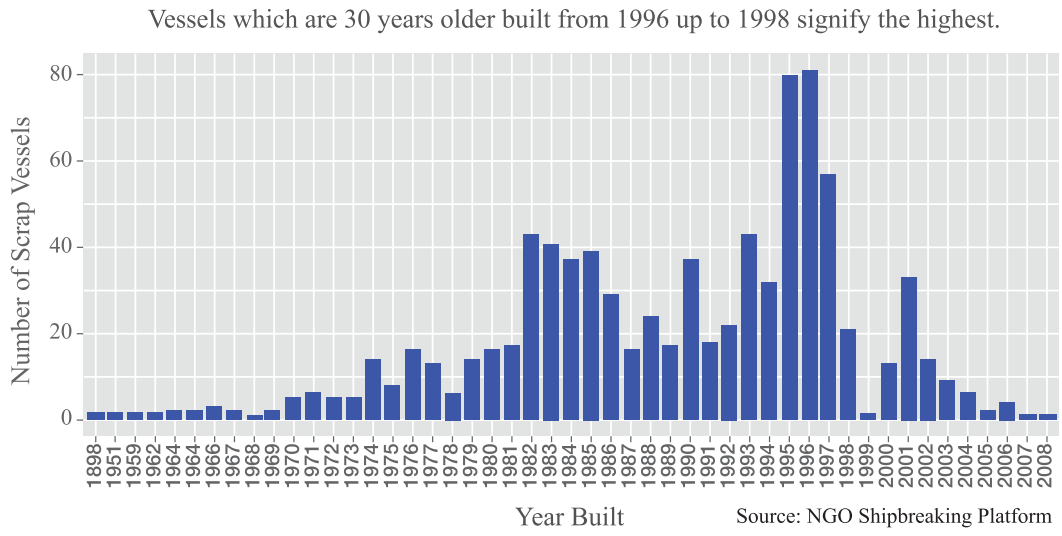


Figure 2: Year of built of scrap vessel recycled in 2016.

In Bangladesh, an average of 200 different types of obsolete ships are recycled annually in different yards located in Chittagong. Those different types of ships are the bulk carrier, tanker, container carrier, cargo carrier, passenger or ferry, refrigerator ship, LPG, LNG, floating pontoon/restaurant, and other different types of ships. In fig 3below, the total number of different types/category of ships recycled annually in Bangladesh between the years 2009 to 2015 has been shown. Again, from on-ground statistics of ship recycling yards of Bangladesh, we can see that average 2,000,000 Light Dead-Weight Ton (LDT) different types of obsolete ships are recycled annually in different yards in Bangladesh. In figure 4 below, total LDT of different types/category of ships recycled in Bangladesh between the years 2009 to 2015 has been shown. Reusable material factor and average materials output per year has been shown in table 2 below.

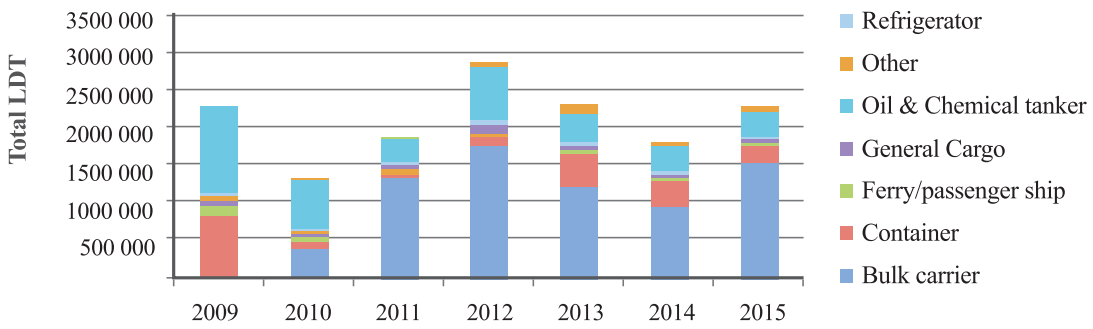


Figure 3: Total LDT of ships recycled in Bangladesh by type/category (2009 to 2015).

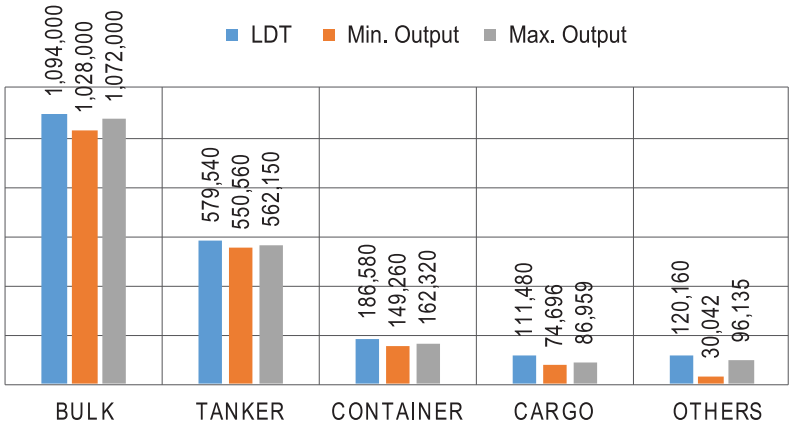


Figure 4: Average annual LDT vs average annual reusable material output (2009 to 2015).

Table 2: Reusable material factor and average materials output per year (2009 to 2015).

SN	Type of Ship	Average LDT (MT) per year	Reusable Material Factor (%)		Average Reusable Material per year (MT)
1	Cargo	111,486	0.67	Min.	74,696
			0.78	Max.	86,959
2	Bulk Carrier	1,094,566	0.94	Min.	1,028,892
			0.98	Max.	1,072,675
3	Tanker	579,542	0.95	Min.	550,565
			0.97	Max.	562,156
4	Container	186,583	0.8	Min.	149,266
			0.87	Max.	162,327
5	Others	120,169	0.25	Min.	30,042
			0.8	Max.	96,135
6	Total	2,092,346		Min.	1,833,461
				Max.	1,980,252

Ship Recycling Management Technique and the State of MFA

MFA as an Analytical Technique: The author of this article gathered inspiration from both operations management and environmental engineering to implement a well-known technique to improve the ship recycling industry. Therefore, this article reviews the analytical technique of both domains. This article concludes that MFA, an analytical tool used in environmental engineering, is the most practical tool for calculating material output from the ship recycling industry. The methodology and input data for carrying out MFA on a ship recycling yard has explained in brief. In this research work, the MFA is implemented using two dozen different types and size of EOL ships. The article also explained the importance

and shortcomings of applying MFA to the ship recycling industry.

Operations Management Technique: Operations management is the methodical planning, execution and control of operations. Operations are a total term that includes services and manufacturing. Operations management involves scheduling work, assigning resources, managing inventories, assuring quality standards and process-type decisions such as capacity decisions, maintenance policies, equipment selection, worker training options and the sequence for making individual items in the product-mix set. In the last few decades, due to significantly increased levels of competitiveness in the modern industry, a range of methodologies and techniques aimed at improving the performance, productivity and profitability of the operational activity have been developed. These techniques can be broadly classified into two main categories: diagnostic tools (process mapping, process flowcharting, value stream mapping, pare to analysis, fishbone diagrams, etc.) and improvement tools (just-in-time (JIT), total quality management (TQM), total preventive maintenance (TPM), theory of constraints (TOC), business process reengineering (BPR), etc.). A wide variety of such management practices, methods, tools and techniques are encompassed under a production approach called lean manufacturing, based on the Toyota Production System.

Manufacturing and Production Technique: It involves the transformation of inputs (labour, machines, and materials) into desired goods and services. The inputs are combined by the process, often including many sub-processes, resulting in the production of units of goods or the creation of types of services. Ship recycling is a one-of-a-kind production system where the inputs are the ship, labour and equipment (such as cranes, gas torches, forklifts, etc.) which are transformed into outputs (such as ferrous scrap, non-ferrous scrap, re-usable items, waste, etc.) as a result of various processes, such as pre-cutting, cutting and post-cutting. Lean thinking has been successfully applied to the industries where inputs are transformed into outputs. This includes the manufacturing, healthcare, construction and process industry. However, it needs to be investigated further whether lean and other aforementioned tools can be implemented to improve sustainable and effective ship recycling process.

Lean Manufacturing Technique: The starting point of lean manufacturing is to identify measure and eliminate ‘waste’ from the system to improve its performance. ‘Waste’, in the context of lean thinking, means any activity in a process that does not add value to the final product. The most sought after areas of improvement using lean tools are inventory and quality management because both these areas significantly drive down the costs in a normal production system. However, their application to the ship recycling industry is not feasible because the high fluctuation in demand and supply on both the input and the output side of the ship recycling process and the quality of the finished product of ship recycling i.e. scrap does not depend much on the ship recycling process. Instead, it depends on the construction, operation and maintenance of the ship.

Diagnostic Technique: The diagnostic technique like as process mapping can be useful in understanding the basic ship recycling process and identifying the problem areas. It can be targeted both for developing and make sustainable ship recycling process and to improving the entire ship recycling industry. In any industrial process usually, there are three types of flows. Such as information, product and resources. The information flow contains the

technical data controlling the operation itself. The product flow is initiated due to the transformation of raw materials into delivered products as a result of the industrial process. The flow of resources includes the people and means required to make the product. Resources must enter the system and leave the system as 'used' resources. The product flow or the flow of materials is the most critical flow because it influences the revenue generation and the cost factors of a ship recycling process. That's why a process mapping tool that focuses on material flow is ideal for analysing and improving the ship recycling process.

Improvement Technique: For ship recycling industry application of improved technique can be helpful. As an example; a technique to improve the efficiency and effectiveness of people, equipment, space, time and energy can result in reduced costs and increase profits. Such technique can help re-engineer the ship recycling process to utilise the resources (such as labour, machinery, cranes, equipment, etc.) further up the economic hierarchy of materials to extract as much value from the EOL ship as possible. However, in the case of sustainable ship recycling, a yard must also employ resources to handle the materials which are lower down the economic hierarchy (such as hazardous materials) as it improves the environment and the workers' health as well as safety.

Operations Management Technique: It presents a limited application within the 'green' ship recycling industry due to its unique challenges as discussed earlier. However, the environmental engineering technique might be more suitable for the ship recycling industry because this industry handles EOL ship's products having hazardous materials. Hazardous materials need proper treatment and disposal to protect human health and the environment in a workable process.

Environmental Engineering Technique: It is the learning process concerning the management of natural resources and the reduction of pollution and contamination of the environment caused by anthropogenic activities. Environmental studies require a thorough understanding of the material flows within and between the environment and the anthropic area. For this purpose, a tool based on the mass balance principle and system analysis called material flow analysis (MFA) has been developed. MFA is an analytical technique of systematic assessment of flows of materials within a complex system defined in space and time. MFA is applied in different fields such as environmental management, industrial ecology, resource management and waste management. An MFA can also contribute to the design of better products that can be easily recycled once they become obsolete and turn into 'waste'. MFA can potentially be used by production, manufacturing and commercial entities as a standard analytical technique in decisions on materials management to locate and examine inputs, outputs and source of waste materials. So, MFA can be a suitable technique to analyse and subsequently improve the ship recycling process.

Consideration: Two aspects must be considered before applying MFA to a ship recycling yard. (1) From a systems perspective, an analysis of a ship recycling yard is a micro-level analysis; nation or economy-wide analysis being the macro-level; while local (city, river lake, basin) analysis being the meso-level analysis (2) From the environmental management perspective, a ship recycling yard is essentially a waste management system managing EOL ships. MFA is applicable for waste management on any system defined in space and time,

from both a treatment process plant and up to a nation. Moreover, the applicability of MFA in waste management as a decision support technique as well as a micro-level system flow mapping tool is very well documented.

Importance of MFA and Its Software STAN: By using the software STAN an MFA can be carried out. STAN is useful not only to produce a graphical representation of a waste management system but also to determine the types of materials that flow into, within and out of the system. MFA can help both to manage the waste in such a way that the recycling process is not threatening to human health as well as the environment and at the same time, to assists resource conservation as well as allows segregation of non-recyclables from recyclables so that inappropriate disposal strategy (landfill or energy recovery) can be implemented. I consider the waste of a ship recycling yards as any substance, material or object originating from dismantling an EOL ship and is required to be discarded and disposed of appropriately in accordance with applicable laws, regulations and management standards. An MFA applied to a ship recycling yard on an EOL ship and that can help determine the flows of materials through each stage of the recycling process. A known material flow for each ship can help a recycling yard determine the required number and capacity of resources (such as cranes, forklifts, machinery, etc.) for each step of the recycling process, earning a potential of each material stream, and the scale of waste generated during the recycling process. Such parameters can assist in developing a detailed plan of recycling a ship by increasing the efficiency of resources and by using effective waste management strategies which is friendly to human health and the environment. In fact, waste management strategies such as 'waste to energy' and optimum collection of reusable material for any recycling yards willing to invest in advanced technologies that are suitable to handle the heterogeneous waste generated by recycling of ships. The results of an MFA study can help determine the technical and economic feasibility of such capital intensive, advanced waste management technologies.

The Advantage of MFA: There are many advantages of using MFA. Such as; an analysis technique in a ship recycling yard. However, the quality of results depends on the quality of the input data. Data collection has historically been a problem in the ship recycling industry, because of uncertainty and disbelief among recycling yards and a lack of coordination among the various stakeholders. On the other hand, since research in this field of study is still in its preliminary stage. Various authors have discussed this issue of unavailability of data hampering the research in ship recycling. However, the author discusses above, the methodology to collect data and carry out MFA on local ship recycling yards. It is a better technique to determine and calculate reusable material and waste output of any EOL ships. It is a viable option for any recycling yards to economic assessment and determines the benefit of the recycling process.

Methodology and Input Data for MFA: For carrying out an MFA on any ship recycling yards, following steps need to be followed. It can start with defining the space and time boundaries of the system. Then, the reusable material composition of EOL ship(s) must be determined. At the same time, the waste material composition of EOL ship(s) to be recycled and disposed of must be determined. Then, various steps of the ship recycling process must be recognised. Then, flow diagrams can be created using suitable or open source software like

'STAN'. Finally, the flow diagrams need to be analysed. The flow diagram has been shown below in fig 5. Again, the feedback to design phase of the ship's life cycle has been shown in fig 6 below.

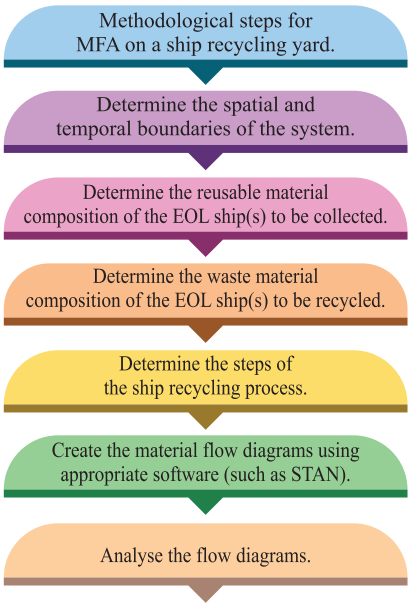


Fig 5: Methodological steps for MFA on a ship recycling yard.

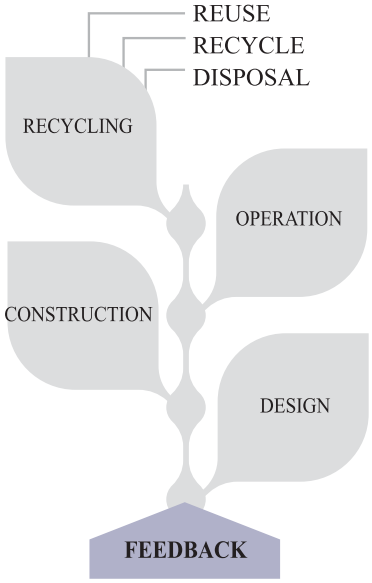


Fig 6: Feedback to design phase of the ship's life cycle.

Spatial and Temporal Boundary: The spatial boundary of an MFA for ship recycling can range from all world-wide ship recycling yards to a single ship recycling yard. The temporal boundary can range from a few years to a single day. The choice of spatial and temporal boundaries depends on the objective of the MFA. In this article, since the objective of MFA is to make sustainable recycling process for local recycling yards which can carry out an MFA on each ship it will recycle to determine the areas of improvement within the recycling process. Therefore, the spatial boundary is the recycling yards themselves while the temporal boundary is the time required to complete two dozen recycling project (around 26 types and size of different dismantled ships).

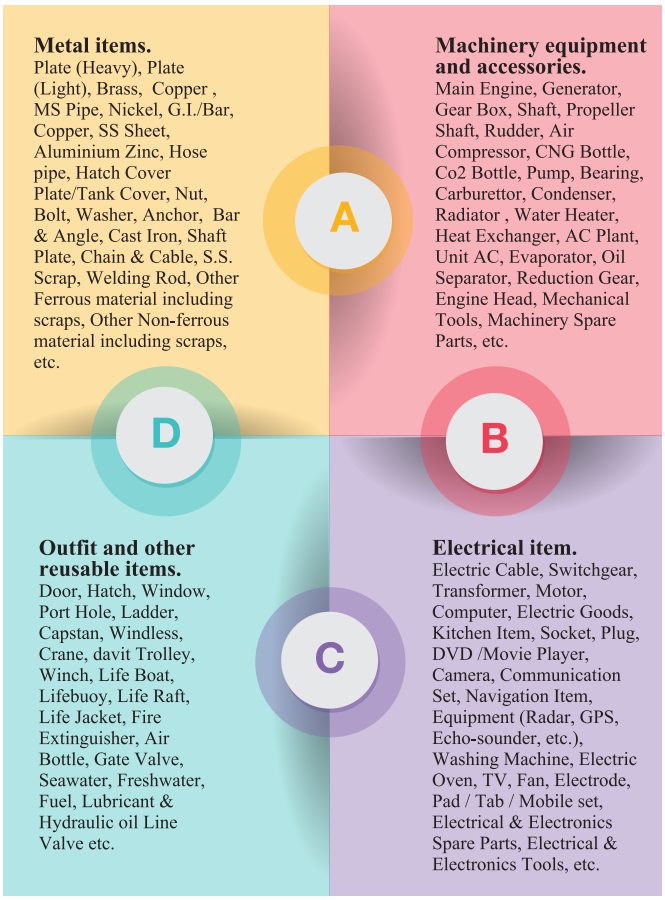
Quantification of the Material Composition of EOL Ships: The study carried out by Jain and his team determined that out of the nine studies available on the quantification of material composition of EOL ships, none present a methodology that can be used by the ship recycling yards to determine the material composition of an individual ship. Therefore, they presented a methodology which determines the material composition of a 2006 built 11044 T lightweight bulk carrier on the basis of its lightweight distribution provided in its stability manual. The material composition of the case ship calculated by Jain and his team does not contain the values for the material stream 'liquids, chemicals and gases' (LCG) because they considered that the most of the LCG material stream is operationally generated and is not part

of the ship's lightweight. The material composition of the case ship corrected for LCG material stream is compiled and the value for LCG material stream is taken from a study carried out by Andersen for a bulk carrier. But for this article author consider realistic data taken by him from more than one dozen local yards of 26 different types and sizes of EOL ships since last six years. The more interesting fact is that different types, categories and size of EOL ships have been selected from different local yards to make the study more authentic and realistic. The general and exclusive data, analysis, result, graph and output has been described in detail in my PhD research work.

Optimum Steps and Phases of MFA Technique

Steps of the Ship Recycling Process: The required number of feasible steps needs to be finding out of an MFA on a ship recycling yard to determine the optimum steps of the ship recycling process. Though ships are recycled by employing different docking methods (i.e. beaching, slipway, alongside and dry dock) in different parts of the world, the process of dismantling and recycling a ship takes place in a series of steps which are independent of the method employed to dock the vessel. Ship recycling is generally performed by cutting away large sections of the ship's hull, which are then moved to shore for further dismantling. The entire recycling process can be divided into three main phases – pre-cutting, cutting and post-cutting. Each phase of the ship recycling process is a process in itself because some form of transformation takes place. The pre-cutting process involves various surveys and hull preparations for gas cutting. The cutting process is the process where actual cutting of steel hull and machinery into small pieces takes place. The post-cutting process involves sorting and segregation of materials. Each of these processes can be examined further to determine

Table 3: Reusable material of an EOL ship can be divided into following four broad categories.



other processes that take place within them. Reusable material of an EOL ship can be divided into four broad categories and that has been show in table 3.

Pre-cutting: The pre-cutting process comprises of all the activities of the ship recycling process that takes place before the cutting of an EOL ship starts. It consists of various sub-processes such as the removal of loose items; removal of liquids; removal of hazardous materials; removal of insulation, flooring and tiling, cement works, removal of cables and electrical equipment. The economic value stream and non-economic value stream originating from pre-cutting is an input for post-cutting where further separation and sorting takes place.

It is assumed that the economic value stream of pre-cutting process is comprised of loose items (such as furniture, lifesaving appliances, firefighting appliances, galley appliances, household appliances, spare parts, paint drums, etc.) having second hand value; liquids (such as waste oil, lube oil, fuel oil, hydraulic oil, etc.); non-hazardous re-usable insulation (glass wool) and copper cables. The non-economic value stream is assumed to comprise of hazardous materials such as asbestos and asbestos-containing materials, PCB, glass, Ozone-depleting substances, etc.; ballast water; sewage and other waste that needs to be disposed of safely. Based on the above assumptions, it is estimated by MFA that around 2.5% and 4% of LDT of the sample ships would originate as NEVS and EVS respectively from the pre-cutting process. The remaining ship (93.5% of LDT) would flow into the next process, cutting.

Cutting: The cutting process is divided into two sub-processes: primary cutting and secondary cutting. The primary cutting is the process where a ship's hull is cut into ferrous blocks and non-ferrous items are extracted from the hull. The ship's machinery is cut from the base either to be sold in the second-hand market as reusable machinery or to be fed into the secondary cutting as scrap machinery. The separation of machinery into reusable and scrap machinery is depicted by the sub-process machinery separation. The machinery is turned into scrap if it fails to sale in the second-hand market. Both primary cutting and secondary cutting sub-processes are connected by a separation of ferrous, non-ferrous and machinery sub-process. It also depicts the transfer of bigger blocks from the primary cutting area to the secondary cutting area. The ferrous

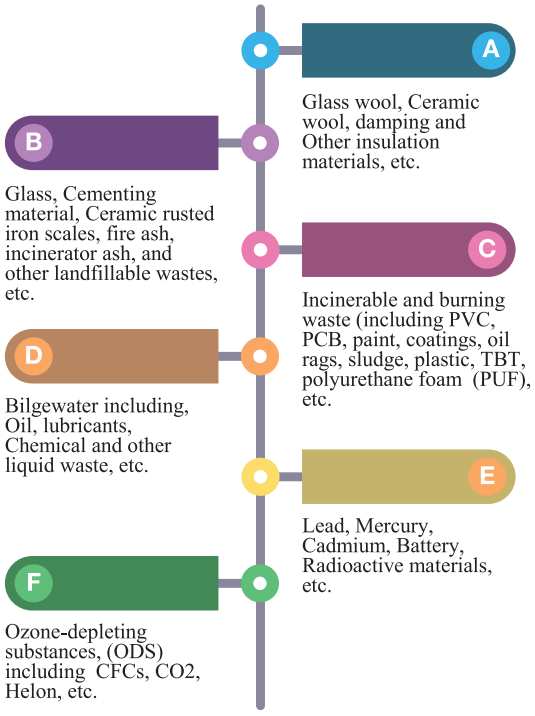


Table 4: Waste material of an EOL ship can be divided into following six broad categories.

blocks and obsolete machinery which has no second-hand value (in scrap machinery) fed as an input to the secondary cutting. Non- ferrous items, owing to their small size, do not need to be fed into the sub-process secondary cutting. The secondary cutting is the process where ferrous blocks are cut into steel plates and smaller pieces of steel scrap while the scrap machinery is cut into the smaller pieces of machinery scrap. The processes of primary cutting and secondary cutting are executed mainly using gas cutting torches. The cutting process results mainly in an EVS owing to the high value of ferrous and non-ferrous scrap. The only NEVS out of the cutting process is paint chips and other waste which can neither be sold in the second-hand market nor can be recycled as scrap. Based on the values of material streams (Table 3) above ship can be divided into six broad categories and that has been shown in table 4.

Post-cutting: The post-cutting process comprises three sub-processes. Those are collection and storage, separation and segregation, and finally transportation. The EVS and NEVS of the first sub-process are picked-up from their respective originating sources for storage. Eventually, EVS is fed to the sub-process transport, where products are sent either for reuse or recycling. The NEVS originating from sub-process collection and storage is fed into sub process separation and segregation, where products are further separated into NEVS and EVS. The sub-process separation and segregation is an important activity of the post-cutting process where further separation of products which were originally considered as non-economic value owing to their large amount of waste takes place. For example, a machinery component, such as a valve or pipeline insulated with asbestos, may be initially considered as NEVS. However, it can be further separated into metal (EVS) and asbestos insulation (NEVS) if the cost of separation (asbestos removal) can be offset by the metal value. The NEVS and EVS originating from the sub-process separation and segregation is fed into the sub-process transportation, where the EVS is transported either for reuse or recycling and the NEVS is transported either to landfill sites or to downstream disposal sites. All downstream activities (including reuse, recycling, disposal, landfill, incineration, etc.) are considered out of the system boundary of the ship recycling process as these activities do not take place on the ship recycling yard. Based on the assumptions as mention above, it is

estimated by means of an MFA that 1.5 to 2.5% of LDT of the sample ships would be sent for disposal (in most cases to a landfill and incineration site) and 75 to 96% of LDT of the case ship can either be reused or recycled. Detail calculation result, analysis fact and figures for different types of EOL ships has been explained in my PhD research paper. Cutting and post cutting result of different types/categories of six sample EOL ship dismantle in local yards in Bangladesh has been shown in fig 4 to 9. These figures also assume that around 20 to 30% of the weight of the NEVS can be extracted as EVS during the separation sub-process of the post-cutting process. This value can change depending on the separation capacity and techniques employed by the recycling yard. The amount of EVS and NEVS obtained from each sub-process of recycling the sample different types of ships as derived from the MFA diagrams for the applied assumptions has shown in my PhD research paper.

Analysis of MFA Technique

Material Flow Diagrams: In order to develop the material flow diagrams using STAN, data for the input and output flow of each process must be fed by the user as far as practicable. In

case the input or output flow is not known, a user can feed the transfer coefficients of the processes. A transfer coefficient of a process defines the relationship between the input and output flows of a process. For example, an input flow to a process can be divided into two or more output flows based on the defined ratios. Such data can be generated by reconciling the material composition data of the ship. Based on such data, STAN calculates the value of each flow. If the user-defined data is not sufficient to perform such calculation, STAN displays an error message. The flows of materials of an EOL case ship on a recycling yard are presented in the next section of this article.

Assumptions: The aim of carrying out an MFA for the sample ships is to understand the expenditure and income associated with its recycling. Thus, all material streams originating from each process are categorised into two major streams; economic value stream (EVS) and non-economic value stream (NEVS). EVS stream is the stream having the products which can either be sold for reuse or recycling, resulting in cash in-flow for the recycling yard. NEVS is the stream having the products which need to be disposed of either at a waste treatment facility or at landfill sites resulting in cash outflow for the recycling yard. The distribution of material streams into the EVS and NEVS can differ for yards as depending on the factors such as location, recycling practices, second-hand market, regulations and time. Since this article does not focus on specific recycling yards, so there are few assumptions. The assumptions made here represent a scenario where there is an existing scrap market (local market in Bangladesh) for ferrous and non-ferrous scrap and a second-hand market for items such as mechanical equipment, electrical and electronic waste, outfit, household items, insulation items, liquids (waste oil, sludge, fuel oil, lube oil, hydraulic oil, etc.) and machinery. In Bangladeshi local market, scraps of any materials, waste liquid from EOL ships, old insulation materials, and all sorts of electrical and mechanical items, old household items, and furniture can be sold. It may be surprising to develop and developing countries that, almost everything collects from EOL ship can be sold and used by local people of Bangladesh. About the cost and price of collection and selling of reusable materials in the local market has not discussed in this article.

Shortcoming: A shortcoming of using MFA as a planning tool on a ship recycling yard is that it relies extremely on the input data. This data, in most cases, is either difficult to obtain or inaccurate. This can be overcome by improving the way information is passed to the recycling yards or direct physical involvement of the researcher. The shipbuilding yards should develop a document defining the material composition of ships in the form of a list of materials and their weights available on a ship. This is in line with the principle of extended producers' responsibility. It must also be updated during the ship's lifetime as required by the Hong Kong Convention for the Inventory of Hazardous Materials described how such a document can be developed (in the form of ship's lightweight distribution) and added to the ship's stability manual.

Results: Summarise fact and figure as an average reusable material factor and annual reusable material output of those samples 26 different type/category EOL ships have been shown in table 1 above. The researcher has determined that there are average 1,833,461 MT (minimum) and 1,989,252 MT (maximum) reusable materials have been collected annually from ship recycled industry of Bangladesh. To calculating and determining the number of

reusable materials and factor, Researcher has taken help from free commercial software like Microsoft Excel and Material Flow Analysis (MFA) software STAN in addition to manual calculation. The researcher has found that my manually calculated result of reusable material vary up to 0.4% with STAN software result, whereas no variation found with MS Excel result. In table 2 above, average reusable material factor and amount of materials output per year in MT for different types of recycled ships in Bangladeshi yards has been shown. Again, the most basic level of the reusable material flow diagrams for recycling of five sample bulk, container, tanker, cargo and other EOL ships (out of 26 sample ships) which recycled in local yards of Bangladesh, developed by software STAN has been shown in figure 7 to 11 respectively. Estimation and output of reusable material of different types and sizes of 5 bulk and 6 containers, 5 tankers, 5 cargos and 5 other types of EOL ships by using MFA technique has been shown in figure 12 to 16 respectively. The detail and exclusive data, compilation, analysis, result, graph and output of reusable material of 26 EOL ships have been done by using MS Excel broadsheets and programming.

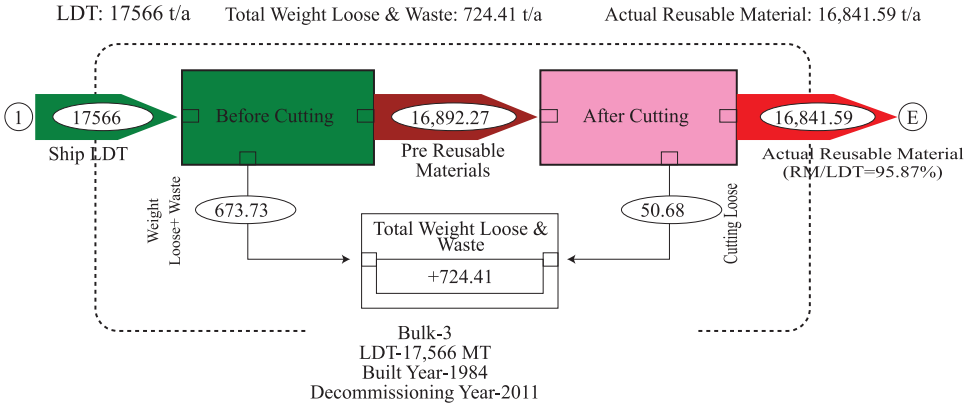


Figure 7: Reusable material flow diagrams for recycling of sample bulk EOL ship.

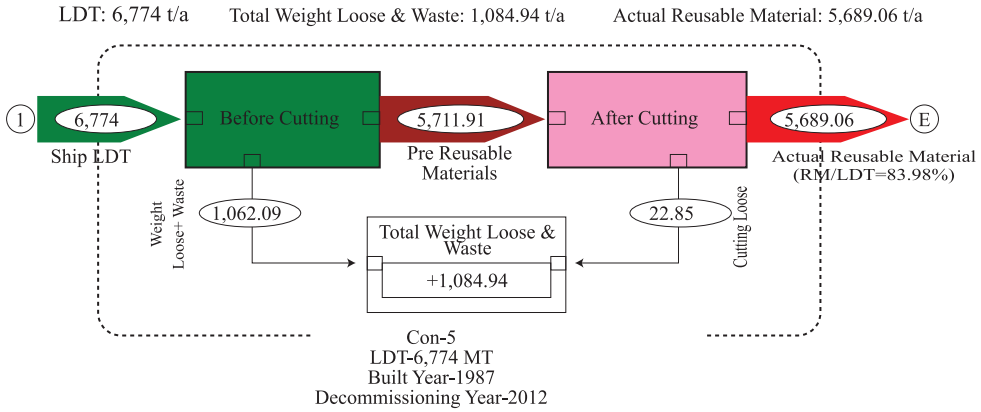


Figure 8: Reusable material flow diagrams for recycling of sample container EOL ship.

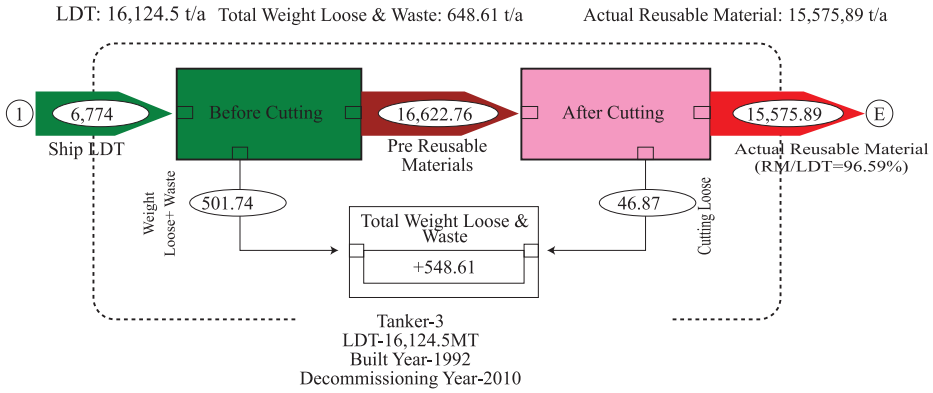


Figure 9: Reusable material flow diagrams for recycling of sample tanker EOL ship.

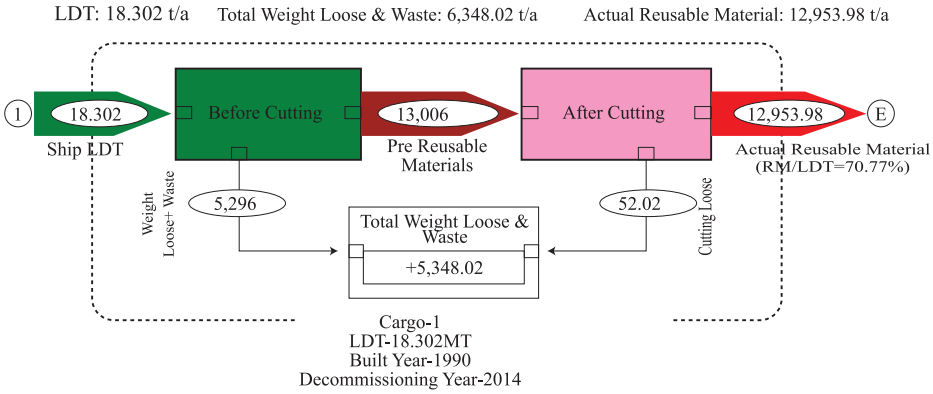


Figure 10: Reusable material flow diagrams for recycling of sample cargo EOL ship.

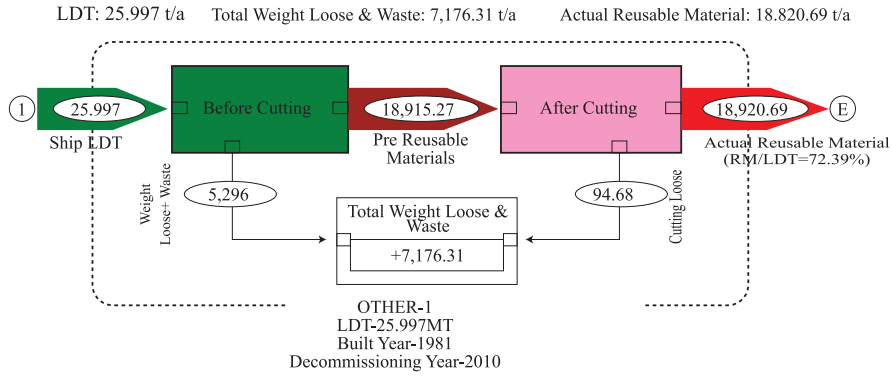


Figure 11: Reusable material flow diagrams for recycling of sample ore carrier EOL ship.

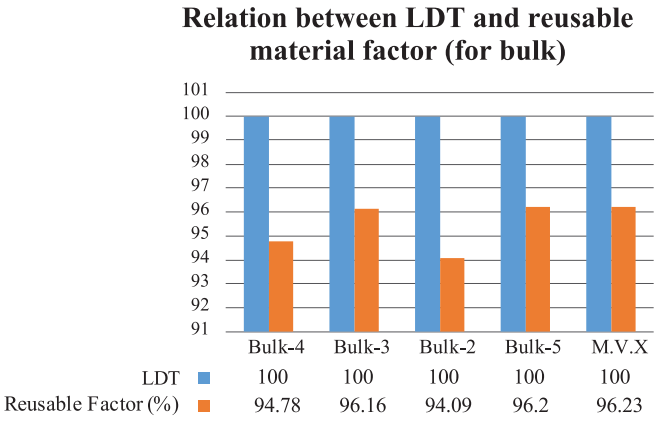


Figure 12: Output of reusable material of different types and sizes of 5 bulk EOL ships.

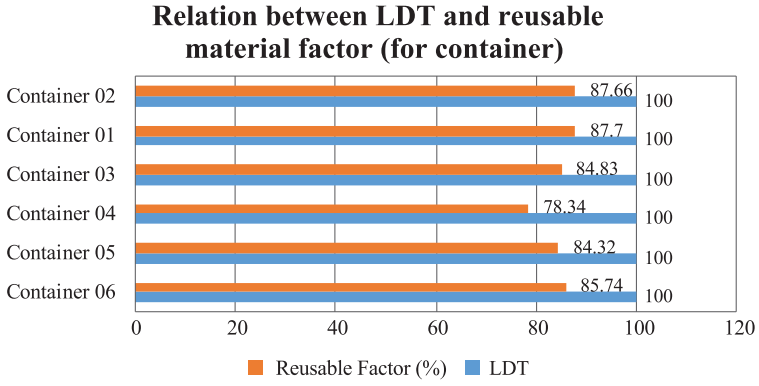


Figure 13: Output of reusable material of different types and sizes of 6 container EOL ships.

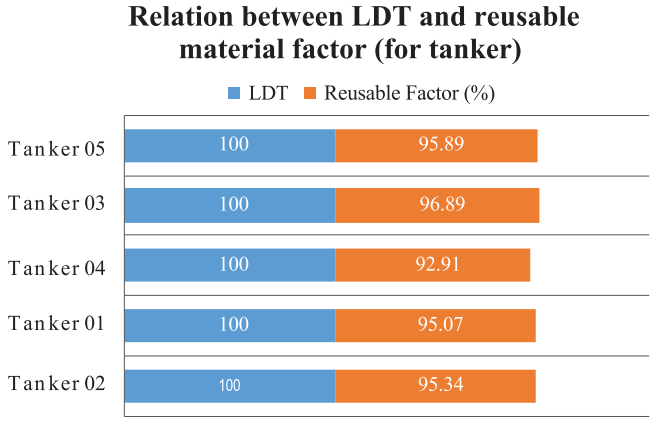


Figure 14: Output of reusable material of different types and sizes of 5 tanker EOL ships.

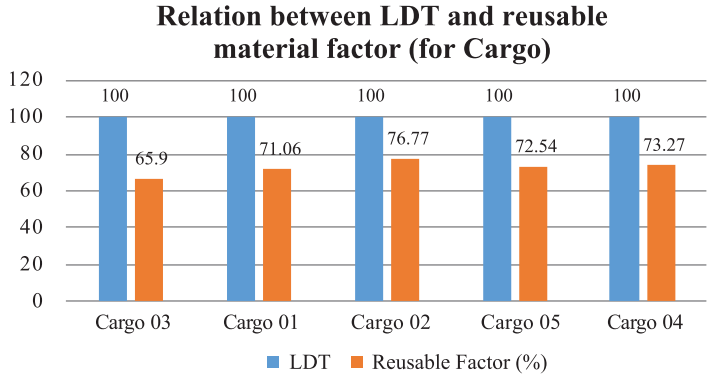


Figure 15: Output of reusable material of different types and sizes of 5 cargo EOL ships.

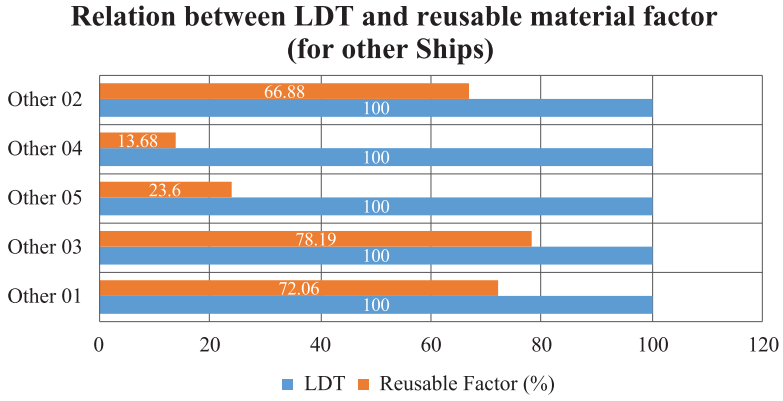


Figure 16: Output of reusable material of different types and sizes of 5 other EOL ships.

Argument

Data Accuracy: The results of the MFA mainly depend on the accuracy of input data and the understanding of different sub-processes of the ship recycling process. It is not possible to conduct an MFA study on a ship recycling yard without knowing the material composition data of ships, design and building construction and the relation between the input and output flows of each sub-process of the ship recycling process. The material flow analysis carried out in the above of this research determined the quantity of waste and recyclables generated as a result of dismantling six samples of EOL ship carrier under the applied assumptions. Actually, any ship recycling yards recycle several ships at the same time in most cases. Therefore, an MFA need to be carried out for all the ships together. In that case, the spatial boundary still remains the same but the temporal boundary must be determined on the basis of the time frame for which the analysis is to be carried out. Material composition data must also be available in an aggregate form for all the ships that would be recycled within the set

time frame. Nevertheless, an MFA carried out on a ship-by-ship basis provides enough details to a ship recycling yard to visualise, plan, execute and improve its processes. However, in my PhD research paper MFA has been carried out on 26different types, categories and sizes of EOL ships which dismantled in local yards in Bangladesh.

MFA Scenarios and Practical Output

The flows of materials shown in the preceding MFA diagrams depict the ideal amount of materials that can be derived from the case ships for the assumptions made in this research. In the actual situation, the amount of each material that can be derived from the case ships depends on the recycling process employed. For example, the amount of input material and percentages of the EVS and NEVS coming out of separation sub-process may differ. Some amount of ferrous and nonferrous material might also go into the separation sub-process. There might be no EVS coming out of the removal of insulation, flooring and tiling, cement work, the subprocess of the pre-cutting process depending on the demand of reusable insulation in the market and the possibility of removing insulation in good condition at a reasonable cost. For an example, in South East Asian countries, intact glass wool insulation panels are purchased by resellers to cater the needs of cold storage firms and other industries requiring insulation material. Again, there is a strong demand for almost all the materials/ products recovered from EOL ships by the network of secondary processing firms located around the ship recycling yards in Bangladesh. Various scenarios and possibilities of material flows exist depending on the recycling process employed and socio-economic state of local yards. The MFA can be used as a tool to visualise, estimate, plan, and compare different scenarios that can arise as a result of the recycling of any EOL ship.

Literature Review

Comparison with Other Industries: It would be worthwhile to discuss why it is important to develop a methodology for material quantification of EOL ships by comparing the ship recycling industry compared with other industries like the aircraft and the vehicle recycling industry. The recycling approach of the shipping industry resembles the approach used by the aircraft recycling industry. The aircraft recycling involves disassembly of reusable components and then shredding the remaining hull to obtain ferrous and non-ferrous scrap using the separation technologies. Similarly, the ship recycling industry is predominantly based on salvaging as many components as possible having second-hand value in the market and then cutting the ship's hull into plates, frame and blocks of sizes that are readily accepted in the scrap market. On the contrary, the vehicle recycling industry mainly relies on shredding the vehicle hull to obtain ferrous and non-ferrous scrap for recycling using the separation technologies because of the non-existent market of reusable components. Moreover, the vehicle recycling industry has a frequent supply of small units unlike the ship recycling industry having an intermittent supply of large units. Though, the ship recycling industry resembles the aircraft recycling industry in following a similar recycling approach; its earning model is similar to that of the vehicle recycling industry, contrary to the earning model used by the aircraft recycling industry. It depends more on scrap value than on component value. This is the reason why material quantification related studies are

abundantly available within the literature of the vehicle recycling industry while the literature of aircraft recycling industry is more focused on disassembly of reusable components. In conclusion, the ship recycling industry is similar to both vehicle and aircraft recycling industry in certain aspects; yet the difference not only due to large size and various types of ships but also due to large age range, infrequent supply and dynamic composition of ships due to change in regulations over time makes it difficult to instantly apply the existing quantification models of other industries. The strong market presence for EOL ship's machinery, equipment and other reusable items is similar to that of aircraft recycling while high demand for high-value non-ferrous scraps such as special bronze and ferrous scrap in the form of plates and blocks in the scrap market is similar to that of the vehicle recycling industry. Both these factors make it vital to quantify the material streams of an EOL ship to calculate cost and income of recycling a ship.

The Material Composition of EOL Ships: For this study, all the available research papers and technical reports on material quantification of EOL ships were reviewed. Unfortunately, unlike the car and aircraft industry, the number is very limited (around a dozen). The very small number of studies available on this subject is attributed to ship recycling yards being unconvinced about sharing the information and data. The prevalent scepticism is mainly due to continuous scrutiny of recycling yards by environmental watchdogs. Other stakeholders, such as classification societies and ship recycling consultants are bound by the non-disclosure agreements of the proprietary data. The literature review found that the studies used four different methods to quantify material streams of EOL ships. This includes interviews of ship recyclers, sampling on a few ships, sampling on the beaches of a few recycling yards, and an input-output method applied at a particular recycling yard based on the approximate historical data of few ships. While Andersen et al. (1999) aimed to quantify the materials of environmental concerns available on an EOL VLCC ship by sampling; Hiremath and Sarraf attempted to quantify waste streams of various ship types on an aggregate level whereas Reddy attempted to quantify the waste generated by Alang, ship breaking yard in Gujarat, India in terms of MT per day by sampling on beach. Although all four authors attempted to quantify only the waste streams while ignoring other material streams such as ferrous, non-ferrous, machinery etc., their studies are unfortunately not comparable due to different move toward of research used by them. The study carried out by Hiremath is the most accurate of these studies because the authors used a relatively large sample set of 241 ships. However, both the type of ships demolished and the materials on board vessels change over time. The first change was due to economic circumstances and the second due to changes in regulations. As an example, IMO started banning asbestos by means of SOLAS convention in 2002, which was eventually banned totally for use on all installations on all ships in 2011 (Lloyds Register, 2011). This means resampling will need to be done regularly to make sure the values of emission factors remain correct. It was also noted that bilge water was assumed as part of LDT, but as it is operationally generated, it should be part of DWT used GT to represent the ship size, which is rather impractical as GT is a measure of volume rather than a weight. As Sarraf had no access to proprietary data of Inventory of Hazardous Materials (IHM) of various ships available with classification societies, so his making estimation was difficult and inaccurate.

Different Studies of EOL Ships and Contribution of Author: On the other hand, the results obtained by Reddy et al (2003) are the most inaccurate, as his calculation had discrepancies and calculation based on unrealistic assumptions; such as the only source of waste collected at Alang, beach and had no extrapolation of the amount of waste found in three months to the value for one year. The studies carried out by Adak, Andersen, Demaria, Hess and Sujauddin are an attempt to quantify all the material streams of EOL ships using different research ideologies. While Adak and Hess focused on material quantification of three major ship types General cargo, Bulk carrier and oil tanker, Demaria and Sujauddin focused on ships in general. These estimates are on an aggregate level based on the experience of ship recyclers and waste disposal data published by government agencies in India and Bangladesh. They are mere approximations of the number of material streams of an EOL ship. Unexplained weight losses of 9% to 16% of the weight of the vessel are reported by Adak and Hess. This weight loss might be due to margins of error and wrong declarations. In East Asia, there have been few instances of discrepancies in declared import weight and material sold for re-rolling. The wrong declarations can be for several reasons; the material stream is either escaped to the environment, is dumped illegally either into the sea or at nearby villages, or quite simply done for tax evasion. The study carried out by Andersen for classification society DNV is the only one that focused on individual ships Tanker and Bulker to calculate their material composition by sampling on a VLCC ship and using empirical estimations available in the ship design literature to calculate the weight of machinery, outfitting and steel. This is the most detailed and comprehensive of all the studies. Other studies on ship recycling have used this data as well. The major drawback of this study is the use of inaccurate and backdated data. So it is clear that all of these studies use aggregate data for large groups of ships, none of these studies presents a methodology that can be used by recycling yards to determine the number of various material streams for a particular ship. However, K P Jain and his team had presented a methodology to quantify the material streams of an EOL ship using the information available from the ship at the time of offering. In this article, the author has present a methodology to quantify the material streams of an EOL ship using the information available from a group of different types, categories and size of EOL ships (26 in number). So the author wants to say that, it is more authentic and close to accurate for estimation and decision-making process for the stakeholders.

Conclusion

MFA is better Technique in ship recycling. It is established in this article that analytical technique MFA can be used by ship recycling yards to better plan the ship recycling process by establishing the flows of materials through different sub-processes taking place within a recycling yard. The flexibility of MFA as a technique or tool in terms of spatial and temporal boundary settings makes it very useful, not only for planning and improving the ship recycling process on particular yard for one or more ships but also for understanding and predicting the outputs of the ship recycling industry on the local, regional, national and global level. MFA diagrams indirectly contribute to reducing recycling costs and increasing revenue. Moreover, MFA helps to determine the maximum revenue potential of recycling a number of ships within a particular time frame. Ship recycling yards can work on optimising their

revenue potential by finding ways to generate income from the waste anticipated to be generated as a result of recycling the EOL ships. Again, MFA can be used to compare waste management strategies such as landfill, waste to energy conversion, incineration, etc. This article discussed the technique available within the field of production and environmental management that are potentially applicable to the ship recycling industry for achieving its objectives. So ship recycling can be considered as a reverse engineering process with the help of MFA technique. MFA can be used as analytical tools for environmental management as it is a natural fit due to the involved waste and environmental management issues. MFA has emerged as an essential technique that can improve ship recycling and materials and waste management at ship recycling yards by determining the earning potential of each project as well as planning the utilisation of resources to attain maximum profit.

MFA can be used by recycling yards for understanding the material flows within the recycling process, for comparing the status quo with different recycling scenarios, as a decision-making technique to decide on waste management strategies. It can use as a calculating tool to determine the amount of material generated for reuse and disposal. It can also use as an analytical technique to plan the recycling process by calculating required material handling capacity and anticipated recycling steps. This paper also discusses a standard and viable ship recycling process that can be used by a recycling yard to dismantle different types of EOL ships irrespective of the docking method employed. In this article, it has been proved that by using MFA and software STAN it is possible to determine and calculate (almost accurately) reusable and waste materials of any type and size of EOL ships dismantle of any yards. Finally, the author wants to say that MFA can be used as a viable and sustainable ship recycling technique to an economic analysis of the recycling industry. So MFA is a better technique and that can be used as a decision-making tool for ship recycling industry as a whole.

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A National and International Regulatory Framework for Establishing Sustainable Shipbreaking Industry in Bangladesh

Md. Ashabur Rahman[1], Mansura Akter[2] and Wahidul Sheikh[3]

Abstract

Shipbreaking and recycling activities are mostly done in Bangladesh, India, Pakistan and China. Bangladesh is one of the leading countries around the world in shipbreaking. Shipbreaking industry generates huge employment opportunities for workers. Although working in Shipbreaking industry is very difficult, risky and hazardous, it may contribute a lot to the economy of Bangladesh provided sustainability is ensured. International regulations like the Basel Convention, the MARPOL (Marine Pollution) Convention, the Hong Kong International Convention, the IMO Convention, the ILO Guidelines and other international instruments play important role in controlling the environmental and safety issues concerned with the shipbreaking industry in Bangladesh. Present Shipbreaking laws of Bangladesh reflect the international conventions and guidelines. The Bangladesh Ship Recycling Act, 2018 is obviously a good legislative initiative by the government. However, the government is working with national and international bodies for ensuring sustainable Shipbreaking industry in Bangladesh.

Keywords: Ship Recycling, Shipbreaking Industry, Employment Opportunity, Waste Management.

Introduction

Shipbreaking refers to the process of ship re-conditioning. It is involved with dismantling of outdated vessels for further use. The Shipbreaking concept is a vast idea because it requires huge manpower and logistic support. In Bangladesh, it is being developed as a profitable industry creating huge employment opportunity. As a potential sector for Bangladesh, the industry is being administered through many national and international laws. Effectively starting off in the 1980s, the Bangladesh ship recycling industry has emerged in course of the

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[1] *Advocate, Dhaka Judge Court, presently serving as an apprentice lawyer of the Supreme Court of Bangladesh*

[2] *Assistant Professor, Department of Maritime Law & Policy, Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh*

[3] *Lecturer, Department of Management, Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh*

past few decades as one of the leading destinations for dismantling and recycling end-of-life seagoing vessels of the world (Ahammad and Sujauddin, n.d.). At present many Shipbreaking industries are working in Bangladesh who are buying outdated vessels from various countries and exporting them after recycling. Such activities of Shipbreaking yards are bringing both challenges and opportunities for Bangladesh; it is a very important source of iron for Bangladesh but also responsible for environmental pollution in the coastal area. So it has become mandatory for the Bangladesh government to imply national and international laws properly.

Methodology

This article is an independent desk study. The review is two-fold, as it covers factual as well as regulatory aspects of the shipbreaking practices. The international normative frameworks presented and discussed in this article are a mix of so-called hard and soft law.

The data gathering for the factual description of the shipbreaking practices in Bangladesh included collecting and reviewing secondary sources, such as academic literature, analytical reports, and publicly available data which meet the criteria of being available online and in English. The article is based on sources that we consider to be reliable, and the findings are referenced throughout the report. Facts were also retrieved from relevant NGOs working to prevent dangerous pollution and unsafe working conditions caused by beaching.

Research Approach

Though the proposed study is primarily qualitative in nature, both qualitative and quantitative approaches have been used for validity and reliability. In order to find out an adaptable legal solution as a means of accelerating strategies, a comparative study has been held.

Statement of the Problem

Shipbreaking industry has dramatically expanded in Bangladesh, at the cost of environmental degradation and severe labour exploitation. Despite environmental and human rights violations, the Shipbreaking industry represents a vital source of income for the country and a livelihood for a significant portion of its population. Shipbreaking activities in Bangladesh present both opportunities and challenges for Bangladesh. If the government can establish such a system for this industry to ensure minimum environmental hazard through a strict legal framework, this industry may be a great avenue of employment and income. As per our review of the literature, there is a few research work on this field that describes the international and national legislation for shipbreaking and there is no research that suggests the guidelines for making this industry sustainable and environment-friendly.

This paper examines the national regulatory framework for shipbreaking and recycling. This article also examines relevant international instruments which prescribe the core principles for regulating the shipbreaking industry and evaluates the legal regulation of the Bangladesh shipbreaking industry against these international instruments. On the basis of the national and international legal framework, this paper provides a guideline for making the Shipbreaking industry sustainable and environment-friendly.

Background of Shipbreaking Industry in Bangladesh

In Bangladesh, the Shipbreaking industry was born out of a severe cyclone in 1960, which killed thousands of people and a Greek ship "M D Alpine" was driven ashore by the devastating tidal storm and could not be refloated and was confined to Faujdarhat seashore of Sitakunda Upazilla (M. M. Hossain and Islam 2006). In 1964, Chittagong Steel House bought the vessel and scrapped it (M. M. Hossain and Islam 2006). In 1974, 'Al-Abbas', a salvaged Pakistan Navy vessel sunk during liberation war and was scrapped in a Bangladeshi scrap-yard in Chattogram (K. A. Hossain 2015). The Karnaphuli Metal Works Ltd scrapped the vessel; which is treated as first commercial Shipbreaking in Bangladesh. The Bangladeshi Shipbreaking industries are being popular because of the availability of cheap and expert labour as well as massive demand for steel and iron. The shipbreaking yards are located near the Dhaka-Chattogram high ways at Salimpur, Bhatiary, Kumira areas of Sitakund Upazilla. The Pakistani and Indian businessmen are not importing big ships due to their adverse laws and environmental reasons; some Bangladeshi industrialists are taking the opportunity to import them and making a huge amount of profit. Shipbreaking activities are measured through Light Displacement Ton (LDT). LDT means the weight of the ship without any water, fuel, cargo, passengers or crew on the board. Bangladeshi businessmen have started to lead the international market of Shipbreaking and established their goodwill. About 23% of total LDT shipbreaking in the world is done in Sitakunda which indicates Bangladesh's supremacy in this sector (Kutub et al. 2017).

Figure 1: Ship dismantling records by country 2015("NGO Shipbreaking Platform » Press Release – NGO publishes 2015 list of all ships dismantled worldwide" n.d.).

The NGO shipbreaking platform secretariat of Brussels released data of 2015 regarding ship dismantling records by country on 4 February 2016. It shows that 768 large ocean-going

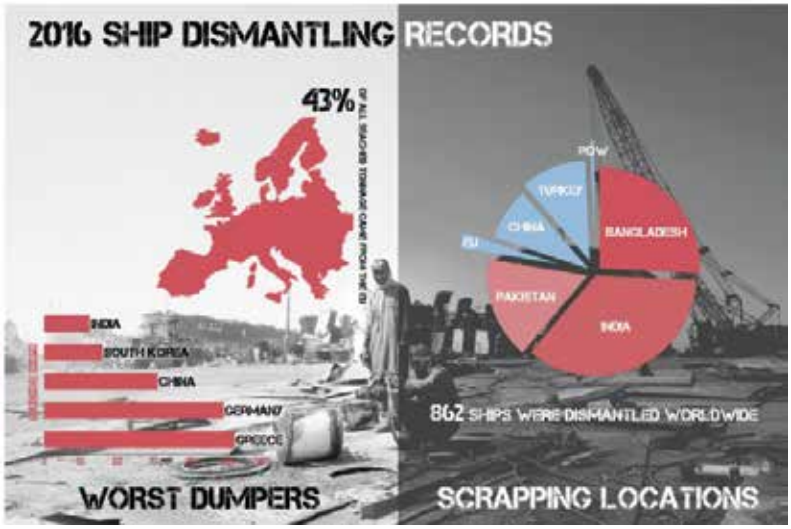

Figure 2: Ship dismantling records by country 2016 ("NGO Shipbreaking Platform » Press Release – Platform Publishes List of Ships Dismantled Worldwide in 2016" n.d.).

vessels were dismantled in the year where 469 were broken on the beaches of India, Pakistan and Bangladesh.

The organisation also published their data of 2016 regarding ship dismantling records by country on 1 February 2017 in Brussels. It shows that 862 vessels were dismantled in the year

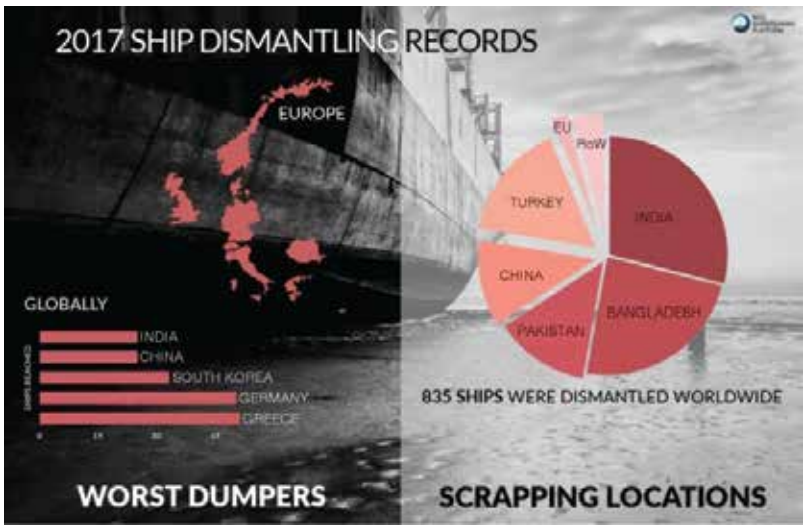

Figure 3: Ship dismantling records by country 2017 ("NGO Shipbreaking Platform » Press Release – Platform publishes a list of ships dismantled worldwide in 2017" n.d.).

where a total number of 668 vessels were dismantled on tidal beaches, that is as much as 87% of all tonnage dismantled internationally.

According to new data released on 20 February 2018 by the NGO shipbreaking platform in Brussels show that 835 large ocean-going vessels were sold to the shipbreaking yards in 2017 where 543 were broken down in Bangladesh, India and Pakistan. The ship dismantling records of 2015, 2016 and 2017 prepared by the NGO shipbreaking platform expresses that the growing Shipbreaking industries of Bangladesh are the sign of industrialism and economic development. The government needs to do something more for sustainable development of such industry.

The Contribution of Shipbreaking Industry

Bangladesh government is working to create new job opportunities for the people. There is a limited number of jobs both in the public and private sectors. Shipbreaking industries offer huge employment opportunity for skilled and unskilled workers in the shipbreaking yards

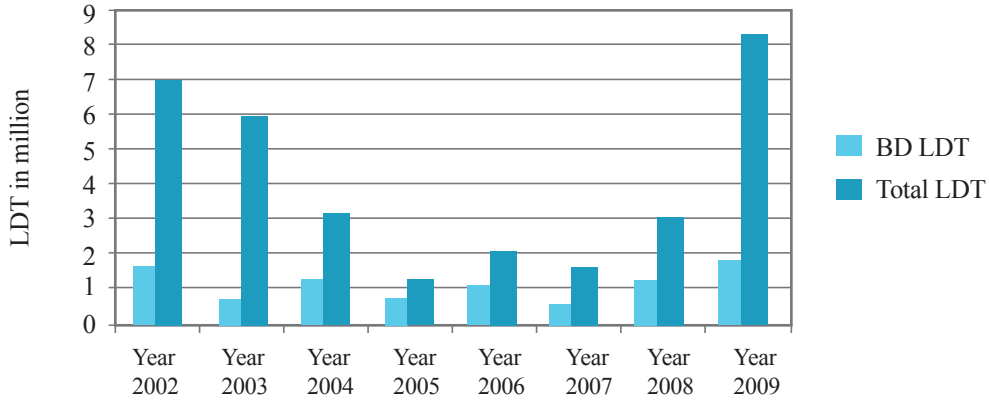

Figure 4: Statistics of shipbreaking in Bangladesh (2002-2009) (K. A. Hossain 2015).

which help to contribute to increasing GDP of Bangladesh. However, shipbreaking activities are increasing day by day in Bangladesh (Figure-4). Statistics of shipbreaking in Bangladesh is given below.

The demand for construction ingredients in the local market is supplied by the ship breaking industries. The ships contain non-ferrous substance like aluminium, bronze, copper, brass and nickel which are precious and expensive. Other substances like FFA, LSA and bridge equipment are sold to the local coastal vessels and merchant's vessels. Actually, the raw materials are purchased by the inland shipbuilding industry, re-rolling mills, steel mills, oxygen plants, cable, ceramics, furniture factories etc. Almost 100% of materials are reused locally. Shipbreaking industries have a contribution of about US$ 2 billion to the national economy. Furthermore, recapture the value of part and component of the ship, which mostly

made up from metal, promising a considerable profit for the actor of the business and provide tax revenue for the related government (Neşer et al. 2008). That 39% of the steel industries are using recycling materials from the ship breaking sector and over 50,000 people are involved with the industry directly or indirectly (Rinku, Managing Director of the PHP Shipbreaking & Recycling Yard 2017).

International Regulations Regarding Shipbreaking

The shipping industry has traditionally been subjected to international regulation to protect the health and safety of workers as well as the maritime environment {International Law and Policy Institute (ILPI) 2016}. In recent decades, awareness of the detrimental potential for both the environment and human health as a result of improper handling and disposal of hazardous wastes has gained renewed impetus (Alam and Faruque 2014). With the global shift of the industry from developed, highly regulated nations towards countries with weak regulatory and enforcement systems came calls for international regulation to ensure the protection of human rights standards for occupational health and safety as well as the environment {International Law and Policy Institute (ILPI) 2016}. Ultimate responsibility lies upon the yards themselves and the authorities in which countries the shipbreaking industries are situated. However, the authorities of ship breaking industries are responsible for reducing difficulties from the shipbreaking yards before the IMO's Hong Kong Convention comes into effect. Undoubtedly ship recycling is a representation of 'green' industry. So to protect the future of these potential industries, international regulations regarding Shipbreaking should strictly be followed. The relevant international legal mechanisms which are connected to ship breaking are being discussed below.

The Convention on the International Maritime Organisation (IMO), 1948: IMO is primarily concerned with the safety of shipping and the prevention of marine pollution, but the Organisation has also introduced regulations covering liability and compensation for damage, such as pollution, caused by ships {"International Maritime Organisation (IMO)" n.d.}. Article 1 (d) of the IMO Convention has introduced an important purpose of the Organisation as; "to provide for the consideration by the Organisation of any matters concerning shipping and the effect of shipping on the marine environment that may be referred to it by any organ or specialised agency of the United Nations" {International Maritime Organisation (www.imo.org) 1948}. According to Article 15 of the Convention, IMO recommends its members for passing necessary laws to protect the marine environment from pollution occurs through shipping. The Marine Environment Protection Committee (Formed under Article 37 of the IMO Convention) at its fifty-third session held on18 to 22 July of 2005 developed the IMO guidelines on ship recycling; where ship-owners are urged to enter into contracts with recycling facilities with the ability to maintain and monitor ships in "gas-free-for-hot-work" condition during the whole process of ship recycling (2003).

The MARPOL (Marine Pollution) Convention, 1973: The International Convention for the Prevention of Pollution from Ships is known as MARPOL (Marine Pollution) Convention which was adopted in 1973 at the IMO. It is an international legal instrument which introduces a system for the prevention of marine pollution. Bangladesh is a party to

MARPOL 73/78 with all its annexes (Karim, 2010). Bangladesh has accessed the convention but yet to ratify. Each signatory nation is responsible for enacting domestic laws to implement the convention and effectively pledges to comply with the convention, annexes, and related laws of other nations ("MARPOL 73/78" 2018). According to the Article 4 (1), any violation of the requirements of the present Convention shall be prohibited and sanctions shall be established therefore under the law of the Administration of the ship concerned wherever the violation occurs; if the Administration is informed of such a violation and is satisfied that sufficient evidence is available to enable proceedings to be brought in respect of the alleged violation, it shall cause such proceedings to be taken as soon as possible, in accordance with its law (1973). So it is urgent for Bangladesh government to take necessary steps for the proper implementation of the MARPOL convention due to upholding sustainable Shipbreaking industry.

The United Nations Convention on the Law of the Sea, (UNCLOS) 1982: Article 145 of the Convention says "Necessary measures shall be taken in accordance with this Convention with respect to activities in the Area to ensure effective protection for the marine environment from harmful effects which may arise from such activities (United Nations Convention on the Law of the Sea 2009)." It also says about the protection of the marine environment against the harmful effects of some activities like drilling, dredging, disposal of waste, construction, pipelines and other related activities; Article 146 of the Convention also says to take necessary measures for the protection of human life and for the reason the concerned authority can adopt appropriate laws to assist existing international law. So the Convention has given power to the state parties to protect their own marine environment; whereas the concerned authority can regulate the ship breaking industries. Accordingly, there are different layers of compliance control: By exercising enforcement jurisdiction upon ships flying their flag or of their registry, i.e. by controlling and enforcing compliance with a number of specified international regulatory instruments and related standards, flag states themselves comply with their respective obligations under UNCLOS (Nordquist, Moore, and University of Virginia 1999). This United Nations Convention on the Law of the Sea covers some issues not regulated under IMO treaty instruments - for example, the jurisdictional power of the coastal State {"International Maritime Organisation (IMO)" n.d.}. However, the UNCLOS plays important role in adopting guidelines for controlling the global Shipbreaking industries.

The Basel Convention, 1989: The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal was adopted on 22 March 1989 in Basel, Switzerland which came into force on 5 May 1992. It is among the most significant international environmental conventions of the past decade. It represents a systematic effort to balance the desire to ship wastes internationally with the desire to reduce the risks to health and the environment caused by the mismanagement of wastes (Murphy 1993). Three elements are crucial for the application of the Basel Convention to the issue of shipbreaking: (i) proof that the waste will not be properly dealt with by the shipbreaking country, (ii) the legal recognition that ships are waste & (iii) an established 'intention to discard' by the owner of the ship (M. M. Hossain and Islam 2006). According to the Convention, an exporting country must reject the export of a ship containing unsafe ingredients, if it observes that the unsafe ingredients cannot be processed in a safe way by the ship breaking industry. Environmentally Sound Management

(ESM) of recycling, whether of domestic or imported raw materials, is a goal to assure protection of human health and the environment and to avoid 'sham' recycling - final disposal of wastes masquerading as recycling (Alter 1997). The operations which do not meet with environmentally sound management system would be treated as a sham. However, the Convention text lays out in Article 4 - general obligations (its 29 Articles & 9 Annexes), the basis for inclusive management of legal environmental controls of the shipbreaking industries.

The Hong Kong International Convention, 2009: The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships was adopted at a Diplomatic Conference held in Hong Kong, China on 15 May 2009 aiming to prevent unnecessary risk to human health and safety or to the environment. It was developed by the IMO member states and non-governmental organisations with the help of ILO and the parties to the Basel Convention. The Convention addresses all the matters regarding Shipbreaking including the ships sold for scrapping and environmental conditions for ship recycling facilities. Ship recycling yards will be required to provide a Ship Recycling Plan, to specify the manner in which each individual ship will be recycled, depending on its particulars and its inventory (The Hong Kong Convention 2009). The Hong Kong Convention on Ship Recycling and other maritime agencies have all along been laying stress on some principles and guidelines in shaping up the shipbreaking and recycling industry throughout the world (Lim, Secretary General of the International Maritime Organisation 2017). According to Article 5 of the Convention, every ship has to fulfil with the survey and certification requirements suggested by the flag State; whereas the regulations 10 and 11 specify the system of survey for certifications. The ship breaking States have the responsibility to confirm that ship-recycling facilities are being conducted in accordance with the regulations of this Convention. Health safety, as well as sound and safe environment in shipbreaking industries, are enclosed in Regulations 19 to 23 of the Convention. So the Hong Kong International Convention is called the pioneer of regulating the ship breaking industries.

The European Union (EU) Ship Recycling Regulation (No. 259 of 1993): On 1 February 1993, the European Union (EU) adopted a regulation on the supervision and controls of shipments of waste within, into and out of the European Community through Regulation No. 259. Then the European Parliament prohibited the export of hazardous waste from the non-OECD countries through Regulation No. 1013 of 2006. Moreover, on 30 December 2013, the European Union (EU) amended the regulation on ship recycling which was set for

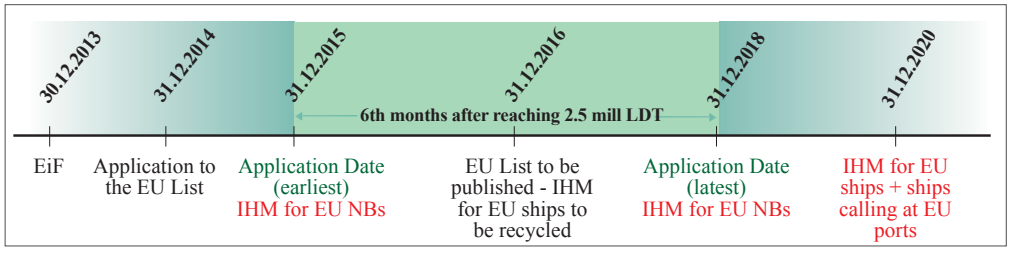

Figure 5: The planned European Union (EU) Ship Recycling Regulations ("EU Ship Recycling Regulation Update" n.d.).

the recycling of EU-flagged ships through Regulation No. 1257. The Regulation will start to work by 2019. It asks the European Commission to establish a global list of ship recycling facilities that comply with the requirements of the Regulation and requires that all ships entering EU ports have an Inventory of Hazardous Materials (IHM) onboard ("European Laws and Guidelines" n.d.). The Regulation is mainly based on the Basel Convention; where all waste including end-of-life ships as well as vessels, intended for disposal is subject to the requirement of prior notification. Furthermore, the countries related to dispatch, destination and transit have to give their prior permission to the shipment. The ship recycling regulation shall be applicable to the commercial seagoing vessels sailing under an EU flag. It will not be applicable to any warships, naval support or other ships owned by a state. The EU Member States' authorities will control European ships to verify whether they are ready for recycling certificate or they have a valid inventory of hazardous materials. After 31st December 2018, all newly built ships in the EU will be required to have an Inventory of Hazardous Materials (IHM) (Figure 5).

Although the international community and the EU have made good progress in creating a proper legislative framework for ship recycling and impressive technical expertise has been invested in the supplementing IMO guidelines and parallel ISO standards (2012). Article 13 (1) of the EU Regulation as amended in 2013 says that for being in the European List, a ship recycling facility shall comply the requirements in accordance with the Hong Kong Convention and the guidelines of the IMO, the ILO, the Basel Convention and the Stockholm Convention (EU Amending Regulation 2013). However, the member states should introduce "effective, proportionate and dissuasive penalties" to ensure proper shipbreaking.

The International Labour Organisation (ILO) Guidelines for Safety and Health in Ship Breaking: The International Labour Organisation (ILO) guidelines for Asian countries and Turkey were adopted in a meeting held in Bangkok, Thailand from 7 to 14 October 2003 aiming to ensure proper safety and health in shipbreaking industries. Cooperation among all participants helped in developing such an inclusive and practical set of guidelines which ensures to benefit all worker of the shipbreaking industry. These guidelines are issued in accordance with the other international instruments like the IMO Convention, the Basel Convention, the London Convention and the International Chamber of Shipping (ICS) industry code of practice on ship recycling. Safety and health in shipbreaking industry mean that the employer implements preventive measures to minimise risks according to the ILO guidelines. It can be through proper maintenance of workplaces, equipment, tools and machinery as well as providing health facilities. The ILO guidelines contain the system to minimise accidents, to maintain shipbreaking yard and to track chemicals. Using welding helmets, suitable eye shields and gloves are also included in the guidelines. Occupational safety and health, including compliance with the OSH requirements pursuant to national laws and regulations, are the responsibility and duty of the employer (International Labour Office 2001). The employer should show strong leadership and commitment to OSH activities in the organisation, and make appropriate arrangements for the establishment of an OSH management system (International Labour Office 2001).

The Organisation for Economic Co-Operation and Development (OECD) Guidelines for Multinational Enterprises: The OECD Guidelines were adopted by the OECD member

states in 1976. The Guidelines were updated several times. The updated Guidelines and the related Decision were adopted by the 42 adhering governments on 25 May 2011 at the OECD's 50th Anniversary Ministerial Meeting (OECD Guidelines for Multinational Enterprises, 2011 Edition). Changes to the Guidelines were to insert a new human rights chapter in accordance with the Guiding Principles on Business and Human Rights: Implementing the United Nations "Protect, Respect and Remedy" Framework (OECD Guidelines for Multinational Enterprises, 2011 Edition). The new chapter says about the States duty to protect human rights. It also says that the enterprises should be within the framework of international human rights law as well as relevant domestic law. Chapter VI (7) of the Guidelines include: provide adequate education and training to employees in environmental health and safety matters, including the handling of hazardous materials and the prevention of environmental accidents, as well as more general environmental management areas, such as environmental impact assessment procedures, public relations, and environmental technologies (OECD Guidelines for Multinational Enterprises, 2011 Edition).

The United Nations Guiding Principles on Business and Human Rights (UNGPs)

The United Nations Guiding Principles on Business and Human Rights (UNGPs) is an instrument consisting of 31 principles implementing the United Nations 'Protect, Respect and Remedy' framework on this issue of human rights and transnational corporations and other business enterprises ("United Nations Guiding Principles on Business and Human Rights" n.d.). Developed by the Special Representative of the Secretary-General (SRSG) John Ruggie, these Guiding Principles provided the first global standard for preventing and addressing the risk of adverse impacts on human rights linked to business activity, and continues to provide the internationally accepted framework for enhancing standards and practice regarding business and human rights ("United Nations Guiding Principles on Business and Human Rights" n.d.). Guiding Principle 23 provides guidance for businesses in three different situations: where national law is weak or silent, where national standards directly conflict with international standards, and where businesses face the risk of being complicit in gross human rights abuses. All three may be relevant when operating in conflict-affected areas (Davis 2012). Principle 23 clarifies that companies should respect international human rights standards wherever they operate, including seeking ways to do so when faced with conflicting requirements (Davis 2012). The guiding principles play an important role in addressing adverse human rights activities by outlining the international human rights law implications for the states which are most challenging and conflict-affected.

The International Convention on the Control of Harmful Anti-Fouling Systems on Ships, 2001: The International Convention on the Control of Harmful Anti-fouling Systems on Ships was adopted on 5 October 2001 at London. The United States of America deposited the Convention on August 21, 2012, which entered into force on November 21, 2012. That resolution A.895 (21), adopted by the Assembly of the International Maritime Organisation on 25 November 1999, urged the Organisation's Marine Environment Protection Committee (MEPC) to work towards the expeditious development of a global legally binding instrument to address the harmful effects of anti-fouling systems as a matter of urgency (Great Britain

and Parliament 2012). The Convention bans the use of unsafe organ tins in anti-fouling paints used on ships and creates a system to curb the future use of such harmful ingredients. Anti-fouling paints are used to protect the hull from algae and molluscs but it is very much harmful to the coastal ecosystem as well as human life. For such materials, the ship recycling process becomes too risky for the workers. As a result, marine life falls in great risk and the shipowner cannot sell such ship for recycling.

The London Convention, 1972: The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, commonly called the "London Convention" or "LC '72" and also abbreviated as Marine Dumping, is an agreement to control pollution of the sea by dumping and to encourage regional agreements supplementary to the Convention (“London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter” n.d.). The Convention regulates waste disposal at sea water from vessels which entered into force in 1975. The core objective of the London Convention is to stop indiscriminate disposal of wastes which create hazards to human health and marine life. According to the Article I of the London Convention, contracting parties shall individually and collectively promote the effective control of all sources of pollution of the marine environment, and pledge themselves especially to take all practicable steps to prevent the pollution of the sea by the dumping of waste and other matter that is liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea (The London Convention 1972).

The Stockholm Convention, 2001: The Stockholm Convention on Persistent Organic Pollutants was signed in 2001 and effective from May 17, 2004, aiming to control the manufacture and use of Persistent Organic Pollutants (POPs). It is a worldwide treaty to protect human health and the environment from the POPs. POPs are chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of living organisms and are toxic to humans and wildlife (“The Stockholm Convention” 2004). The Stockholm Convention contains five important aims including (i) Eliminating dangerous POPs, starting with the 12 worst, (ii) Supporting the transition to safer alternatives, (iii) Targeting additional POPs for action, (iv) Cleaning up old stockpiles and equipment containing POPs, (v) Working together for a POPs-free future (“The Stockholm Convention” 2004). If the aims are implemented for all vessels, then after end-of-life the vessels can be recycled without harming human health.

The Rotterdam Convention, 1998: The Rotterdam Convention was adopted on 10 September 1998 by the Conference of Plenipotentiaries in Rotterdam, the Netherlands which entered into force on 24 February 2004 (“The Rotterdam Convention” 1998). It covers pesticides and industrial chemicals are banned or restricted for health and environmental reasons. Such industrial chemicals may be present within ships which should be handled carefully while breaking ships.

ISO 30000:2009 Standard for Safe and Environmentally Sound Ship Recycling: The International Organisation for Standardisation (ISO) published the ISO 30000 series of standards on management systems for ship recycling in 2009. It specifies the requirements for a management system to enable a ship recycling facility to develop and implement

procedures, policies and objectives in order to be able to undertake safe and environmentally sound ship recycling (ISO, 2011) ("Ship Recycling Practice and Regulation Today" 2011). A yard with a properly certified and implemented ISO 30000 management system can give an owner additional confidence that ships are being scrapped in full compliance with the law, and with other stakeholders views taken into account ("Ship Recycling Practice and Regulation Today" 2011). The ISO 30000 certification assures standard and transparency of the management system, the ship recycling policy, the recycling facility and the legal compliance register. So, all the requirements of this International Standard are intended to be incorporated into the management systems of any ship recycling facility (Ships and Marine Technology -- Ship Recycling Management Systems -- Specifications for Management Systems for Safe and Environmentally Sound Ship Recycling Facilities).

Domestic Laws Relating to Shipbreaking in Bangladesh

Shipbreaking is a challenging process, due to the structural complexity of the ships and the many environmental, safety, and health issues involved (Office 2004). It is a sustainable process of disposing of end-of-life vessels which can bring economic benefit and environmental welfare by providing employment opportunity and enabling ship recycling. The methods followed in the recycling processes are often suffering in some safety aspects related to the environment and workers. The legal battle between the environmentalist group and shipbreaking association even brought a temporary shutdown of all shipbreaking activities in the year 2010 for some time (Zakaria and Hossain 2013). But now Bangladesh government has enacted laws for regulating the shipbreaking industries. So that it has become a potential sector of Bangladesh. Such regulating laws passed by the Bangladesh government are being discussed below.

The Environment Court Act, 2010 (Act No. LVI of 2010): The Environment Court Act was passed in 2010 for resolving the disputes and establishing justice over environmental issues. The Act has allowed the Joint District Judge to operate as an Environment Court in addition to his regular functions. On the other hand, an Environment Appellate Court is formed with a District Judge or a District Judge can be given power in addition to his regular functions. To ensure the speedy trial is the main goal of an Environment Court. So an Environment Court can play a vital role in protecting the environment by exercising its jurisdiction over shipbreaking industries.

The Bangladesh Environment Conservation Act, 1995 (Act No. I of 1995): The Bangladesh Environment Conservation Act was passed in 1995 for conserving and developing environmental standards of Bangladesh which also helps to curb environmental pollution. It has given power to the Director General of the Department of Environment to take necessary steps against non-compliance of any provisions or directives under this law. The DoE of Bangladesh works with various issues regarding sound environment which implements the mandate of Article 18A of the Constitution of the People's Republic of Bangladesh. Article 18A says "The State shall endeavour to protect and improve the environment and to preserve and safeguard the natural resources, biodiversity, wetlands, forests and wildlife for the present and future citizens"(The Constitution of the People's

Republic of Bangladesh 1972). Later, the Bangladesh Environment Conservation Act was amended in 2010 (Act No. 50) which has restricted pollutions through shipbreaking. It has empowered the government to impose more penalties than before; whereas the affected persons can place objections to the concerned authority to take necessary legal actions against the polluters. Section 6 (D) of the Act says that "it will not create any environmental pollution and health hazardous by producing hazardous waste from any ship cutting or breaking which have to ensure by every ship owner, importer and user of yard in ship cutting or breaking activities {The Bangladesh Environment Conservation (Amendment) Act, 2010}." It recommends the ship owners and ship importers to confirm that the shipbreaking process is healthy and they are not releasing any hazardous materials. According to Section 12, "no industrial unit or project shall be established or undertaken without obtaining, in the manner prescribed by rules, an Environmental Clearance Certificate (ECC) from the Director General (The Bangladesh Environment Conservation Act, 1995n.d.)." So in accordance with this Act, all industries including shipbreaking industries require ECC before beginning their activities. However, the government has gotten power by section 13 and 20 of the Act to formulate relevant environmental guidelines and rules. So the government can control such industries by formulating guidelines and rules which can ensure hazardous wastes proper disposal as well as the safe environment of the shipbreaking industry.

The Environment Conservation Rules, 1997: The Department of Environment is authorised to prevent environmental pollution derived from shipbreaking activities. For the reason, the Environment Conservation Rules of 1997 was passed for exercising powers conferred under section 20 of the Environment Conservation Act, 1995. Rule 7 (1) of the Environment Conservation Rules, 1997 says that for the purpose of issuance of Environmental Clearance Certificate, the industrial units and projects shall, in consideration of their site and impact on the environment, be classified into the following four categories:- (a) Green; (b) Orange-A; (c) Orange-B; and (d) Red (The Environment Conservation Rules 1997). Whereas the shipbreaking industries of Bangladesh fall under Orange B group of the Rules but practically they should fall under the Red Category. However, there is no exact rule whether the 'Environment Clearance Certificate' is for the shipbreaking yard or for the ship.

The Shipbreaking and Recycling Rules, 2011: The Shipbreaking and Recycling Rules, 2011 was passed in pursuance of the Hon'ble High Court Division of the Supreme Court of Bangladesh and under section 13 & 87 of the Factories Act, 1965. Upon writ petition No. 7260 of 2008 dated May 24, 2011, the Hon'ble High Court Division passed Order with some directions regarding the shipbreaking and recycling which reflect in the Shipbreaking and Recycling Rules, 2011. The Shipbreaking and Recycling Rules, 2011 has introduced the Ship Building and Ship Recycling Board (SBSRB) under the Ministry of Industry in Rule 3 which possess the authority to provide NOC (No Objection Certificate) for facilitating LC (Letter of Credit) to import vessels for recycling. According to the Rule 9, for obtaining permission for beaching a ship, the recycler has to submit documents as per Annexure–II, to the Port Authority along with documents or certificates obtained through SBSRB (The Shipbreaking and Recycling Rules, 2011). At the anchorage, the ship would be boarded and physically inspected by Shipbuilding and Ship Recycling Board Officials and other designated members of associate departments (The Shipbreaking and Recycling Rules, 2011). Rule 13 says after

obtaining beaching permission if it is found that the particular ship is not recycled and operating as cargo vessel domestic or Ocean going to be treated as a criminal offence by the yard owner or company to whom beaching permission was granted. (The Shipbreaking and Recycling Rules, 2011). Furthermore, the ship recycling plan is essential which contains two parts as the Ship recycling plan and Ship Recycling Facility's Plan. The shipbreaking yard must have enough space for movement while cutting ship. "Gas-free and fit for hot work" certificate is also essential which is issued by the Department of Explosive for avoiding accidents concerned with fire, explosion and deficiency of oxygen. However, Rule 18 notifies that the ship recyclers are required to strictly provide the environmental compliance in line with soil, water, air under Environment Conservation Act 1995 (Act 1 of 1995 amended in 2010) and other related national environmental act or law (The Shipbreaking and Recycling Rules, 2011). So these Rules are very important for governing the shipbreaking industries of Bangladesh.

The Hazardous Wastes and Shipbreaking Waste Management Rules, 2011: The Hazardous Wastes and Shipbreaking Waste Management Rules, 2011 was passed under section 20 of the Environment Conservation Act, 1995 for managing hazardous wastes and shipbreaking waste. Many toxic materials are found in a dead ship while breaking. Such materials can be hazardous for the workers and the environment. Asbestos, while extracting asbestos workers can become the victim of lung cancer, mesothelioma and asbestosis. Mercury can damage the nervous system of the human body. Lead can cause hearing impairment and loss of vision. These are the facts behind the regulatory framework to govern the shipbreaking industries of Bangladesh. Any ships scheduled for dismantling must have clearance under Rule 19 (1) of the Hazardous Wastes and Shipbreaking Waste Management Rules, 2011 and no ships can be dismantled without such clearance (The Hazardous Wastes and Shipbreaking Waste Management Rules, 2011).To get such clearance, applicants have to disclose information regarding hazardous material including asbestos, gasohol and lubricant which may be involved in dismantling. The applicants also have to disclose detail waste management process.

The Bangladesh Ship Recycling Act, 2018 (Act No. 08 of 2018): Bangladesh is the leading shipbreaking country in the world although it has some negative impacts on the marine environment. Bangladesh has ratified many international legal instruments regarding shipbreaking activities. For implementing such instruments and controlling marine environment, the Parliament of Bangladesh has recently passed an Act named “the Bangladesh Ship Recycling Act, 2018 (Act No. 08 of 2018)” in its 19th Session of 10th parliament. Section 7 of the Act says that this Act is passed to give effect to the provisions of the Hong Kong International Convention for safe and environmentally sound recycling of ships, 2009 (The Bangladesh Ship Recycling Act, 8 2018). Section 4 of the Act has mentioned about the establishment of a zone for ship-recycling industry where Section 25 specifies that whoever establishes any shipbreaking yard without permission of the government shall be punished with imprisonment of either description for a term which may extend to two years or with fine which may extend to Taka ten to thirty lac, or with both. Section 8 of the Act was intended to constitute a new authority named “Bangladesh Ship Recycling Board” to supervise the ship recycling industry (The Bangladesh Ship Recycling

Act, 2018). Under the law, a 13-member board would be formed headed by an Additional Secretary of the Industries Ministry would administer the activities of the ship recycling industry and sit for meetings at least thrice a year. The punishment for importing a ship without No Objection Certificate (NOC) provided by the shipping ministry is imprisonment not exceeding two years or a fine which may extend to Taka ten to thirty lac or with both and the punishment for creating a fake NOC is a fine between Taka 5 lakh to 20 lakh. As per the law, the government would set up the Treatment Storage and Disposal Facility (TSDF) within three years after enacting the law for proper management of wastage produced from ship recycling.

The Bangladesh Labour Act, 2006 (XLII of 2006): Shipbreaking industry is acknowledged as an industry in Bangladesh because 'manufacturing process' is involved with the industry. The Bangladesh Labour Act, 2006 has defined the 'manufacturing process' in section 2 subsection 2(d) where manufacturing process means construction, reconstruction, repairing, finishing and breaking up of ships or vessels; whereas under section 2(61) of the Act, industrial establishment includes shipbuilding, shipbreaking and ship recycling industry. The law contains the provisions regarding service conditions, health and safety issues, daily working hours, the procedures for leave and compensation system. Under section 3 of the Act, every establishment may have its own service rules and regulations of employment but such rules and regulations must not be less favourable to any worker and under section 10, every worker will get leave of absence through written application to his employer. Every establishment must maintain a healthy and hygienic environment. Regarding disposal of waste, section 54 says that 'effective arrangements shall be taken in every establishment for disposal of wastes and effluents due to manufacturing process carried on therein (The Bangladesh Labour Act, 2006).'Section 100 of the Act says 'no adult worker shall ordinarily work or be required to work in an establishment for more than 8 (eight) hours in a day: Provided that subject to the provisions of section 108 (Extra-allowance for overtime), any such worker may work in an establishment up to 10 (ten) hours also in a day (The Bangladesh Labour Act, 2006).'Under section 150 (1), if any worker is injured by an accident while working, the authority shall pay sufficient compensation. However, any employer or worker of an industry possesses the opportunity to go to the Labour Court formed under section 214 of this Act for the enforcement of any right provided by this Act.

The Fatal Accidents Act, 1855 (Act No. XII of 1855): The Fatal Accidents Act, 1855 was enacted to provide compensation to families for loss occasioned by the death of a person caused by actionable wrong. When the death or injury of a person is caused while working, it needs to take action and recover damages. The party who is liable for such death or injury shall be sued for damages for the benefit of the wife or husband, parent and children of the deceased or injured person. The Court by its judgment or decree shall direct the defendant to pay for the damages as it thinks fit to the family of the victim after deducting all relevant costs and expenses. The provision can be applied for the shipbreaking industries too which can help the workers of the shipbreaking industries either directly or indirectly.

Judicial Verdicts in Regulating Shipbreaking Industry

A writ petition was filed in 2006 by the Bangladesh Environmental Lawyers Association (BELA) challenging the legality of the entry of the vessel M.T. Alfa ship {listed as toxic ship

by Greenpeace (2010)} into the territorial waters of Bangladesh for the purpose of scrapping before the High Court Division of the Supreme Court of Bangladesh; whereas the Court issued a Rule Nisi calling upon the respondents to show cause as to why the permission for entry of the vessel should not be declared illegal and why the respondents should not be directed take immediate steps for banning importation of toxic ships listed by Greenpeace to enter into territorial waters of Bangladesh (Bangladesh Environmental Lawyers Association (BELA) vs. Ministry of Shipping, Bangladesh 2006). The government has already banned the entry of the vessel. In March 2009, the High Court Division of the Supreme Court of Bangladesh ordered that no end-of-life vessels shall be imported by Bangladeshi ship breakers without having been pre-cleaned of hazardous materials like asbestos, PCBs, heavy metals and other toxins before arriving in Bangladesh whereas the pre-cleaning requirement will be in accordance with the domestic laws and the Basel Convention (Bangladesh Environmental Lawyers Association (BELA) vs. Bangladesh 2009). Another writ petition was filed by BELA against the cutting of trees by ship breakers from the coastal green belt of Sonaichhari, under Sitakunda Upazila of Chattogram District for the purpose of setting up of shipbreaking yards on getting the lease of Coastal Belt Area land whereas a rule was issued on 24th February, 2009 calling upon the respondents to show cause as to why the impugned lease agreement and similar other agreements to lease out lands of the coastal green belt of Sonaichhari Mouza under Sitakunda Police Station for setting up of shipbreaking yards therein shall not be declared illegal and against public interest (Bangladesh Environmental Lawyers Association (BELA) vs. Bangladesh represented by the Secretary, Ministry of Environment and Forest and 18 others 2010). The government was directed to protect the environment as well as lands through setting up Mobile Courts. The government was also directed to establish an exclusive zone for the shipbreaking industry. As per the order, the government has passed shipbreaking rules.

Recommendations for Sustainable Shipbreaking Industry

In order to fully comply with the obligations placed on Bangladesh by the international legal framework and given many negative impacts of the shipbreaking industry on the environment, existing environmental laws should be amended. Alternatively, separate legislation regulating the shipbreaking industry should be adopted to address all the environmental, labour and social aspects of the industry. Such a proposed legal framework should also clearly define the roles and responsibilities of different agencies along with the above-mentioned provisions. This is important since without a dedicated legislative framework it would be difficult to operate the shipbreaking industry in congruence with international standards and in an environmentally sustainable manner.

Apart from this, Bangladesh should immediately develop a proper authorisation and inspection system with the aim of ensuring the proper management of hazardous materials, environmental conservation and reporting procedures. Failing to develop the capacity to comply with environmentally sound management requirements in the shipbreaking industry will result in Bangladesh risking its future viability to operate the industry. This will bar other countries to export obsolete ships to a country that fail to comply with the environmentally sound management requirements.

The incorporation of the core principles of the Basel Convention through legal regulation at the national level also depends upon the capacity of the Department of Environment and other related government agencies. Particularly in Bangladesh, the fact remains that the various government departments have not taken necessary initiatives in this regard, as the organisations related with this industry chronically suffer from a lack of resources, infrastructure, equipment, and, most importantly, adequate and qualified manpower. These lacunae in the enforcement machinery need to be properly and promptly addressed.

Nonetheless, the combination of the economic attraction of shipbreaking for a least-developed country such as Bangladesh and the lack of capacity to implement an effective legal regime leads to a regulatory cul-de-sac. Bangladesh's economy, similar to other countries in South and South East Asia, still financially profits from the industry as it provides jobs and financial resources to those least developed whilst remaining highly profitable. Thus, it is not desirable for Bangladesh to fully abandon this industry. However, Bangladesh, like many other countries in the region, lacks the capacity to implement minimum standards of environmental, health and safety, which necessitates the international regulation of environmentally sound management of ship recycling, and compliance of the international standards and requirements need to be made effective and binding. Although mechanisms to provide for capacity building and technology transfer in developing states do exist under the Basel Convention, they have been rendered inadequate by a severe lack of funding.

The ability to strike a fair balance between allowing emerging economies access to the new commodity of waste and preventing environmental degradation and damage to human health is possible if changes can be made to improve the Basel Convention's operation. As waste output in developed states continues to grow and the North-South gap widens, the weaknesses of the current treaty regime must be adequately addressed in order for regulation of waste transfers to effectively balance the multiplicity of interests concerned.

Owing to corporate social responsibilities, shipping companies should send their end of life ships only to facilities that comply with the technical guidelines of IMO, The Basel Convention, and the ILO. Ship-owners, together with shipbuilders commit to the development of clean and environmentally sustainable ships in order to avoid future disposal problems. Responsible management of end of life ships must include regulation at both international and national level with due recognition of environmental, economic and social implications of international trade in hazardous waste.

Conclusion

Shipbreaking is the best way of disposing of end-of-life of a ship. Almost every parts and equipment of a ship can be reused. Particularly for Bangladesh, the industry creates thousands of direct or indirect job opportunities. The conditions of the shipbreaking yards of Bangladesh pushed the watchdogs to interfere in the industry. The Bangladesh government has taken many steps to improve the security of recycling ships. The country's parliament has passed the Bangladesh Ship Recycling Act 2018, keeping the provision of strict punishment for violations of the law. In order to comply with all obligations of the international laws, the

ship breakers should conduct scientific research within the industries. However, a first-ever green vessel named 'Ore Vitoria' has been beached for recycling at PHP Green shipbreaking and Recycling Yard at Sitakunda upazila in Chattogram district on 31 July 2018 ("First-Ever 'Green Vessel' Beached at PHP Shipyard" n.d.). It expresses the commitment of the shipbreaking industries towards green and safer recycling. The shipbreaking industries of Bangladesh should hold the international conference as well as should invite international experts related to shipbreaking to visit their shipbreaking yard regularly which can enhance information sharing opportunity. It will also help to receive global recognition for strictly obeying to national and international rules & regulations for ensuring an environment-friendly industry. Some steps should be taken by all stakeholders related to the shipbreaking industries like strictly following shipbreaking rules and regulations, the government needs to create a specific zone for the ship recycling industries which can be less costly, ensuring easy process in getting a license, No Objection Certificate (NOC) and Environmental Clearance Certificate, government may grant tax holiday for a certain period and assist the industries in purchasing the necessary technology required for shipbuilding and recycling. Finally, by developing a compulsory training system and internal scientific research program, a healthy, safe, environmentally sound and profitable shipbreaking industry can be ensured.

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Control over Maritime Chokepoints an Assurance of Secure Lifeline

Md. Mehadi Amin Miah[1],
S. M. Saief Uddin Ahmed[2] and Kazi Shaila Sultana[3]

Abstract

From ancient time explorers and military people travelled different lands for a living. In course of time, this natural need institutionalised through trade and commerce. Complementary interest rose through exchange mode of trade but contradictory condition developed with coercive military might in pursuit of wealth. Explorers tried to look for a geographical shortest way to save time and energy. Thereby the major geographical choke points of the world have become significant both from geopolitical and geostrategic perspective. There are approximately 200 straits or canals around the world but only a handful are known as chokepoints. Chokepoints are the strategic strait or canal which could be closed or blockaded to restrict energy flow or lifelines of governing states. This type of geopolitical aggression could surely cause international discontent. In 1982 Law of the Sea Convention further protected the international access for nations to sail through straits or canals and ensured these passageways are available as aviation routes for all nations. Hence the control over such geographical choke points and canals can assure politico-economic relief for nations whose main energy flow or lifeline exclusively depends on safe passage through geographical choke points.

Keywords: Shipping, Chokepoints, Energy Flow, Lifeline, Economic Sanction, Geopolitics, UNCLOS.

Introduction

"…. for whosoever commands the sea, commands the trade, whosoever commands the trade of the world commands the reaches of the world and consequently the world itself"

A 15th century English soldier, a qualified intelligence agent and later became British politician Sir Walter Raleigh mentioned those lines on his autobiography published 200 years after his death (Raleigh, 1829). Though Sun Tzu was the pioneer on the art of war strategy on the battlefield, Sir Walter Raleigh was the pioneer to shift the focus of war more on economic control through the sea. Later on, 18th century US Admiral Alfred Thayer Mahan supplements the concept of sea power of a nation with few credentials like; Geographical

[1] *MPhil Researcher, CHSR, Bangladesh University of Professionals*
[2] *Assistant Professor, Business Faculty, Sylhet International University*
[3] *Assistant Professor, Law Faculty, Uttara University*

position, physical conformation, number of population, national character, the character of government and most importantly extent of territory (Mahan, 1660). In 21st Century Geoffrey Till, Eric Groove and Milan Vego further simplify the intent of superpowers at sea on developing sea power.

They clearly signify the aspect of Critical requirement (CR) and critical vulnerability (CV) of any achievable Centre of Gravity (CG) (Vego, 2009). Last decade Strategist Collin S Grey and Charles Hadfield mentioned about the control over geographical choke points and significant canals of the world are the CV to gain control over the trade of the world (Grey, 1999). In today's world, economic security assures the stability of the government.

In this paper, the major geographical choke points of the world along with few canals will be briefly presented with their controlling authority. An assessment specified on power playing nation's politico-economic interest of geographical choke points and canals including their brief history. Finally, a glimpse of thought is expressed on Bangladesh perspective to extract complimentary strategic benefit from power playing nations on the aspect of Geographical choke points.

Conceptual Framework

This paper is a geostrategic meta-analytic research where the concept of geographical chokepoints was described in brief. major geographical chokepoints and man-made chokepoints were also described with geographic maps along with strategic significance. The power politics by the influential nation-state concentrated through geographical choke points were also mentioned in the paper. The growing interest of influential nation state's investment on future manmade choke points and endeavour to dominate in international geopolitics were figured out as an outcome of this paper. Finally, the impact on Bangladesh over maritime politics of geographical choke points were discussed in brief as the future scope of study from this paper. In this exploratory form of research methodology meta-analysis process was adopted as it combines fact from multiple studies for a common outcome. Here multiple geographical chokepoints both natural and man-made were discussed considering the

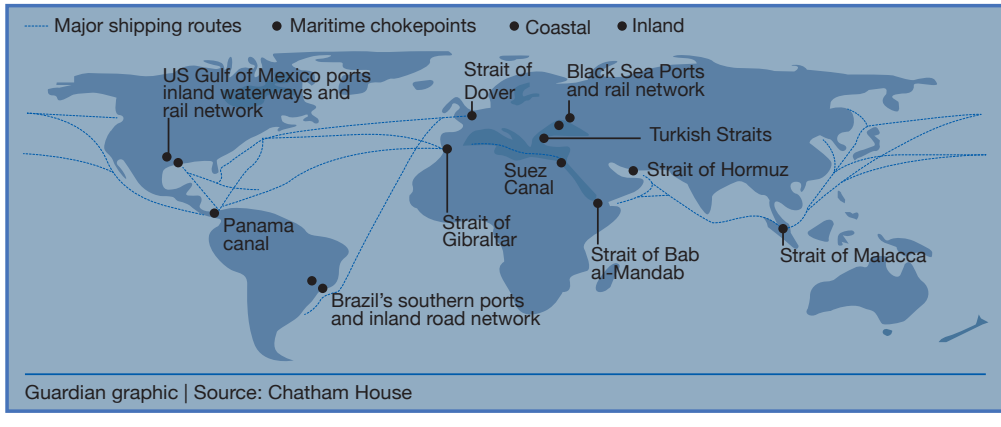

Figure-1: Global Maritime Chokepoints (http://www.bbc.com/news/world-40415756)

international maritime geopolitics evolving around them. Thereby global maritime choke points were discussed briefly with future endeavour by power playing nations over choke point, nation states and third-party State interest like Bangladesh were discussed in this paper.

Geographical Chokepoints

The world's oceans account for nearly 90% of all international commerce. Straits are geographical areas littered across the oceans near land masses that constrict the passage of

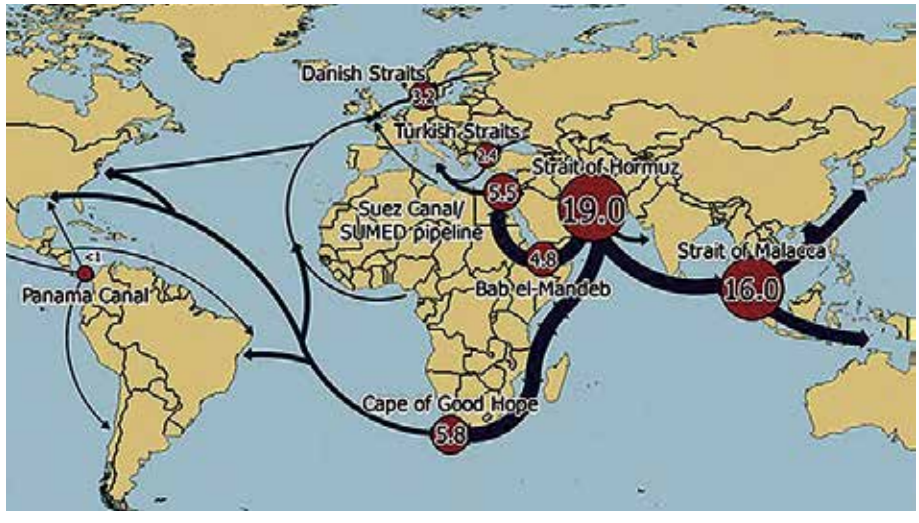

Figure-2: Global Oil production and Consumption flow: million barrel/day-2015
(http://energyfuse.org/wp-content/uploads/2015/04/crude-oil-balance-of-trade

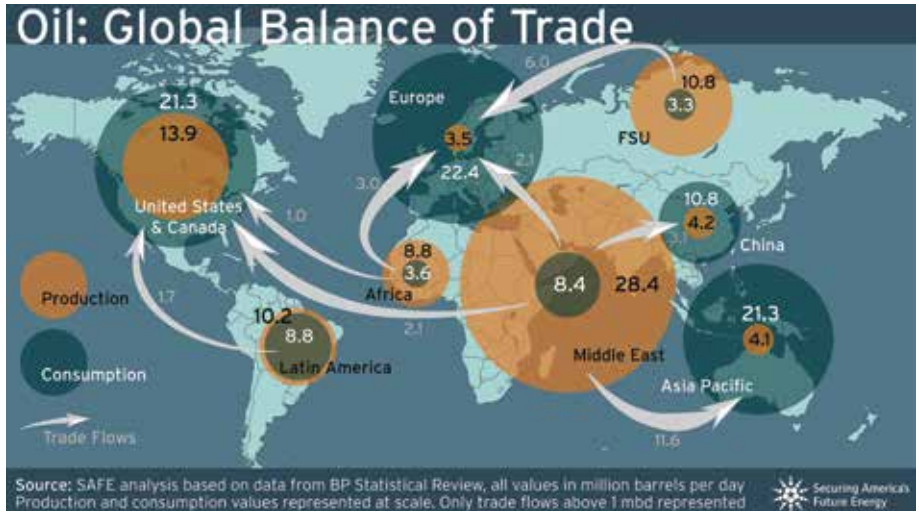

Figure-3: Global Oil transit Chokepoints and energy flow: million barrel/day-2016
(https://www.eia.gov/beta/international/regions-topics.php?RegionTopicID=WOTC)

shipping to narrow passages. These geographical narrow passages are called chokepoints.

In 1982 UNCLOS II protected the international access for nations to safe passage through straits and canals and even ensured that these passageways are available as the innocent passage for aviation (Collins, 1998). These straits often serve as strategic chokepoints those offer potential control of the world's sea lanes of communication. As international shipping lanes are forced to go through these specific vulnerable locations, they are often referred to as the 'Geographical Achilles heels of the global economy'. Many straits are in close proximity to politically unstable nations, which increases navigation risks and compromises access and use. These strategic passages can be mined, blocked by sinking ships or interdicted by naval forces, artillery or missile systems (Jong, 2014).

Major Geographical Chokepoints

There are few geo-strategic oil chokepoints throughout the world. Disruption to any one of these chokepoints could cause unpredictable price fluctuations. Fortunately, these locations are generally safe and are kept clear by the international community, whose economies and standards of living depend on these chokepoints. Uncertainty over maritime security can lead to a global shift in oil prices. If one of these chokepoints were disrupted, ships would need to travel additional thousands of miles to reach an alternate route. The major choke points are appended below in the order of oil flow:

Strait of Hormuz

The Strait of Hormuz is the world's primary oil chokepoint. According to the US Energy Information Administration (EIA), 19 million barrels of oil, representing 30% of all maritime-traded petroleum passed through the strait per day in 2015. Oil from Saudi Arabia, the UAE, Qatar, Iran and Iraq all pass through the strait. These oil flow head mostly towards Asia and

Figure-4: Global Oil flow in Hormuz Strait
(https://www.google.com/search?hl=en&authuser)

tankers head west towards Suez Canal and the Red Sea.

The Strait of Hormuz is able to accommodate the largest oil tankers in the world. The mercury of tension rising centring this strait as the US and its allied domination is often challenged by Iran, China and Russia. Recent Qatar issue further tightened the situation of flow at Hormuz. This is a 47 km strait between Bandar Abbas port of Iran and Kumzar island of Oman. British SOLAS (Safety of Life At Sea) station at Al Jeer port of UAE and Safe energy traffic station of US coalition forces established on Khasab port of Oman (Ramazani, 1979) raised the mercury of tension much higher than predicted. US and UK maintain strong military ties with Saudi Arabia, Oman and UAE for active control on the Strait of Hormuz.

Strait of Malacca

The Strait of Malacca is the shortest waterway which connects the Indian Ocean to the South China Sea and the Pacific Ocean. In 2015, the US Energy Information Administration, EIA estimated that 15.2 million barrels of oil a day passed through the strait, with the fuel from the Middle East primarily heading towards Indonesia, China, and Japan. The Strait of Malacca is also one of the narrowest chokepoints in the world. The narrowest point in the strait is only 1.7 miles wide, which creates a natural bottleneck for shipping. The Strait is 805 km (500 miles) stretched between Peninsular Malaysia (West Malaysia) and the Indonesian island of Sumatra. At Phillips Channel close to the south of Singapore, the Strait of Malacca narrows to 2.8 km (1.5 nautical miles) wide, creating one of the world's most significant traffic choke point (Freeman, 2003).

Figure-5: Crude Oil flow through Malacca Strait
(https://www.eia.gov/todayinenergy/detail.php?id=10671)

It is named after the Empire of Melaka who ruled over the archipelago between 1414 to 1511. From an economic and strategic perspective, the Strait of Malacca is one of the most

important shipping lanes in the world. The strait is the main shipping channel between the Indian Ocean and the Pacific Ocean, linking major Asian economies such as India, China, Japan and South Korea. Over 50,000 vessels pass through the strait per year carrying one-quarter of the world's traded goods including oil, Chinese manufactures and Indonesian coffee. About a quarter of all oil carried by sea passes through this strait (Nordin, 2007). The narrowest point of this channel is about 22 km between Malaysia's Port Dickson and Indonesian Island of Pulut Rupat.

Cape of Good Hope

The Cape of Good Hope, the crossing at the southernmost tip of Africa, is not technically a chokepoint since it's open on one side but considered as a critical trade route. In 2013, the route around the Cape saw 4.9 million barrels of oil a day, approximately 9% of the total maritime oil trade. In 2013, total 3.6 M/bd of crude oil around the world moved eastbound, originating mostly from Africa (2.1 M/bd) and from South America and the Caribbean (1.3 M/bd). Eastbound crude oil flows were nearly all destined for Asian markets (3.5 M/bd). In the opposite direction, nearly all westbound flows originated from the Middle East (1.3 M/bd), mostly destined for the United States (Mulder, 2015).

There is a very common misconception that the Cape of Good Hope is the southern tip of Africa because it was once believed to be the dividing point between the Atlantic and Indian Oceans. In fact, the southernmost point is Cape Agulhas, about 150 kilometres (90 miles) to the east-southeast. The Atlantic and Indian

Figure-6: Oil flow through Cape of Good Hope
(https://www.eia.gov/todayinenergy/detail.php?id=10671)

oceans meet at the point where the warm-water current meets the cold-water current and turns back on itself – a point that fluctuates between Cape Agulhas and Cape Point, about one kilometre east of the Cape of Good Hope. When following the African coastline from the equator, the Cape of Good Hope marks the psychologically important point where one begins to travel more eastward than southward. Thus the first rounding of the cape in 1488 by Portuguese explorer Bartolommeo Dias was a major milestone in the attempts by the Portuguese to establish direct trade relations with the Far East (McKinnon, 2015).

The Cape of Good Hope also functions as the secondary route for oil if the primary chokepoints of the Suez Canal or the Bab el-Mandab were closed. According to the US Energy Information Administration, EIA rerouting oil around the cape would increase oil cost considerably as it would add an additional 2,700 miles of transit from Saudi Arabia to the US.

Figure-7: Traffic lane through Bab-el-Mandeb chokepoint
(http://susris.com/2015/04/14/the-bab-el-mandeb-maritime-chokepoint)

Bab el-Mandab

Only 18 miles wide at its narrowest point, the Bab el-Mandab connects the Red Sea to the Gulf of Aden and ultimately to the Indian Ocean. Instability or closure of the waterway could force tankers to have to travel around the southern tip of Africa. Crucially, the EIA notes, the vast majority of southbound traffic through the Suez Canal must also pass through the Bab el-Mandab, so the closure of the waterway could have a cascade effect (Anderson, 2014).

In 2015, 3.8 million barrels of oil passed through the waterway per day. Oil prices took a recent jolt after the Yemeni government collapsed, raising the possibility of a security crisis in the Bab el-Mandab. The narrowest passage of the choke point is 12 km between former French colony Djibouti and Perim island of Yemen where 2012 UK invested on hotel tourism and maritime safety observer station for passive control (Blazev, 2016).

Danish Straits

The Danish Straits formed out of a series of channels passing around the Danish Islands is among the most secure oil chokepoints in the world. The chokepoint connects the Baltic Sea in the east to the North Sea in the west. Approximately 3.3 million barrels of oil a day flowed through the region in 2013. Despite rising tensions with Russia in Europe and particularly the Baltics, shipping is unlikely to be affected by regional security issues. The EIA estimates that

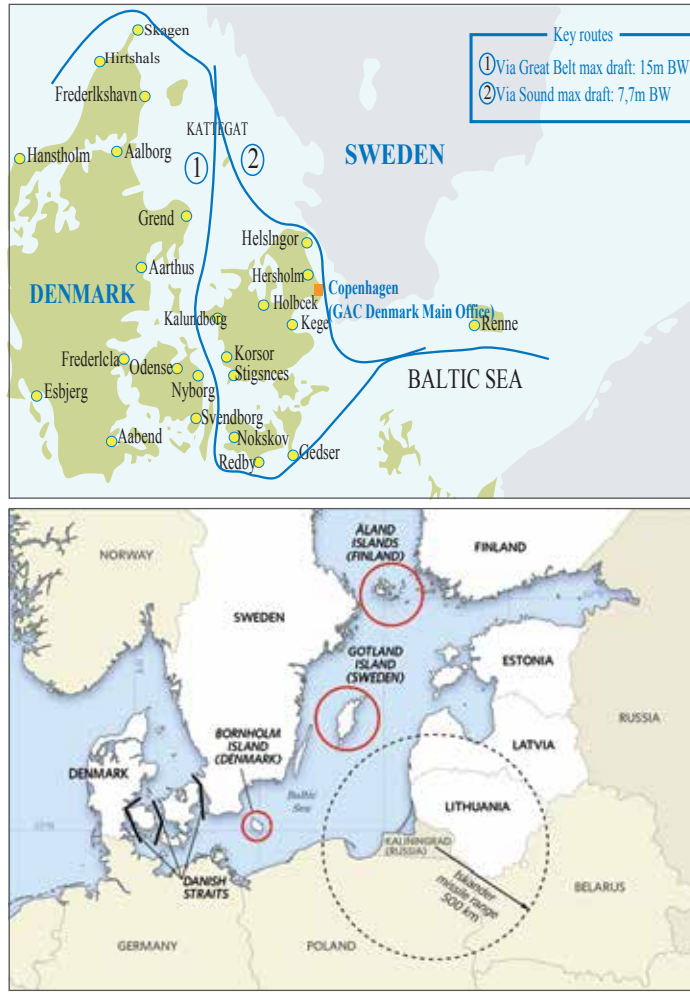

Figure- 8: Traffic lane through Danish Strait
(https://www.trafficlist.net/lyngby-radio-oxz)

42% of all oil shipped through the Danish Straits originated from the Russian port of Primorsk in 2013 to the West. A small amount of Norwegian and British oil also went through the straits to the Baltics (Paul, 2010). If Russia ever blockaded the Strait, it would mostly just be blockading its own oil trade as well.

Strait of Gibraltar

The name Gibraltar is the Spanish derivation of the Arabic name Jabaal Tariq, meaning 'Mountain of Tariq'. It refers to the Rock of Gibraltar, which was named after the Umayyad general Tariq ibn-Ziyad. An Anglo-Dutch force captured Gibraltar from Spain in 1704 during the War of the Spanish Successor on behalf of the Habsburg pretender to the Spanish throne. The territory was subsequently ceded to Britain in perpetuity under the 'Treaty of Utrecht' in

1713. The sovereignty of Gibraltar is a major point of contention in Anglo-Spanish relations as Spain asserts a claim to the territory. Gibraltarians overwhelmingly rejected proposals for Spanish sovereignty in a 1967 referendum and again in 2002. Under the Gibraltar constitution of 2006, Gibraltar governs its own affairs such as defence and foreign relations remaining under the responsibility of the UK Government.

Figure-9: Strait of Gibraltar
(http://attyreycdar.blogspot.com/2014/08/rock-of-gibraltar.html)

The Strait of Gibraltar is a narrow body of water between Spain and Britain that connects the Mediterranean Sea with the Atlantic Ocean. Though the strait having a continuous coast of Morocco, Britain shares the critical entry point of Spanish land and Spain holds the south-eastern part of Morocco. Around 300 cargo vessels pass through the Strait every day. In spite of the heavy concentration of shipping traffic and the noise caused by it, there is still an abundance of whales and dolphins in these waters. The Rock is the Crown property of the United Kingdom and borders Spain (Brown, 2012). The sovereignty of Gibraltar was transferred from Spain to the Kingdom of Great Britain by the Treaty of Utrecht in 1713 after the War of the Spanish Succession.

Bosporus Strait

A strait of Bosporus/Turkish Straits is a 17-mile-long waterway with only 1 km wide, which connects the Black Sea with the Mediterranean Sea and supplies Western and Southern Europe with oil from the Caspian Sea. The strait is made up of the Bosporus and Dardanelles and divides Asia and Europe. The Bosporus joins the Black Sea with the Sea of Marmara and the Dardanelles connects the Sea of Marmara and the Mediterranean Sea. Straits of Bosporus is the world's narrowest strait used for international navigation. The Straits are governed under the Montreux Convention, which gives Turkey control over the Bosporus and the Dardanelles. While Turkish maritime authorities have the right to levy tolls on the passing tankers and are also responsible to check ships for sanitary conditions and safety (Cogliati, 2014), the Bosporus and Dardanelles Straits are considered international waterways and

Figure-10: Strait of Bosporus
(http://www.bosphorustour.com/Currents-Bosphorus-Water.html)

Turkey is prohibited from restricting their use during peacetime.

The Bosporus is a narrow stretch of water that divides both Asia from Europe and splits Istanbul's European and Asian halves. The chokepoint connects the Black Sea to the Mediterranean. In 2013, approximately 2.9 million barrels of oil a day flowed through the Bosporus, with the petroleum coming from Russia, Azerbaijan, and Kazakhstan. According to the EIA, Russia has slowly been shifting its exports to the Baltics while Azerbaijan and Kazakhstan have further increased shipping through the chokepoint. The Bosporus is only a half mile wide at its narrowest point and around 48,000 vessels travel through the waterway a year (Bender, 2015).

Major Manmade Canals as a Chokepoint

There are few manmade-strategic chokepoints throughout the world. Since these choke points are manmade, they represent strong economic and political intention of state government with regional influence. Closure or disruption to any one of them could cause unpredictable price fluctuations of commodities and energy. Therefore, these choke points became the vital regional lifelines exhibiting supreme strategic importance. Economic superpowers also influencing states to have more manmade canals to dominate regional economic growth and establish own interest. Military movement and positioning along the canals further secure the interest of influencing nation and disrupt the interest of other States. Uncertainty over maritime security can lead to a global shift in oil prices. If one of these chokepoints were disrupted, ships would need to travel additional thousands of miles to reach an alternate route. The major manmade canals are appended below in the order of shipping flow:

Suez Canal

Suez Canal is an artificial sea-level waterway in Egypt, connecting the Mediterranean Sea to the Red Sea through the Isthmus of Suez. Constructed by the Suez Canal Company between

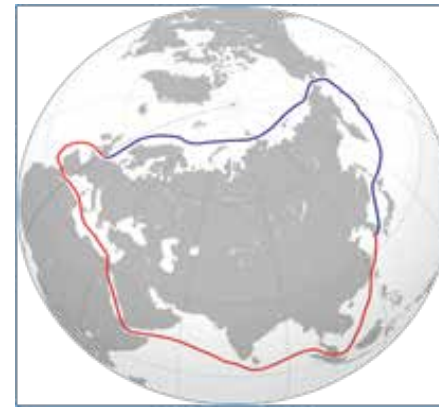

Figure-11: Suez Canal
(http://www.npr.org/sections/thetwo-way/2017/06/14/532960178)

1859 and 1869, it was officially opened on November 17, 1869. The canal offers watercraft a shorter journey between the North Atlantic and northern Indian Oceans via the Mediterranean and Red seas by avoiding the South Atlantic and southern Indian oceans, in turn reducing the journey by approximately 7,000km (4,300 miles). It extends from the northern terminus of Port Said to the southern terminus of Port Tewfik at the city of Suez. Its length is 193.30km (120.11 miles), including its northern and southern access channels (Lesseps, 1876).

Figure-12: Suez Canal Development
(http://english.alarabiya.net/en/perspective/2015-Egypt-s-Suez-Canal)

In 2013, a record 3.2 million barrels of oil a day passed through the canal, mostly to markets in Europe and North America. According to the EIA, the Suez Canal was expanded in 2010 to allow 60% of all tankers in the world to effectively pass through. The fall of dictator Hosni Mubarak in Egypt in

2011 and the resulting unrest did little to deter shipping through the canal. But security remains a primary concern and in September 2013 terrorists planned a failed rocket attack on cargo ships passing through the region. In 2012 total 17,225 vessels traversed the canal which means 47 vessels per day. In August 2014, construction was launched to expand the speed of the canal's transit time to double the capacity of the Suez Canal from 49 to 97 ships a day. The 'New Suez Canal', as the expansion opened with great fanfare in a ceremony on 6 August 2015 (Waterfield, 2016).

Panama Canal

The United States commenced building a canal across a 50-mile stretch of the Panama isthmus in 1904. Chief engineer John Stevens devised innovative techniques and spurred the crucial redesign from a sea-level to a lock canal. His successor, Lt. Col. George Washington Goethals, stepped up excavation efforts of a stubborn mountain range and oversaw the building of the dams and locks. The Canal opened in 1914, oversight of the world-famous Panama Canal was transferred from the U.S. to Panama in 1999. The Panama Canal is strategically important to the United States because it is a rapid link between the east and west coast, saving approximately 13,000km (from 21,000km to 8000km). It is comprised of three

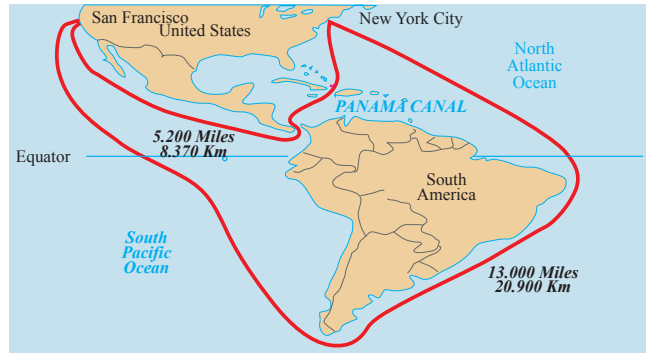

Fig 13: Panama Canal Operation.
(http://marinersgalaxy.com/2015/06/panama-canal-history)

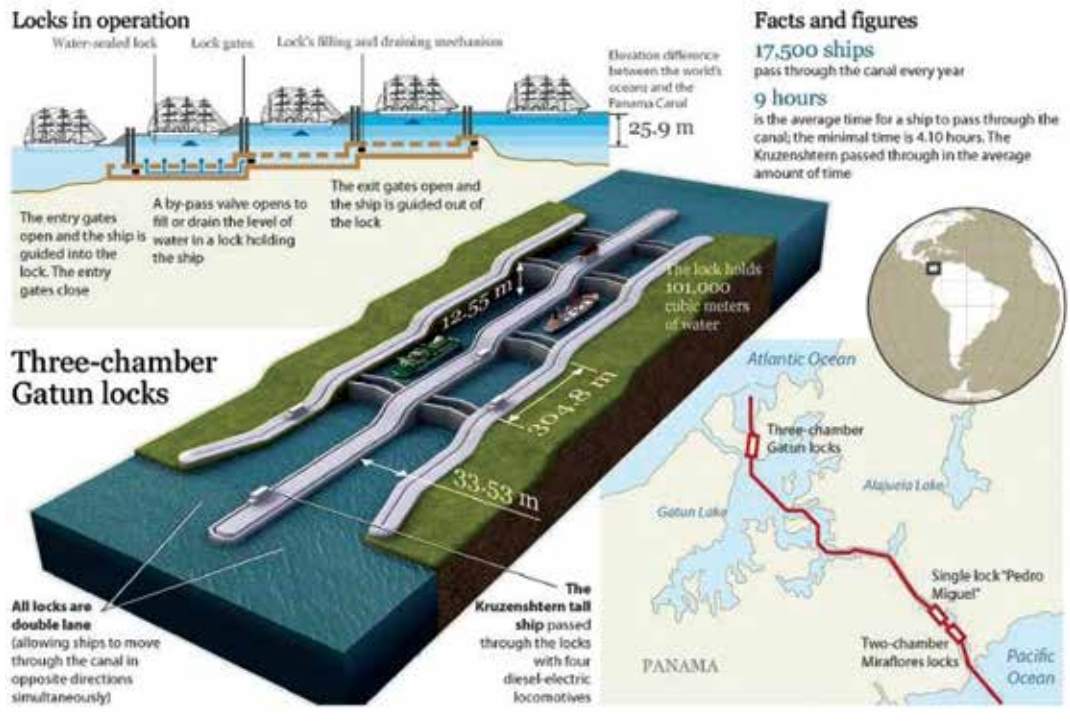

Figure-14: Economic benefit of the Panama Canal.
(http://marinersgalaxy.com/2015/06/panama-canal-history)

main elements, the Gatun Locks (Atlantic Ocean access) the Gaillard Cut (continental divide) and the Miraflores Locks (Pacific Ocean access). The Panama Canal connects the Pacific Ocean to the Caribbean and ultimately to the Atlantic (McCullough, 2001). According to the US Energy Information Administration EIA, the Panama Canal transported 1.4% of all oil and petroleum products globally in 2013. This amounted to approximately 0.85 million barrels of oil a day in 2013. The utility of the canal has waned in the years since it was built.

Today, the narrowest point of the Panama Canal is only 110 feet wide forcing larger super-tankers to avoid the canal. The canal is undergoing an expansion project which should enable larger tankers to pass through the region more easily. The USA will fund the expansion project of the Panama Canal to ensure the safe passage of her Supertankers and Aircraft Carriers. Political negotiation is underway to attain more benefit from Panama and early completion of the development project by 2022 (Friar, 2016).

Kiel Canal

The Kiel canal built between 1887 and 1895, initially served German military needs by eliminating the necessity for ships to travel northward around the Danish peninsula. It was enlarged between 1907 and 1914 to accommodate large naval ships. Prior to World War I the

Fig 15: German Kiel Canal.
(https://www.britannica.com/topic/Kiel-Canal)

canal (former Kaiser-Wilhelm Canal) was owned by the German government. The Treaty of Versailles (June 28, 1919) laid down regulations, internationalised the canal and leaving it under German administration. Traffic on the canal was subject only to general police, shipping, sanitary and customs regulations. These provisions were rejected by Adolf Hitler in 1936. Since World War II the conditions of the Treaty of Versailles guaranteeing freedom of navigation to be practised (Gollasch Stephan, 2006). The canal remains an important route for Baltic shipping.

The canal has been enlarged twice and is today 160 metres (526 feet) wide and 11 metres (37 feet) deep and is spanned by seven high-level bridges that have about 43 metres (140 feet) of clearance for ships beneath them. The locks are 45 metres (146 feet) wide by 327 metres (1,072 feet) long. The canal constitutes the safest, most convenient, shortest and cheapest shipping route between the North Sea and Baltic Sea (Sheffield, 2016). This canal gives the quickest access route to all the rim nations of Baltic Sea like Poland, Lithuania, Latvia, Estonia, Finland and Moscow.

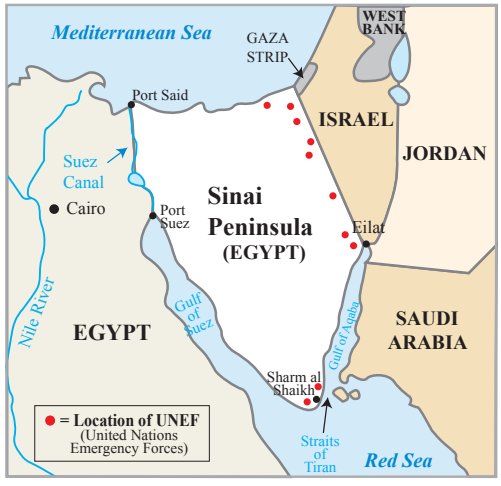

Figure-16: Israeli Lifeline Strait of Tiran
(https://earthobservatory.nasa.gov/IOTD/view.php?id=81772)

Future Exertion on the Canal as the Chokepoint

There are few natural chokepoints new world order will ponder out. Complementary and conflicting interest will open the avenue to think for the execution of new manmade canals. Few future planning of economic giants trying to secure their interest through Geographic and manmade canal development are given below:

Strait of Tiran

The Straits of Tiran are the narrow sea passages between the Sinai and Arabian peninsulas which separate the Gulf of Aqaba from the Red Sea. The distance between the two peninsulas is about 13 km. After the 1956 war, Egypt agreed to reopen the Straits of Tiran for Israeli shipping, whose closure had been a significant catalyst in advancing the Suez Crisis. It has two passages deep enough to be navigable by larger ships. The Enterprise passage, 290 metres (950 feet) deep, is adjacent to the Egyptian side, while the 73 metres (240 feet) deep Grafton passage, surrounded by shallows, is to the east, nearer to the island of Tiran (Lapidoth, 1982). To the east of Tiran and Saudi Arabia, the other strait has reefs and shallows with a single channel has 16 metres (52 feet) depth.

Access to Jordan's only seaport of Aqaba and to Israel's only Red Sea seaport of Eilat is through the Gulf of Aqaba, which gives the Straits of Tiran strategic importance. In 1967, 90% of Israeli oil passed through the Straits of Tiran, making it a target of Egyptian blockade during the Arab League boycott of Israel. In May 1967, Israeli Prime Minister Levi Eshkol repeated declarations that Israel had made in 1957, saying that closure of the Straits of Tiran would be an act of war. Spiritually the route of Exodus gives this strait an added value to Jews (Fritz, 2016), yet Israeli lifeline Strait of Tiran will be protected by her allies in the name of Maritime security.

Nicaragua Canal

This canal is the extended reach of China's string of pearls which negotiates with Nicaraguan government to have an alternative manmade canal other than the Panama Canal. On 26 September 2012, the Nicaraguan Government and the newly formed Hong Kong Nicaragua Canal Development Group (HKND) signed a memorandum of understanding that committed HKND to finance and building the 'Nicaraguan Canal and Development Project'. HKND Group is a private enterprise (Ellis, 2016). The Nicaraguan Government subsequently approved the Master Concession Agreement with HKND on 13 June 2013 thereby granting 'The sole rights to the HKND Group to plan, design, construct and thereafter to operate and manage the Nicaragua Grand Canal and other related projects, including ports, a free trade zone, an international airport and other infrastructure development projects'. The construction work is due to start by the end of 2022.

Figure-17: Panam's Alternative Nicaragua Canal (http://www.globaltimes.cn/content/898353.shtml)

The country has been waiting for the project's completion and a chance to compete with the Panama Canal. This Special Law for the Development of Nicaraguan Infrastructure and Transport to the Canal and Free Trade Zones allow for the construction of the project, which is estimated at USD 50 billion. The agreement establishes that the Canal will have its own special operation team with immunity to Nicaraguan law and HKND descendants will be the

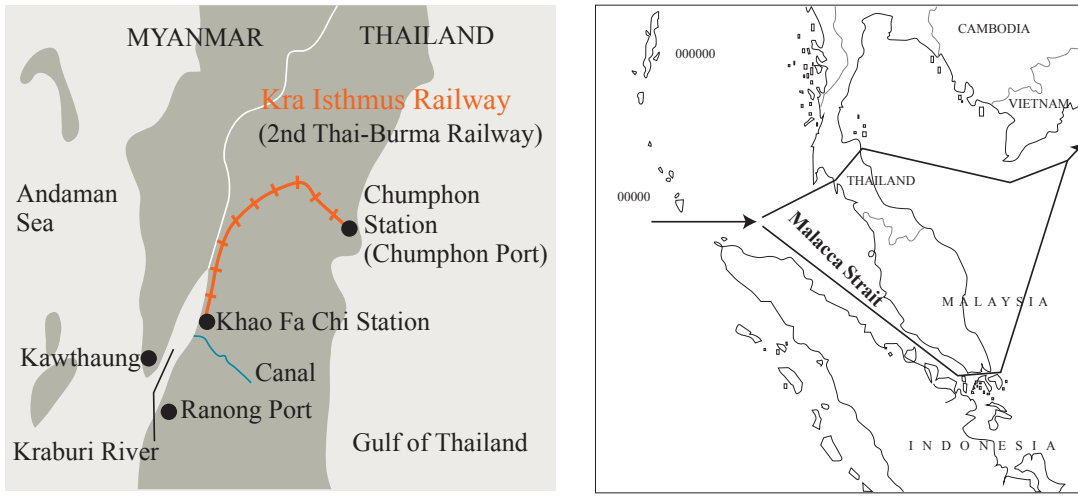

Figure-18: Ranong-Chumphon Canal
(https://books.google.co.uk/books?%Thailand%20Ranong%20Canal)

owners of the Canal until the year 2129 (Ellis, 2016).

Ranong Canal

Ranong is located 586 kilometres south of Bangkok and is the first southern province that is located on the Andaman Sea. The narrowest part Ranong province of Thailand is only 44 kilometres which give explicit chance for any country to invest in manmade canals. China showed interest in this project which may challenge and incapacitate the shipping flow of Malacca Strait. If this canal is established after the hydrographic assessment, it will definitely transform the economic posture of Thailand.

Thailand is seeking investments to build a Canal Zone through the provinces of Ranong and Chumphon. This will shorten the trip from the Middle East by a couple of days by skipping the strait of Malacca. International energy flow duration will be reduced by a day with distance reduction of 2300 km toward China and East Asia (Graham, 2005). Japan is interested but China is ready to invest and start the project by 2022 after political clearance from China's policy-making level.

Bangladesh Perspective on Global Chokepoints

Bangladesh, a littoral state in the Bay of Bengal (BoB), is becoming more and more strategically significant for many countries. Since the BoB leads to the Malacca Strait, that opens up to the South China Sea (SCS), these routes are crucial to economies in the SCS (China, Japan) which explains the growing interest and involvement of extra-littoral players in the Bay. Protection of SLOCs has added to the importance of increasing maritime power projection capabilities in the BoB. Even though relatively manageable in terms of confrontations between nations, the intentions of the major powers are increasingly being

questioned. In terms of foreign policy strategy, China is clearly adopting a 'Look South' policy, reflected through its heavy infrastructure investments in the countries around the Bay. India is opting for a 'Look East' policy, to intensify connectivity to Southeast Asia and the US with its Asia 'Rebalancing' strategy which shifts its focus from the Middle East to this dynamic region (M H Kabir, 2015).

Geographically Bangladesh residing among world economic superpower's like China and India where politico-economic calculation seems tedious on conflicting and contradictory interest. Considering Bangladesh under the 'String of Pearls' policy of China with their deep sea port investment gave huge importance to Bangladesh in the global arena. Chinese interest lies in the investment on Bangladesh's plain fertile land and transit point to develop her southern Sichuan province. On the other hand, India's political influence on Bangladesh assures transit facilities towards her eastern regional development at Tripura, Assam and Mizoram. Internationally as a Muslim state and vibrant UN member state Bangladesh maintains healthy foreign relation with global powers and middle east for safer and smooth flow of petroleum through geographical choke points.

Conclusion

At the dawn of the 15th century, Sir Walter Raleigh recognised the strategic importance of oceanic chokepoints for commercial trading vessels in times of peace and have enhanced the military power of their occupiers in times of war. However, in course of time, structural changes in the shipping industry have had significant consequences for strategic chokepoints, especially the two great canals. Over the last 25 years, the real cost of sea transportation fell by 80% because larger ships generated economies of scale, containerisation reduced labour costs and information technology improved resource allocation. The rise of super tankers and post-Panamax container ships has significantly diverted traffic from the Panama Canal and has motivated the Egyptian government to approve a 10-year 441 million-dollar project to widen and deepen the Suez Canal. The development of railway trans-shipment in Suez and Panama and competition from rail and truck transportation in North America and Europe may further undermine the commercial value of strategic waterways. Moreover, most products of information industries cost very little to transport, even by aeroplane and sometimes can be 'exported' abroad via the internet.

Growing demand and squeezed supplies are unavoidable consequences of the geography of petroleum production, distribution and consumption. The global economy is beginning to realise the full extent of a growing shortage of oil and its inherent economic and geopolitical costs. Current estimates place the peak of global oil production at around 2008-2010. In the meantime, oil consumers are struggling to diversify their oil supplies, but most of the remaining oil reserves are predominantly in the Middle East, a region which will remain the focal point of global oil shipments. Although there is a current energy shift towards renewable and environmentally-friendly resources, such as natural gas and eventually hydrogen, the move from petroleum is likely decades away. Even a transition to natural gas, the reserves of which are substantial, would be very costly since entirely new distribution infrastructures would be required, including additional LNG carriers, terminals and processing facilities.

Meanwhile, an era of insecurity and vulnerability is likely to prevail as petroleum circulation increases with strategic chokepoints bearing the brunt of the tension. Like the limited additional petroleum production capacity, the circulation capacity, which is mainly dictated by the chokepoints of oil circulation, leaves little room for additional growth. These geographical constraints cannot be bypassed easily and will be a significant factor in global insecurity of oil supplies in terms of who will get preferential access to these limited resources. The situation is likely to become very tense among large consumers, such as the United States and China during the second decade of the 21st century. As they compete, the outlets of the Middle East handle the last large volume supply routes of the petroleum era. Since additional economies of scale in maritime shipping are difficult to achieve and alternative routes, including pipelines are limited and insecure so, world economic power seeks alternative ways and routes through new manmade canals to secure their energy flow. Thereby, solutions for petroleum distribution, namely the use of geographical chokepoints will demand rationalised use for the wellbeing of world peace.

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Harnessing Un-retrieved Wave Energy- Sustainable Approach Towards Blue Economy: Bangladesh-Perspective

Abu Hasan Rony[1]

Abstract

Bangladesh has sustained solid economic growth since the last decade. The revolution in agriculture, manufacturing of readymade garments and many other industries are the main contributors for this. As such the power demand also increased exponentially in recent years. According to the Bangladesh Power Development Board, the maximum generation of power was 9479MW in June 2017 which was 4130MW in 2007. The energy demand is skyrocketed and the government is having a tough time keeping pace with it. At this stage, maintaining availability and affordability are the prime concerns for policymakers. The mounting pressure sometimes leads us to take wrong steps such as adopting cheap and dirty energy solutions. Aligning country's energy policy with international requirements, alternatives fuel, and Renewable Energy (RE) options are given consideration at present. All renewables such as Solar Photo Voltaic (SPV), ocean energy and wind energy require equal importance on the basis of their potentials. Recently, there have been significant improvements in the RE sector, especially Solar Photo Voltaic (SPV). But, it is necessary to look for diversified clean energy sources for a greener future. The necessary for a holistic approach and how the blue economic approach of Bangladesh could be made more meaningful are emphasised in this paper. Moreover, how the ocean energy in the Bay of Bengal such as wave, tidal and wind can be made more feasible for sustainable yield. This paper reveals the potential for exploring wave energy to meeting energy demand, especially for coastal community and a brief focus on recent energy policy of Bangladesh, infrastructure, logistics requirements and progress made in wave energy throughout the world.

Keywords: Renewable Energy, Wave Energy, Blue Economy, Sustainability, Diversification.

Introduction

For any nation to maintain growth, the wellbeing of citizens, eradication of poverty and uniform development of the societies, it is the availability, access, and security of energy are among all those matters most. Increasing global population and booming industrialisation are causing the dependency of fossil fuel to rise exponentially.

The anthropogenic pressure on climate, causing radiative forcing, is irreversibly damaging the climate since the last few decades.

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[1]*Chief Engineer (Marine), MEO Class 1, Singapore*

International Panel on Climate Change (IPCC) states, in the case of Business-As-Usual (BAU) scenario as much as 50 per cent biodiversity will be lost by 2050. The extreme events like floods, cyclone, wildfire, and drought are caused by the effect of climate change which is threatening human existence on earth. However, realising the adversity of climate change, the global community is more committed to a green energy solution than ever before. In the Paris Climate Change Agreement (COP21) and United Nations Sustainable Development Goal (SDG), every nation has specific targets on cutting down Greenhouse Gas (GHG) emissions.

The potential of Renewable Energy (RE) for powering our homes, cities, and industries are huge. 90 minutes of the solar energy that hits the earth surface is sufficient for powering the entire world for one year, IEA (2011). As a secondary source of solar energy, oceans have great potential as energy sources. Wave Energy, Ocean Thermal Energy Conversion (OTEC), and tidal energy are abundant in the oceans. These sources are mostly untapped and ignored. Despite having 710 kilometres of long coastline and access to the Bay of Bengal (BoB), the potential ocean energy resources were unnoticed by the policymakers till recently. In 2012 and 2014, respectively, Bangladesh won huge sea area from Myanmar and India after a long dispute and that victories have created increasing interest to the policymakers for embracing the blue economy. This paper reveals the potentials, possibilities, requirements, socio-technical aspects and a brief world outlook for harnessing the huge amount of wave energy available on the coastline of Bangladesh and in the BoB. A holistic approach towards a sustainable yield of ocean energy sources could be the solution to future electricity demand.

Wave Energy

Wave is the secondary source of solar energy which is abundant, free and sustainable. The kinetic energy content in the wave energy is around 1000 times more than the wind. (Ocean Energy Council 2017). About 1 per cent of the energy radiated from the sun reached the earth

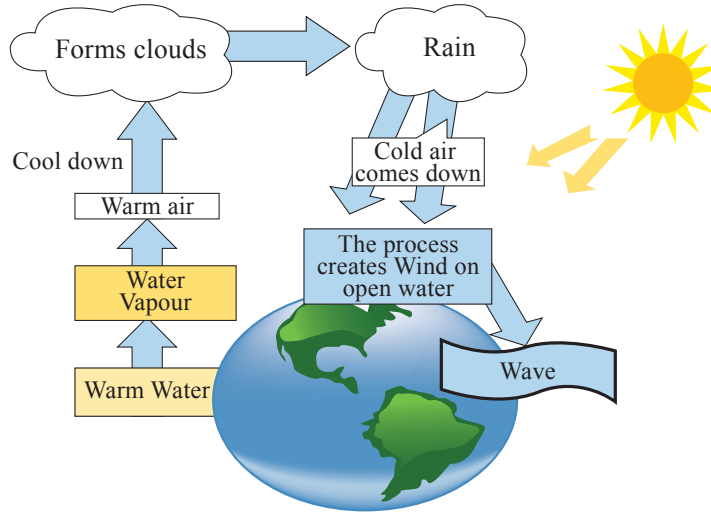

Figure 1: Creation of waves, Source: Author (Adapted from NOAA)

and is being used for creating waves. Long-period waves tend to be larger and stronger and short-period waves are smaller and contain less energy.

Waves are mainly the product of wind. Wind's interaction on the surface of the ocean creates waves on earth. As the earth is affected by unequal heat energy from the sun, the state of the air differentiates between different regions. Warm air expands and rises up while cold air condenses and sinks, hence resulting in the flow of air and forms wind. The wind carries warm water mists evaporated by the heat of the sun which forms clouds and later comes down as rainfall. The creation of different motion of wind on the surface of water produces waves of different motion and magnitude (Figure 1). As much as 95 per cent of the energy in waves is located between the surface and ¼ th of the wavelength. The best wave condition for

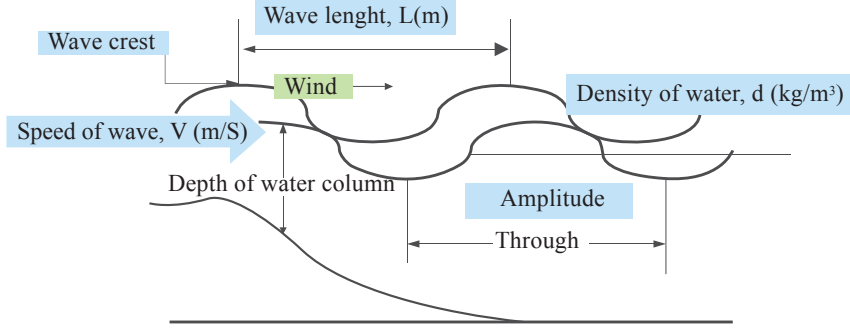

Figure 2: Factors affecting wave energy output, Source: Adapted from Aboobacker, (2016).

exploration is at high- medium altitude and in the deep water at more than 40m of water depth, and wave power density is about 60-70Kw/m in those places, International Renewable Energy Agency (IRENA, 2014).

Wind speed over the water surface determines the strength of the waves. Stronger the wind, the larger the wave is. In figure 2, the influencing factors of the wave energy on the earth

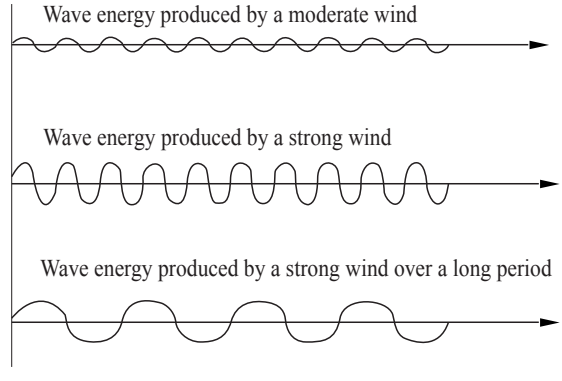

Figure 3: Characteristics of the wave, Source: Adapted from Boyle, 2012. p.363-404

surface are represented such as wave height, wavelength, the density of water and the depth of water. Also, Aboobacker (2016) states that ocean waves are not consistent and largely depend on wind duration (or how long the wind blows), and fetch, which is the distance over water that the wind blows in a single direction.

In figure 3, if the wind speed is slow, only small waves result, regardless of wind duration or fetch. If the wind speed is significant but it only blows for a few minutes, no large waves will result even if the wind speed is strong and fetch is unlimited. Also, if strong winds blow for a long period of time but over a short fetch, no large waves form. Large waves only form when all three factors contribute together (NOAA, 2002).

Energy transport of a harmonic wave can be measured as -

$$P_{Energy} = (\rho g^2 H^2 T)/32\pi \ (Wm^{-1}),$$

where, ρ is the density of water, g is the gravitational acceleration, H is the wave height (metres) and T is the wave period (in seconds). According to Boyle (2016), another important factor to consider for the establishment of wave energy is the location of instalment. The devices situated offshore can produce more energy than nearshore devices, as power density in the deep water is more than the shallower water.

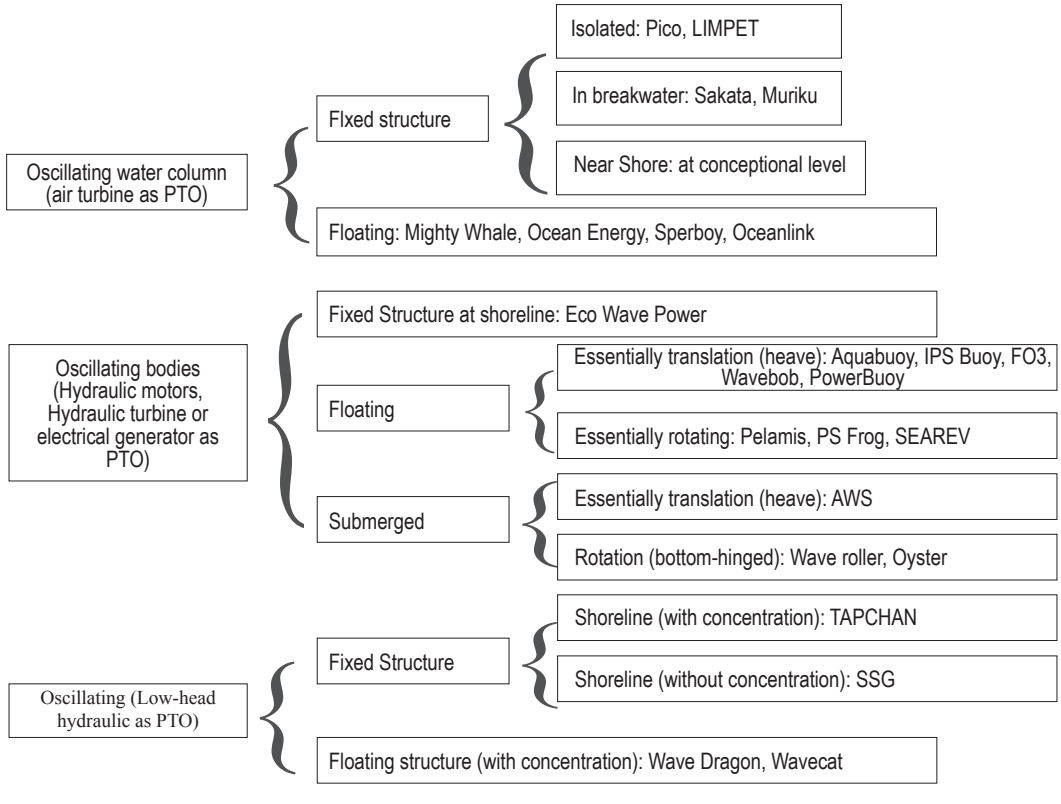

Figure 4: Types of wave energy converters,
Source: IRENA, 2014, Based on Pérez and Iglesias, (2012)

Wave Energy Converters

The available Wave Energy Converters (WEC's) are being classified on their employment and characteristics of places where the energy is extracted. With the available technology, three types of wave motions which can be converted into energy, such as horizontal front and back, horizontal side to side and vertical up and down motion can be extracted to energy (Kempener & Neumann, 2014). The WEC's are classified into three main categories, such as, Oscillating Water Column (OWC), Oscillating bodies (OB) and Overtopping which are then subdivided depending on their installation. The categorisation of WEC's is best described in figure 4.

Most of the WEC's are simple and have less moving parts which incur less maintenance. The principal parts of these technologies involve- the prime movers or power generation, foundation and securing arrangement with the seabed, Power Take Off (PTO) devices and the control systems for optimal performance of the installation. Some of the prominent WEC's are namely- Green Wave & Wavegen Limpet (Scotland/UK), Oceanix (Australia), Ocean Energy Buoy (Ireland), Pelamis, Wavestar, Oyster, Wave dragon (Denmark) and Wave cat (Spain). However, not all the converters are suitable efficient use in all condition of wave intensity.

Exploring Wave Energy Potential in Bangladesh

Geographically, Bangladesh is blessed with the vast shoreline of the BoB which can be a solution for RE for the coastal community and for the remote islands as described by Haque (2014). There are many sites available for wave energy production. Among them the south west of Cox's Bazar, Moheskhali island, Kutubdia island, Sandwip island and the Hiron point are the most suitable and potential wave energy sites in Bangladesh (CORDIS, 1995). The wave height in Bangladesh coastal area is about 1 to 2 metres, depending on the seasons.

The annual average of the wave power density is about (8-15) KWm-1 in the BoB (Boyle, 2012, p. 363-404) which is considered as a low concentration of energy. Saint Martin, Kutubdia and Sandwip Islands are the potential places where OWC's could be installed where power density is optimal for cost-effective operation. The average concentration wave energy is high between May to October for a single wave based on everyday data of wave height, as represented in figure 7. The most suitable wave energy devices for Bangladesh are OWC's and Pelamis device. OWC's are having a simple construction, required less maintenance, equipped with

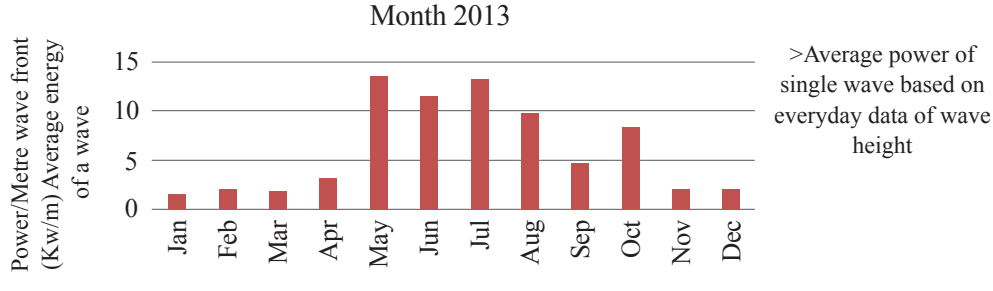

Figure 5: Average wave power, 2013, Source: (Haque, 2014)

wells turbines which rotate in any direction of air flow. For Pelamis device, low environmental impact, low cost, work at any direction of the wave, Shah Md. Salimullah etal., (2016).

The detail wave power assessment and compatibility study for integration with other ocean energy enhances reliability and integration with two or more energy resources on the same platform reduces the Capital Expenditure (CAPEX) and Operating Expenditure (OPEX) for per unit energy output.

Recent Energy Policy of Bangladesh

The total power generation of Bangladesh is about 15500MW and the share of RE is just about 2.8 per cent, illustrated in figure 9, of the total power generation of the country and over 50 per cent is gas. In 2008, the Renewable Energy Policy (REP) was enacted and a target was set. According to REP, by 2020 as much as 10 per cent share of total energy generation will be from renewable energy, Sustainable and Renewable Energy Development Authority (SREDA, 2017).

The Solar Home System, Domestic Biogas Programme, Solar Irrigation Programme, Solar Mini and Micro Grid System, Biogas based power Projects and Biomass-based Power Projects receive significant loan facility to promote to the end users. Recently, Solar energy has been promoted significantly by the government (figure 8). Table 1 represents the present status of RE in Bangladesh. It is time to think about the wave energy potential and includes it in the national REP for future strategy. A significant share of RE can be provided from wave which is comparatively simple and consistent than other sources.

The extended maritime boundary, in figure 10, opens a treasure for Bangladesh to explore natural resources on the surface, in water, on the ocean floor and under the seabed. The mean average power available in the Bay of Bengal region is represented in figure 11. From both figures, 10 and 11, it can be comprehended that a moderate intensity of wave energy can be

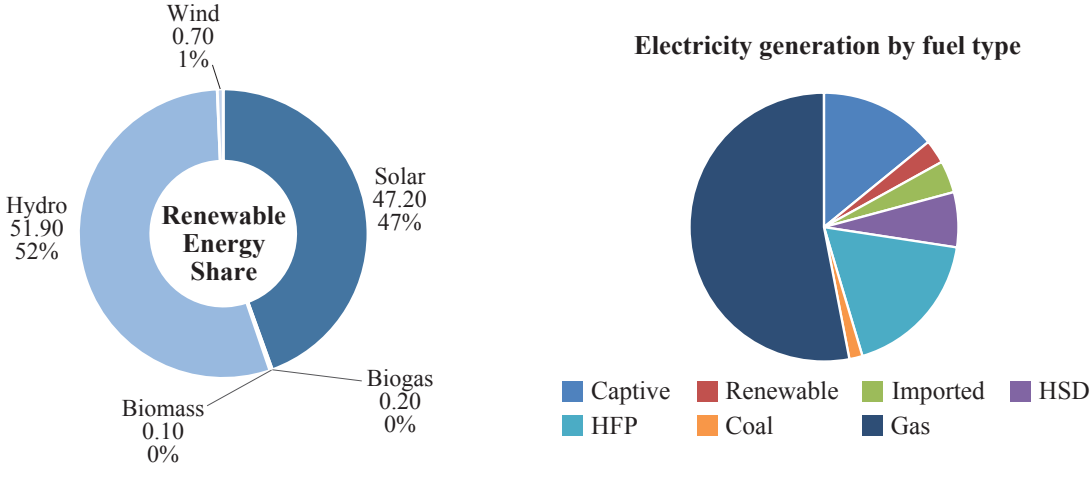

Figure 6: Electricity generation by fuel type, Source: SREDA

utilised for powering the energy-hungry nation in the extended and redefined maritime boundary of Bangladesh. However, wave energy did not receive sufficient attention from the policymakers.

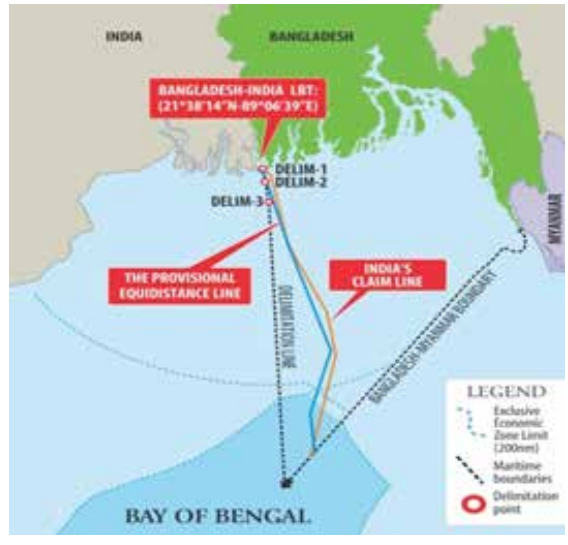

Figure 7: Reclaimed sea area of Bangladesh (Source: The Daily Star, July 08, 2014),

Building Expertise

Human elements are as important as technology in energy management and should be treated equally (Kitada & Ölçer, 2015). It is of utmost importance to ensure quality education and research on energy. Knowledge about the sustainable use of ocean energy is also important for citizens as well as policymakers. In 2013, Bangladesh established Bangabandhu Sheikh Mujibur Rahman Maritime University (BSMRMU) to enhance education for promoting maritime education in the country which has begun its journey in 2016. Besides, many public and private universities are providing education on oceanography, electrical and electronic engineering department for providing education of ocean energy to some extent. However, to build quality experts in this field, more funding on quality maritime education and research is required for capacity building for the future.

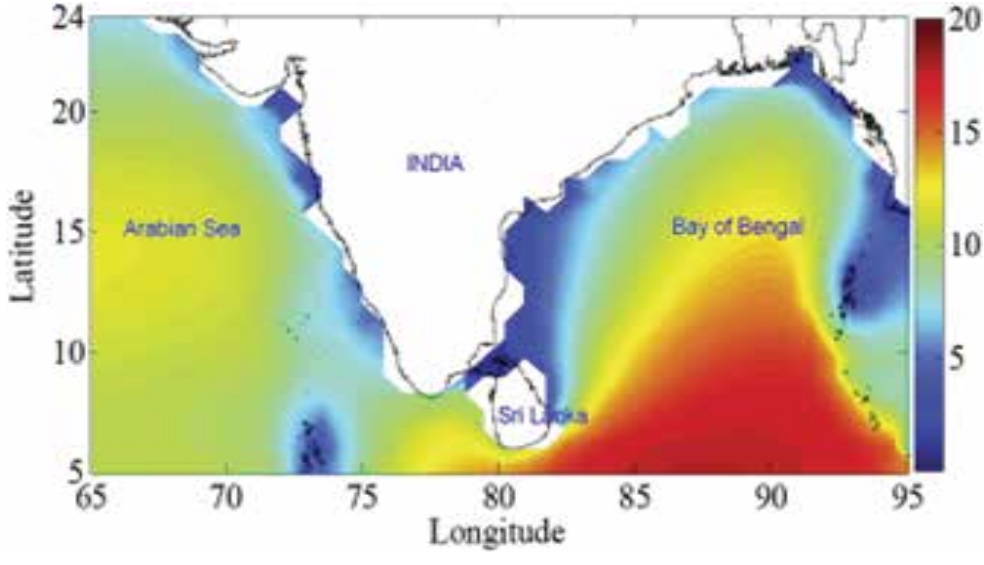

Figure 8: Mean Ave wave power-BoB(Source: Sanil Kumar &Anoop, 2014)

Dealing with Renewable Energy in Bangladesh

Bangladesh has very limited natural resources. The limited reserve of natural gas is not sufficient to meet local consumption. In December 2009, after ratifying REP, the Bangladesh Government established Bangladesh's only RE authority SREDA, Power Division, under the Ministry of Power. The SREDA deals with energy management in the country and now has an ambitious target of producing 2000MW of electricity from renewable sources by 2021. However, the policy of SREDA is so far lacking in diverseness in exploiting all sorts of natural resources.

Availability and Affordability of Technology

About 100 pilot projects based on wave energy are ongoing in the different parts of the world. As technology gets maturity, simultaneously, the extraction of wave energy will be cheaper with research and innovation. However, now it is expensive compared to other sources. The

Table 1: Comparison of the cost of energy sources, (Source: Ocean Energy Council, 2017)

Energy Sources	Cost of production
Fossil fuel	3.58 Cents/KWh
Wind	4.5 Cents/KWh
Wave	7.5 Cents/KWh
Coal	2.6 Cents/KWh
Combined cycle natural gas	3.0 Cents/KWh

production cost also varies depending on the intensity of energy in waves, distance from the shoreline and geographical location of the farm (Ocean Energy Council, 2017).

Figures in table 2 do not conclude that availing wave energy will be most expensive. Considering all concerning aspects such as environmental impact, OPEX, CAPEX, Levelized Cost of Energy (LCOE) and Social cost of Energy (SCOE), the unit price will be considerably reduced which will make it suitable for deployment.

Development of Infrastructure

In Bangladesh, many coastal area and islands are still not connected with the national electrical grid. Prior to setting up any RE farm, it is necessary to bring all remote areas under the distribution network. The infrastructures for a wave farm are required for electricity generation, supply grid infrastructure, connection, port facilities and mooring where the wave energy converters are stationed in deep water. Sometimes, it needs more complicated installations as it requires substation, long distance underwater cabling and maintenance station (Kempener & Neumann, 2014). Boyle (2012) describes that as the intensity of wave varies, great care must be taken to connect with the small power grid and varying output can be accommodated by the dump load to eliminate fluctuation in demand.

Logistics of Wave Energy

Wave energy needs a similar supply chain as oil and gas (Kempener & Neumann, 2014). A wind farm can be integrated into any forms of offshore energy installation. So, the wave and ocean current harnessing devices could be fixed into the same platform for wave energy, Manasseh SA. et. al. (2017). This helps to improve PTO systems and connections which allows multi arrays of systems well connected to each other in the same grid. The direct use of wave power from the plant can be arranged, but it is recommended to connect it with the electricity grid as varying wave power, phase factor, transmission loss and power factor correction should be considered as influencing factor (Freris & Infield, 2008).However, there is a huge lack in cohesion and supply chain for the development of wave energy technology (Kempener & Neumann, 2014).

Analysing LCOE and SCOE of the Wave Energy

For pre-assessment and feasibility study, it is important to calculate the LCOE, the net present value of all cost of the sources over the lifetime divided by the output energy by the source, which is the first thing to consider and forecast.

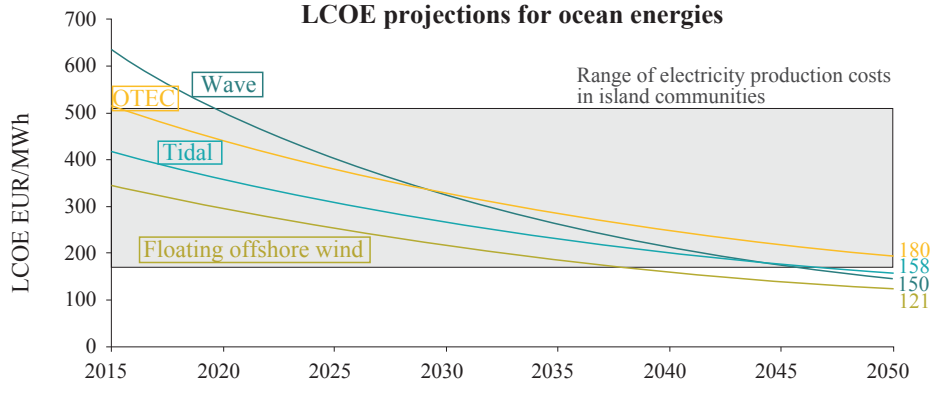

Figure 9: LCOE Projection for ocean energies, (Source: arena.gov.au)

The LCOE is a very important factor and it depends on capital cost, operational cost, maintenance cost and cost of fuel used. LCOE decreases, when installed capacity of the wave energy reduces, Penesis et. al. (2016). Figure 12 forecasts the LCOE over time till 2050 which also shows great potential for wave energy use beyond 2030. At present, LCOE for wave energy is about EUR 330-630/MWh, which will come down to EUR 113-226/MWh in near future (Kempener & Neumann, 2014).

The environmental cost of providing that energy to society also needs to be considerd, which is termed as SCOE. The SCOE requires an environmental assessment to perform on the site and beyond, effect on biodiversity in the life span, energy use, storage and at last the recycling or beyond insurance cost ensuring the minimal adverse impact on the public health and environment. For some energy sources, such as coal and fossil fuel, the environmental impact and the SCOE are huge as the adverse impact on public health and climate change.

The Forerunners of Wave Energy

In IPCC's assessment in 2007, it has been estimated that the wave energy could be deployed by 2 per cent of 800,000 Km coast of the world where power density is above 30KW/m. According to geographical location and power density of wave energy, Australia, UK, Ireland, Chile, USA, New Zealand and South Africa have the most favourable condition for wave energy exploration with a power density of 40- 60KW/m. Among them, the United Kingdom is in the most suitable position for harnessing wave energy as it lies end of long fetch of. It is estimated that around 15-20 per cent of the UK's energy demand could be met by wave energy, Boyle, (2012). World first wave energy converter was established in Isle of Islay, Scotland which was a 5 MW plant, Ocean Energy Council, (2017). More than 100 pilot projects exist all over the world (Kempener & Neumann, 2014). Below table shows leading wave energy producers in the world.

Table 2: Top wave energy potential countries and their current production
(Data gathered from Australian Energy Council, Marine Renewable Canada, Australian Renewable Energy Agency, www.energy.gov, World ocean review, Wave Power: AENews, Ernst and Young Associes)

No	Country	Wave Energy Potential (TWh/Year)	Current Power Production from Wave	Recent Investment
1	Australia	2760TWh/year	1.25MW	AUD43Mil/3MW
2	USA	2640TWh/year	0.06MW	USD64 Millions (Oregon)/1.5MW
3	Canada	1863TWh/year	0.759MW	None
4	South Korea		0.5MW	0.3MW
5	UK	350TWh/year	1MW	40MW
6	China		0.5MW	2.8MW
7	Japan	19TW/year	0.15MW	350MW
8	All Europe	2830TWh/year	2.25MW	85.6MW
9	Global	11400TWh/year, (1700TWh/Year-sustainable-production)	Around 4MW	Around 411MW

Table 2 represents the leading producers of wave energy and also their efforts and strategy for the future. Basically, in the current situation, it is difficult to name one particular country as the leader in wave energy. Australia, USA, Canada, South Korea, UK, China, Sweden and many other European countries are showing huge interests in wave energy. Thanks to the COP21 and other environmental regulations, UK, Australia and Japan are taking big leaps towards wave energy for a sustainable solution to cut their GHG emission. As such now it is time for Bangladesh to start exploring this area.

An Apple-to-Apple Comparison

The wave energy density along the Bay of Bengal coast of India and Bangladesh are similar. Thus, initiatives which were taken by the Indian Government in this respect could be an inspiration for Bangladesh. A multi-resonant OWC has been installed in a breakwater utilising a wells turbine (axial flow, unidirectional) situated at Trivandrum coast in India (Figure 14). As shown in figure 14, wave strikes on the harbour wall situated in the breakwater, which makes air to escape from the top of the wells turbine and drives the electrical generator. The wells turbine is of 2 metres in diameter and capable of driving 150KW generator.

The power density in the Indian coast is about 5 to 10KWm-1 and output of the plant varies significantly, between April to November it is 75KW and December to March about 25KW. The two units of power conversion systems are incorporated in the systems as both of them

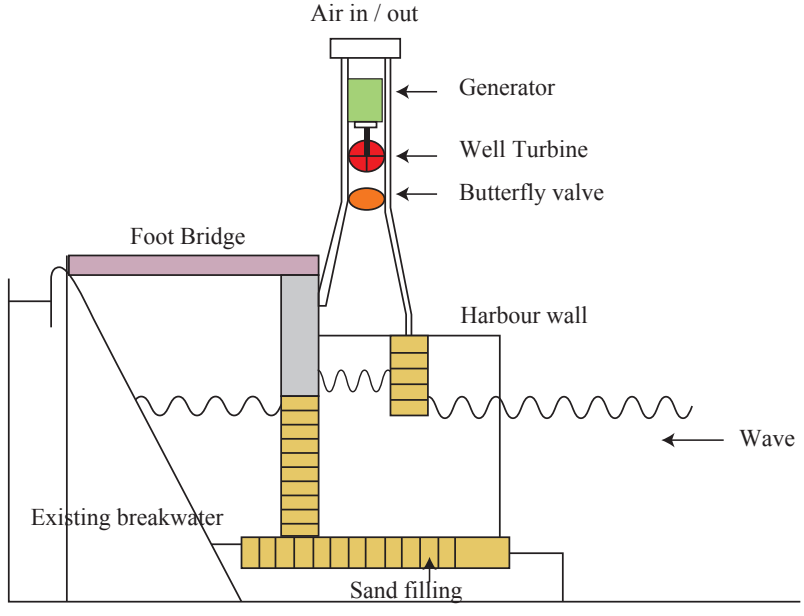

Figure 10: Cross-sectional view of Indian breakwater OWC, Source: Boyle, 2012.p.363-404

could be operated at a peak energy density period. A plan has been taken by the Indian Government that many more such devices are to be installed along the Indian coastline considering the potential of the energy source (Boyle, 2012).

Recommendations

Transition to wave energy is much desirable from Bangladesh perspective. Wave power can save coastlines from breaking waves and adverse coastal erosion as the array of wave energy devices could significantly reduce the wave height (Shields & Payne, 2014, page no. 9-12).

The offshore renewable energy farm could be a great habitat for marine species and protected zone for fisheries. Considering the positive impacts, wave energy can be a lucrative solution to electricity shortage.

Ocean literacy has to be enhanced among students and individuals through education and knowledge about our blue planet, life underwater, coastal management, fisheries management and ocean energy. More funds need to be allocated for R & D on the ocean in various public and private educational institutions in the country.

Besides REP, the government should enact Ocean Energy Policy for better protection of the ocean, detail energy mapping, and sustainable ocean management. Bangladesh Government's policymaking needs to be directed towards renewable energy future and investment have to be made on research for local solutions and promoting climate literacy and innovation in the early stage of education. Such a system will provide a greener solution while reducing the carbon dioxide emission and meeting the requirements of SDG 7 and COP21 goals and targets. All public and private sectors could be the potential participants for the green energy exploitation to power up economic development through collaboration and mutual partnership.

The shoreline of Bangladesh could be utilised for the exploration of ocean energy for powering the coastal population and remote islands mostly the poor community of the coastal are still deprived of electricity supply. The Isolated islands, such as Saint Martine Island, Andar Char, Dublar Char, Nijhum Dwip and many more islands could get their power supply from renewable sources. Development of smart grid system integrating all power sources could be a feasible solution in this case. An expert's assessment and research on sustainable ocean energy yield and holistic marine spatial planning are required at this stage.

Conclusion

A huge population is still out of the electricity supply network, mostly living in rural and coastal areas. Paradoxically, Bangladesh has registered tremendous growth during the last ten years, Gross Domestic Product (GDP) stayed over 7 per cent for the past few years. To keep the momentum of the development she needs to ensure sustainable and affordable energy for all citizens. Looking for diverse sources while reducing the carbon footprint is the key issue here. Recently, gaining access to the continental shelf of the BoB has created a great opportunity for exploration of resources on the water, sub-surface and seabed. Extensive research on wave energy resource modelling and mapping are now extremely important for boosting Bangladesh's recent drive to the blue economy. As we can see the wave energy is getting momentum and increasingly becoming a focal point as the alternative source of energy in many countries. With respect to geographical condition and wave energy potential, the most suitable wave energy devices for Bangladesh are OWC's and Pelamis device which need to be explored. The wave energy may not seem to be cost-effective alone at present, however, in a holistic approach, wave energy including the wind and tidal energy can create huge difference and positive impact on the development of Bangladesh.

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A Study on the Determination of Heavy Metals in Freshwater Aquaculture Ponds of Mymensingh

Nashid Sultana[1], Md. Jahangir Sarker[2] and Md. Amin Ullah Palash[3]

Abstract

Levels of copper (Cu), zinc (Zn), led (Pb), cadmium (Cd) and chromium (Cr) were determined in the waters of a fish farm in Mymensingh district, Bangladesh by Atomic Absorption Spectrophotometer. Metals were found to be present in varied concentrations: Cu (0.02–0.1 mg/L), Zn (0.055–0.072 mg/L), Pb (0.039–0.066 mg/L), Cd (0.014–0.29 mg/L) and Cr (0.13–0.23 mg/L). The results signify that levels of Cd slightly exceeded and Cr in water was almost 1 order of magnitude higher than the values stated by ADB (Asian Development Bank, 1994); EPA (Environment Protection Agency, 2002); WHO (World Health Organisation, 1993); WPCL (Water Pollution Control Legislation, 2004) and USPH (United State Public Health). In general, the rank order of heavy metals was Cr > Pb > Cu > Zn > Cd. This suggests that water of the investigated fish ponds is contaminated with metals and in turn, fish of that aquaculture farm could be harmful to human health.

Keywords: Heavy Metal; Freshwater; Bangladesh.

Introduction

Heavy metals can cause great harm to the aquatic environment, as metals are not perishable. Moreover, metals are harmful to organisms (MacFarlane and Burchett, 2000). "Heavy metals" is a general collective term, which applies to the group of metals and metalloids with atomic density greater than 4 g/cm 3 or 5 times or more greater than water (Duruibe, et al., 2007), and heavy metals include lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), arsenic (As), silver (Ag) chromium (Cr), copper (Cu) iron (Fe), and the platinum group elements. Moreover, they are also known as trace elements because they occur in minute concentrations in biological systems.

Heavy metal concentrations in aquatic ecosystems are usually monitored by measuring their concentrations in water, sediment and biota (Camusso et al., 1995). Though heavy metals generally present in low levels in water but achieve significant concentrations in sediments and biota (Namminga and Wilhm, 1976). Heavy metal cannot be despoiled, hence they are deposited, assimilated or integrated into water, sediment and aquatic biota, causing pollution

[1], [2], [3]*Department of Fisheries and Marine Science, Noakhali Science and Technology University, Noakhali-3814, Bangladesh*

of heavy metal in all parts of the environment. Fish accumulate heavy metals directly from water and diet, and pollutant residues may eventually attain concentrations hundreds or thousands of times higher than those measured in the water, sediment and food (Osman et al., 2007; Goodwin et al., 2003; Labonne et al., 2001).

In Mymensingh district, freshwater aquaculture is widely practiced under improved traditional farming system where different fish species such as koi (Anabas testudineus), Shing (Heteropneustes fossilis), Magur (Clarius batrachus), Silver carp (Hypothalmicthys molitrix); Tilapia (Tilapia mossumbica), Rui (Labeo rohita) and Pangus (Pangasius pangasius) are cultured in the fish farm for 120 days to 300 days depending on the prices and demand of fish market. In a single culture cycle, a stocking density of 40-45 fish/decimal and a feeding regime 150-250 kg/decimal is followed with regular water exchange. In spite of overwhelming importance of heavy metals in freshwater aquaculture pond, some scientific work has been conducted to determine the heavy metals in freshwater fish farm that deal with sediment, feed, fish tissue and water of aquaculture (Ahmad et al. 2010; Flowra et al. 2014; Sarker et al. 2016). But there needs more precious study especially in freshwater fish farms of Mymensingh region in Bangladesh, which supply a significant amount of fish in the country. Therefore, the present study was accomplished with a view to know the heavy metal concentrations in some freshwater aquaculture ponds and compared to different international standards.

Materials and Methods

Sample Collection

The present study was conducted in 21 ponds and triplicate water samples were collected from 7 different freshwater aquaculture ponds of Talukdar fish farm located at Shambhuganj Guripur Upazila of Mymensingh, district in Bangladesh. The research work was carried out in the month of October 2015 following the sampling techniques as outlined by Sincero and Sincero, 2004.

Preparation of Sample

The water samples were acidified immediately with 2ml of HNO3 per litre of water and preserved in a refrigerator at 4˚C for laboratory analysis and samples were taken to the Bangladesh Agricultural Research Institute (BARI), Gazipur.

Analysis of Heavy Metals

1 ml of water sample were taken and 5 ml of a di-acid mixture (5ml conc. HNO3: 1ml 60 per cent HClO4) were added to each sample in a boiling flask. The entire mixture was kept in a digestion chamber for 2 hours at 180˚C and then the solution is filtered. The stock solution was ready to determine the heavy metal analysis. It was passed through the nebuliser in the Spectrophotometer and reading were shown in the monitor of a computer attached with it. The concentration of Cu, Zn, Pb, Cd and Cr in water samples were calculated by the following formula:

Heavy Metal Concentration = (ppm conc. Observed *final volume of sample in ml) / (water sample was taken in ml.)

Results

Metal contents ranged over following intervals: Cu: 0.02-0.10 mg/L, Zn: 0.01- .072 mg/L, Pb 0.039 – 0.068 mg/L, Cd: 0.002- 0.029 mg/L and Cr: 0.123-0.23 mg/L (Table 1). In the present study, the rank of heavy metals concentration in water was as:

$$Cr > Pb > Cu > Zn > Cd$$

Cu concentration in water samples ranged 0.008-0.1 mg/L (Table 1), but a high concentration of these elements in the water is toxic. The highest value of Cu was recorded in pond-1 and the lowest value was found in the pond-5 (Table 1). The mean value of copper was varied from 0.013±0.007 (Pond-5) to 0.06±0.04 mg/L (Pond-1).

Table 1: Heavy metal concentrations (mg/L) in water samples from aquaculture fish farm (Mean ± SD)

Pond No	Cu	Zn	Pb	Cd	Cr
1	0.06 ± 0.040	0.064±0.009	0.049±0.011	0.023±0.008	0.173±0.045
2	024±0.010	0.035±0.007	0.051±0.009	0.017±0.009	0.176±0.036
3	025±0.0110	0.028±0.01	0.057±0.012	0.016±0.01	0.188±0.04
4	03±0.013	0.03±0.011	0.041±0.005	0.012±0.009	0.156±0.056
5	0.013±0.007	0.025±0.013	0.051±0.011	0.014±0.009	0.193±0.048
6	0.029±0.013	0.029±0.015	0.051±0.009	0.014±0.008	0.179±0.038
7	0.026±0.008	0.033±0.025	0.057±0.013	0.014±0.007	0.183±0.04

The concentration of zinc (Zn) in twenty-one water samples ranged from 0.01 to 0.072 mg/L (Table 1). The lowest value was obtained from pond-7 (0.01) and the highest from pond-1 (0.072) (Table 1). In pond-5 the highest mean value of Zinc (Zn) was 0.064 ± 0.009 mg/L and in pond-1, the lowest mean value of Zinc (Zn) was 0.025±0.013 mg/L.

Lead (Pb) in the water was in the range of 0.037-0.068 mg/L (Table 1). The lowest mean value was obtained from pond-4 and the highest from pond-7. The mean value of lead was varied from 0.041±0.005 (Pond-4) to 0.057±0.012 mg/l (Pond-7) (Table 1).

The concentration of cadmium (Cd) in water samples ranged from 0.002 to 0.029 mg/L. The lowest concentration was obtained from pond-4 with a value of 0.002 mg/L and the highest from pond-1 with a value of 0.029 mg/L. The mean value of cadmium (Cd) was varied from 0.012±0.009 (Pond-4) to 0.023±0.008 mg/L (Pond-1) (Table 1).

The concentration of chromium (Cr) in water samples ranged from 0.13 to)) 0.23 mg/L. The lowest concentration was obtained from pond-1 with a value of 0.002 mg/L and the highest from pond-3 with a value of 0.23 mg/L. The mean value of chromium (Cr) was varied from 0.156±0.056 (Pond-4) to 0.193±0.048 mg/L (Pond-1) (Table 1).

Discussion

Cu

Copper is an essential element that is carefully regulated by physiological mechanisms in most organisms. Cu is a useful element for our biological helps to produce blood cells and strengthening bones. But, an excess of Cu can cause health problem (Demirezen and Uruc, 2006). The mean value of Cu was varied from 0.013± 0.007mg/L (Pond 5) to 0.06±0.4mg/L (pond 1) which were in the permissible limit (EPA, 2002). Among the total 21 samples, all of the samples were found within the recommended limit. Flowra et al. (2012) found the mean concentration of Cu was varied from 0.05±0.02 to 1.79±0.88mg/L in the water of some ponds in Rajshahi, values that are higher than the present study. Kundu et al. (2017) found the mean value of Cu in the fish (Tilapia) samples was 21.13±1.44mg/L, values that are higher than the present study. Das et al. (2017) found that the concentration of Cu in sediment was 13.00-23.20mg/kg, which was higher than the present findings.

Zn

Zn is vital for human health. It helps macronutrients disintegrating in food and healing wounds (Demirezen and Uruc, 2006). The mean value of zinc (Zn) was varied from 0.025±0.013 mg/L to 0.064±0.009 mg/L which were in the range of fish culture (ADB, 1994). Similar observation for Zn was reported by Rahman et al. (2012) in Bangshi river water, Bangladesh. Considering all the value Zn concentration in all of the samples was within a suitable range for all purposes. Sarker et al. (2016) found that the mean value of Zn in the sediment of Mymensingh district was 208±31.388mg/kg, which was higher than the present study.

Pb

Lead is a non-essential element and it is well documented that lead can cause neurotoxicity, nephrotoxicity and many other adverse health effects. The mean value of Pb in the study varied from 0.041±0.005mg/L (Pond-4) to 0.057±0.012 mg/L (Pond-7) which was under the limit of fishing water (ADB, 1994). Kundu et al. (2017) found that the mean value of Pd in the fish (Tilapia) samples were varied from 9.92±3.57 to 14.83±1.336mg/Kg which was higher than the present study. Sarker et al. (2016) found that the mean value of Pb in sediment was 14.845±1.995 mg/Kg which was higher than the present study as well. Das et al. (2017) examined the value of Pb in sediment was varied from 6.43-8.65mg/Kg. The mean value of lead (Pb) was varied from 0.14±0.12 to 4.92±1.66 mg/L in the water of some urban ponds in Rajshahi (Flowra et al. 2014), which was much higher than the present study.

Cd

An industrial process such as smelting or electroplating or electroplating and the addition of fertilisation can increase the concentration of Cd in the pond (environment). The mean concentration of Cd was varied from 0.012±0.009mg/L (pond-4) to 0.023±0.008mg/L (pond-1). In only one was slightly exceed with the standard value as described by ADB (1994), EPA (2002) and WPCL (2004). The run-off and waste materials from land and agriculture might be a potential source for Cd concentration. However, the Cd in the observed samples were found between 9.43±0.37 to 9.84±0.55mg/kg (Kundu et al. 2017). Sarker et al.

(2016) found Cd concentration in the sediment samples was 0.009±0.001mg/Kg which was lower than the present study.

Cr

The mean value of chromium (Cr) was varied from 0.156±0.056 (Pond-4) to 0.193±0.048 mg/L (Pond-5) which were almost 1 order of magnitude higher than the findings described by EPA (2002), WHO (1993) and WPCL (2004). Considering this limit, Cr concentration in all of the samples was not within a suitable range for all purposes; which was slightly higher than the polluted category (Cr>0.05 mg/L). Fish feed might be a potential source for higher Cr concentration. Das et al. (2017) found the Cr concentration which was ranged from 7.32 to 15.41mg/Kg in sediment samples. Similarly, Sarker et al. (2016) found the Cr concentration in sediment samples was 63.054±6.922mg/Kg, which was higher than the present study.

Correlation Matrix

Correlations among heavy metals may reflect the origin and migration of these elements (Suresh et al., 2011). Metals with a positive correlation are possibly from the same pollutant sources (Üstün, 2009; Mansouri et al., 2011). Table 2 showed the correlation between metals, where significant positive correlation ($p < 0.05$) were found between Cu-Zn (0.94); Cu-Cd (0.78); Zn-Cd (0.91); and Pb-Cr (0.82) in water.

Table 2: Pearson's correlation coefficients among heavy metals concentration (mg/L).
** Values >0.05 or < - 0.05 are significantly correlated.*

	Cu	Zn	Pb	Cd	Cr
Cu	1				
Zn	0.94209*	1			
Pb	-0.24154	-0.14389	1		
Cd	0.78946*	0.90526*	-0.11993	1	
Cr	-0.44303	-0.28366	0.82088*	0.037018	1

Conclusion

Research work was conducted to evaluate the heavy metals concentrations in water samples collected from the aquaculture fish farm in Mymensingh. The present study has shown that the concentrations of heavy metals in water samples were varied and sometimes it is slightly polluted and dangerous for the aquatic ecosystem and human health but most water samples were not dangerous. In respect of Cu, Zn, Pb and Cd contents, all water samples under the study area could safely be applied for long term fish culture without any harmful effect but in case of Cr, some samples were not within the permissible limit. From the results of the

present investigation, it might be concluded that the quality of water in the study area is in general good for utilisation in fish culture & other purposes. Measures should be taken to regulate the water quality determining parameters. It is recommended that further research should be done on the levels of other heavy metals in the water in order to monitor and prevent it from reaching high levels that make them toxic to living organisms.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Review of Empirical Studies of Washback in Language Testing

Raju Ahmmed[1] and Kh. Atikur Rahman[2]

Abstract

Washback is one of the very few areas of English language assessment research in the last 25 years that has gained substantial attention. Commencing with the phenomenal work of Alderson and Wall (1993), a considerable body of empirical studies of washback has been carried out throughout the world. This paper reviews ten recent empirical studies of washback in language teaching between 2011 and 2018. The studies have been collected from several databases like ScienceDirect, ERIC, ResearchGate, Google Scholar and the peer-reviewed journals and university websites. This review demonstrates the research findings and theoretical underpinnings of the washback of assessments and tests in language teaching and testing. This review research finds that washback of high stakes test has both positive, negative and mixed (both positive and negative) impacts depending on the specific contexts and learners' levels. The negative washback occurred when the focus shifted from learning the English language to test-taking strategies whereas the positive washback affected teachers, teaching methodologies, teaching contents, materials, learners and learner strategies.

Keywords: Washback, Teaching Methodologies, Teaching Contents, Learner Strategies.

Introduction

Madaus (1988: 83) opined that "it is testing, not the 'official' stated curriculum, that is increasingly determining what is taught, how it is taught, what is learned, and how it is learned." This research article investigates recent studies (2011-2018) of washback to examine if they demonstrate this to be the case. The term, 'Washback' refers to the influence or impact of assessment and testing practices on the teaching-learning process. 1993 is the year which marks the beginning of the washback effect because this was the time when Alderson and Wall got their article titled 'Does washback exist?' published. The concept of the effect and influence of examinations, especially high-stakes examinations on language teaching and learning is, however, indicated by several terms such as 'backwash' (Hughes,

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[1]*Lecturer, Department of English, Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh*

[2]*Assistant Professor, Department of English, Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh*

1989), 'washback' (Alderson & Wall, 1993) and 'impact' (Baker, 1991; Wall, 1997), 'consequential validity' (Messick, 1989, 1996), 'systemic validity' (Frederiksen & Collins, 1989), 'measurement-driven instruction' (Popham, 1987) or 'curricular alignment' (Madaus, 1988; Smith, 1991). Below, the definitions given by various researchers are placed under the groupings of (a) backwash, (b) washback and (c) test impact.

Backwash

Biggs (1995) opines that backwash denotes that testing controls not only the curriculum but also teachers' teaching methods and students' learning strategies. Spolsky (1994:2) defines 'backwash' as a term that deals with the unforeseen side-effects of testing and not to the intended effects when the primary goal of the testing is the control of curricula. Hughes (1989:1) very precisely specifies backwash as "the effect of testing on teaching and learning".

Washback

"Public examinations influence the attitudes, behaviours, and motivation of teachers, learners, and parents, and because examinations often come at the end of a course, this influence is seen working in a backward direction, hence the term, washback" (Pearson, 1988:98). Quite similar to Hughes (1989:1), Bailey (1996:259) defined washback as the "influence of testing on teaching and learning." Alderson and Wall (1993) described washback as a phenomenon that forces teachers and learners to do certain things because of the test. Messick (1996:1) gave a similar definition of washback. He said washback is "the extent to which the introduction and the use of a test influence language and teachers to do things they would not otherwise do that promote or inhibit language learning". Shohamy, et al. (1996:6) delineated washback as "the connections between testing and learning". For Cheng (2005:8), washback indicates "an intended or unintended (accidental) direction and function of curriculum change on aspects of teaching and learning by means of a change of public examinations".

Test Impact

Some researchers opine that tests have far-reaching effects in the educational world than in the language classroom. For example, Bachman and Palmer (1996:12) used the term "test impact" to refer to the effects that tests have on individuals (teachers and students) or educational systems and on the society at large. Wall (1997:11) held a similar view by stating that "Test impact refers to any of the effects that a test may have on individuals, policies or practices within the classroom, the school, the educational system, and society as a whole". McNamara (2004:10) claimed that "Tests can also have effects beyond the classroom. The wider effect of tests on the community as a whole, including the school, is referred to as test impact". Andrews (2004:9) used "test impact" to describe "the effects of tests on teaching and learning, the educational system, and the various stakeholders in the education process".

Theoretical Framework

Alderson and Wall (1993:120-121), the pioneer, developed 15 washback hypotheses

according to what is influenced: teaching, learning, content, rate, sequence, degree, depth, attitudes and the number of teachers or learners affected by a test. The 15 hypotheses are: A test will influence 1) teaching; 2) learning; 3) what teachers teach; and 4) how teachers teach; 5) what learners learn; and 6) how learners learn;7) the rate and sequence of teaching; and 8) the degree and the depth of learning; 9) the degree and the depth of teaching 10) the degree of learning; 11) attitudes towards the content and method of teaching and learning; 12) Tests that have important consequences will have washback; and conversely; 13) Tests that do not have important consequences will have no washback; 14) Tests will have washback on learners and teachers; 15) Tests will have washback effects for some learners and some teachers, but not for others. When studying washback, focus can be put on participants (teachers, students, material developers, publishers), process (actions by participants towards learning), and products (what is learned and the quality of learning), as suggested in Hughes's trichotomy model (Hughes, 1993 as cited in Bailey, 1996). The 3Ps introduced by Saville (2009) mentions these three principal aspects of washback, namely participants, processes and products (see Figure 1).

On the flip side, washback is conceptualised by Watanabe (2004) in terms of dimension (specificity, intensity, length, intentionality and value of the washback), aspects of learning and teaching that may be affected by the test, and the factors mediating the process of washback being generated (test factors, prestige factors, personal factors, macro-context-factors).

As far as the types are concerned, two types of washback can be observed: negative and positive. Negative washback occurs when test contents or format was based on a narrow

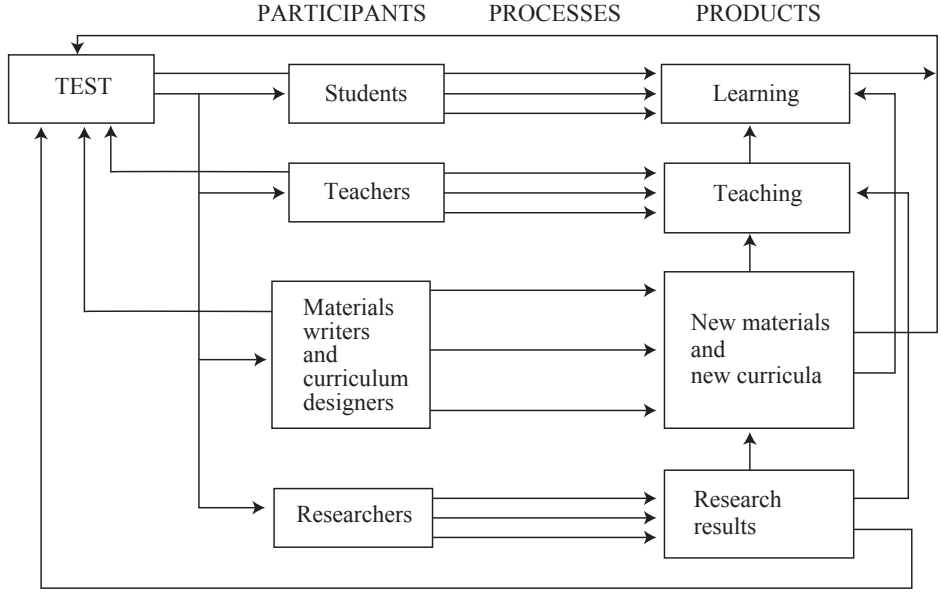

Figure 1: Basic Model of Washback (Baily, 1996)

portrayal of language ability, and it confines the teaching-learning contexts. It refers to negative or undesirable influence on teaching and learning of a test, which means a poor test in which areas/activities that the teacher or student does not like to teach or learn and a discrepancy between the content (e.g., the material/abilities being taught) and the test (Alderson and Wall, 1993; Brown, 2004). Washback takes the form of negative washback when there is a discrepancy between construct definition and the test, or between content (e.g. the materials/abilities being taught). On the other hand, 'positive washback' refers to tests or examinations that influence teaching and learning beneficially (Alderson and Wall, 1993); where testing procedure promotes 'good' teaching practices (Taylor, 2005). Consequently, both teachers and students have a positive attitude towards the test and work voluntarily towards achieving its objectives.

The Rationale of the Study

The key to understanding and practically applying the findings of any investigation into test impact hinges upon the interpretation and analysis of the concept of washback. The goal of this review aims at playing that part. The review will help further understand the nature and complexity of washback which can facilitate teachers, test developers, curriculum specialists and other stakeholders to administer such tests which may create a positive effect.

The Methodology of the Study

This paper is a review based study on secondary data. Recent literature on washback studies from 2011 to 2018 has been reviewed. These reviewed studies have been collected from several databases like ScienceDirect, ERIC, ResearchGate, Google Scholar and peer-reviewed journals and university websites based on keywords e.g., washback studies, testing, and assessment etc. Data retrieved from various secondary sources are duly acknowledged.

Major Findings from the Studies Reviewed

This paper reviewed ten empirical studies of washback in language teaching conducted around the world between 2011 and 2018. The major finding of these studies are summarised and analysed below:

Cholis and Rizqi (2018) - Entrance Exam of Universities (EEU) in Indonesia

Cholis and Rizqi (2018) tested the effects of entrance exam in Indonesia which is a standardised test determining students' entry into universities. In the first part of this research, the researchers tried to find out how EEU affected teachers' attitudes in teaching. They found that EEU created some pressure or extra work (e.g. more lesson preparation, preparing and revising more materials, and preparing the students for the test and for the teachers). In the second part of this study, the researchers explored the teachers' point of views regarding the adoption of the teaching method. The respondents mentioned of more students' participation in class, putting more stress in the integrated skills (e.g. reading, writing, listening and speaking), using communicative approach and finally giving less emphasis on reading

comprehension. The result of the study reported positive washback since the teachers taught based on curriculum regardless of EEU format. So, the study of Cholis and Rizqi (2018) showed that the test did not bring any negative backwash as the teaching pedagogy was not completely dependent on the test contents and patterns. On the other hand, the majority of the respondent teachers in this research did not intend to adopt new teaching methods and employ real-life tasks which were examples of negative washback. At the same time, revising some of the existing materials, experiencing new challenges in teaching, and arranging new objectives of teaching, arranging additional examination practices for EEU test were examples of 'teaching to the test' and were evaluated as the negative effects of entrance examination in this research. However, as concluded in the study the positive influence of the entrance examination test outweighed the negative effects.

Khoshsima, Saed and Mousaei (2018) - Effect of Teaching Test-taking Strategies on Reading Section of IELTS in Iran

This study attempted to assess the impacts of teaching reading test strategies of IELTS candidates in Iran. The study was conducted on forty participants by an experimental research design in which the experimental group (20 participants) received test-taking instructions and the control group (the other 20) received general instructions. Before that, the researchers checked the participants' homogeneity (same level of competence). After the teaching sessions being done, the researchers took the reading test on the 40 candidates and scored the results. The result of this study showed that the mean score of the participants of the experimental group, who received test-taking instructions for their reading skill, was higher than those of control group, who were taught in a traditional method for their reading skills. So, the study of Khoshsima, Saed and Mousaei (2018) found that the teaching test-taking strategies had positive effects on Iranian IELTS candidates' performance on the reading section. They also took the perceptions of the experimental group participants regarding the teaching test-taking strategies and they found the same positive attitudes. This research finally recommended teaching strategies as 'beneficial' for the test-takers on a specific item in the IELTS test.

Munoz (2017) - Attitudes Towards Tests Scale (ATS) in Chile

Munoz (2017) studied the attitudes of the learners towards test in Chile. The study was conducted in experimental research design in which 25 learners were kept into the experimental group and 27 learners were in the control group. The researcher taught both of the groups for four hours of English instruction per week over a period of four months. Munoz (2017) taught the control group with the traditional practice of giving students' assessment results (just grades) whereas he taught the experimental group with washback techniques through which he graded the tests and written quizzes; handed them over to the students and discussed the answers. The result of this study showed that the experimental group had a better attitude towards tests regarding how tests helped them learn the contents; develop test-taking strategies such as time management or organisation skills; enhance self-confidence and motivation. This study finally suggested utilising washback techniques and indicated the improvement of respondents' attitude towards assessment and evaluation.

Khodabakhshzadeh, Zardkanloo, and Alipoor (2017) - Effect of Mock Tests on Iranian IELTS Candidates

This study attempted to find out whether mock IELTS exam (a preparatory test) is useful for IELTS test takers for increasing their scores. The study tried to see the role of IELTS preparatory courses and how its result could assist the material developers and curriculum designers to include or exclude these items in courses. Like the two previous reviewed studies, this study was also conducted in experimental research design in which 25 participants were put in Group 1 and 26 participants in Group 2. The researchers collected the data from their observations of the respondents who were from upper intermediate and advanced levels and did not participate in the IELTS course previously. In group 1, the researchers gave a mock test in each session and mailed the results to the participants before the next session. On the other hand, they taught group 2 with conventional deductive teachings like explaining the procedure, individual tasks in subsections and ways of

Table-1: Washback studies from 2016-2018

Studies	Cholis and Rizqi (2018)	Khoshsima, Saed and Mousaei (2018)	Munoz (2017)	Khodabakhshzadeh, Zardkanloo, and Alipoor (2017)	Barnes (2016)
Exams Studied	Entrance Exam of Universities (EEU) in Indonesia	Test-taking strategies on reading section of academic IELTS in Iran	Attitude towards Test Scale (ATS) in Chile	Mock tests in IELTS preparation courses in Iran	TOEFL iBT in Vietnam
Purposes	To explore the washback effect of a high-stakes test on teachers' attitude and teaching methods used	To investigate the impact of teaching reading test-taking strategies on the IELTS candidates' performance on the IELTS reading section	To improve learners' attitudes towards tests	To find out whether Mock IELTS exam could have any effect on IELTS candidates overall score on the IELTS exam	To investigate the washback effects of a high-stakes English language proficiency test, TOEFL iBT, in Vietnam.
Methodology	Survey design and questionnaire	Experimental design- experimental group received test taking instructions and the control group received general instructions	Action research- mixed method design, interview and questionnaire	Experimental design by dividing the participants in two groups and comparing their post-test scores	Observational data were collected
Collected Evidence	The respondent teachers showed positive attitudes. They showed a few negative issues in teaching methods	The score of experimental group was more than the general group. The respondents had a positive attitude	The experimental group scored higher than the control group. The experimental group showed positive attitudes towards tests	The group which practiced mock test outperformed the group that did not sit for mock test	The materials were dependent on TOEFL iBT text books. The teaching pedagogies did not change due to over dependence on the book
Conclusions	Positive influence outweighed the negative results	Teaching test-taking strategies had positive effects	Positive washback observed	Using Mock tests in the IELTS preparation courses can positively affect the participants scores on IELTS exam	Both the contents and pedagogies were influenced by the test. Negative washback found

answering certain types of questions. Khodabakhshzadeh, Zardkanloo, and Alipoor (2017) conducted ten sessions over a period of three months and after that, they compared the post-test scores of the participants of both groups. The results of the study revealed that the difference between the post-test scores of the two groups was significant and group 2 outperformed group 1. It became evident from this research that practising test-taking strategies were more effective than teaching course content in term of high stakes tests like IELTS. So, this research advocated the use of mock tests in IELTS preparation courses in Iran due to positive washback.

Barnes (2016) - Washback of TOEFL in Vietnam

Barnes' study (2016) examined the effects of TOEFL on the teaching contents and teaching pedagogy in Vietnam. The researcher chose two language centres in Vietnam which offered TOEFL preparation courses. The data was collected from the teaching materials and classroom observations. Barnes (2016) found teachers' overdependence on TOFEL iBT book and the existence of commercial materials. The researcher noticed that the majority of the materials collected in the class observations were not created by the teachers, but came directly from the classroom textbooks. Therefore, the teaching methods were not influenced much due to their reliance on TOEFL iBT textbook materials. Moreover, the majority of the practised tasks expected students to respond to questions individually. Barnes (2016) observed that the interactions in the class were from students to teachers, vice versa and students to students. Examples of the student to student or class interaction included oral presentations and class discussions. This study found that teaching activities took more time in class than student activities. All these findings of this study suggested that TOEFL iBT preparation courses in Vietnam emphasised the test skills but not the skills necessary for mastering a language. So, this study found the negative influence of the TOEFL iBT test on teaching methodologies and contents.

Mahmoudi (2015) - Washback of National University Entrance Exam in Iran

The study of Mahmoudi (2015) investigated the washback effect of Iranian National University Entrance Exam (INUEE) on the English learning process. This research was conducted on 218 female students at two pre-university schools in Iran and the instruments for collecting the data were students' questionnaire and an observation checklist. The study found that students' learning process and the teachers' teaching method were affected by the entrance exam. The INUEE affected learners' learning contents and learning strategies negatively whereas teachers' teaching method affected their learning in both positive and negative ways. As indicated in this research, the INUEE negatively affected the teaching and learning strategies through pushing the students towards mastering the test-tackling strategies rather than pursuing English for the sake of genuine learning. The majority of the respondent students studied their whole textbooks. Besides, most of the students did self-study to master the strategies for the entrance test. Mahmoudi (2015) identified students' most practice areas (grammar, vocabulary and reading) and the least practice areas (writing, speaking and listening). Students also changed their learning strategies to adjust to the entrance test and practised sample tests when the examination got closer. Therefore, Mahmoudi's study (2015)

suggested that students' learning has been affected both positively as well as negatively. The washback was positive in the sense that students themselves developed some of the skills that were tested in the entrance exam. On the contrary, the washback was negative because only preparing for the test was not sufficient for learning the English language. However, this research concluded that the negative washback of the Iranian National University Entrance Exam outweighed the positive sides in the Iranian context.

Aftab, Qureshi and William (2014) - Intermediate English Examination in Pakistan

The study of Aftab, Qureshi and William (2014) investigated the nature and scope of the washback effect of the intermediate English examination in Pakistan which determines students' entrance into university. The study used qualitative data collection method utilising interviews to take views of the teachers and students.

The respondent students demanded practice of examination related activities and relied on cramming of materials from guide (practice) books. As indicated in this research, students'

Table-2: Washback studies from 2011 – 2015

Studies	Mahmoudi (2015)	Aftab, Qureshi and William (2014)	Watanabe (2013)	Kirkpatrick (2012)	Sukyadi and Mardiani (2011)
Exams Studied	Iranian National University Entrance Exam (INUEE)	Intermediate English Examination in Pakistan	Center Test for University Admissions (an achievement test) in Japan	English Assessment System in Bhutan	English National Examination (ENE) in Indonesia
Purposes	To investigate the washback effect of INUEE on English learning process	To explore the nature and scope of the washback effect from the Pakistani Intermediate English examination	Explored the test validation and its effects on students' achievement	To examine the washback effect of English assessment system	To evaluate the washback effect of ENE
Methodology	Questionnaire and Observations	Qualitative design-interviews	qualitative research method-exploratory analysis	Questionnaire	Qualitative method-observation, interviews, questionnaire and documents
Collected Evidence	Students' learning process and teachers' teaching methods were affected	Students crammed the answers. The teachers taught only the skills that were tested in the test	Measured the skills that were supposed to be measured. Students developed communicational skills which were tested in the test	Teachers' willingness to accept new approaches to teaching, diagnostic feedback, use of rubrics. Lack of teacher training, lack of curriculum materials, crowded classes, and overemphasis on summative assessment	The school of high-level achievers had more positive washback. The school of moderate and low level achievers had more negative washback
Conclusion	Have both positive and negative washback.	The test had negative washback on teaching methodology, content and learning	The Centre test had positive washback	The new curriculum produced both positive and negative washback	Both positive and negative washback

tendency to memorising the answers for the test suggested that they treated English as a subject to be passed in the examination but not a language to be learnt. Simultaneously, the teachers heavily relied on practising examination related tasks. As a result, this study revealed that the test had negative washback on teaching methodology, content and learning since many of the students' language learning needs were neglected in the intermediate English examination.

Watanabe (2013) - Centre Test for University Admissions in Japan

Watanabe (2013) studied the national centre test for university admissions in Japan which is an achievement test held in different places nationally. It measures students' achievement in the last year of upper secondary level. Watanabe (2013) sought the validation and impact of the centre test. This centre test determines students' admission in national public and private universities and also attempts to improve the teaching-learning process for helping students develop their communicative skills. The test consists of both writing and listening components and it is designed and produced by the national centre for university entrance examinations. Watanabe (2013) mentioned that the test was fair to assess the respondent students and provided a valid measurement of students' competence to study in universities. Moreover, this study analysed the test scores obtained by the students and found that students reached the level of required achievement and the scores predicted the candidate's success at university. In addition, the test influenced the improvement of test preparation materials at the institutes which dealt pre-college- level education. Watanabe (2013) finally concluded that the test had positive washback on the learners and teaching materials.

Kirkpatrick (2012)- Washback Effect of the English Assessment System in Bhutan

The study of Kirkpatrick (2012) examined the washback effect of the English assessment system associated with the new curriculum of secondary schools in Bhutan which was modified in 2006. The data in this research was collected from 56 EFL secondary school teachers by means of questionnaire responses. The study suggested that the new curriculum and assessment system had positive as well as negative washback. The positive washback effects found in the study were teachers' willingness to accept new approaches to teaching, diagnostic feedback along with the grading given to the learners by the teachers, use of criteria, rubrics, and checklist samples for assessment. The negative washback as reported in this study occurred due to the mismatch between syllabus contents and time allocation, huge workloads on students and teachers, and the tendency of grade inflation. Besides, the factors like lack of teacher training, lack of curriculum materials, crowded classes, and overemphasis on summative assessment also led to the negative impacts. This study recommended for keeping the balance between summative and formative assessment. Kirkpatrick (2012) mentioned that the new assessment system brought some changes and improvement of teaching and learning in secondary schools in Bhutan but it did not meet the academic, workplace and development needs of contemporary Bhutan. In addition, Kirkpatrick (2012) referred that many of the teachers were being unable to implement the new assessment system but they could assess the students with proper guidance.

Sukyadi and Mardiani (2011) - English National Examination (ENE) in Indonesia

Sukyadi and Mardiani (2011) studied the washback effect of English National Examination (ENE) which is a high stake test held at the end of secondary schools in Indonesia. Three secondary schools were selected for this study from three different levels namely high-level achiever, moderate- level achiever and low-level achiever. The participants of this research were the students and teachers from the tenth, eleventh and twelve grades. The researchers found that ENE had mentionable impacts on teachers and students. Teachers' time arrangement, their teaching materials, contents, teaching methods, strategies, ways of assessment were affected by ENE. This study found that the ENE also affected the students' learning in the classroom in which teachers made the students practice the test and enhance their test-taking skills. Sukyadi and Mardiani (2011) found the effect of washback was only on the twelfth grade English teachers' classroom teaching, but not for lower grades like the tenth and the eleventh. The finding of this research indicated that the washback effect occurred only when the students and teachers felt that the ENE preparation is an obligation. However, Sukyadi and Mardiani (2011) referred that the school of high-level achievers encountered more positive washback in the teachers' teaching and students' learning practice, while the school of moderate and low-level achievers had more negative washback, particularly in teaching materials and teaching contents. The washback varied due to the condition of the students and so the study concluded that ENE had both positive and negative washback depending on the contexts.

Critical Commentary and Conclusion

This review study covered the empirical researches on washback effects in countries like Indonesia, Iran, Vietnam, Pakistan, Japan, Bhutan and Chile. All the studied examinations were of high stakes such as university entrance examination, national examinations, IELTS and TOEFL. All the reviewed studies sought to identify the nature and scope of washback, its effects on teaching methods, teachers' and learners' attitudes, and learners' test-taking strategies. The methodologies that these studies followed were experimental design, action research, survey design and qualitative research in which the data were collected through questionnaire, interview and observation. The evidence collected in these studies showed positive attitudes of the teachers, learners' better performance in the test. Conversely, the evidence was also meant to be negative when students crammed the answer for the test and the teachers taught only the skills tested in the test. Moreover, the washback effects were sometimes mixed (both positive and negative) and this happened due to the variance of learners' levels and their contexts.

The studies bring forth several findings with regard to washback. Such as, it is seen that rather than having a direct and simple effect, washback is quite complex and elusive. So, washback is very broad and it has many variables except the test itself. Some of the factors that affected washback include teacher and student factors (e.g. beliefs, attitudes, experience, education, training, personality, teaching and learning style, etc.), textbook writers and publishers (e.g. their interpretation of exam requirements), the status of the subject being tested, resources and classroom conditions, management of practices in the schools, communication between

test providers and test users, the socio-political context in which the test is put to use, etc. In addition, although external factors such as the teacher or student factors have been identified, insufficient research has been done to reveal how they function and interact with a test to bring about the results observed.

As far as pedagogical issues are concerned, this review reveals that teachers play an important role in bringing about washback effects (either positive or negative). Therefore, they should be a central factor of any empirical study conducted on washback. They play a vital role in the pedagogical implementations of bringing about positive washback envisaged by test developers and policymakers and expected by students and parents. Teachers can learn from these washback studies and (1) be aware of the existence of washback, (2) understand the influencing factors of washback, and (3) enhance their knowledge of educational theories related to washback. In this way, they can contribute to policy making and curriculum on which assessments are developed, whether and how teachers address students' learning styles and needs, how their students respond to their instructional activities, whether and how parents are involved in students' learning practices, and equally important, which kind of socio-cultural and educational context students are situated in. By doing these teachers can enhance their capacity to produce positive washback effects.

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Temperature Dependence of Electrical Properties of Biopolymer Gel with Increasing Polymer Concentration

Nusrat Jahan[1]

Abstract

This study is aimed to investigate the electrical properties of biopolymer gel as functions of polymer concentration and temperature. To perform this study, gellan gum was used as a biopolymer, which is a bacterial polysaccharide. The gellan polymer in solution dissociates into polyelectrolyte and it forms polyelectrolyte gel under a suitable condition. We studied the ionic conductivity variation of this gellan gel electrolytes with varying polymer concentration from 0.5 wt.% to 3.5wt.% which exhibit a slight increase in ionic conductivity at room temperature. In addition to different polymer concentration, we investigated the effect of temperature dependent electrical property from 30^0C to 80^0C and the Arrhenius plot obtained from this temperature dependence of conductivity revealed a stronger network with increasing polymer concentration.

Keywords: Biopolymer, Bacterial Polysaccharide, Polyelectrolyte Gel, Gellan Gum, Conductivity

Introduction

Interest in the study of electrically conductive, renewable and biodegradable, biopolymer system has been continuously growing as a result of its promising application such as electronics, medicine, food packaging, bioplastics and coating. There are two types of biopolymers available: neutral and charged. Gelatin or agarose is the neutral biopolymers and on the other side gellan, carrageenan etc. are the charged biopolymers. The charged biopolymers form polyelectrolytes in solution along with the metallic ions as their counterions. Biopolymer gel formed from these polyelectrolytes can be considered as gel electrolytes. For the interesting properties of biopolymers different polymer electrolytes (SPE) have been obtained from cellulose derivatives, starch, chitosan and pectin among others.

Gellan gum is an anionic microbial polysaccharide derived from *Pseudomonas elodea*. This heteropolysaccharide is basically composed of repetitive units of tetrasaccharide (-D-glucose, -D-glucuronic acid, -D-glucose and -L-rhamnose), and it contains one carboxyl side group per repeating unit.

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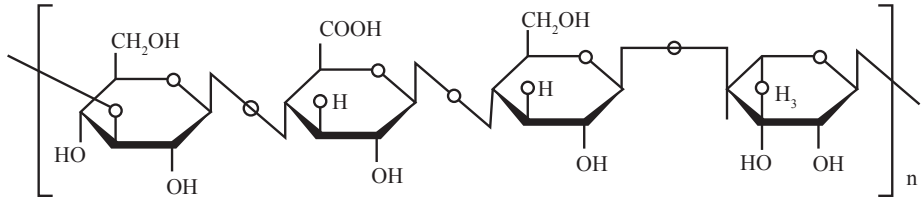
[1]*Lecturer, Department of Physics, Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh*



Low Acyl form

Figure 1: Gellan gum structure

Gellan gum forms a loose gel by itself because carboxylic side groups in the gellan gum molecule repulse each other by electrostatic interaction which hinders the tight bonding of helices and also a tight aggregation of helices. However, physicochemical properties of gellan gels are influenced strongly by the presence of cations, due to their ability to shield the electrostatic repulsion of the carboxylic groups.

Gellan gum is also a thermo-reversible gel-forming polymer. At temperatures more than 80^{o}C, its chains adopt a random coil, which then undergoes a conformational transition to double-helices upon cooling below 30^{o}C. This conformational transition has been observed and characterised extensively using a variety of experimental techniques including rheology, light scattering, nuclear magnetic resonances, viscometry and circular dichroism spectroscopy. The changes in polymer morphology during the conformational transition and the structure of the gel network formed have even been directly visualised utilising transmission electron microscopy and atomic force microscopy. Due to the compatibility and no danger for the human body, this macromolecule found great application for ascorbic acid carriers in foods, ophthalmic drug delivery and tissue-engineering.

So, considering the intensity of research interest on gellan biopolymer, we think it is an insightful selection of a time to investigate the conductivity property of gellan. At present, there is plenty of research going on increasing of gellan biopolimer conductivity.

N. F. A. Halim, S. R. Majid, A. K. Arof, F. Kajzar, And A. Pawlica studied the electrical properties of pure gellan-based polymer electrolytes, doped with LiI and plasticised with glycerol. Their ionic conductivity measurements showed that the salt concentration influences the ionic conductivity of electrolyte increasing it from 10^{-8} S/cm (pure gellan) to 3.8 $\times 10^{-4}$ S/cm for gellan doped with 40 wt% of LiI. Addition of 10 wt% of glycerol promotes another increase of the ionic conductivity, up to 1.5×10^{-3} S/cm for the sample with 40 wt% of LiI. The repeated ionic conductivity measurements as a function of temperature show that the membranes of the doped sample can be reversibly used between the room temperature and 100^{o}C.

Cameron J. Ferris and Marc investigated the gelation and conductivity behaviour of gellan gum–carbon nanotube composite materials. It has been shown that the addition of carbon nanotubes allowed more efficient cooling and heating of composite dispersions compared to

gellan gum solutions. In their study, it was suggested that the current contains an electrical contribution from electron transport through the nanotubes and an ionic contribution due to cations. They showed that increasing the nanotube mass fraction increases the relative contribution to the current of the electron transport over ion mobility & the ionic contribution was found to scale exponentially with increasing nanotube mass fraction.

Our main objective of this research will be to investigate the DC electrical behaviour of gellan in solution and gel state and the variation of conductivity as a function of polymer concentration and temperature which may reveal the application of this biopolymer in electronic devices.

Experiment

Materials

In this study, we used gellan powder as the main raw material. This commercial powder sample was obtained from Saneigen F.F.I Inc. Japan and used in this study without further purification. To get the best result nano-pure water (conductivity 0.055 micro-siemens/cm) was used for preparing the solution.

Sample Preparation

To prepare the sample solution of certain polymer concentration required amount of powdered gellan was mixed with nano pure water. To ensure homogeneity and complete dissolution of powdered gellan magnetic stirrer and a water bath maintained at temperature 70˚-80^{o}C was used. For example, to make polymer concentration, C_p=2wt.%, 0.2gm of gellan powder was mixed with 9.8gm. of water in a 50ml bottle. After the mixing, a magnet was inserted inside the bottle and the entrance was sealed with Teflon, so the concentration of the prepared solution remains the same during the entire preparation process. Then the solution bottle was put inside a water bath on a magnetic stirrer for 1 hour at a temperature between 70- 80^{o}C. After 1 hour the hot gellan solution was poured into a sample holder. The solution turned into gel just after reaching the room temperature. By this method, we prepared 5 samples of different polymer concentration from 0.5 wt% to 3.5 wt%.

Measurement Technique

Simultaneous measurement of different samples electrical characteristics was carried out using an experimental system consisting of a sample holder placed within a controlled temperature chamber and electrical characterisation equipment. The sample holder consisted of two electrodes separated by an insulator and they were connected with electrical characterisation equipment (keithely 2401 source meter) by two copper wire. The equipment itself was operated through Lab tracer 2.9 software. For Current (I) – voltage (V) characteristics we choose to apply the voltage range from -5V to +5V from the source menu and current data were recorded with sweep delay 10 (ms). The temperature dependence of electrical transport through the sample was determined by measuring the I–V characteristics inside the controlled temperature chamber as the temperature was slowly increased from 30–70^{o}C.

Results and Discussion

The electrical conductivity of any material is the ability of a material to carry the flow of an electric current (a flow of electrons). In this study, we have observed the variation of conductivity as a function of temperature and polymer concentration. The electrical conductivity (σ) of the sample was found using the equation,

$$\sigma = d/RA \qquad \text{(i)}$$

Where R is the resistance, d is the thickness of the sample and A is the area of the sample in contact with the electrode. The temperature dependence electrical conductivity of a polymer is known to be given by

$$\sigma = \sigma_o \exp\left(-E_a / RT\right) \qquad \text{(ii)}$$

Where, E_a is the activation energy. We found the activation energy required from plot lnσ vs 1000/T. The slope found from this linear plot was then used in the following equation (iii) to give the activation energy, E_a,

$$E_a = -(\text{slope})R \times 1000 \qquad \text{(iii)}$$

The electrical properties were measured for 5 samples of concentration 0.5 wt. %, 2.0 wt%, 2.5 wt. %, 3.0 wt. %, 3.5 wt. % from temperature 30^0C to 70˚C.

Temperature Dependent Conductivity Variation

Figure: 2 (a) clearly demonstrates the resistivity of gellan polyelectrolyte decreases with increasing temperature which is analogous to a semiconductor behaviour. In fig (b) and (c) we see the change of conductivity at different temperature for polymer concentration, C_p= 0.5wt% and C_p=2.0wt%. We find that the conductivity rises non-linearly for C_p= 0.5wt% from 6.56×10^{-4} S/cm at 30˚C to 4.74×10^{-2} S/cm at 70˚C.The reason for this drastic increment suggests as with increasing temperature the gellan forms a complete viscous liquid and the counterion present in the viscous liquid becomes highly mobile. Whereas in Fig (c), the conductivity for C_p=2.0wt% is found to increases linearly with temperature from 7.95×10^{-4} S/cm at 30^0C to 1.52×10^{-3} S/cm at 70˚C. It can be explained by suggesting that, as the gellan polymer changes in conformation from double helices to a random coil with increasing temperatures, the counter ions in gellan achieves high mobility which therefore increases conductivity.

Lastly, the activation energy, E_a, found from conductivity vs temperature for samples from 2.0wt% to 3.5wt% in Table 1 suggests with increasing temperature gellan solution is of Arrhenius type, and therefore can be used as sensor materials.

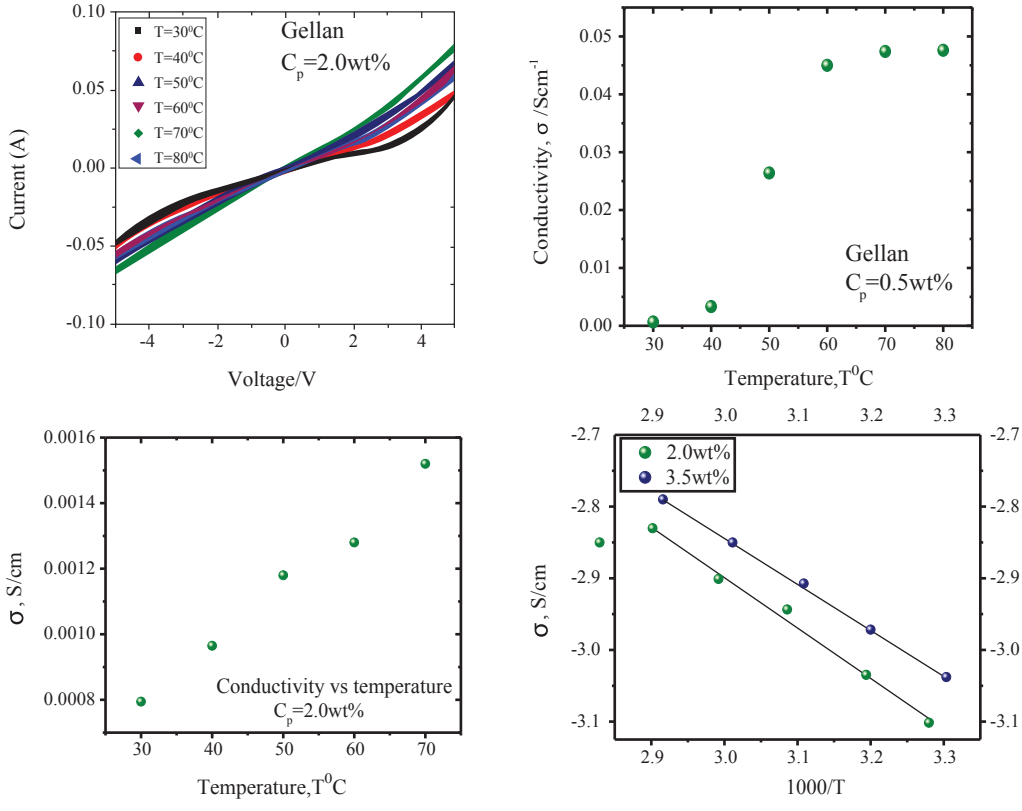


Figure: 2 Conductivity variation of gellan gum as a function of temperature a) Plot of I-V characteristic curve for polymer concentration, C_p=2.0 wt.%. b) Plot of Conductivity Vs Temperature at 0.5wt% c) Plot of Conductivity vs Temperature at 2.0wt% d) logσ vs 103/T (K^{-1}) with increasing polymer concentration.

Table 1: Activation energy with increasing polymer concentration

Polymer Concentration, C_p	*Activation Energy, E_a KJ/mol*
C_p=*2.0 wt.%*	4.74 KJ/mol
C_p=*3.5 wt.%*	5.20 KJ/mol

From Table 1, we find that the activation energy increases with increasing polymer concentration which confirms the formation of stronger and concentrated network.

Concentration-dependent Conductivity Variation

The conductivity as a function of concentration has been studied in figure 3 which demonstrates with increasing concentration from 2.0wt% to 3.5wt% the conductivity increases slightly from 7.95×10^{-4} S/cm to 9.26×10^{-4} S/cm. Since the temperature was kept constant at 30°C this increase suggests that it is entirely determined by the polymer concentration.

As we increase our concentration 1.8 times the counterion concentration also increases with decreasing water content. So, we suggest with increasing concentration the transport properties are governed by counter ion concentration.

Conclusion

DC electrical properties of gellan biopolymer gel have been intensively studied as a function of temperature with varying polymer concentration. The I-V characteristic curve was analysed and the increase of conductivity with temperature confirms that gellan conductivity is temperature depended and increasing polymer concentration also increases in conductivity confirms counterion concentration plays an important role in increasing its conductivity. The variation of conductivity as a function of temperature and concentration confirms that gellan conductivity can be controlled. From the results, we would like to emphasise that cation mobility and polymer conformation plays an important role in gellan conductivity and the control over conductivity can find its application as a bio-sensor in many electronic devices.

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Book Review

Towards Regional Integration in South Asia: Promoting Trade Facilitation and Connectivity,

Md. Mamin Ullah[1]

Abstract

The growth of regional integration is now a major feature of international politics. It is not a new phenomenon; however, the regional trading block is still a dream for 1.7 billion South Asian people. Despite its shared history, culture, and geography, South Asia is one of the least integrated regions in the world (World Bank, 2017). Intra-regional trade accounts for only 5 per cent of total trade in SAARC in against of 25 per cent in ASEAN. Intra-regional investment, in addition, is smaller than 1 per cent of the overall investment. Nonetheless, this region is considered the most critical strategic location for global trade. The book under review addresses a number of issues that are critical to deepening regional cooperation and integration in South Asia along with a special focus on trade facilitation and connectivity. Given the backdrops in regional cooperation and integrations in South Asia, the need for a comprehensive book reviewing the current trends and challenges of regional integration is obvious. This book has fulfilled this need to a large extent. The book has identified the major barriers towards regional integration in South Asia in addition to providing concrete proposals to overcome these barriers based on statistical evidence and generated knowledge. This book is, therefore, a welcome guide for researchers, academics, and policymakers. Accordingly, the book deserves the rights for critical review.

Keywords: Regional Integration, Connectivity, Trade

Introduction

Professor Mustafizur Rahman is a renowned economist in Bangladesh with special expertise in development policy and international trade. He is now the distinguished fellow of Centre for Policy Dialogue (CPD) which is one of the leading civil society think tanks in Bangladesh. Prior to joining CPD, Professor Rahman taught at Dhaka University. He was a visiting Post-Doctoral Fellow at Oxford University and Warwick University, UK and a Senior Fulbright Fellow at Yale University, USA. In addition to academic excellence and PhD in Development Economics, he has tremendous publishing records in national and international journals. He also wrote and edited a notable number of books and book chapters including *Regional Integration in South Asia: Essays in Honour of Dr. M. Rahmatullah* (co-editor with

[1]*Assistant Professor, Department of Management Studies, University of Barisal, Barisal-8200, Bangladesh*

Dr. Prabir De), *Bangladesh: Perspectives on Deepening Cross-Border Links* (published by Asian Development Bank Institute), *Cross-Border Transport Infrastructure* (with Khondaker Golam Moazzem), *Non-tariff Barriers in South Asia: Nature and Modalities to Address the Attendant Issues* (published by Commonwealth Secretariat), *Connecting South Asia and Southeast Asia: A Bangladesh Country Study, Development of the Private Sector in South Asia: Addressing the Challenges for Building Competitiveness* (presented at Sixth South Asia Economic Summit), *Macroeconomic Management in the Face of Global Challenges,* and so on. There are four authors of this research-based book who are/were the research associates at CPD having sound academic and publishing backgrounds. Thus, the authors' outstanding backgrounds and the editor's expertise in relative fields have increased the credibility of this book.

Review

This book was critically reviewed in six logical sections: bibliographic information, thesis statement, authors' and editor's credentials, content analysis, critical evaluation, and conclusion. The basic criteria for reviewing this book included title justification, book structure, language, relevance and consistency in the discussion, evidence, implications, and comparative evaluation with other relevant books.

This book is divided into three chapters addressing different dimensions of regional integration in South Asia. The first chapter presents a detailed picture of the current state of trade and transport facilities which are critically relevant to regional connectivity and cooperation among the countries in South Asia. Rahman, Akhter, and Saif showed calibre in identifying the bottlenecks faced by intra-regional traders in South Asia. At the beginning of Chapter 1, authors justified the need for unique trading frameworks and transport facilities based on a thorough review of existing literature. As per the evidence presented in this chapter, the major barriers towards trade facilitation in this region are complex documentation, difficulties in moving goods across borders, lack of standardisation, inadequate human resources, and weak harmonisation of customs practices. Sultana and Asrat (2014) stressed that poor port and transport infrastructure mainly lead to poor regional integration in South Asia. Rahamatullah (2012), for example, argued that transport connectivity is supposed to bring significant benefits for regional cooperation in South Asia. Rasul (2009) further emphasised the need for adequate transport facilities and infrastructure for promoting regional connectivity among the SAARC countries. The findings of this chapter are thus supported by the research evidence to a large extent.

In chapter 1, authors placed a greater emphasis on Bangladesh perspective. The trade direction and trade flows in Bangladesh with other regional countries were presented with tables and figures in succinct forms. The authors revealed that:

Bangladesh's exports are mainly concentrated in the European Union (EU) and the North American regions that account for more than 70 per cent of the total export of Bangladesh. (p. 9)

The main trade routes and corridors of Bangladesh were presented along with a short note on logistics performance index (table 1.8, p. 20). The authors showed calibre in presenting the

outcomes of the SASEC road connectivity project with a critical evaluation (diagram 1.1, p. 34). The chapter is concluded with a review of the major projects for customs automation and modernisation in Bangladesh. Several suggestions for improving regional cooperation are also outlined.

Chapter 2 focuses on the most opt-complained issues of non-tariff barriers in the form of SPS-TBT. According to the authors of this chapter, these non-tariff barriers limit the potentialities of Bangladesh-India bilateral trade. The existing list of tests and testing agencies for tradable products were presented based on a comprehensive survey (table 2.3, p. 76). One of the critical findings of this study is as follows.

Most of the respondents felt that the majority of the institutions that deal with SPS-related measures are not efficient and adequately equipped (p. 78).

The authors proposed a framework for an SPS agreement between Bangladesh and India with a comprehensive graphical presentation (diagram 2.2, p. 88). The chapter is concluded with concrete policy recommendations for improving bilateral trade between Bangladesh and India. Despite a consistent analysis of SPS agreement, the contents of this chapter do not match with the scope of the title of the book. Much of the discussion remained at bilateral level i.e., Bangladesh and India. Moreover, a significant number of earlier studies (e.g., Bhuyan, 2008; Raihan, 2011; De et al., 2012) covered these issues to a large extent. Nonetheless, the proposed framework for a comprehensive SPS agreement is undoubtedly useful for policymakers.

Chapter 3 is contributed by Rahman, Siddique, and Saha that provides an in-depth examination of the various MVA proposals in the SAARC based on the review of relevant secondary materials. An overview of the current state of cross-border transport movement is presented with evidence (p. 119). The theoretical framework presented for CBTA/MVA analysis is praiseworthy (diagram 3.1, p. 112). The authors illustrated the components of an ideal cross-border road transport agreement incorporating the main elements of existing MVAs. The importance of adequate transport logistics for regional cooperation is articulated at the beginning of the chapter as follows.

Good connectivity reduces the cost of doing business and raises competitive strengths of trading partners within regions and sub-regions, and enabling them to operate on the basis of competitive comparative advantages (p. 103).

The relationship between transport link and trade facilitation was repeatedly emphasised in the chapter. This was probably done due to the importance of good transport connectivity from Bangladesh perspective. The research evidence suggests the arguments of the authors. Wilson et al. (2004), for example, found that improvement in port efficiency may lead to the highest export promotion effect (37 per cent) for Bangladesh from all South Asian countries. The chapter is concluded with policy recommendations for better operational modalities for implementing cross-border road transport movement. Despite a significant number of studies are available in transport connectivity (e.g., Rahmatullah, 2009; De & Bhattacharyya, 2007; Teravaninthorn & Raballand, 2009), this chapter has put forward concrete suggestions for promoting MVA in South Asia based on a thorough review of global best practices. The authors observed that:

Whilst at policy level many regional cooperation initiatives have been put in place in SAARC, much remains to be done at the implementation level (p. v).

The number of books and monographs of regional integrations has been increasing since the early 2000s. Maurice and Alan (2003) examined regionalism from the perspective of developing countries and concluded the book with a comprehensive account of existing economic theory. Ncube et al. (2015) reviewed the current trends and challenges of regional integration in Africa. Czerewacz-Filipowicz and Konopelko (2016) critically evaluated the regional integration processes in the Commonwealth Independent States. Mikic and Bruno (2016) explored the regional integration of ASEAN countries along with a proposed model. Kim (2013) offered the most vivid account of regional integration in Europe and Asia.

Like Africa, America, and Europe, there are a significant number of books dealt with regional integration in South Asia including Regional Integration in South Asia: Trends, Challenges and Prospects (Razzaque & Basnett, 2014); Regional Integration and Economic Development in South Asia (Rahman et al., 2012); Regional Integration in South Asia: Essays in Honour of Dr. M. Rahmatullah (De & Rahman, 2015); Does South Asia Exist?: Prospects for Regional Integration (Dossani et al., 2010); and Regionalism and Regional Security in South Asia: The Role of SAARC (Ahmed, 2014). Despite these abundant books of regional integration, Rahman's book of regional integration is unique at addressing the backdrops of regional integration in South Asia and providing the concrete policy recommendations for overcoming the existing challenges towards better regional cooperation and connectivity.

Overall Observation

The authors' stated objectives set in the book are adequate and matched with the discussions to a large extent. They have tried to examine the different dimensions of South Asian regional integration with evidence and they largely accomplished their stated purpose. The concepts are clearly defined with necessary illustrations. The language is clear and lucid. The ideas are solidly grounded with convincing policy options. The book is well structured to some extent and the chapters are logically presented. The print type and size are appropriate and legible with an attractive binding. The illustrations and diagrams are properly placed to aid in the understanding of the text. The discussions of the book are supported with adequate references. A list of tables, figures, charts, maps, and diagrams is presented at the beginning of the book along with a list of acronyms. The book is ended with a list of appendices containing vital information for readers and researchers.

Concluding Remarks

Although this book is an important contribution to the field of regional integration, some backdrops are clearly observed. The title of the book does not match with the contents to a large extent. Although the title implies for regional integration in South Asia, most of the discussions remained at Bangladesh-India case. The title and scope of the book are thus inappropriate and ambiguous. The referencing style is confusing. Although this is a research-based book, it should include a list of indices at the end of the book. Despite these

minor limitations, the book is supposed to add value to the existing field of research.

Conclusion

This book presents the ins and outs of regional integration in South Asia with reliable information and expertise. In a thorough analysis of the trade facilitation and dynamics of regionalism, the book explored the less addressed areas of implementation and operationalisation of policies and initiatives, which the authors argue should be exploited to the maximum extent. Indeed, the book offers a more comprehensive, lucid and judicious account concerning regional integration in South Asia with an emphasis on trade facilitation and transport connectivity. Accordingly, the book has achieved its goals to a large extent. Designed as a practical guide for policymakers, this book will also be of interest to academics, researchers, and experts.

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Notes for Contributors

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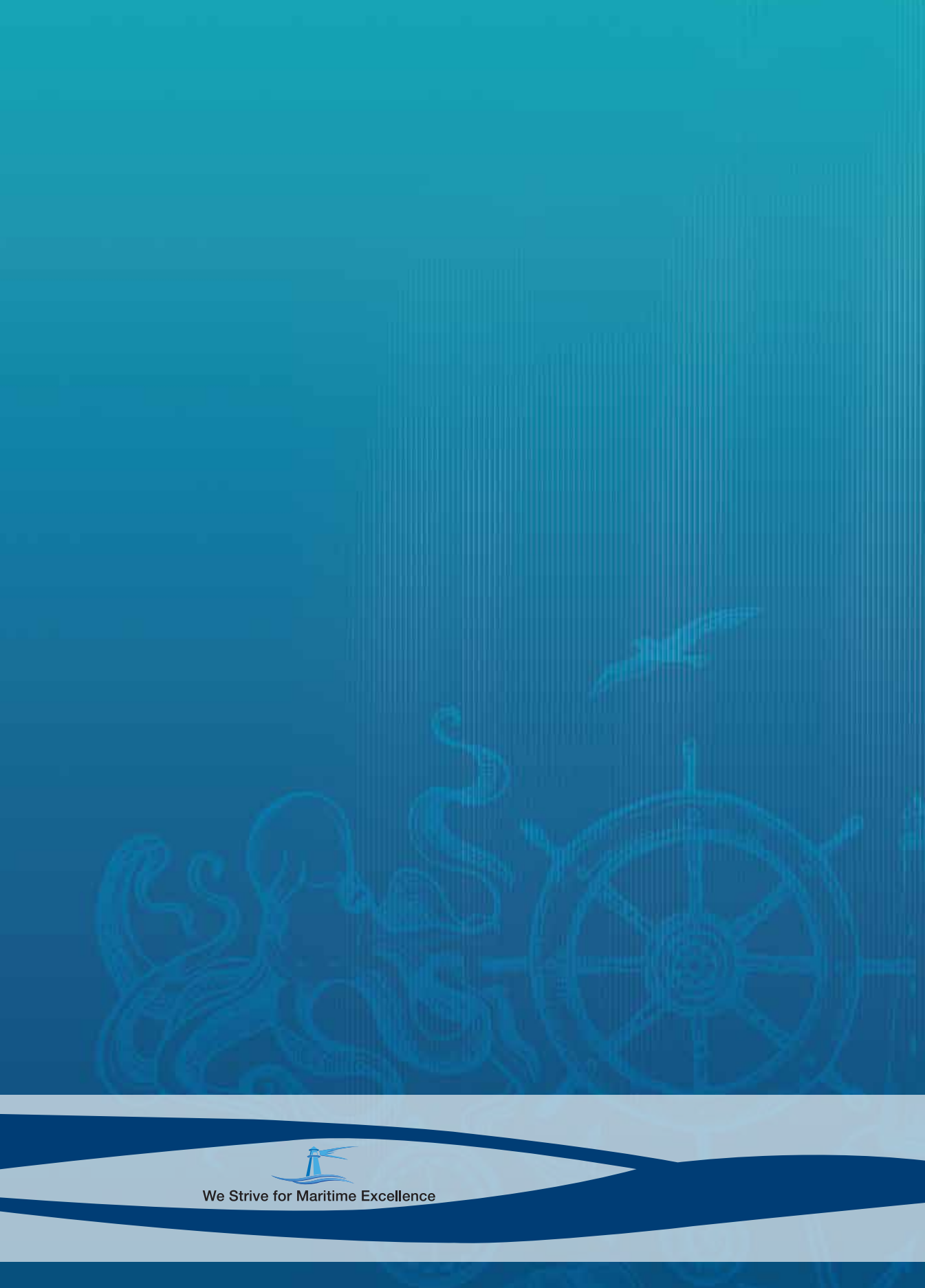

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