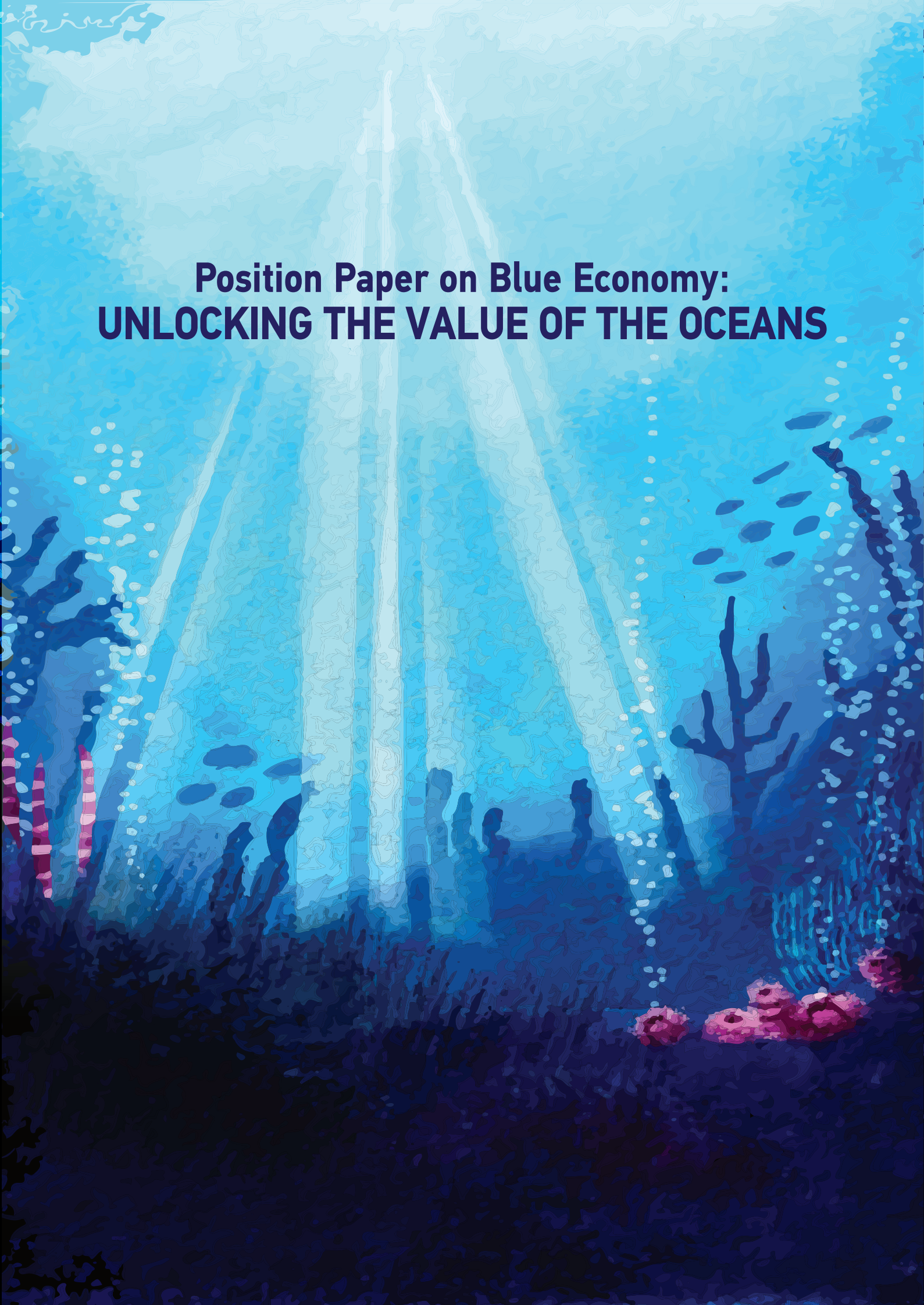
Position Paper on Blue Economy:
UNLOCKING THE VALUE OF THE OCEANS



Position Paper on Blue Economy: Unlocking the Value of The Oceans

ASM Special Interest Group on Blue Economy

Position Paper on Blue Economy:
Unlocking the Value of the Oceans

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LIST OF ABBREVIATION

3R	Reduce, Reuse, Recycle
4IR	Fourth Industrial Revolution
10-10 *My*STIE	10-10 Malaysian Science, Technology, Innovation and Economy 10-10 *My*STIE
Framework	Framework
8R-NCBE	8R-Nature Centric Blue Economy
AI	Artificial Intelligence
ASM	Academy of Sciences Malaysia
B2B	Business to Business
B2G	Business to Government
CAGR	Compound Annual Growth Rate
CBD	Convention of Biological Diversity
CCS	Carbon Capture and Sequestration
CEPA	Communication, Education and Public Awareness
CLCS	Commission on the Limits of the Continental Shelf
COE	Centres of Excellence
CSO	Civil Society Organizations
DOF	Department of Fisheries Malaysia
DOSM	Department of Statistics Malaysia
EBM	Ecosystem-Based Management
EEZ	Exclusive Economic Zones
EPU	Economic Planning Unit
ESG	Environmental Social Governance
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussions
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HICoE	Higher Education Center of Excellence
HREE	Heavy Rare Earth Elements
ICC	International Coastal Cleanup
IMO	International Maritime Organization
Industry4WRD	National Policy on Industry 4.0
INOS	Institute of Oceanographic Studies
IR4.0	Fourth Industrial Revolution
ISA	International Seabed Authority
JMG	Jabatan Mineral dan Geosains
KPI	Key Performance Indicator
LCA	Life Cycle Analysis
LNG	Liquefied Natural Gas
MARPOL	International Convention for the Prevention of Pollution from Ships
MDC	Membrane Distillation Crystallisation
MIDA	Malaysian Investment Development Authority
MITI	Ministry of International Trade and Industry
MMEA	Malaysian Maritime Enforcement Agency
MOSTI	Ministry of Science, Technology and Innovation
MPA	Marine Protected Areas
MSP	Marine Spatial Planning
MSW	Municipal Solid Waste
MYKE	Malaysian Knowledge Economy Study

NGO	Non-Governmental Organisation
NM	Nautical mile
NOD	National Oceanography Directorate
OECD	Organisation for Economic Co-operation and Development
OSV	Offshore Supports Vessels
OTEC	Ocean Thermal Energy Conversion
RDICE	Research, Development, Innovation, Commercialization and Economy
ROI	Return on Investment
ROV	Return on Value
SBSR	Malaysian Shipbuilding and Repair
SDG	Sustainable Development Goals
SME	Small and Medium-sized Enterprises
STI	Science, Technology and Innovation
STIE	Science, Technology, Innovation and Economy
SWRO	Seawater Reverse Osmosis
TEU	Twenty-foot Equivalent Unit
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environment Programme
WHO	World Health Organization
WWF	World Wide Fund for Nature Inc.

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Foreword

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Malaysia is surrounded by seas. Its maritime space is virtually two times bigger than its area with a long coastline as well as a large area of an exclusive economic zone (EEZ) comprising a continental shelf, extended continental shelf, and more than 870 islands. This huge area presents a massive opportunity to boost the nation's economic growth. Therefore, Blue Economy is crucial to surge advancements and potential of our ocean resources and its related emerging sectors in a sustainable way.

As the nation's thought leader for sciences, technology, and innovation (STI), the Academy of Sciences Malaysia (ASM) has taken the lead in developing this position paper on 'Blue Economy: Unlocking the Value of the Oceans'. This STI-based approach position paper aims to provide comprehensive input to effectively manage the nation's ocean and marine resources, which will benefit the economic growth as well as the communities and industries that rely on the oceans for their livelihood.

The government is continuously taking measures to ensure sustainability is incorporated into the development of all socio-economic sectors. As indicated by the 12th Malaysia Plan and 10-10 *My*STIE Framework, sustainable development of ocean and marine resources will have a significant positive socio-economic spill-over impact on the country's other socio-economic drivers.

This aligns with the 10-10 *My*STIE Framework put forward by ASM. Insights from this position paper will also be valuable for the National Planetary Health Action Plan mandated by the National Science Council (NSC) to be developed by the Ministry of Science, Technology, and Innovation (MOSTI) through ASM.

I would like to take this opportunity to congratulate the ASM Special Interest Group on Blue Economy under the leadership of Emeritus Professor Dr Phang Siew Moi FASc for producing this position paper. Tremendous effort has been made by the group to engage with various stakeholders and gather inputs that have given rise to a holistic position paper. I believe that the input from this position paper can provide an excellent tool in the decision-making process for the sustainable management of the Blue Economy sectors.

Preface

Emeritus Professor Dr Phang Siew Moi FASc

Chairperson, ASM Special Interest Group on Blue Economy

This position paper on Blue Economy: Unlocking the Value of the Oceans is the product of a combined effort of the Special Interest Group on Blue Economy under the Academy of Sciences Malaysia (ASM). Their members come from at least 13 universities and organisations. This team comprises marine and ocean biologists, engineers, economists, lawyers, and policymakers, as well as ocean industry practitioners, all of whom have a passionate reason for participating in this extensive endeavour of producing a position paper on Blue Economy for Malaysia. It is without a doubt that the ocean and marine resources of Malaysia, with its extensive coastline and continental shelf, represent great wealth and immeasurable opportunities. Blue Economy is driven by the sustainable development of ocean-based resources and innovations, bringing inclusive economic and societal benefits while conserving the integrity of natural ecosystems.

Blue Economy also comprises all economic activities related to marine and ocean resources and is ocean- or coastline-based. These activities range from traditional industries like fisheries and aquaculture, coastal and marine tourism, marine transport, shipping, ports, and related activities, to extractive industries, renewable energy, marine bioprospecting and biotechnology, waste management, and desalination for freshwater. To be globally competitive, a vibrant blue-economy ecosystem (underpinned by the 8R-Nature Centric Blue Economy (8R-NCBE) philosophy, 8i-ecosystem, and 10-10 *My*STIE Framework is proposed. It will potentially increase the contribution of marine and ocean resources from 24.8% of the GDP to 47.3%, which is close to USD499.7 billion in the Malaysian economy, from 2020 to 2030.

This position paper on the Blue Economy aims to provide a constructive framework for the development of a sustainable, lucrative, inclusive, and future-proofed economy for the marine and maritime sectors in Malaysia. It will provide science-based policy inputs for the governance mechanism as well as a collaborative nexus involving central agencies, other government agencies, academia, and industry.

On behalf of the team, I would like to thank and acknowledge the support of ASM management, all government agencies, the scientific community, industry practitioners, NGOs, and all stakeholders who participated in our stakeholder engagement sessions to provide valuable inputs. Thank you also to the ASM Management and Analysts for their support in developing this position paper. I hope this very timely and informative position paper on Blue Economy will enable all Malaysians to benefit from our richly endowed marine and ocean heritage.

Executive Summary

Malaysia is a maritime nation, with a long coastline totalling 4,675 kilometres (CIA, 2022), 449,477 km^2 of EEZ[1] comprising a continental shelf and an extended continental shelf (19,926.6 km^2), and more than 870 islands. The ocean is not a new economic frontier but has lagged far behind its neighbours in terms of economic productivity. In 2015, Malaysia had the third-highest gross value-added ocean economy in the Southeast Asian region, amounting to USD 61 billion, and is the third most productive ocean economy (USD 0.14 million/km^2), compared to Singapore (USD 20.6 million/km^2) and Thailand (USD 0.39 million/km^2) (PEMSEA, 2021). With a comparatively larger EEZ, Malaysia has the potential to increase its ocean economy's productivity, while simultaneously transitioning into a sustainable Blue Economy.

"Blue Economy" may be defined as a "sustainable ocean economy that emerges when economic activity is in balance with the capacity of ocean ecosystems to support this activity and remains resilient and healthy." Blue Economy is driven by the sustainable development of ocean-based resources and innovations, bringing inclusive economic and societal benefits, while conserving the integrity of natural ecosystems. Blue Economy has diverse components that comprise traditional ocean industries such as fisheries, aquaculture, tourism, and maritime transport, as well as new and emerging activities such as ocean renewable energy, seabed extractive activities, marine biotechnology, and bioprocessing. Carbon sequestration, coastal protection, waste disposal, and the existence of coastal and marine biodiversity also significantly contribute to the economy.

Globally, the United Nations has also announced the Decade of Ocean Science for Sustainable Development (2021-2030), highlighting the importance of ocean health and ensuring the sustainability of the Ocean. The WWF (2015) estimated global ocean assets (including goods and services) to be worth at least USD 24 trillion. Oceans are essential for the global economy and a healthy planet in which healthy and productive oceans provide jobs, food, and drive economic growth while keeping the planet cool.

Blue Economy is a complex, interconnected ecosystem that has multiple linkages across many economic, environmental, and social sectors. This Position Paper on the Blue Economy aims to provide a constructive framework for the development of a sustainable, lucrative, inclusive, and future-proofed economy for the marine and maritime sectors in Malaysia. It will provide science-based policy inputs for the governance mechanism as well as a collaborative nexus involving central agencies, other government agencies, academia, industry, and community organisations. Eight sectors, namely fisheries and aquaculture; coastal and maritime tourism; extractive industries of non-living resources; maritime transport, ports, and related services as well as shipping and shipbuilding; renewable energy; waste disposal management; marine biotechnology and bio-prospecting; desalination for freshwater generation, have been identified as current and potential Blue Economy socio-economic sectors. Meanwhile ocean ecosystem services and ocean health are included to represent the environmental sector. Ecosystem services include carbon sequestration, shoreline protection, provision of feeding, breeding grounds for fishery life, as well as climate change management. Habitat loss, pollution, and other impacts from land- and sea-based activities affect both the productivity and resilience of the oceans.

[1] EEZ refers to the Exclusive Economic Zone, which is an area beyond and adjacent to the territorial sea that extends to 200 nautical miles from the baselines under which the coastal state has sovereign rights and jurisdiction over the natural resources. For more details, refer to the United Nations Convention on the Law of the Sea (1982). https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf

Each of these sectors is described based on the following aspects: definition and review of the sector in terms of performance; state of the ecosystem; gaps, issues, and strategies for success; policies and governance. Each of the sector's ecosystems was analysed using the following 5 pillars: (i) Governance and Collaborative Platform; (ii) Industry Competitiveness; (iii) Talent; (iv) Research, Development, Innovation, Commercialisation and Economy (RDICE); and (v) Environmental Social Governance (ESG) and Climate Change issues. Sector data are used to assess the effectiveness of policies, governance, and regulatory frameworks in supporting ocean industry development and ocean health preservation, as well as to analyse the sectors using the 8i ecosystem framework. The 8i enablers are mapped to the 5 pillars mentioned above. The key policies addressed in this paper include the 10-10 *My*STIE Framework, National Development Policies, Shared Prosperity Vision 2030, National Policy and Master Plan on STI 2021-2030, Industry4WRD, SDGs, UNCLOS, CBD, Kyoto Protocol, etc.

The fisheries and aquaculture sub-sectors play a significant role in the Blue Economy as both are key food-producing sectors, providing an important source of animal protein as well as livelihoods to the coastal communities. In 2019, the fisheries sector in Malaysia contributed 1.1% of the global fish production, contributing 12% to the total national agricultural gross domestic product (GDP), (DoF, 2019; FAO, 2020). Whereas, in 2020, capture fisheries formed 77.3% and aquaculture 22.4% of the total national fish production (1.79 million tonnes valued at RM13.84 billion). The capture fisheries production contributes to 2% (1.38 million tonnes) of global fish consumption in 2022 (The State of World Fisheries and Aquaculture, 2022). Per capita consumption of 46.4 kg is one of the highest in the world like global aquaculture that grows at the fastest rate among food-producing sectors, Malaysian aquaculture also provides foods, nutrition, income and employments for millions of people nationwide. Asia contributes more than 99% of global tiger shrimp production. However, due to its weak aquaculture efficiency, Malaysia currently sits at the 9th spot amongst the Asian countries (FAO, 2021).

Tourism is the second largest foreign exchange earner in Malaysia. Malaysia receives 4.32 million international tourists and recorded RM12.66 billion in tourism income from January to December 2020 (Ministry of Tourism, Arts and Culture, 2020). Meanwhile, domestic tourism recorded a total of 131.7 million domestic visitors in 2020 and a total expenditure of RM40.4 billion (DOSM, 2020). The tourism sector is linked to a diverse range of multi-sectored industries that consist of transportation, accommodation, restaurants, recreation, and entertainment. Surrounded by beautiful islands and coastal beaches, Malaysia's marine tourism inadvertently attracts a large percentage of the total number of tourists in the country. Like fisheries and aquaculture, marine tourism is very much dependent on healthy marine and coastal ecosystems.

The oil and gas sector, the most mature of the ocean industries, contributed RM57 billion to the Malaysian government in 2018. The total mineral production value in 2020 was approximately RM 2,000 billion in revenue. The main minerals exported were metallic minerals (71%), non-metallic minerals (12%), energy minerals (15%), and by-product minerals (2%) (Malaysian Mining Industry, 2020). The rising demand for minerals in most sectors, including technology, has led to a surge of interest in the exploration of mineral resources from the seabed. Mining the seabed in Malaysian waters, such as for marine sand and minerals, will help the country's National Blue Economy because it can generate income for the country.

Malaysia is a maritime nation located strategically, which makes it stand out on the map of maritime trade where 90% of trade is via shipping (MEPSEAS, 2020). Malaysia is the world's fifth-best connected country in terms of shipping line connectivity, ahead of the Netherlands and the United States. With a total throughput of 26.2 million TEUs in 2019, Malaysian ports handled almost as many containers as the ports of Rotterdam and Antwerp combined. While the majority is transhipment or cargo that does not enter the country, Malaysian exports and imports accounted for 4.5 and 4.4 million TEUs of throughput, respectively.

As one of the world's largest liquefied natural gas (LNG) exporters, Malaysia is home to the first floating LNG port facility and the largest palm oil terminal in the world (IRO, 2019). Several ports, such as Penang Port, have been certified as Shariah-compliant ports and have been promoted to be involved in the production of halal products for export. Penang Port is now a major halal port in Malaysia, also known as the second biggest halal port in the world, following in the footsteps of Rotterdam Port, which is considered the largest halal port in which halal traceability and Shariah-compliant logistics are the most trustworthy.

With an estimated 300 exajoules (EJ) per year or 90% of the global ocean energy potential, OTEC has the largest potential of the different ocean energy technologies. The total estimated available resource for OTEC could be up to 30 terawatts (TW), with deployment up to 7 TW having little effect on the oceanic temperature fields. To date, only OTEC plants up to 1 MW have been built. The deployment of OTEC is beginning to gain traction and several success stories, such as the successful deployment of 100 kW OTEC plants located in Okinawa, Japan, and Kailua, Hawaii, and the latest being the commissioning of a 1 MW OTEC plant that runs on R32 working fluid in Busan by the Korean Research Institute of Shipping and Ocean Engineering (KRISO). Wave energy technology is reported to possess a high energy potential of 8000–80,000 TWh/year, although its development is still lagging with regard to technology.

Within the marine biotechnology sector, drugs and health supplements derived from marine resources contributed more than USD 21 million in the year 2021 and are forecasted to exceed USD 33 million in the year 2027, growing at a CAGR of 6.74% over the forecast period. Marine drugs constitute 76.77% while marine nutraceutical products as health supplements also represent a large portion, 23.23%, of the global marine biopharmaceutical market. Marine collagen market is expected to project encouraging growth with a CAGR of 7.9% in the forecast period of 2021 to 2026 and is expected to reach USD 1,137 million by 2026 from USD 778 million in 2021 (Market and Market, 2021). Among the various sectors of the Blue Economy, marine biotechnology is relatively new in Malaysia, but it has great potential to contribute to sustainable economic growth, the generation of new jobs, and the sustainable use of ocean resources via a circular economy. Still, the biotechnological potential of a lot of the country's marine resources hasn't been looked into in-depth yet.

Freshwater is predicted to be an invaluable resource in the new future. The oceans are a reservoir for this resource. Desalination is a process that removes the excess salt and other minerals from saline water to obtain freshwater that is fit for human and animal consumption as well as for irrigation. Globally, desalination has been acknowledged as an essential alternative to conventional water reclamation technologies to tackle water shortage issues in many arid and water-stressed regions. Membrane-based processes in particular account for more than half of the newly constructed desalination plants in the world. It has been estimated that the number and size of the global desalination market are growing at a fast pace of 5–6% per year, corresponding to the production of an additional 3.0-4.0 million m^3/day of freshwater from these newly installed desalination plants. Currently, Malaysia has one full-scale seawater desalination plant located in Pantai Senok, Kelantan. This seawater desalination plant, which was commissioned in February 2018, can produce 500,000 litres of treated water per day to meet the water demand of the people living nearby (AMTEC, 2022). Desalination is still an energy-intensive process, and the high electricity costs have similar economic implications to fuel or other operational costs that cannot be amortised over the life of the project. The ability to bypass these energy costs could potentially be critical for development.

Marine debris has become a more alarming issue in the last decade, reaching a critical situation of coastal pollution due to improper waste management. The dominant component within the marine debris stream is plastic, comprising more than 60% of the total waste stream by weight, followed by

cigarette butts, paper, and metal. In 2021, Malaysia was labelled as being among the top contributors of plastics to the world ocean, ranking at number three. There is an urgent need to implement waste management policies to protect both the marine ecosystems and the ocean industries that rely on clean and healthy ecosystems.

Frequent changes in ministerial mandates can be unsettling for ocean governance unless it is to consolidate the matter. There is no national ocean policy in Malaysia. The status quo of piecemeal solutions to ocean policy cannot be the way forward. For Malaysia to lay claim to its seafaring and coastal nation status both regionally and internationally, as well as to legitimise its claims to maritime resources and features, systematically and sustainably, the country needs to implement such a national policy. Such a policy must apply to Malaysia, East and West. The National Ocean Policy to East Malaysia must be carefully crafted so that it fits within the terms of the Malaysia Agreement 1963 and other legal documents that are in place.

The problems in Malaysia in the context of ocean governance are multi-faceted. The first problem is the conflict between Federal and State powers over jurisdiction over territorial resources. The second problem is the lack of rigorous scientific methods to assess the efficacy of existing policies. One of the key challenges is the lack of quality longitudinal data that can be used to assess the effectiveness of the ocean policies and initiatives undertaken by the different stakeholders. Accessing quality data is plagued by secrecy regarding data and information due to the Official Secrets Act 1972, which prevents key stakeholders from sharing vital information for strategic decision-making. The third problem is that the lack of effective policies has resulted in unsustainable practices that have undermined the quality of national ocean resources. Fourth, while Malaysia has become technology savvy in many sectors of the economy, the use of advanced technology to manage ocean resources has been low. It is one of the sectors that has been classified as a "laggard" in the use of advanced technology and knowledge management tools to enhance the return on value[2] (ROV). Fifth, Malaysia shares the ocean with several countries in the region, which is plagued by territorial disputes, transboundary pollution, piracy, and maritime security concerns. Careful ocean diplomacy is needed to effectively manage ocean resources.

A comprehensive assessment of the state of the Blue Economy from an ecosystem perspective was conducted by incorporating the 8R-Nature-centric Blue Economy (8R-NCBE) philosophy[3], namely, Respect the marine and coastal environment; Rethink the value of marine and coastal resources; Reduce wastage; Reuse wastage; Recycle waste; Restore biological marine plants and animals; Repurpose biodiversity conservation initiatives for higher-value use; and Revitalise marine and coastal resources. The state of development ("stress-test") of the Blue Economy was undertaken using the 8i-ecosystem framework[3]. The framework identified several gaps in the Blue Economy ecosystem. Among them are the following:

- A lack of sophisticated physical and natural infrastructure, as well as facilities that use advanced technology to provide efficient and sustainable Blue Economy services;
- There is weak digital architecture in many of the Blue Economy locations, so access to valuable information for strategic decision making is scarce;
- There is a shortage of adequate talent with sound multidisciplinary, technical, entrepreneurial, and leadership skill sets to transform the Blue Economy sectors into knowledge-intensive sectors;

[2] ROV is the value gained from continuous improvement via the use of new technology, systems, processes, and business models (ASM, 2021). Return on investment (ROI) is a function of ROV.
[3] Refer to Chapter 4 for a detailed description.

- Weak governance systems in places, especially harmonised policies and strategies among the federal and state governments;
- The absence of a national ocean policy to provide more direction for the sustainable development of the Blue Economy sectors;
- Inadequate fiscal and non-fiscal incentives schemes to support research, development, innovation, and commercialisation activities;
- There is over-reliance on foreign knowledge and inadequate incentives to develop local technology and advanced supply chains in the Blue Economy sectors;
- The absence of an institutional champion for the Blue Economy sector in the country;
- Coordination and cooperation among institutions and key stakeholders in the Blue Economy sector are rather patchy and fragmented, and
- Lack of a robust internationalisation strategy to nurture strong cooperation between local and leading international players in the Blue Economy sectors to foster technology and knowledge transfer. This has resulted in many of the Blue Economy sectors being unable to meet global best practices and standards; hence, operating at the lower end of the value chains compared to other regional players.

These gaps identified above highlight that Malaysia's Blue Economy sectors have not achieved a full ROV from the ocean and marine resources of the country. The study proposes measures to close these gaps to ensure the sustainability and competitiveness of the Malaysian Blue Economy sectors.

Blue Economy sectors are important economic drivers for Malaysia. To remain globally competitive, it needs to become more knowledge-intensive, underpinned by a sound technology plan. Under the 12th Malaysia Plan, the government introduced the 10–10 *My*STIE Framework[4], which integrates 10 global science and technology drivers with 10 socio-economic drivers. One of the key socio-economic drivers is the environment and biodiversity of the nation, which is critical for ensuring sustainable development of the ocean and marine biodiversity. Sustainable development of ocean and marine resources will have a significant positive economic spillover on the other socio-economic drivers of the country, as identified in the 12th Malaysia Plan and 10-10 *My*STIE Framework . Hence, national and industrial policies, strategies, and regulatory reforms should be implemented to support the creation of a vibrant and competitive Blue Economy, underpinned by the 10-10 *My*STIE Framework and adherence to global best standards.

In select areas within the Blue Economy, Malaysia should endeavour to lead some of the innovation, global best practices, and standards. Hence, a carefully curated 10-10 *My*STIE Framework, anchored on the 8R-NCBE philosophy and 8i-ecosystem, will lead to STI and economic spillover. These new recombinant innovations, discoveries, and technological developments are envisaged to increase the economic multiplier impact across the different Blue Economy sectors. All of which will increase economic wealth and high-income job opportunities in this sector and for the nation.

[4] The 10 Key Technologies and the 10 Key Socio-economic Drivers (10-10) Science, Technology, Innovation, and Economic (STIE) framework is a national policy strategy introduced in the 12th Malaysia Plan to close the gap between the STI and socio-economic drivers. A more interlinked STI initiatives to the socio-economic drivers will increase the productivity and competitiveness of the various economic sectors of the country, while reinforcing their development of locally based value-adding STI initiatives and programmes.

Based on the 8i-ecosystem analysis, many of the Blue Economy sectors were found to be underdeveloped in many localities across the country, due to several weaknesses in the enablers of the ecosystem itself. These have a major impact on the socio-economic development of communities living in these localities that are dependent on marine resources. Due to gaps in the enablers of the ecosystem coupled with low-income and education levels in many of the Blue Economy sectors, many of the communities living in these localities use unsustainable business practices. This adversely impacts the quality of the ocean and coastal environment.

If the 8R-NCBE philosophy forms the basis of strengthening the enablers of the ecosystem (8is) in these respective localities using the 10 global technologies identified under the 10-10 *My*STIE Framework, the potential for increasing the ROV and return on investment (ROI) from the coastal natural resources will be very high. Many of the traditional and unsustainable Blue Economy practices can be transformed into vibrant and sustainable economic sectors that are aligned with the planetary health philosophy for the Blue Economy. These ecosystems can be supported by a strong Research, Development, Innovation, Commercialisation and Economy (RDICE) ecosystem that consists of the various institutions of higher learning (IHLs) and government research institutions (GRIs) that become key "knowledge enablers". These institutions, working closely with industry, government agencies, and community organisations, can help nurture a vibrant RDICE ecosystem to support the development of the local communities and enable them to derive higher ROV and ROI from the blue-ocean sectors. This will also lead to capacity building of skilled future talents and spawn new knowledge-intensive and high-value added ocean and marine-based industries.

An advanced RDICE ecosystem in the Blue Economy sectors can play a catalyst role in enhancing the multiplier effect and positive network externalities within their respective Blue Economy localities, as well as across the different localities and economic sectors in the country. These network externalities will enable economic agents to share best practices and sustainably complement their economic activities. This is aligned with the Shared Prosperity Vision 2030, whereby the country's wealth from its rich ocean resources is shared equitably among people of different socio-economic status across the country. A leapfrog trajectory (underpinned by the 8R-NCBE philosophy, 8i-ecosystem, and 10-10 *My*STIE Framework) is predicted to potentially increase the contribution of marine and ocean resources in 2030 to 31.5% of the GDP, as compared to 21.3% of the GDP if the Blue Economy ecosystem was to continue operating at status quo. The cumulative net gain from 2020 to 2030 of such a vibrant Blue Economy could be close to RM 1.4 trillion.

Malaysia's dependency on the ocean can never be understated and it is naturally so, given that it is surrounded by seas and its maritime space is virtually two times bigger than its area. This dependency extends to almost all Blue Economy sectors. However, there shouldn't be any unscrupulous exploitation of the country's marine natural resources for the sake of economic growth per se, as sustainable economic growth should always be in line with maintaining the ocean's health. With that goal in mind, a champion is needed at the national level for the Blue Economy to be fully realised for Malaysia and our natural resources optimised for competitiveness and sustainability. MOSTI as a leading ministry in ensuring a robust ecosystem is proposed to spearhead the Blue Economy, particularly in the RDICE context. This would forge relevant synergy and STI-based action toward socio-economic advancement and environmental sustainability. This would also serve as continuity for MOSTI, who previously helmed the National Oceanography Directorate (NOD). With MOSTI driving science and technology applications, EPU can also play a role in ensuring requisite investments in Blue Economy-related initiatives for inclusive, fair, and equitable growth. This would facilitate an integrated approach to leverage and optimise the wealth of Malaysia's oceans toward becoming a high-income, developed nation secure in food resources, climate and health navigation, and trade, among others.

The gaps identified in the 8i Blue Economy ecosystem need to be addressed to create an optimal path to achieve a sustainable Blue Economy. This position paper proposes three key recommendations as suggested below, based on the gaps identified in the Blue Economy ecosystem.

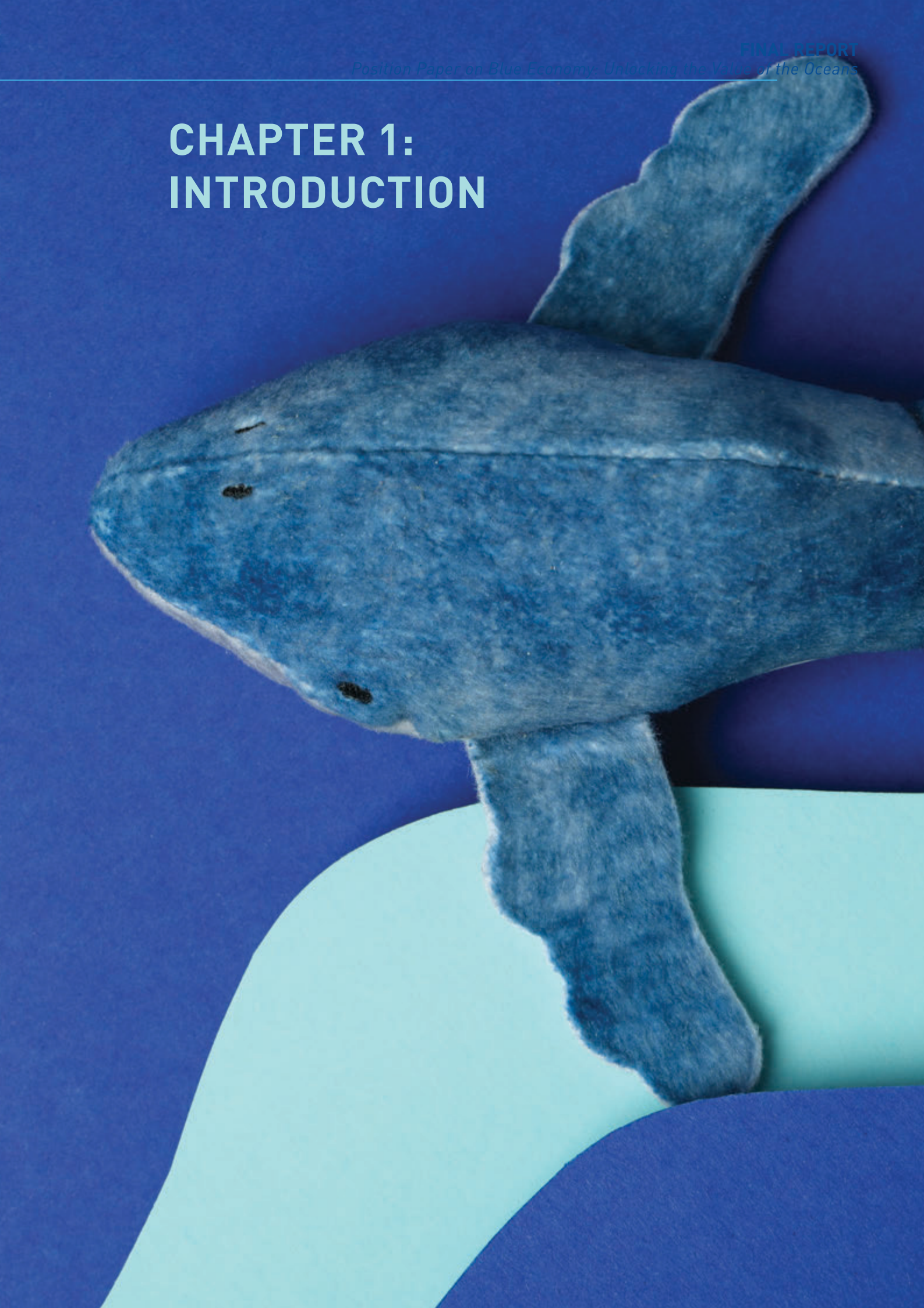
Recommendation 1: In principle, for the government to formulate National Ocean Policy and Ministry of Science, Technology & Innovation (MOSTI) in collaboration with relevant ministries and central agencies to formulate Blue Economy Policy based on science, technology, innovation and economy (STIE) to strengthen governance and provide direction for Blue Economy in Malaysia towards an integrated, effective and sustainable ecosystem by unravelling the potential of this sector.

Recommendation 2: To drive the eight strategic sectors of Blue Economy in Malaysia to align with 8R-Nature-centric Blue Economy (8R-NCBE) philosophy towards value creation, socio-economic growth, and to be embedded in the National Planetary Health Action Plan.

Recommendation 3: To establish the RDICE Matching Fund Scheme for Blue Financing towards enhancing public and private participation in empowering Blue Economy.

The above three recommendations are critical for ensuring effective management of ocean and marine resources in the region, in partnership with other countries in the ASEAN region. Sustainable management of the Blue Economy aligned to the 8R-NCBE (Planetary Health) philosophy will generate higher ROV from ocean resources and create more sustainable and higher-income jobs. These will improve the quality of life of many communities that are dependent on the oceans for their livelihood. The proposed recommendation in this report is aligned with the development agenda outlined in the Shared Prosperity Vision 2030 and the 12th Malaysia Plan to balance economic prosperity with planetary health considerations.

CHAPTER 1: INTRODUCTION



Chapter 1: Introduction

1.1 Definition

The United Nations has announced the Decade of Ocean Science for Sustainable Development (2021-2030), highlighting the importance of ocean health and ensuring the sustainability of the Ocean. The WWF (2015) estimated global ocean assets (including goods and services) to be worth at least USD 24 trillion. Oceans are essential for the global economy and a healthy planet. Healthy, productive oceans provide jobs, food, and drive economic growth while keeping the planet cool. Oceans are a primary source of income (3-5% of global GDP) and ocean-based jobs are expected to increase 120% between 2010 and 2030. Besides that, fisheries & aquaculture assure the livelihoods of 10-12% of the world population (World Bank Group & European Commission, 2021). The biggest ocean-based industries in 2018, according to the report, were coastal and marine tourism ($1.1 trillion), followed by marine high technology and other manufactures not classified elsewhere ($595 billion) and maritime transport services ($399 billion) (Figure 1).

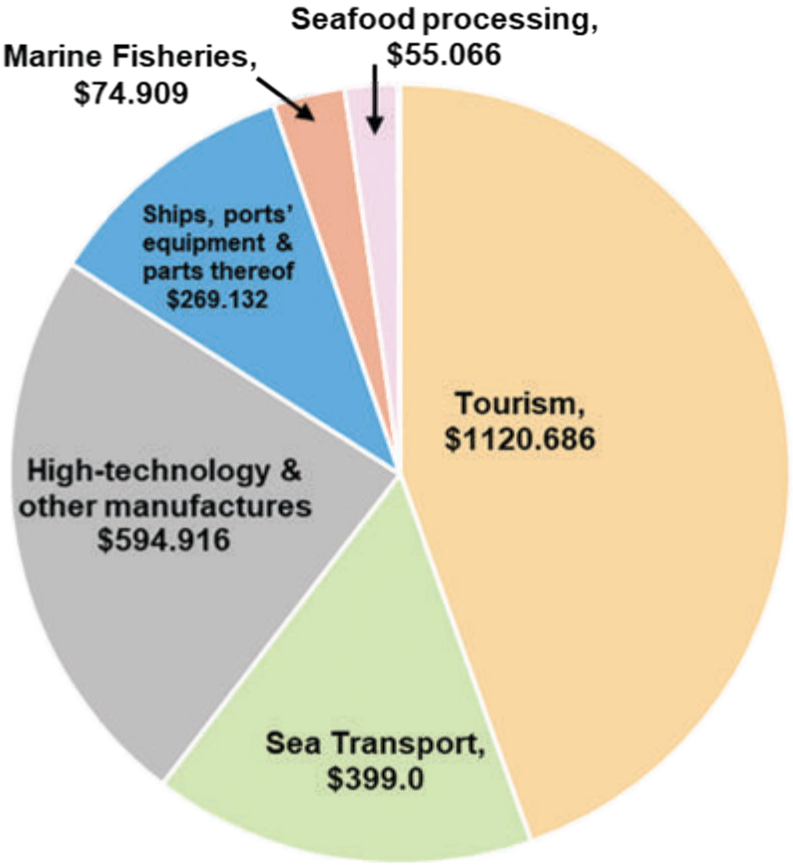


Figure 1 Export value of ocean-based industries (UNCTAD, 2020)

Malaysia is a maritime nation with 4,675 kilometres of coastline (CIA, 2022), 449,477 km2 of EEZ comprising the continental shelf and extended continental shelf (19926.6 km2), and over 870 islands. The country is endowed with high marine biodiversity due to its location within the Coral Triangle and its year-round sunshine. Therefore, the ocean is not a new economic frontier. Where does Malaysia stand as a player in the global Ocean Economy, better known as the Blue Economy? Nations worldwide have set their targets on harnessing great wealth from their respective oceans. The oceans promise

economic growth, the birth of new industries, food security, employment, and ecological services for climate management. The ocean depths harbour novel medicines, oil, gas, minerals, and even renewable energy. In 2015, Malaysia (USD 63 billion) ranked 4th after China (USD 1,041.92 billion), Indonesia (USD 182.54 billion), and Thailand (USD 118.19 billion) in the size of the ocean economy in the East Asian Seas region (PEMSEA 2021). Twenty-three percent of the Malaysian GDP is contributed by the Blue Economy, which is dominated by offshore energy that includes crude petroleum and natural gas production as well as petroleum refineries, followed by fishing and aquaculture, and marine transport and tourism (Juneja et al., 2021). In 2023, the global ocean economy is estimated to double from the 2010 estimate of USD 1.5 trillion, or 2.5% of global gross value, to USD 3 trillion (Sumaila et al., 2021).

A healthy ocean is critical for sustaining an aggressive ocean economy. In 2012, the UN Conference on Sustainable Development (Rio+20) decided to replace the Millennium Development Goals with Sustainable Development Goals (SDGs). In 2015, the 17 SDGs were developed and adopted. SDG 14 specifically addresses "Life Below Water." The Changwon Declaration of 2012 called for the sustainable use of ocean resources for economic growth, livelihoods, and jobs while preserving the health of oceans and ecosystems (Ebarvia, 2016). The Jakarta Declaration on the Blue Economy, from the Indian Ocean Rim Association in 2017, called for the sustainable management and protection of coastal and marine ecosystems while achieving inclusive economic growth in the Indian Ocean region. In 2018, 53 Commonwealth countries signed the Commonwealth Blue Charter with the promise of "Shared Ocean, Shared Values" through cooperation to ensure sustainable ocean development. These agreements align with and help other international agreements, such as UNCLOS, AICHI Biodiversity Targets, Convention on Biological Diversity, Ramsar Convention, CITES, MARPOL, and UNFCCC. There are few countries in the world that have formulated ocean policies, plans, or acts (Figure 2). However, Malaysia has yet to launch an Ocean Policy.

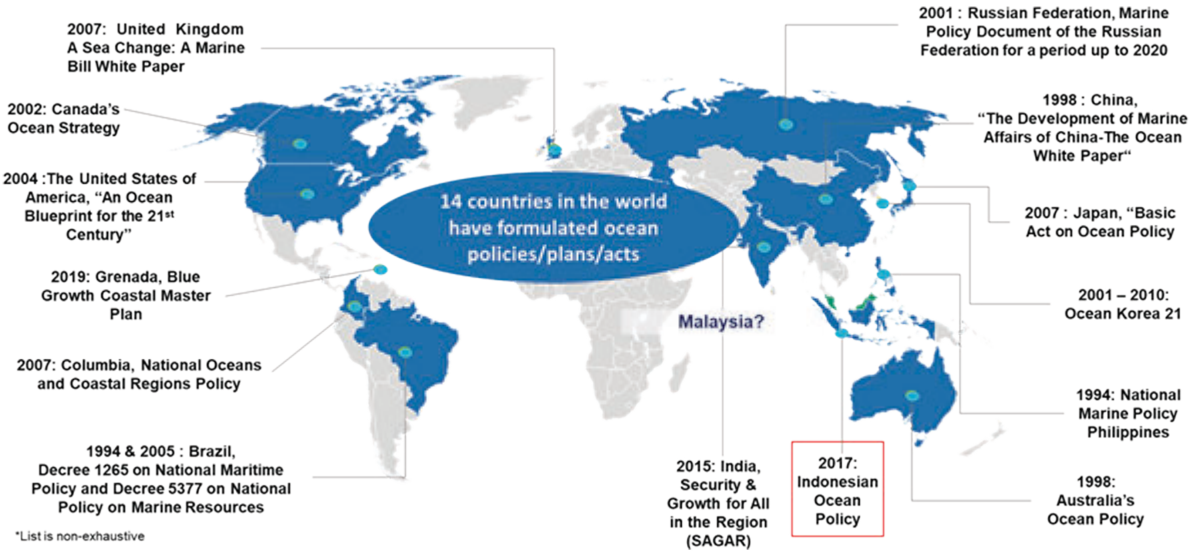


Figure 2 Global Outlook: Ocean Policies, Plan and Acts around the World

In this position paper, the working definition of the Blue Economy underlines the following concept: "A sustainable ocean economy emerges when economic activity is in balance with the capacity of ocean ecosystems to support this activity and remain resilient and healthy." The Blue Economy is driven by the sustainable development of ocean-based resources and innovations, bringing inclusive economic and societal benefits, while conserving the integrity of natural ecosystems.

1.2 Scope of the Blue Economy

The term "Blue Economy" refers to all economic activities derived from the use of both living and non-living resources, as well as the ecological services of the ocean, marine, and coastal ecosystems. Activities based on the oceans and coasts include fisheries and aquaculture; coastal and marine tourism; extractive industries of non-living resources; maritime transport, ports, and related services as well as shipping and shipbuilding; renewable ocean energy; marine biotechnology and bioprospecting; desalination of freshwater generation as well as waste disposal management. Ocean-related activities include the exploration of new sources of food, medicine, and industrial materials; the generation of freshwater via desalination; maritime law, trade, and insurance. Ocean health depends on scientific research and innovations to protect the environment; a framework for ocean resource valuation and accounting; management of wastes; and engagement of all stakeholders, especially the coastal and maritime communities. Last but not least, there is the need to interact with the global community to achieve a niche within this lucrative Blue Economy.

Blue Economy has diverse components, including the establishment of traditional ocean industries such as fisheries, tourism, and maritime transport as well as new and emerging activities such as offshore renewable energy, aquaculture, seabed extractive activities, and marine biotechnology and bioprocessing. Carbon sequestration, coastal protection, waste disposal, and the existence of biodiversity all have a substantial economic impact.

The mix of oceanic activities in each country varies depending on national circumstances and the national vision adopted to reflect its conception of the Blue Economy. The components of the Blue Economy must satisfy the following criteria:

- Provide social and economic benefits for current and future generations;
- Restore, protect and maintain the diversity, productivity, resillience, core functions, and intrinsic value of marine ecosystems; and
- Rely on clean technologies, renewable energy, and circular material flows to reduce waste and promote material recycling.

The scope of the Blue Economy includes:

- All economic activities (must be sustainable) with a direct relationship with the ocean, coastal, and marine resources, which are ocean-based and ocean related;
- Marine education and research, as well as activities of the public-sector agencies with direct coastal and ocean responsibilities;
  New activities or innovations that aim to protect ocean health, thereby contributing to Blue Economy development;
- The ocean generates economic values and ecosystem services that are not usually quantified.

However, the Blue Economy faces a few important challenges, including the need to better comprehend and manage the many aspects of ocean sustainability, including sustainable fisheries, ecosystem health, and pollution. Another important thing is that people are starting to realise that sustainable management of ocean resources requires a level of cooperation between nations and between the public and private sectors that have not been done before.

Malaysia is a maritime nation with extensive coastal and marine areas that are administered at national, state, and local levels. Malaysia has the potential to extend its continental shelf beyond 200 NM (but not exceeding 350 NM from the breadth of its territorial sea) for the maritime areas in Sarawak and West Sabah (Abdullah, 1993: Yahaya et al., 2016). These unique advantages offer Malaysia tremendous economic value and prospects. The major economic activities include the offshore petroleum industry, marine transport, marine tourism, fisheries, and aquaculture.

Even so, marine and coastal areas are complex in terms of biodiversity and highly dynamic, comprising abundant marine resources, and social interaction, and require economic planning and development. A sustainable, holistic, and well-informed governance structure is needed to balance conflicts between marine resource use, habitat recovery, and area development. Demands for coastal and marine resources include uses for military purposes, recreation, nature and conservation, fisheries and aquaculture, waste disposal and pollution control, shipping and navigation, mineral and fossil fuel extraction, engineering work, agriculture, and coastal and maritime settlements.

Malaysia's ocean governance involves various ministries and agencies. Due to jurisdictional overlaps, there is a need for an overarching policy encompassing all maritime aspects, including security, safety, the economy, and the environment. Therefore, among other objectives, this project will facilitate the management of marine resources in support of the Blue Economy Blueprint in the 12th Malaysia Plan. This initial project also provides inputs for an ocean governance institutional framework in this country. Thus, Malaysia must comprehend the Blue Economy concept, which highlights the importance of such an approach, identify some of the key challenges to its adoption, and suggest some broad next steps to ensure its implementation.

Blue Economy is a complex, interconnected ecosystem with multiple linkages across many economic, environmental, and social sectors. The effective development and management of the Blue Economy lie in a systematic approach to addressing the gaps and issues of the existing ocean and coastal economy. This Position Paper on the Blue Economy aims to provide a constructive framework for the development of a sustainable, lucrative, inclusive, and future-proofed economy for the marine and maritime sectors in Malaysia. It will provide science-based policy inputs for the governance mechanism as well as a collaborative nexus involving central agencies, other government agencies, academia, and industry. Eight sectors, namely fisheries and aquaculture, coastal and maritime tourism, extractive industries of non-living resources, maritime transport, ports, and related services, as well as shipping and shipbuilding, renewable energy, waste disposal management, marine biotechnology and bio-prospecting, desalination for freshwater generation, have been identified as current and potential Blue Economy socio-economic sectors, whereas ocean ecosystem services and ocean health are included to represent the environmental sector. Ecosystem services include carbon sequestration, shoreline protection, provision of feeding, breeding grounds for fishery life, as well as climate change management. Loss of habitats, pollution, and other impacts from land- and sea-based activities, affect both the productivity and resilience of the oceans.

Each of these sectors is described based on the following aspects: definition and review of the sector in terms of performance; state of the ecosystem; gaps, issues, and strategies for success; policies and governance. Each of the sector's ecosystems was analysed using the following enablers: (i) Governance and Collaborative Platform; (ii) Industry Competitiveness; (iii) Talent; (iv) Research, Development, Innovation, Commercialisation and Economy (RDICE); and (v) Environmental Social Governance (ESG) and Climate Change issues. Sector data are used to assess the effectiveness of policies, governance, and regulatory frameworks in supporting the ocean industries while preserving ocean health, as well as to analyse the sectors using the 8i ecosystem framework and linked to the five blue ocean enablers mentioned above. The addressed key policies include the 10-10 *My*STIE Framework, National Development Policies, Shared Prosperity Vision 2030, National Policy and Master Plan on STI 2021-2030, Industry4WRD, SDGs, UNCLOS, CBD, and Kyoto Protocol.

CHAPTER 2: SOCIO-ECONOMIC & ENVIRONMENTAL SECTORS

Chapter 2: Socio-Economic & Environmental Sectors

The current and potential Blue Economy socio-economic sectors are fisheries and aquaculture, coastal and maritime tourism, extractive industries of non-living resources, maritime transport, ports, and related services, as well as shipping and shipbuilding, renewable energy, waste disposal management, marine biotechnology and bio-prospecting, and desalination for freshwater generation, while ocean ecosystem services and ocean health are included to represent the environmental sector. Ecosystem services include carbon sequestration, shoreline protection, provision of feeding, breeding grounds for fishery life, as well as climate change management. Loss of habitat, pollution, and other impacts from land- and sea-based activities reduce ocean productivity and resilience.

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2.1 Fisheries & Aquaculture

2.1.1 Introduction

The fishing sector has for decades played an important role as a major supplier of animal protein. In 2020, total fishery production in Malaysia amounted to 1.79 million tonnes, comprising 1.38 million tonnes from capture fisheries and 0.4 million tonnes from aquaculture (excluding seaweeds). Malaysia produced 0.19 million tonnes of farmed seaweed, in 2019, which makes it the seventh-largest producer and ranked third for tropical carrageenan seaweeds farming. It was reported that Malaysia is a net importer of fishery products valued at USD 976.6 million, with approximately USD 10 million of live fish imports in the year 2017 (FAO, 2019). Meanwhile, Malaysia's exports are in the form of high-value products such as shrimp and sashimi tuna with total export earnings of USD 714.1 million. In 2019, the total number of fishers was estimated to be 129,790 (both marine and inland waters), and 20,149 people as full-time aquaculture personnel. A total of 2,867 non-motorised vessels were reported under 12 m length overall (LOA) with an addition of 49 640 decked, motorised vessels. Per capita consumption of fish was estimated to be about 59 kg in 2016, which is one of the highest in the world due to the increase in the demand for fish (FAO, 2019), but declined to 42.61 kg in 2020 (DoF, 2020). In 2020, the Department of Statistics Malaysia reported a decrease of 1.4% in brackish water aquaculture production (from 307.2 million tonnes to 302.9 million tonnes) as well as a decrease of 5% in freshwater aquaculture (from 104.6 million tonnes to 97.2 million tonnes) (DOSM, 2021).

The fisheries and aquaculture sectors play a significant role in the Blue Economy as both are key food-producing sectors, providing an important source of animal protein as well as an important source of revenue to the country. The ocean supports livelihoods and contributes to social, cultural, and religious values. Like other agriculture sectors, fisheries and aquaculture are central to attaining the complete set of sustainable development goals (SDGs), the blueprint to achieving a better future for all while facing various global challenges. Many SDGs are directly relevant to Fisheries and Aquaculture, such as the end of poverty (SDG 01) and hunger (SDG 02), as well as ensuring healthy life (SDG 03), sustainable economic

growth (SDG 08), and sustainable production and consumption (SDG 12), but the most related goal is SDG 14 (conserve and sustainably use the oceans, seas, and marine resources). Globally, around 1 in 10 people make their living from fisheries and aquaculture (FAO, 2018b).

2.1.2 State of Ecosystem

World fisheries production was estimated to be 178 million tonnes in 2020 (FAO, 2022), with 157 million tonnes for human consumption and 20 million tonnes for products such as fish meal and fish oil. Approximately 51% of the global production comes from captured fisheries (90.3 million tonnes in 2020), and 49% from aquaculture. The global capture fishery has been stagnating since the 1990s due to overharvesting, habitat change, pollution, climate change, and other anthropogenic-related activities (Figure 3). The aquaculture industry, on the other hand, has been increasing greatly, contributing 49% of the world's fisheries production in 2020. Aquaculture is the world's fastest-growing food sector, increasing by 228% in volume and 492% in value since 1995, the year in which the Code of Conduct initiated by FAO was adopted (FAO, 2018a). Approximately 89% of total fishery production was used for direct human consumption in 2020, while the rest was used for non-food products such as fishmeal and fish oil (FAO, 2022). About 44% of the fish for human consumption was in live or fresh form. The 2022 State of World Fisheries and Aquaculture (SOFIA) report estimates that total fish production is set to increase to 202 million tonnes in 2030, up 14% from 2020, with aquaculture's share growing from its current 49% to 53% (FAO, 2022). FAO estimates that 34.2% of all marine fish stocks are fished beyond biologically sustainable limits, a threefold increase since monitoring started in 1974.

Globally, 3.3 billion people depend on fish for their animal protein (approx. 20% of the average per capita) as the world's fish consumption increased from 9.9 kg per capita in 1960s to approximately 20.5 kg per capita in 2019, while it slightly declined to 20.2 kg in 2020 (FAO, 2022). In some less developed countries, the per capita consumption is greater than 50%. The increase in consumption was not only due to the increased production but also to a combination of factors related to population growth, nutraceutical, and health issues, improved availability, rising income, and urbanization. Approximately 200 million people are involved in the fisheries and aquaculture sectors, of which 59.5 million are directly employed in both industries. Most of the global population engaged in fisheries and aquaculture sectors are in Asia (85%), whilst the rest are in Africa (9%), Latin America, and the Caribbean (5%).

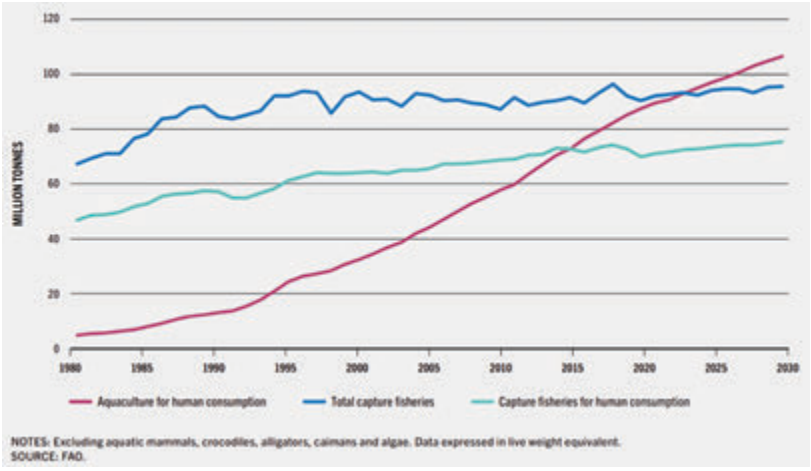


Figure 3 Estimated and projected (beyond 2020) global capture fisheries and aquaculture production, 1990 – 2030

Source: FAO, 2022

Based on Figure 3 and Figure 4, aquaculture was projected to reach 109 million tonnes in 2030 while contributing to an increase in global fish production. However, the share of farmed species in global fishery production (for food and non-food uses) is projected to grow from 46% in 2018 to 53% in 2030.

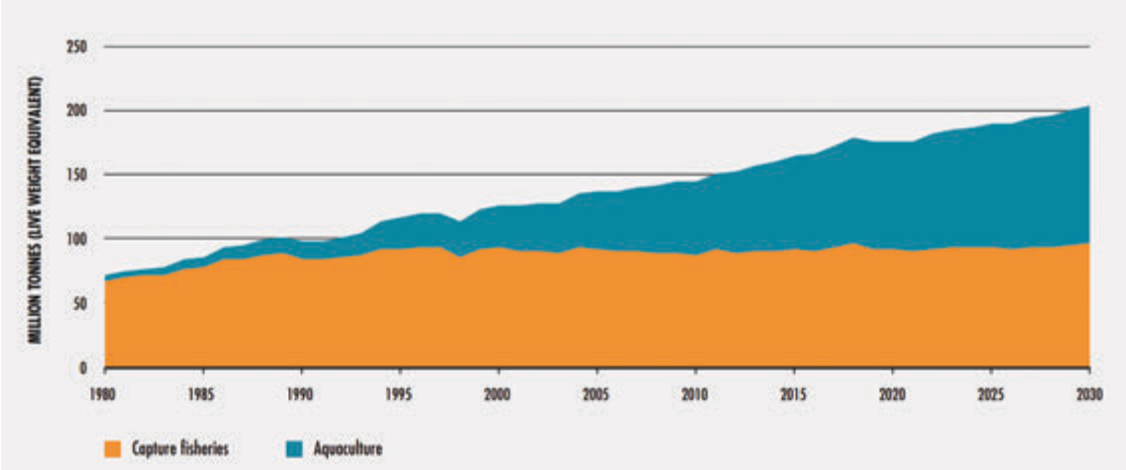


Figure 4 The trend of world capture fisheries and aquaculture

Source: FAO, 2020a

As per Table 1, Malaysia's annual production has shown a slight decrease from the year 2016 to 2020. Compared to the total fisheries and aquaculture production globally, Malaysia continues to show a very low percentage (~1%) each year.

Table 1 Annual Capture Fisheries and Aquaculture Productions

Annual Productions	2016	2017	2018	2019	2020
World Fisheries (million tonnes)	89.6	93.1	96.5	92.2	90.3
World Aquaculture (million tonnes)	76.5	79.5	82.5	85.2	87.5
World Fisheries and Aquaculture (million tonnes)	166.1	172.7	178.9	177.4	177.8
Malaysia Annual Productions (million tonnes)	1.99	1.90	1.85	1.87	1.79
Malaysia production compared with World production (%)	1.20	1.10	1.03	1.05	1.01

Source: FAO, 2020

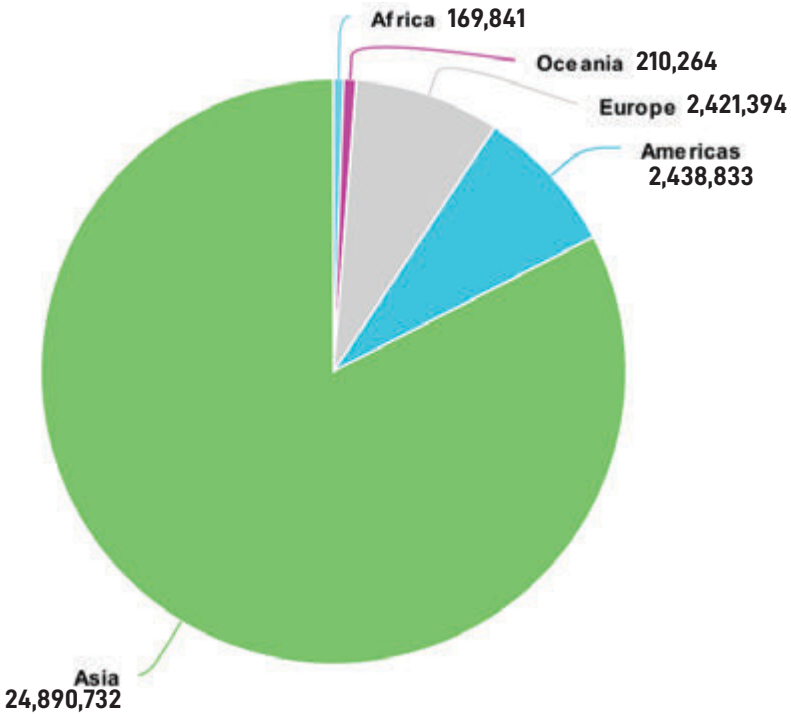


Figure 5 Aquaculture Production by Region

Table 2 Aquaculture Production by Region

Region/ Country	2013		2017	
	Productions (tonnes)	Value (USD'000)	Productions (tonnes)	Value (USD'000)
Africa	**121,232**	**1,948**	**135,627**	**5,074**
Americas	**13,270**	**23,356**	**16,792**	**35,269**
Europe	**2,484**	**1,018**	**1,718**	**2,001**
Oceania	**17,164**	**1,059**	**19,120**	**791**
Asia	**25,027,063**	**9,424,756**	**30,878,276**	**11,200,838**
Malaysia	**269,431**	**25,653**	**202,966**	**10,383**
Grand Total	**25,450,644**	**9,477,790**	**31,254,499**	**11,254,356**

Being a maritime nation, Malaysia harbours a large pool of marine resources that contribute significantly to the country's economy. Based on the report by DOSM (2021), fisheries contributed approximately 11.2% of the total agriculture sector. From time immemorial, the fisheries sector has been playing a major role in supplying animal protein to the Malaysian population as well as supporting the livelihoods of the littoral communities. The declining number of Malaysia's aquaculture products should be tackled to increase the value of aquaculture for the economy (Figure 5 and Table 2). Fisheries and aquaculture are important key drivers of Malaysia's Blue Economy.

2.1.2.1 Capture Fisheries in Malaysia

In Malaysia, the total annual production of capture fisheries and aquaculture in 2020 was 1.79 million tonnes valued at RM13.84 billion (Table 1). The Straits of Malacca (west coast of Peninsular Malaysia) produced 56% of the production followed by the east coast (19%), Sabah (15%), and Sarawak (9%). The rest (~1%) was contributed by the Federal Territory of Labuan (Figure 6). Amongst the states, Perak contributed the highest landings probably due to a higher density of mangroves along its coast compared to others (Figure 7). There is a slight decrease in fishery production from 2018 to 2020, mostly contributed by the inshore fishery (Figure 8). Lower production from deep-sea was mainly due to lower exploitation

related to logistics problems.

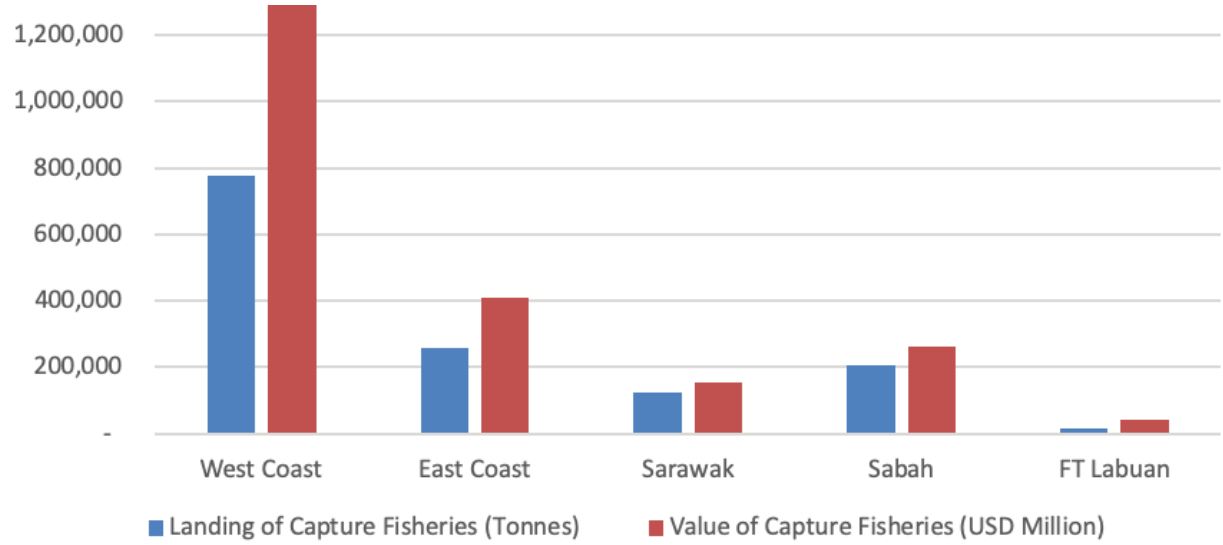


Figure 6 Landing and value of capture fisheries in different regions in 2020

In 2020, a total of 119,828 fisherman was engaged in the capture fishery industry involving 48,826 licensed vessels. Sabah had the highest number of fisheries and the number of vessels compared with other states (Figure 9). Sabah and Sarawak have among the highest percentage of fish landings which is most probably related to the number of fishing vessels compared to other states in Malaysia (Figures 7 and 9).

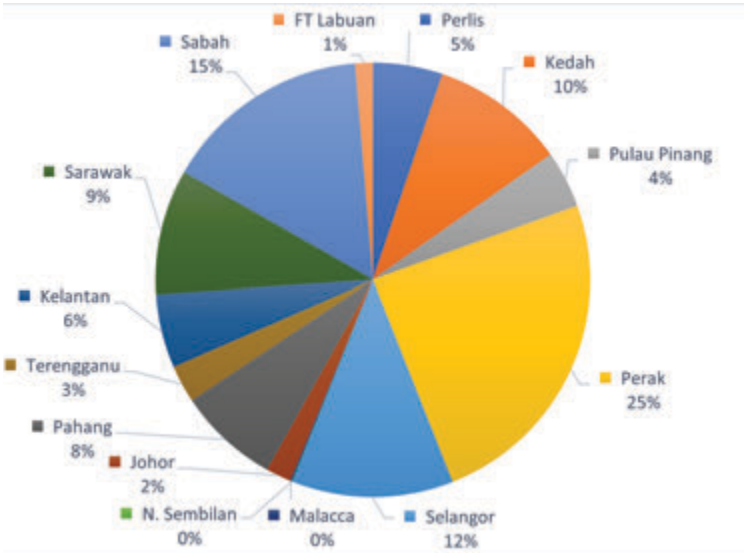


Figure 7 Fish landings in different states (percentage) in 2020

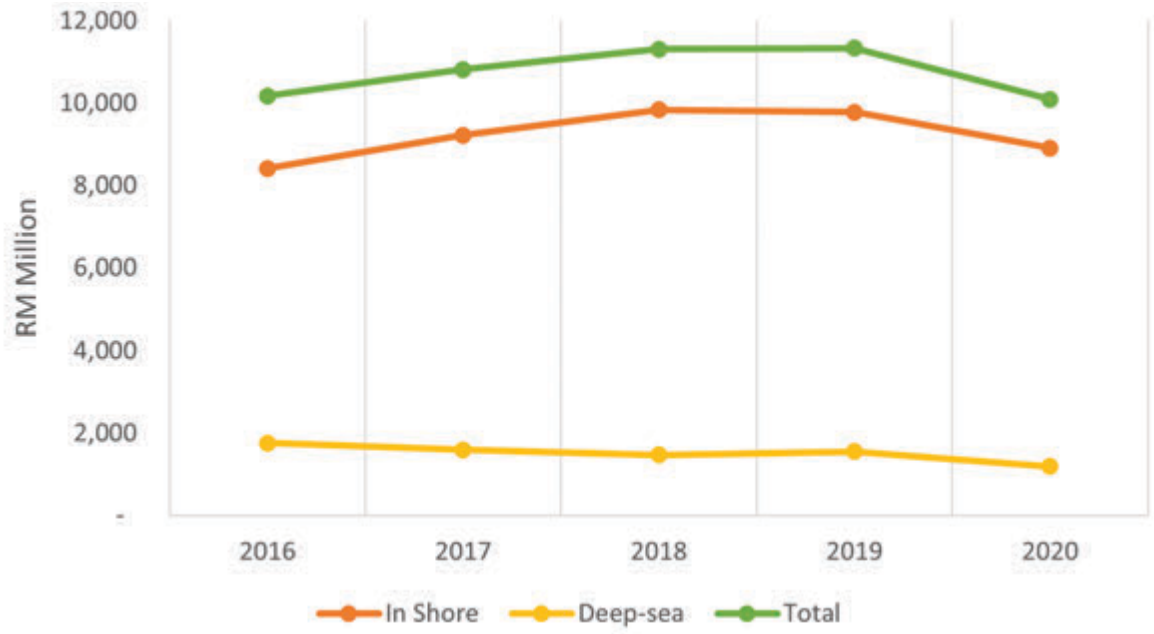


Figure 8 Value of capture fisheries (RM Million) from 2016 to 2020

Capture fisheries are the only major food production that heavily depends on ecosystem health, biodiversity, and population dynamics of wild populations to ensure their sustainable productivity. Degrading the environment, anthropogenic impacts, and climate change have resulted in declining fish stocks in some areas that could eventually threaten the biologically sustainable level.

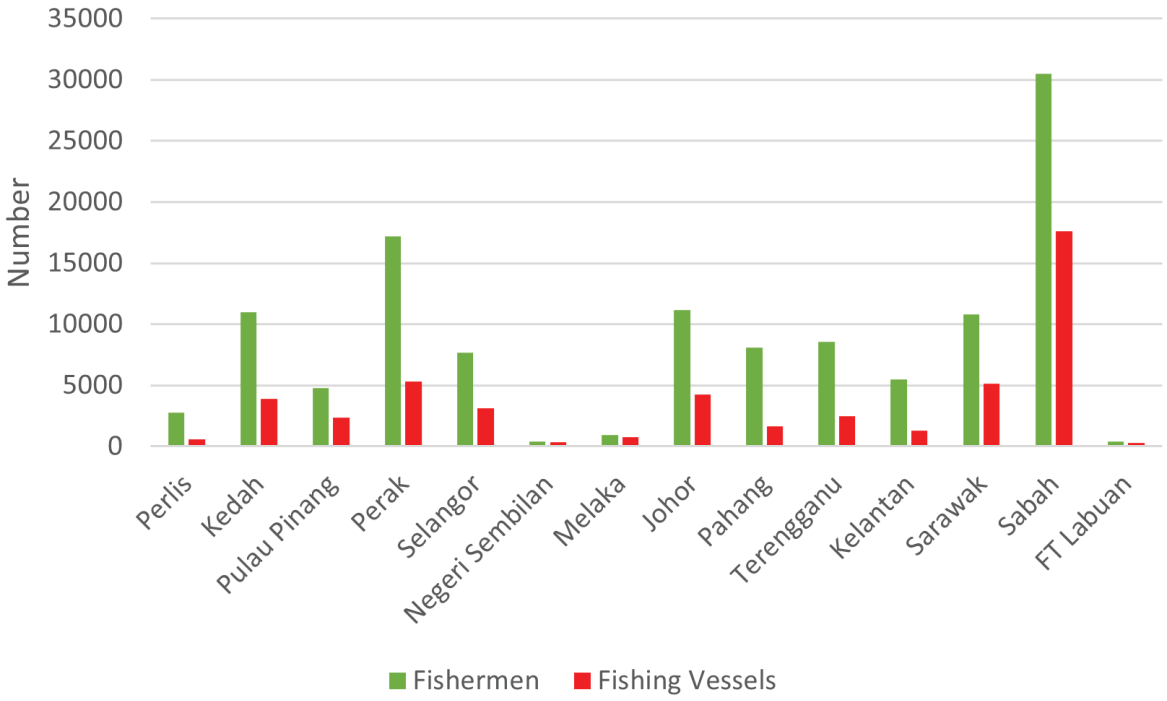


Figure 9 Number of fishers and fishing vessels in different states in 2020

2.1.2.2 Aquaculture

Since the 1980s, Malaysia's manufacturing sector has been spearheading the country's economic growth, with its contribution to the national GDP quickly surpassing that of the agricultural sector. In 2019, Malaysia's fisheries sector contributed 1.1% of the global output share, with 0.4% contributed from aquaculture. Aquaculture contributes 8.9% to the total national agricultural gross domestic product (GDP) and creates an estimated 1.75 million jobs for Malaysians (DOSM, 2016). It shows that the sector not only has to offer national food security but also acts as a potential contributor to alleviating hunger and poverty around the world. The sector has made progress in genetic breeding programs, culture systems technology, aquaculture best management practice, and aquaculture feed. This is because it has the potential to make it easier for people to get enough food.

Among all the agricultural sub-sectors, the aquaculture sector is expected to play an important role in generating higher export revenues. In the National Agro-Food Policy (NAFP) (2011-2020), the development of the aquaculture industry as a high-value activity has been given a lot of attention. It is expected that the industry will grow by 8.6% between 2011 and 2020.

Although the fisheries sector contributes only 10.7% to the agriculture sector and less than 1.5% to the national GDP, it is still an important component of the economy of the country, employing millions of people, especially in rural communities. It also tackles poverty among coastal communities and contributes about 44% of the total animal-sourced protein intake, particularly of the poorer classes. Fisheries, therefore, contribute to food and nutrition security, employment, and national economic growth. Demand for aquatic food products is expected to rise because the population is growing and people are eating more animal protein because of changes in lifestyle and higher incomes.

However, Malaysia's aquaculture sector at the moment is still unable to compete with global and regional players due to lower quantum and USD value of production (OECD, 2022) (Figure 10). Asia contributes more than 99% of global Tiger Shrimp production. However, due to Malaysia's weak aquaculture efficiency, it struggles to compete with regional players. Malaysia currently sits at the 9th spot in Tiger Shrimp production among peers due to the aquaculture sector's lower quantity and USD value production (FAO, 2021) (Table 3).

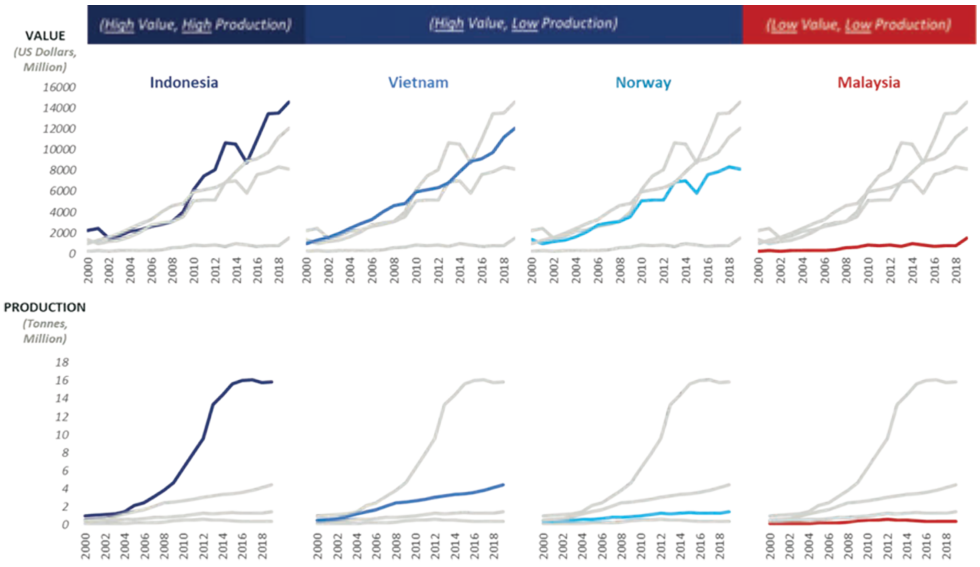


Figure 10 Total Aquaculture Production from 2000 to 2019

(top: million US Dollars, bottom: million tonnes)

Source: OECD, 2019

Table 3 Total Tiger Shrimp Production in 2019 (Source: FAO, 2021)

Country	2019		% World Production	Rank
	Tonnes	USD'000		
Vietnam	*261,000*	*2,668,513*	*33.80%*	*1*
Indonesia	*189,000*	*1,239,469*	*24.48%*	*2*
China	84,066	613,682	10.89%	3
Bangladesh	63,171	467,498	8.18%	4
Myanmar	***51,796***	***362,575***	***6.71%***	***5***
Philippines	*45,733*	*443,854*	*5.92%*	*6*
India	34,615	201,535	4.48%	7
Thailand	*17,364*	*139,591*	*2.25%*	*8*
Malaysia	*14,633*	*96,425*	*1.90%*	*9*
Sri Lanka	5,858	32,773	0.76%	10
Total World	772,184	6,312,747	99.36%	

Other than that, the production from marine-capture fisheries on the west coast of Peninsular Malaysia may become unreliable since many fish stocks have been over-exploited. Recognising this, various means of increasing production through aquaculture are now being explored. Indeed, the aquaculture sector is potentially the only source to meet future demand for fish.

The sustainable supply of fish through aquaculture, capture fisheries, and a reduction in fish waste and loss in the value chain is a cornerstone for the Blue Economy in Malaysia. To turn these sectors into sustainable food systems, it is important to increase the supply of fish and aquatic foods that are cheap, healthy, safe, and of high quality.

In Malaysia, fish contributes around 44% of the total animal-sourced protein intake. Malaysians are among the world's biggest consumers of fish (56.9 kg/capita/year), which is far above the world average of 20.3 kg per capita. However, the country's supply of fish cannot meet domestic consumption. In 2018, Malaysia imported about 224,578 tonnes of fish valued at RM1.7bil (~ USD 406,086,650) (DOF, 2018). The domestic demand for fish exceeded that of the local supply.

Increasing the supply of aquatic food sources from freshwater and the sea without damaging these ecosystems further requires a combination of better fisheries management, investment in sustainable aquaculture, and a reduction in fish loss and
waste.

Globally, one in three fish caught is lost in post-harvest processing. Aquaculture can help to minimise the pressure on wild stocks by producing fish at affordable prices for domestic markets, as well as high-value seafood for tourism and export markets. At the same time, better management practices in capture fisheries can improve the long-term health of resources, increase local supplies, and create new ways for women and young people to make money by adding value to the fish they process and sell.

Sustainable aquatic foods and fish production systems not only provide economic benefits; they also help maintain a healthier population, particularly in reducing non-communicable diseases such as diabetes and heart disease.

Blue Economy can help to promote good public health through the supply of nutritious and safe aquatic foods, fish, and fish products that are high in micronutrients and essential fatty acids. Low seafood consumption during pregnancy increases the risk of the foetus's sub-optimal neuro-developmental outcomes, including poorer cognition and fine motor skills.

Despite the important contributions that fisheries and aquaculture make to nutrition, employment, and trade, their economic value has not fully been tapped. This is likely due to problems in the evaluation of small-scale fisheries. Data are not easily available. The number of people who depend on fisheries and aquaculture for their livelihoods is probably greatly underestimated, along with the sector's actual contribution to development.

The aquaculture industry has multi-functional roles as a matrix of development in ensuring food supply, assisting economic growth, and preserving rural communities. The importance of fish and fishery-based activities to food security is most prominent in communities engaging in small- to medium-scale operations. This not only affects their consumption of fish but also their income.

The aquaculture sector is often responsible for substantial multiplier effects on economic development, by supporting the growth of other industries and sectors, particularly the food processing industry. If fish could be caught close to home, it would help keep costs down and make production more sustainable.

Besides, aquaculture development would have cumulative effects on the agriculture and tourism sectors. Indeed, integrated agriculture-aquaculture systems would enhance farm efficiency and sustainability. For instance, fish farming in rice fields or rice-fish culture contributes to integrated pest management as well as increased farm income. Moreover, water from ponds provides storage reservoirs for irrigation and livestock during water shortages. Aquaculture centres also have the potential to become attractions for foreign tourists and students of various types, providing them with a chance to experience breeding fish first hand.

2.1.2.3 Blue Production

Marine fisheries production depends on environmental integrity, ecosystem health, biodiversity conservation, sustainable fish stocks, and effective governance. There are sufficient legislation, policies, and institutions under the auspices of the Department of Fisheries Malaysia (DoF) and the Fisheries Development Authority of Malaysia (LKIM) to move the industry. However, the sector is still mired with problems, including:

1. Lack of scientific assessment of stocks leads to inefficient management of stocks and declining resources, especially for slow-maturing species.
2. Lack of application of new technologies, mainly due to financial constraints and human capital shortages. As a result, the fisheries sector remains labour-intensive, low in competitiveness, and is perceived to be an unattractive profession. The industry is therefore dependent on foreign workers, which is unsustainable.
3. High fuel cost and a long distance to cover due to low fish abundance near shore.
4. Lack of local processing factories to produce highly competitive products (post-harvest fisheries industry). Non-competitive/low-quality products.
5. Fisheries management measures – despite many legislation and policies, the fisheries sector is

subjected to threats related to the persistence of IUU (illegal, unreported, and unregulated) fishing, increased pollution, and habitat destruction. Continued use of destructive fishing gears such as trawls and unproductive practice of subsidies could promote unsustainable fisheries.

6. Ineffective and weak governance: weak collaboration among the institutions, government departments, fishing communities, and related agencies/stakeholders.
7. Fragmentation of the administration. Multiple institutions with overlapping roles and mandates.
8. Lack of long-term objectives and missions.
9. A lack of political consensus, communication, and awareness makes accountability gaps in institutions even worsen.

Strategic Interventions

1. Determine the status of the fisheries sector's sustainability by determining trends (fish production, fishing pressure, stocks relative to MSY (maximum sustainable yield). Major challenges are a lack of tools for scientific assessment, fisheries management, and replenishment of stocks.
2. Develop cost-effective assessment approaches to provide adequate scientific facts for holistic resource management. To determine the sustainability, carrying capacity, ecosystem health status, biodiversity status, and indices for use in predictive modelling of the resources.
3. Link biodiversity conservation (sustainable marine living resources and the conservation of marine ecosystems) and food security.
4. Link food security and nutrition. To ensure sustainable future food production from the ocean. Sustainable fisheries development should consider nutritional-environmental trade-offs.
5. Implement ecosystem-based approaches to ensure responsible fisheries and aquaculture management to enhance sustainability and productivity. Implement bottom-up management involving fishing communities.
6. Achieve adequate technical capacity, to allow the ability to implement high technical approaches.
7. Provide access to information – a key to successful management is effective communication, knowledge sharing, participation, and cooperation amongst stakeholders.
8. Strengthen the institutional framework and governance – ensure the ability to implement and enforce the regulation. Legislation/enactments/ordinances require review (some could be outdated).
9. Effective implementation and enforcement by the authorities. Establish a Commission under the Prime Minister's Department as a coordinating body.
10. Strengthen accountability across the board- setting clear and representative Key Performance Indicators (KPI), goals, and monitoring.
11. Strengthen the roles of NGOs.
12. Establish strategic alliances among fishers, entrepreneurs, academia, and government/related authorities. SEAFDEC and World Fish are in Malaysia. These agencies can be effective platforms to link and expedite partnerships and collaboration in the fisheries and aquaculture industries.
13. Provide strong support and leadership from relevant authorities.

2.1.2.4 Blue communities – livelihoods

The blue growth initiatives should focus on the blue communities that directly depend on marine resources for their livelihoods. Currently, most fishery communities are marginalised groups living below the poverty level, especially with declining resources and high operation costs. This group plays a key role in fisheries but often faces discrimination in rights to access to resources, credit, technology, and training. However, the sustainability of livelihoods in the fisheries sector is increasingly under threat due to overfishing, habitat destruction, pollution, and social and cultural issues.

Strategic Interventions

1. Understand the needs and interests of fishing communities.
2. Involve these groups to work alongside governments and civil society to advance policies and regulations. Strengthen the roles of NGOs.
3. Empower the communities to safeguard the marine environment, and ensure their access to decent work, livelihood, food security and nutrition, and social protection (resilience to shocks).
4. Include them as vital engines to build vibrant blue communities.
5. Address the development needs of fishers and their communities in terms of food security and nutrition, poverty, and overall socio-economic stability. This is important because small-scale fishers are often economically poor, politically weak, and are therefore vulnerable.
6. Develop joint, integrated goals for biodiversity and food security to make sure that seafood can get to those who need it most, reduce bad effects and food waste, and fight malnutrition and hunger at the same time.
7. Increased stakeholder involvement and secured rights and access.

2.1.2.5 Blue Trade and Marketing

Fisheries provide income for many littoral communities working as fishers and in related activities such as net making, boat building, fish processing, marketing, and trade. Small-scale fisheries involve more people than all other ocean-based economic activities put together. However, problems related to competition, access to resources as well as marketing and trading cause growing inequalities as many fishers' struggle to make ends meet, and they are forced to work in unsafe environments.

Strategic Interventions

1. Fisheries management and governance should address ways of enhancing trade and marketing of fisheries resources, taking into account the needs of small-scale fisheries
2. Establishment of cooperatives to help the fishers' economic activities
3. Access to loans and financial help.
4. Improve their products, markets, and access to trade.
5. The marine fisheries industry doesn't only support the livelihood but also supports the economic development of countries, with an emphasis on developing countries' improving their markets and products and access to trade.
6. Improve socio-economic measures like better access to credit, finance, and insurance, especially in the small-scale sector, and the integration of market-based mechanisms with measures to protect non-market, social, and ecological value.

2.1.2.6 Blue Governance - Environmental Social Governance (ESG) & Climate Change Issues

Issues in governance include:

1. Over-emphasis on economics rather than sustainability and environmental conservation (exploitation tendencies).
2. Fisheries management in the face of a changing climate: The impacts of climate change are not currently incorporated within fisheries and aquaculture management and decision making.
3. Awareness of environmental impacts among fishers in Malaysia is very low. No one champions addressing environmental governance sustainability (ESG) issues in the fisheries and aquaculture sector.
4. Fisheries information systems and new technologies.
5. Policy opportunities for fisheries in the twenty-first century.

Several cross-cutting issues appeared under governance, although this issue is also addressed under each blue growth initiative.

Strategic Interventions

1. Integrate fisheries into a broader planning and governance framework that brings multiple sectors together and facilitates the implementation of evidence-based assessment and management.
2. Capacity building improves the country's ability to better assess and monitor fisheries resources.
3. Communication on fisheries' issues needs to be largely improved.
4. Political will should be sought and the capacity to improve the implementation of existing policy frameworks should be strengthened. Policy innovations in the sector are required to address emerging challenges such as climate change, and the increasing demand for fish and fish products.
5. Promote strategies for synergistic and supportive actions and policies at multiple scales to support sustainable fisheries while meeting international commitments.

2.1.2.7 Blue Innovation

Training and implementation of emerging technologies and trends in fisheries sustainability.

1. Use tools and technologies to prepare effective predictive models and indices for sustainable ecosystem health and production in the face of many unpredictable events (powerful multispecies and ecosystem models to provide real-time and multi-decadal forecasts).
2. Ability to be adaptive as tools and technologies need to change as the systems change, both to human and natural stressors such as climate change.
3. Government intervention in addressing the potential impacts of natural disasters and phenomena such as early warning systems and other predictive mechanisms.

2.1.2.8 Aquaculture

The sustainability of fish and seafood production through aquaculture is essential for food security and helps to reduce pressure on wild fisheries and alleviate other environmental impacts. On top of that, fisheries and aquaculture are important sources of income for some countries.

Several certifications related to sustainable aquaculture for the Blue Economy can be obtained from the Aquaculture Stewardship Council (ASC) and Friends of the Sea. A sustainable aquaculture practice should include cultures produced from stocks that are not overexploited, and it should not negatively impact the surrounding natural habitat.

Mangroves have been destroyed to make way for culture farms for seafood such as prawns. This is bad news – mangroves are essential as they play many roles, such as protecting shorelines from damaging waves, storms, and floods. They prevent soil erosion with their steadfast and tangled root systems. Mangroves also team with organisms such as crustaceans, fish, and molluscs, and serve as a nursery ground for some species.

In aquaculture, the use of growth hormones is frowned upon. Seafood produced by a sustainable aquaculture farm should be fed with permitted aquafeed and aim towards the reduction of their carbon footprint. Responsible wastewater parameter management is another important factor when it comes to farm sustainability.

In general, Malaysia's current aquaculture issues and challenges include slower growth caused by fish stock depletion, which has triggered the rising feed costs; national environmental issues (e.g. flood occurrence and El-Nino phenomena); diseases that affected cultured species; media influences

on spreading false information, unethical feeding practiced in halal perspective; and poor interaction between stakeholders. The industry is continuously encountering new global competitors and new technology development worldwide.

Adopting the Blue Economy approach in Malaysia will require a clear vision that brings together the government, businesses, and the local community, especially small-scale fishing, into a facilitated dialogue that will be mutually beneficial for all. Also, public-private partnerships need to be established to help agencies to communicate with each other so they can better understand each other and share ideas and strategies.

The information base must be strengthened to improve the valuation of the costs and benefits of different economic sectors on marine ecosystems and services. Good data are needed to support transparent decision-making and can be used to harness new technologies and encourage innovation.

Aquaculture is an alternative to over-fishing, but it needs more scientific knowledge and better technology in many areas to become a sustainable way to produce food and make money.

Moving towards a sustainable future not only requires innovative thinking but also global knowledge. While recognizing aquaculture as one of the thrust areas for economic growth, the impact of aquaculture on coastal ecosystems as well as socio-economic linkages in rural communities needs to be studied. In the future, production should be done in ponds or tanks on land, as waterways may not be able to be used for cage operations due to environmental concerns.

Challenges faced include:

1. High production costs are made heavy by dependence on imported feed.
2. Pollution and low water quality have led to an increase in incidents of disease, which results in a reduction in the industry's economic returns.
3. Environmental change influences the quality and quantity of aquaculture production.
4. Labour shortages are also a serious factor in the aquaculture sector. With sustained industrialization in the country, this factor has remained a constraint on the sector's growth. Since local young people would prefer to make more money working in factories, aquaculture has had to rely heavily on foreign workers.

   Even though fish farming is a prevalent solution to the over-exploitation of stocks and destruction of marine habitats, some forms of aquaculture create new problems such as ecological damage and water pollution. Economically viable aquaculture requires high-value fish. However, high-value fish tend not to be environmentally sustainable. Hence, the critical challenge is to develop a model for aquaculture that is both good for the environment and good for business.

Strategic Interventions

(i) Use digital technology to disseminate information.
   Interactive and efficient communications amongst the stakeholders along the value chain could be developed by using the internet as the technology transmits huge amounts of information at fast and cheaper costs compared to traditional media. Use of online systems (e-diesel, e-declaration, fish online, e-entrepreneurs, e-extension, and e-aquaculture) and conducting IT courses and seminars related to computer applications, such as Global Positioning System (GPS), echo sounder, sonar, and internet to fishermen and aquaculture farmers.

Through a mobile app, tools such as the Internet of Things (IoT) can be used to disseminate aquaculture information.

(ii) Smart Aquaculture with Artificial Intelligence (AI)

AI can be used to:

1. Reduce waste feed. Feeding represents the biggest cost to fish farmers, so optimization in this area always means better profitability. Aqua culturists will be able to rely on data-driven decision-making advice to optimise feeding schedules. This reduces waste and improves both profitability and sustainability while offering users a better work-life balance by eliminating the need to be out on the water in dangerous conditions.
2. Preventing diseases and tracking prices. Programmes can predict disease outbreaks before they happen by annotating collected data, presenting it, and applying preventive measures, thus minimizing stock mortality. Smart technology is the key to better productivity and disease management.

Sensor-equipped drones and robots can also collect data such as water pH, salinity, dissolved oxygen levels, turbidity, pollutants, and even the heart rates of stock. All of this information can be viewed on a smartphone.

Through AI, aqua culturists can remotely switch pumps, motors, aerators, or diffusers on or off. Production and demand can be forecasted by altering programme parameters, further improving farm efficiency and monitoring ability. Even optimizing economics during harvesting, which most farmers gauge based on educated guesswork, can be dictated by machines. Therefore, efforts to fully embrace and invest in AI and automation can significantly produce more seafood to feed the world's growing population while reducing the cost and environmental footprint of aquaculture operations.

(i) Appropriate aquaculture species and cultivation systems

Aquaculture of herbivorous species can provide nutritious food with a low carbon footprint. Farming of shellfish, such as oysters and mussels, is not only good business but also helps clean coastal waters while culturing aquatic plants (seaweeds) helps remove waste from polluted waters.

It is important to combine high and low-value species to enhance efficiency—match products with local objectives and preferences for food security and/or export.

Climate change may affect aquaculture to various extents depending on climatic zones, geographical areas, rearing systems, and species farmed. Further research is needed in selective breeding to develop strains resistant to climate change impacts; nutrient-rich feed to enhance immunity to increased disease and parasitic infections. Aquaculture models that will leave a low carbon footprint should be developed.

(ii) Use blockchain to optimise the supply chain.

1. Halal Certification.

(iii) Use blockchain to optimise the supply chain.

1. Grants, debt and equity
2. Social and economic challenges to aquaculture
3. Large-scale and small-scale aquaculture should be treated equally by the government and international development communities

(iii) Capacity development
1. Education & Traceability
2. Environment integrity, certification and food safety
3. Healthy and wholesome aquaculture

Research should be focused on increasing disaster preparedness and emergency response in aquaculture planning and management.

2.1.3 Issues, Gaps and Challenges

Table 4 Issues, Gaps and Challenges for Fisheries and Aquaculture Sector

Governance and Collaborative Platform	Industries Competitiveness	Talent	RDICE	ESG & Climate Change Issues
• Weak governance. • Fragmented coordination. • Lack direction to modernize the sector. • Lack of trust among the stakeholders. • Regulations are outdated and not enforced effectively. • Rent-seeking behaviour prevalent. • Weak collaboration among the institutions, governance bodies and farmers. • Lack of measures to ensure institutional accountability. • Use of destructive fishing gears that promote unsustainable fisheries.	• Labour intensive due to lack of new technologies. • Poor logistics support, port storage facilities, processing plants. • Poor access of fishing community to resources, credit, technology and training. • Non-competitive/ low quality products. • Lack of local processing factories to produce highly competitive products. • Neighbouring countries outpricing local products.	• Negative perception of the fishery and aquaculture industry - Unattractive career for the young. • Lack of training in new technologies. • Industry is dependent on foreign workers. • Education system lack of hands-on and fail to create passion among the younger generation. • Weak education on sustainability and environmental impact awareness for farmers.	• Low level of R&D activities. • Low adoption of new technology and sustainable management practices. • Lack of stock assessment, ineffective stock management. • New technologies not accessible to fishers & farmers. • Weak collaboration between stakeholders (institutions, NGOs, farmers). • Intellectual properties (KPI) unattractive to industry. • Lack of prioritization (e.g. species to promote) • Insufficient research funding.	• Over-emphasis on economics rather than sustainability and environmental conservation (explotation tendencies). • Impacts of climate change are not currently incorporated within management & decision making. • Habitat destruction & high polution. • Low awareness on environmental impact among farmers. • Fragmented coordination due to involvement of many ministries. • No champion in addressing ESG issues. • Sea level rise-impact key aquaculture practices. • Extreme weather affecting the aquaculture activities - Reduced production. • Disease problems

2.1.4 Way Forward

Recommendations of Strategic Plans for Fisheries and Aquaculture by Stakeholders:

1. Strengthening collaborations between Government Agencies, Universities, Industry, and Stakeholders. (e.g., National Roundtable Discussions).
2. Establish a Commission under the Prime Minister's Department as a coordinating body.
3. Review and harmonise existing legislation/enactments/ordinances relevant to Fisheries and Aquaculture.
4. Sustainable Fisheries Standards for Malaysia to comply with international standards and certification.
5. Intensifying R&D on seed, fish nutrition, and fish health, e.g., Disease resistance bloodstock domestication program.

2.1.4.1 Fisheries

Figure 11 shows the way forward in the fisheries sector for more than 10 years.

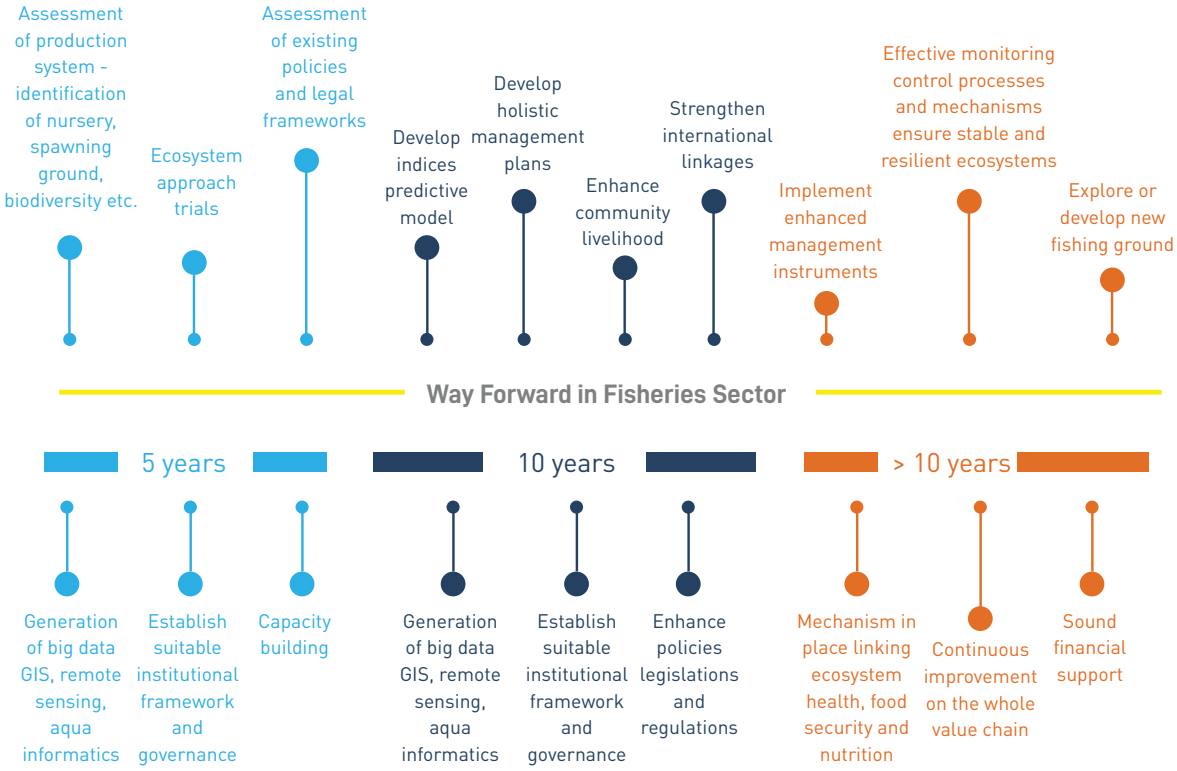


Figure 11 Way Forward in Fisheries Sector

2.1.4.2 Aquaculture

Figure 12 shows the way forward for the aquaculture sector:

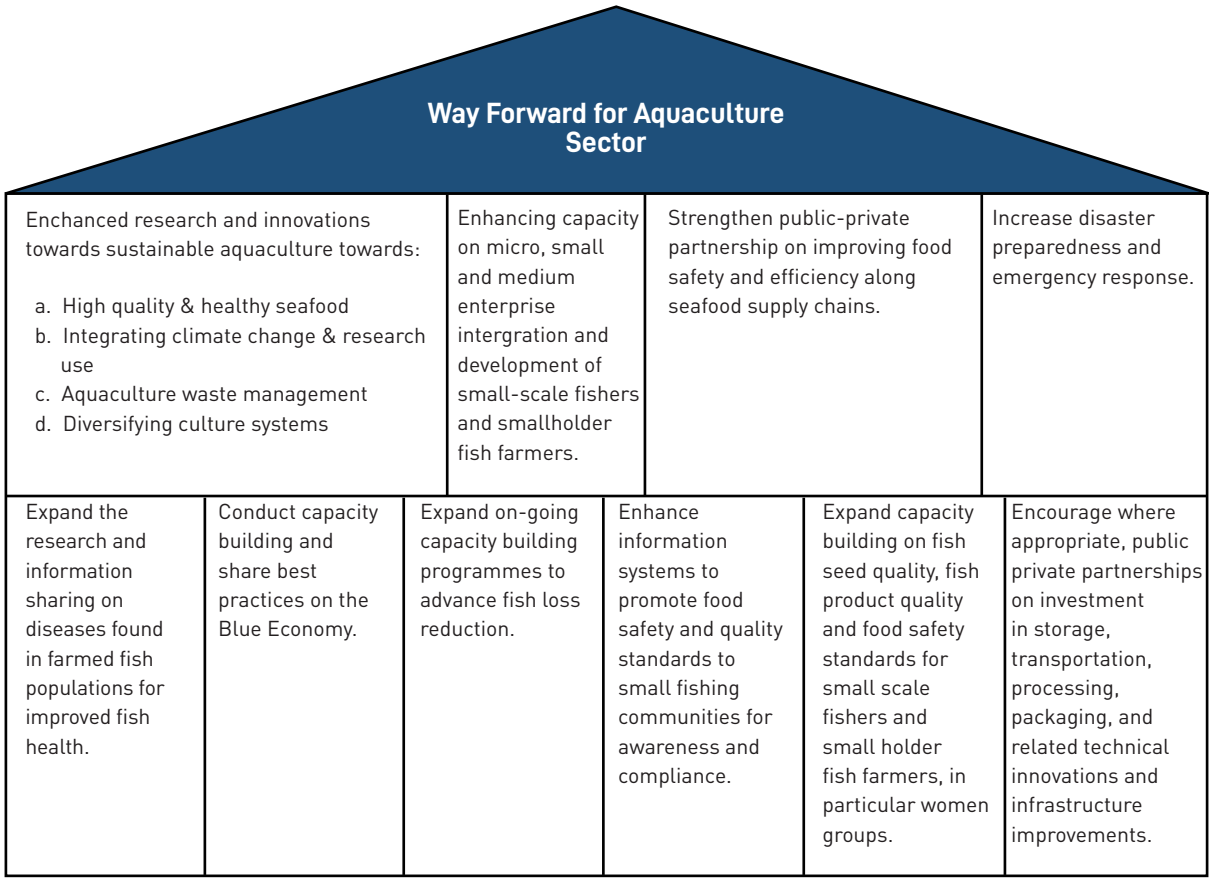


Figure 12 Way Forward for Aquaculture Sector

2.2 Coastal & Maritime Tourism

2.2.1 Introduction

The tourism industry has been a success due to the Visit Malaysia Year (VMY) programs since 1990. Tourist arrivals increased to 7.4 million in that year, compared to the 1989 figure of about 5 million. Compared to the period between 2007 and 2019, the number of tourists entering Malaysia has increased by a staggering 24.46% (Tourism Malaysia 2020). In the hotel and tourism sectors alone, private investments of 71 applications in 2019 and 38 applications in 2020 were approved (MIDA 2021). Both incurred a total investment of RM5,117.3 million and RM2,833.7 million, respectively. As Malaysia is considered a maritime country, our tourism sector is heavily invested in marine tourism, which is focused on coastal areas and islands, together with all the water sports and other leisure activities associated with the sea. Figures 13 and 14 show a survey on the status of coral reefs at local tourist destinations, and the majority of coral reefs are in the range of good to fair condition. Only a small portion of the coral reefs was identified to be in excellent status and quite a number of them were categorised to be in poor condition. Ecotourism activities are based on leveraging the natural resources for "green" tourism practices without harming the coastal and marine environments, thus demanding the need for proper measures to be taken to ensure environmental and resource management for sustainability. However, it is a challenge to those responsible for monitoring and ensuring the protection and conservation of the health of these ocean resources. Therefore, any actions directed at developing a sustainable Blue Economy industry such as ecotourism should be inclusive and benefit all levels of society, i.e., from

the industry to the consumers and the stakeholders who are part of the ecosystem. It is clear that marine tourism is consistently developing and will continue to do so in the time to come. Nonetheless, unpredicted calamities like the COVID-19 pandemic have struck globally and seriously affected the tourism and transportation sectors. Tourism Malaysia's data showed a tremendous negative loss amounting to RM21.77 million in 2020 compared to the previous year (Tourism Malaysia, 2020).

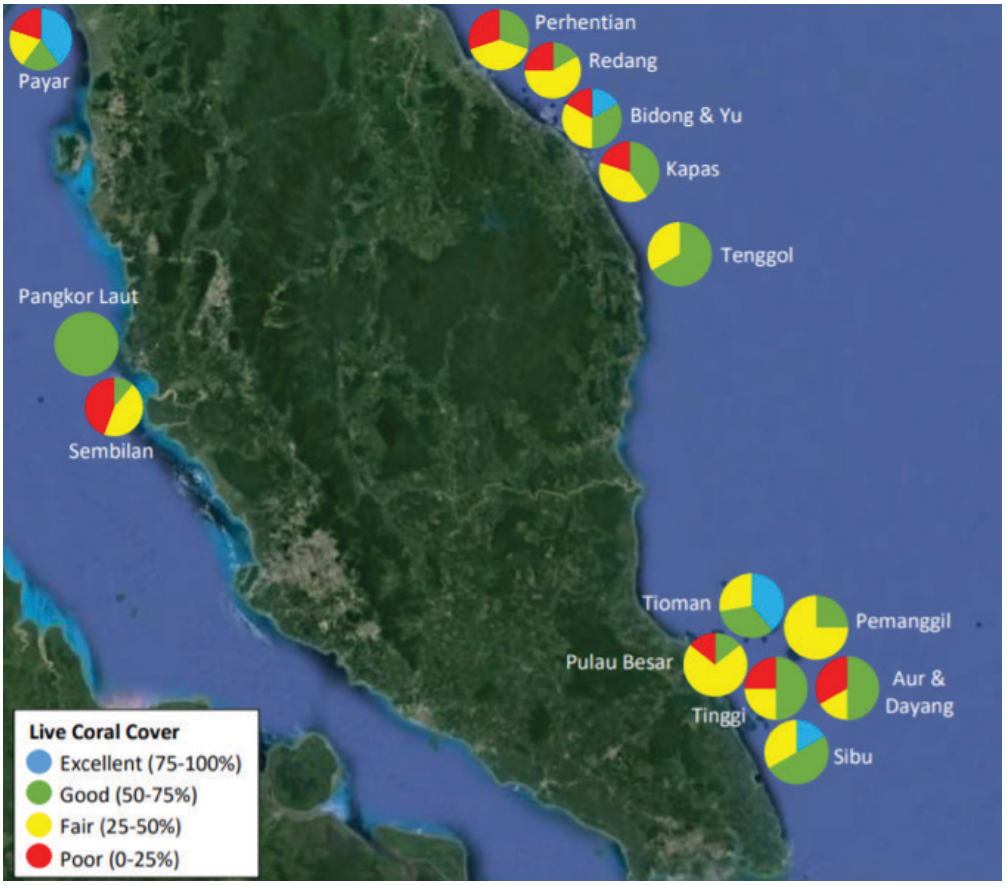


Figure 13 Status of Live Coral Reef in Peninsular Malaysia

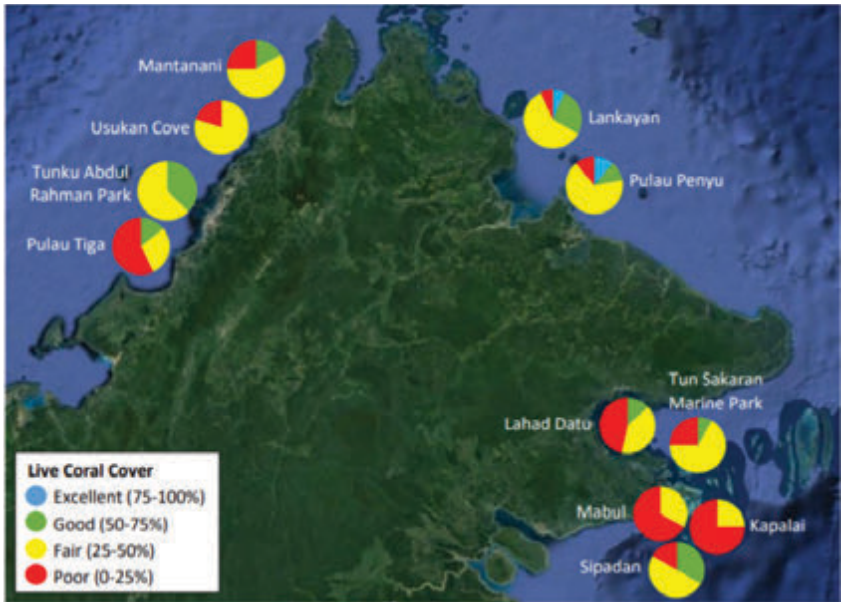


Figure 14 Way Forward for Aquaculture Sector

2.2.2 State of Ecosystem

The World Travel and Tourism Council (WTTC) (2020) reported that before the pandemic, travel and tourism (including its direct, indirect, and induced impacts) accounted for at least one in four new jobs created across the world, contributing to 10.6% of the total jobs (334 million), and 10.4% of global GDP (USD 9.2 trillion). International visitors contributed USD 1.7 trillion in 2019 (6.8% of total exports and 27.4% of global services exports). Malaysia receives 4.32 million international tourists and recorded RM12.66 billion in tourism income from January to December 2020 (Ministry of Tourism, Arts and Culture, 2020). Meanwhile, domestic tourism recorded a total of 131.7 million domestic visitors in 2020 and a total expenditure of RM40.4 billion (DOSM, 2020). However, over the last year, the contribution of the travel and tourism sector dropped to about USD 4.7 trillion in 2020, with the contribution to GDP reduced by 49.1% compared to 2019 and relative to a 3.7% GDP decline in 2020. In 2020, 62 million jobs were lost, representing an 18.5% reduction compared to 2019.

The total contribution of Travel and Tourism to GDP in Malaysia dropped by 49.1% from USD 9,170 billion (10.4% of GDP) in 2019 to USD 4,671 billion in 2020. There was a drop of 18.5% in jobs (272 million) in 2020 compared to 2019. International tourists spent MYR 44.4 billion, 1.7% of total exports (USD 3.4 billion), showing a drop of 84% compared to MYR 89.8 billion in 2019. Domestic tourists spent MYR 61.8 billion in 2020, compared to MYR 98.1 billion in 2019. Tourism is known to be the second-largest foreign exchange earner in Malaysia. The tourism sector is linked to a diverse range of multi-sector industries that consist of transportation, accommodation, restaurants, recreation, and entertainment. Surrounded by beautiful islands and coastal beaches, Malaysia's marine tourism inadvertently attracts a large percentage of the total number of tourists in the country. Generally, the marine tourism industry involves activities like water sports, diving, or just relaxing and swimming in the sea. Nonetheless, the growth of the marine tourism sector has made tour agencies and operations that focus on recreational activities such as scuba diving more apparent. A well-developed marine tourism industry will benefit the country and its communities. For example, in the Semporna district of Sabah, a positive reaction is seen in its surrounding coastal communities due to the homestay tourism opportunities in addition to seaweed cultivation, which provide additional income for them.

More specifically, dive tourism has become a major source of income for many coastal communities in Southeast Asia (Pascoe et al. 2014). Indonesia, Malaysia, Philippines, Papua New Guinea, Solomon Islands, and Timor-Leste are part of the Coral Triangle region and are home to 75% of the world's reef-building corals. Corals, beautiful marine species, and shipwrecks have become one of the main attractions for divers and consequently provide the livelihood of the surrounding communities. From 1967 to 2020, 28 million diver certificates have been issued globally, making it one of the more popular water sports, contributing to the booming of related tourism industries (PADI, 2021).

Aside from marine water activities, mangrove forests found in sheltered estuaries and along riverbanks and lagoons in the tropics and subtropics (FAO 2007) may have the potential to be promoted as ecotourism destination areas. In Peninsular Malaysia, mangrove forests constitute about 17% of the total mangroves of Malaysia (0.58 Mha), with the rest found in Sabah (58.6%) and Sarawak (24.4%) (Kanniah et al. 2015). Malaysia's natural tourism could grow if mangrove forests and the facilities around them were better-taken care of.

Issues and Strategic Interventions

The growth of this industry has had significant impacts on the environment, the economy, and the socio-cultural ecosystem of the nation. Malaysia has a rich diversity of coastal and marine resources that are highly attractive to international tourists, especially due to the mild climate, good infrastructure, and

stable political system. Furthermore, ecotourism allows the community to understand the importance of natural resource management and conservation and to participate in managing and restricting unlawful urbanization. The spin-off effects from this industry to other service-related activities like hotels, travel, restaurants, handicrafts, etc. increase job opportunities and the overall revenue and improve the living standards of the coastal and island communities.

However, despite the huge potential economic contribution of this industry to Malaysia's GDP, there is minimal inter-agency collaboration in advancing ecotourism. Although management of the marine natural assets is carried out by several agencies, including the Malaysian Maritime Enforcement Agency, Fisheries Department, and the Marine Department, there is no dedicated central coordination agency, especially in ensuing coherence in land-sea governance, resulting in fragmented management of all activities related to the coastal and marine ecosystems. Non-governmental organizations like the Malaysian Nature Society, Reef Check, and the Malaysian Society of Marine Sciences, as well as various scuba diving clubs, also contribute to the surveillance and protection of these valuable marine resources. There is, however, a lack of long-term monitoring programs for the impacts of this industry. Talent development, including the training of knowledgeable tour guides, environmental officers in the hotel industry, and the use of local communities in tourist activities, needs to be enhanced. For tourism to be sustainable, the right technologies need to be created. For example, sustainable potable water supplies for island resorts, the bio-recovery of wastes like plastic debris, the use of renewable energy, etc., are all examples of these technologies.

Without coordinated growth of the industry, the marine environment would get worse, the sociocultural ecosystem would break down, and Malaysia would lose its reputation as a sustainable country that works to meet the Sustainable Development Goals (SDGs), especially SDG 14.

Ecotourism is based on leveraging natural resources for multiple purposes such as tourism without harming the coastal and marine environments. However, it is a challenge to those responsible for monitoring and ensuring the protection and conservation of the health of these ocean resources. Therefore, any actions directed at developing a sustainable Blue Economy industry, including ecotourism, should be inclusive and benefit all levels of society, from the industry to the consumers and the stakeholders who are part of the ecosystem. It is clear that marine tourism is consistently developing and will continue to do so if no other precedent problem occurs. Nonetheless, unpredicted calamities such as the COVID-19 pandemic have struck globally and have seriously affected the tourism and transportation sectors.

2.2.2.1 Benchmark with international strategies and policies to identify gaps and challenges for use in developing best practices for Malaysia

Blue Economy is basically to put forward marine resources based on an ecosystem service framework to tackle environmental issues and ensure sustainable coastal blue growth. A workable conceptual framework designed to maximise the marine resources for exploration for the Blue Economy should be achieved without harming the environment and marine life. Some of the following broader strategies to support the Blue Economy could be considered (Wenhai et al., 2019).

A. EU's Blue Growth Strategy and Blue Innovation Plan

In 2012, the Blue Growth strategy was suggested. The plan then evolved in 2014 to specify three main aspects that should be considered:
(1) Develop sectors that have a high potential for sustainable jobs and growth, the tourism industry obviously will provide more opportunities for the locals to develop any business that involves water activities as an example;

(2) Essential components to provide knowledge, legal certainty, and security in the Blue Economy; and
(3) Sea basin strategies to ensure tailor-made measures and to foster cooperation between countries.

By 2017, reports based on the previous plan had been issues, describing a few points: (I) pushing for growth in five focus areas, including blue energy, aquaculture, coastal and maritime tourism, blue biotechnology, sea bed mineral resources, (II) The benefits of marine data, spatial planning and maritime surveillance to facilitate growth in the Blue Economy, (III) promoting a partnership approach, (IV) boosting investment and (V) making blue growth strategy fit the future challenge.

B. Indonesia's Sustainable and Equal Growth of Marine and Coastal Regions

Indonesia has focused on the development of the marine and fishing industries. This action leads to the formulation of comprehensive economic and environmental protection policies, in which any action should be taken with precaution without affecting the environment. They also put forward and boost regional economic development; realise sustainable development by promoting clean production systems; and encourage creative and innovative investment. These strategies boost the Blue Economy concept and tourism as well. Their plans to set up Blue Economy demonstration zones in Lombok and Anambas islands and Tomini Bay are to explore the Blue Economy model with the marine industry, fishery, breeding, seaside tourism industries, and small island collective, regional, and bay development—which could also be considered.

C. China's Blue Silicon Valley

On January 31, 2012, Qingdao Blue Silicon Valley finally began operation. The Blue Silicon Valley plays an important role in driving biotechnology, scientific research, and education. The plan to create a world-leading centre for marine achievements has assisted the marine industries by clustering blue education and talents, as well as innovation focusing on blue tourism and healthcare.

Strategic Interventions

1. Develop vibrant and iconic tourism products.
2. Implement local natural resource conservation and management for Ecotourism.
3. Establish natural resource accounts and valuation.
4. Increase Marine Protected Areas (MPA) - reserve also MPAs for resource development and species sustainability.
5. Introduce Green shipping practices including mindful energy, resource usage, and consumption needs. Guidelines on oil dumping or water ballast removal need to be made clear and strictly adhered to.
6. Management:
    i. Manage urbanization of coastal zones.
    ii. Adopt technologies for minimizing coastal erosion/sedimentation, and pollution, especially marine plastic debris, oil spillage, and aquaculture wastes.
    iii. Establish habitat and species surveys, to enable resource accounting and valuation.
    iv. Restrict fishing activities (set limits) based on marine species population inventories.
7. Educate communities to minimise waste and carbon emissions.
8. Improve planning and maintenance of existing tourism sites based on green and sustainable practices and adopt Green Tourism for marketing.
9. Provide access to communication such as high internet speed and telephone in hotels, etc.

10. Provide incentives for ocean/river rangers to monitor and ensure sustainable practices amongst the visitors. Promote upskilling of tour operators using the Green certification scheme (Green Fin).
11. Implement Sustainable Finance Instruments e.g., carbon credit initiatives, price instruments, quantity instruments, and fiscal instruments.
12. Industry can leverage the Special Tourism Investment Zone (STIZ), as well as other available incentives (hospitality-related projects and adopting green initiatives), via MIDA.
13. Open to foreign investments.
14. Promote Nature-Based Solutions (NBS).
15. Conduct carrying capacity for tourism development and implementation, especially for vulnerable habitats and protected areas.

2.2.3 Issues and Challenges

Table 5 Issues, Gaps, and Challenges for Coastal and Maritime Tourism Sector

Governance and Collaborative Platform	Industries Competitiveness	Talent	RDICE	ESG & Climate Change Issues
• Weak governance. • Fragmented coordination. • No clear direction to modernize the industry using the best technology advanced management systems. • No exhaustive laws for recreational boat drivers (license). • Poor policy implementation. • Poor communication between institutions and industry. • Inefficient monitoring on extraction of natural resources. • Community was denied in the involvement and lack of capacity study in ecotourism. • Oversea and local tourists harvesting our coastal treasure without permission. • Polluted tourist zones. • Lack of support and financial incentives in tourism sector.	• Lack of high-grade facilities for tourists. • Low up-keep of marine and oceans (high pollution). • Security is an issue that impact perception among foreign tourists. • Low adoption of emerging technologies. • Poor communication between institutions and industry. • Lack of support for tourism players. • High turnover rate.	• Poor talent development. • Difficulty in attracting good talent to the industry due to limited career prospects • Low involvement/ utilization of local communities. • Lack of procurement for local technologies. • Lack of collaboration in the university and industry. • Weak data collection and sharing.	• Lack of R&D in in appropriate new technologies for improvement of facilities e.g., RE, water supply, etc. • Low level of sophistication in assessing market intelligence and promotion (weak demand-side management of industry). • Minimal collaboration interdisciplinary in ecotourisms. • Weak enforcement of environmental protection laws and low monitoring, • Lack achievement for those receiving grants from government. • Lack of supporting infrastructure.	• Lack of R&D in appropriate new technologies for improvement of facilities, e.g., RE, water supply, etc. • Low level of sophistication in assessing market intelligence and promotion (weak demand-side management of industry). • Loss of habitats equal to loss of tourism. • Negative impact of mass tourim. • Greenwashing. • Anthropogenic sources (marine debris).

Fisheries Flagship Projects recommended by Stakeholders:

1. Investigate and apply virtual/hybrid tourism as an alternative to physical tourism.
2. Promote underwater attractions (Biorock & Reefball).
3. Adoption of blue and green technologies into the industry.
4. Enhance education awareness in nature-/educo- tourism.
5. Develop and implement Blue finance mechanisms to enhance community engagement and formulate payment for ecosystem services.

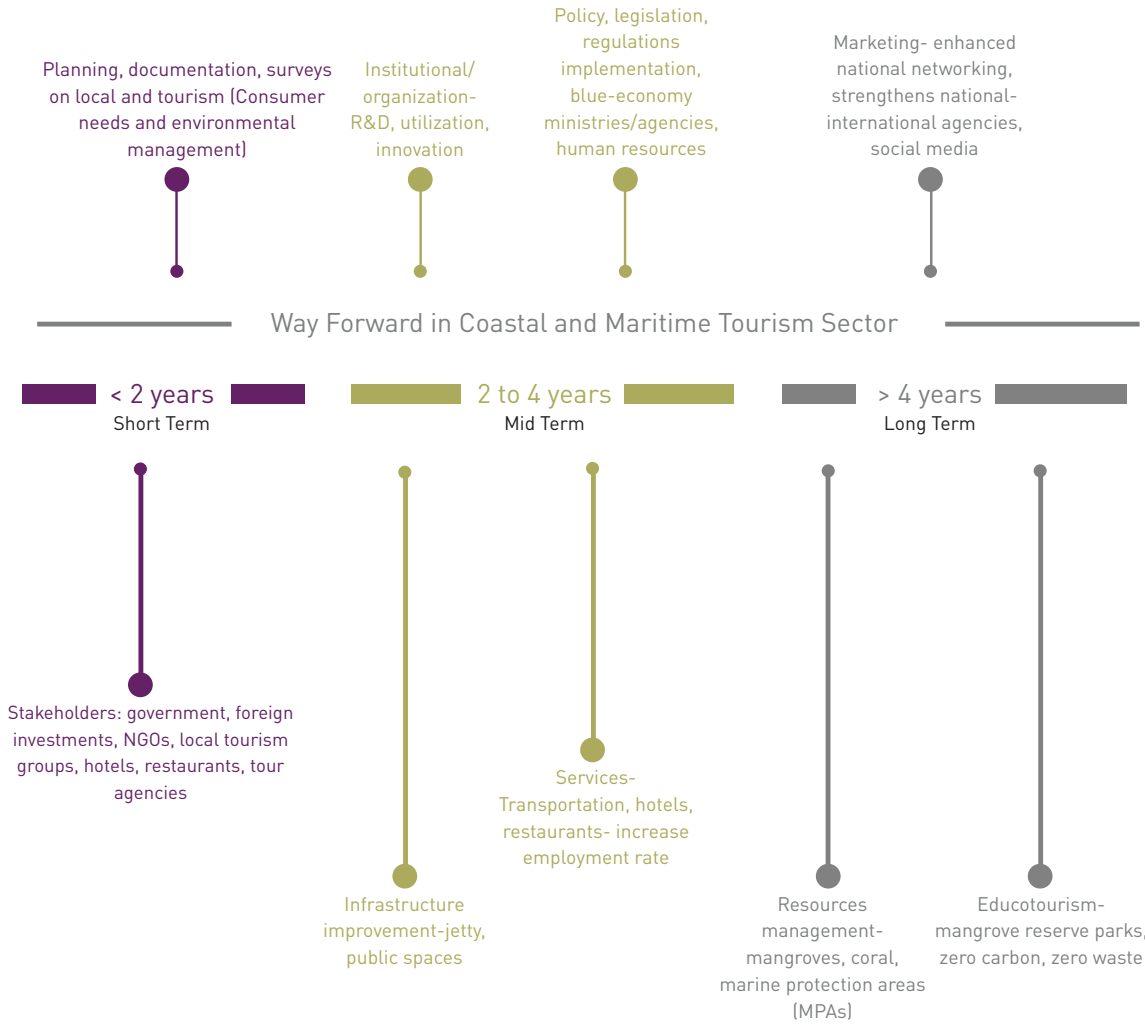


Figure 15 Way Forward in the Coastal and Maritime Tourism Sector

2.3 Extractive Industries of Non-living Ocean Resources

2.3.1 Introduction

Definition; potential; global activities

Non-living natural resources of the seabed and subsoil of the continental shelf mainly consist of three categories. First, hydrocarbons (oil and natural gas) and gas hydrates have traditionally been the main contributors to the national economy. Secondly, tin, sand, gravel, silica sand, and other minerals are being extracted from the shallow waters of our seas. Thirdly, deep-sea minerals, which include mainly polymetallic sulphides, manganese nodules, and cobalt-rich crusts, mostly occur in deep waters beyond national jurisdiction. In addition, future potential resources also occur in the seawater column itself.

The occurrence of these different types of resources is principally controlled by the geology and bathymetry (water depth) of the marine areas. Geological conditions dictate that hydrocarbons are likely to occur where there are thick accumulations of sediment (at least 2-3 km of sediment thickness are needed for the organic matter within them to generate significant amounts of hydrocarbons), whereas deep-sea minerals are found on or beneath the seabed of the deep oceans, which are generally "starved" of sediment. Thus, in general, sites for hydrocarbon exploration/exploitation and deep-sea mineral exploration are unlikely to overlap.

2.3.1.1 Oil and Gas

Conventional oil and gas (O&G) occur at continental margins (shelf to slope) over a wide range of water depths: shallow water (0-500 m), deep water (500-2000 m), and ultra-deep water (> ~2000 m). In Malaysia, deep water wells have been drilled to more than 2800 m of water in the Sabah Trough. It was reported by DOSM (2019) that 36,776 people were involved in the extraction of crude petroleum and natural gas, including support activities (Figure 16).

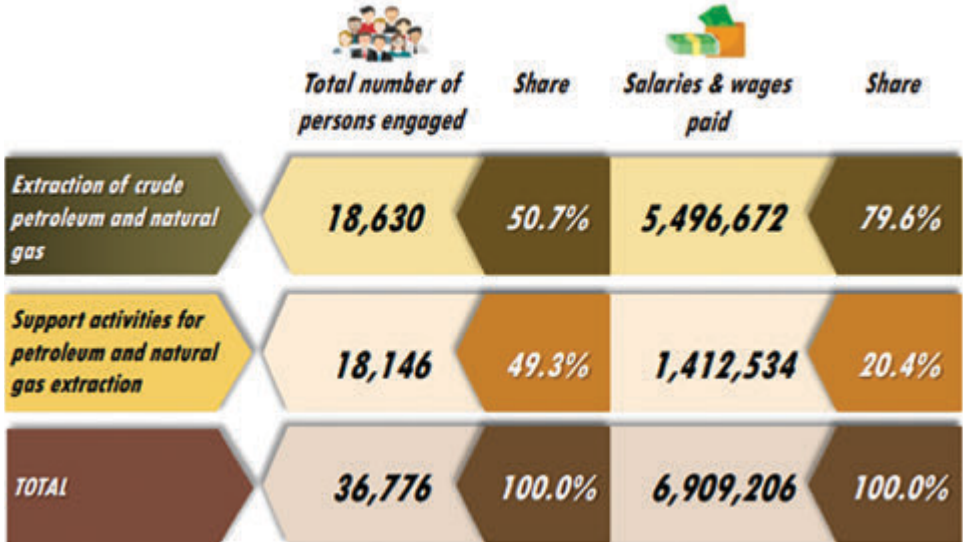


Figure 16 Number of persons engaged and salaries & wages paid for Petroleum and Natural Gas mining by a group in Malaysia, 2019

Conventional O&G exploration, managed and regulated by PETRONAS under the Petroleum Development Act 1974, has been ongoing for over 50 years (or 100 years if the pre-PDA era in Sabah and Sarawak is taken into account). Exploration and exploitation will take place further and further into the deep sea, and beyond 200 nautical miles (nm), the normal limit of natural jurisdiction, where geological conditions are conducive for hydrocarbons to occur, such as the presence of sufficiently thick sediments on the continental margins. So far, Malaysia's O&G exploration and exploitation are mainly within 200 nm, and only recently have exploration wells drilled beyond 200 nm but generally within Malaysia's 1979 map boundaries ("Peta Baru 1979"). Figure 17 shows the oil production and consumption by region in 2020.

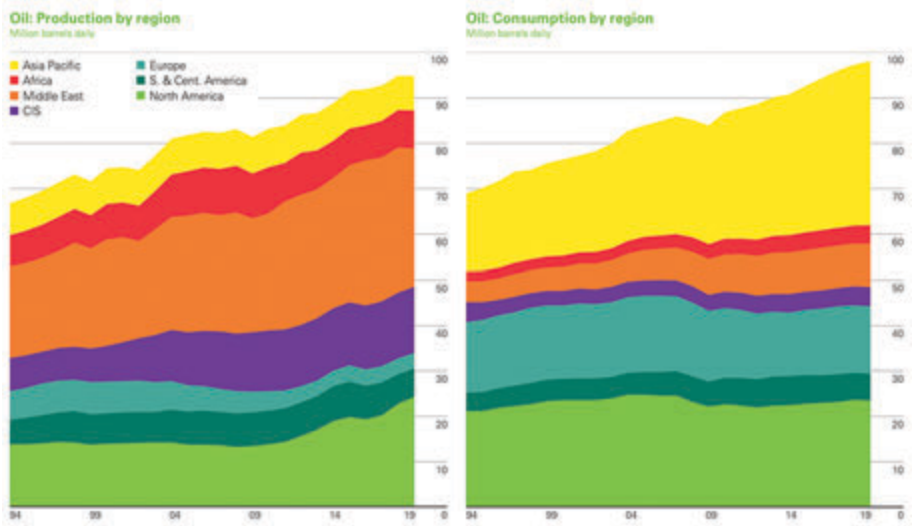


Figure 17 Oil production and consumption by region, 2020

Source: bp Statistical Review of World Energy 2020

Overall, conventional O&G exploration and exploitation are at a relatively mature (advanced) stage, especially in the Malay Basin offshore east of Peninsular Malaysia, which is the most mature area with declining reserve addition (i.e., discovery volumes), whereas the Sabah and Sarawak basins may still have significant potential due to bigger marine areas that are still under-explored, including those beyond 200 nm.

2.3.1.1.1 Gas Hydrates (Methane Hydrates)

Gas hydrates, on the other hand, have a limited spatial distribution on continental margins due to the hydrate-stability zone, which is correlated with seabed temperature and hence water depth. In Malaysia, gas hydrates are known to occur in the deep waters of the Sabah Trough area in the water depth range of 1150 to 2700m (Sharef et al., 2018). These deposits occur at depths of between 250 and 350 meters below the seabed, but the estimated volumes of gas hydrate resources have not been published. Gas hydrates are believed to be the energy source of the future and occur on continental margins all around the world, including in the South China Sea. A handful of developed countries including the US, Japan, Canada, Korea, and China, are actively researching this potential resource base. Some efforts have been made by PETRONAS to map the extent of gas hydrate occurrences in the Sabah Trough. So far, gas hydrates are not considered a priority, but only as a future resource. Hence, not much research work is currently ongoing.

2.3.1.2 CO_2 Capture and Sequestration

Malaysia is not just blessed with O&G resources (in fact we have more gas than oil) but carbon dioxide (CO_2). CO_2 is a by-product (or waste) from O&G production and can occur in significant volumes, especially in the so-called high-CO2 gas fields. Besides oil and natural gas, CO_2 is a large component of naturally occurring gases in the O&G fields, some making up to 70% of the total gas volume. High-CO_2 gas fields (with CO_2 content >20%) pose technological challenges for O&G production to minimise the release of CO_2 to the atmosphere and mitigate its impact on climate change. A sustainable method of producing hydrocarbons from high CO_2 gas fields may help unlock significant amounts of hydrocarbon reserves that otherwise would remain untapped due to high CO_2 content. Some fields that were discovered decades ago could not be exploited due to the prohibitive economics, or cost-effectiveness, after taking into account the potential investment required for CO_2 capture and sequestration. Carbon capture and sequestration (CCS) is a proven technology for capturing and permanently storing or sequestering CO_2 in the ground. In offshore O&G production, CO_2 is captured or separated from the oil and gas stream and transported and re-injected into a depleted oil or gas reservoir for permanent storage. The storage reservoir (depleted field) could be at the same site as the source of the CO_2 or in another place. CO2 is also utilised in enhanced oil recovery (EOR) projects by pumping it into a producing oil reservoir whose production rate is declining. CCS technology is regarded as a key enabler in the effort to mitigate CO_2 emissions from oil and gas fields. In October 2020, PETRONAS declared its sustainability goal to achieve Net Zero Carbon Emissions (NZCE) by 2050. Part of the aspiration is to cap greenhouse gas (GHG) emissions to 49.5 million tonnes of carbon dioxide equivalent in its domestic operations by 2024.

For more than a decade (since 2010), research efforts by PETRONAS and its partners have been focused on developing high-CO_2 gas fields using CCS technology that is both economically viable and environmentally sustainable. Finally, in 2021 PETRONAS launched the first-ever CCS project in Malaysia with the Kasawari CCS Project offshore Sarawak. The project aims to capture and process CO_2 from the Kasawari gas field and inject it into one of the depleted offshore gas fields nearby. The Kasawari CCS project is expected to be in operation by the end of 2025. It is expected to reduce CO_2 emissions by 76 million metric tonnes.

CCS is a potential industry that can provide business opportunities and contribute to the Malaysian Blue Economy. Countries that are leading in this technology are Australia and Norway. It is said that CCS is the petroleum industry "turned backward", in the sense that the same skillsets and technologies used in finding hydrocarbons (O&G) are now being used to pump back CO_2 into the ground for permanent sequestration. In other words, at least some of the petroleum industry personnel will not be redundant if CCS is implemented as part of a national strategy to combat climate change and is made a legal requirement, and therefore is not merely imposed under PETRONAS regulations but under the National Climate Change Policy and Greenhouse Gas Mitigation Strategy.

2.3.1.2.1 O&G Infrastructure Decommissioning and Abandonment

In a maturing O&G industry, PETRONAS and the country will need to deal with abandoned O&G infrastructure in the oceans through decommissioning and abandonment. Decommissioning, in the context of O&G assets, is the dismantling, removal, and disposal of the structures that make up those assets and their associated infrastructure, along with plugging and abandoning the underlying wells and restoring the sites. Decommissioning is a legal requirement under the 1958 United Nations Geneva Convention on the Continental Shelf ("Geneva Convention"), which requires signatories to remove all offshore installations at the end of field life. The Geneva Convention was effectively superseded by the 1982 United Nations Convention on the Law of the Sea (UNCLOS), which adopted a revised approach to decommissioning, with partial and, to a lesser extent, no removal being permitted provided that "generally accepted international standards established in this regard by the competent international organization" (a generally accepted standard is that contained in the International Maritime Organization Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and the Exclusive Economic Zone, 1989).

It is a big topic of discussion in preparation for the abandonment of old oil and gas fields, what to do with the structures when they are abandoned, and their possible impact on the environment. Decommissioning is an activity to restore a previously producing site to a safe and environmentally stable condition. It involves well abandonment, which is preparing for a well to be shut permanently, and upstream facilities' decommissioning once they reach the end of their production life, or when there is insufficient hydrocarbon to make production activities commercially viable.

In its Activity Outlook Reports 2020-2022 and 2021-2023 (Petronas, 2019, 2020) PETRONAS, stated that well abandonment activities were performed on around 38 wells in 2019, followed by around 15 wells in 2020 and 13 wells in 2021. The number is projected to increase to 50 from 2022 to 2024 (Petronas, 2021). Thus, based on the data from PETRONAS, decommissioning presents a business opportunity for the Malaysian Blue Economy and these activities are expected to intensify as many assets have been operating for 40 years. The above figures represent about 10% of the currently active offshore platforms (>350 units), >10000 km of pipelines, and >3500 well strings. Under international law, these offshore structures cannot simply be abandoned or dumped, and solutions to dispose of them safely to minimise their impact on the environment must be thoroughly and carefully considered.

2.3.1.3 Mining of Seabed Minerals in marine areas within the National Jurisdiction

The rising demand for minerals in most sectors, including technology, has led to a surge of interest in the exploration of mineral resources from the seabed. Seabed mining within Malaysian waters, including the mining of marine sand and minerals, will contribute to the development of the National Blue Economy as it can generate income for the country. The income is based on revenues from royalties collected by state and federal governments. In Malaysia, sand and minerals are used locally and exported to other countries. The International Seabed Authority (ISA) is an autonomous intergovernmental body consisting of 167 members. Since its establishment in the year 1982, it is the responsible body for

regulating human activities on the deep-sea floor beyond the continental shelf and has issued 27 mineral exploration contracts that cover a total area of more than 1.4 million km2 and is still actively developing rules for commercial mining.

2.3.1.4 Sand

The National Offshore Sand Resource Study is a major effort by the Government to ensure that the mining of offshore sand resources is carried out systematically and sustainably with minimal environmental impacts on the marine living resources and coastlines. This comprehensive study was undertaken by the Department of Mineral and Geoscience Malaysia (JMG) in 1999 and comprises a geophysical survey, seabed sediment sampling, and hydraulic, and environmental assessment of the offshore sand resources. Towards this end, a comprehensive ranking methodology has been developed to enable the evaluation of offshore-sand resources according to the potential impacts of their exploitation. The development of an appropriate ranking framework is of fundamental importance in guiding the overall mining of sand reserves. Thirteen (13) environmental criteria (ranging from water quality, living resources, habitats, as well as non-living and man-made resources) are used to rank the sand reserve. The ranking involved two primary tiers in which sand resources are categorised as Non-Exploitable and Exploitable.

Based on this study by JMG, the vast amounts of sand reserves in the Straits of Malacca and Sarawak offshore amounting to about 9.67 billion m^3 and 17.1 billion m^3 respectively were categorised as exploitable (Sulaiman et.al, 2018). Based on the current royalty rates of RM3 per cubic meter, the total potential Federal Government revenues that can be generated through sustainable mining of these offshore-sand reserves would amount to RM80.31 billion. The study also indicated that the distribution of exploitable sand in offshore areas is greatly controlled by the environmental impact criteria that mainly involve coral reefs, marine protected areas, cables, oil pipelines, oil platforms, and, to a lesser extent, artificial reefs, living aquatic resources. and turtle landing sites. The impacts of sand mining activities in Malaysia were first studied by JMG at Ramunia Shoals (Johor) where it had been actively dredged from 1996 to 2010. Offshore sand mining activities, if improperly managed, can result in economic loss and environmental degradation. This is because human activities involved in offshore sand mining, such as dredging, extraction, and transportation of the sand, could harm the hydrodynamics and ecology of the mining site and adjacent areas (Sulaiman et al., 2018).

2.3.1.5 Tin

Malaysia has the potential for offshore tin mining based on previous studies in the Straits of Malacca (offshore Negeri Sembilan and Perak) in 1976 and 1979. These studies were joint surveys by the Geological Survey Department of Malaysia (GSM) and the Federal Institute for Geosciences and Natural Resources (BGR). Placer deposits of cassiterite were found in a Pleistocene River valley and a tidal scour channel off Cape Rachado. The studies indicated the potential occurrence of tin deposits, especially in offshore Negeri Sembilan. However, a more detailed study must be carried out to confirm the tin reserves and the potential for mining. Several issues must first be attended to, such as the technology required for sustainable offshore mining: Government policy and regulations; and Standard Operating Procedures (SOP) especially for licensing, enforcement and royalties. To embark on offshore tin mining, the Government must first review the existing laws and regulations. The existing technology and SOPs for offshore tin mining in Lumut may be used as the baseline information.

2.3.1.6 Silica Sand

Malaysia, known for its abundant natural sources, is home to 640 Mt of silica sand, with 492 Mt coming from tin mine tailing sand and 148 Mt coming from natural silica (Azhar et al., 2020). A study conducted by JMG in offshore Negeri Sembilan in 2015 has found offshore silica sand deposits that can potentially

be mined. The study was carried out upon request from a company in the glass-making industry. The results showed that the silica content of the offshore sand deposits is in the range of 95–98%, which indicates a high potential as a source for offshore silica. However, a more detailed study must be carried out for further verification of the silica sand reserves, and the potential for mining.

2.3.1.7 Rare Earth Elements

A report commissioned by the Academy of Sciences Malaysia (ASM) entitled "Revitalising the Rare Earth Mineral Industry in Malaysia: A Strategic Industry", pointed out that Malaysia's aspiration to become a high-income nation is highly dependent on the success of its involvement in high and green technology. In another ASM publication published in 2014, entitled "A Blueprint for the Establishment of Rare Earth Industries in Malaysia – A New Source of Economic Growth", it was highlighted that the opportunity exists for Malaysia to become a centre for the manufacturing of rare earth permanent magnets, phosphors, lasers, and oil-refining catalysts.

The rare earth elements (REEs) comprise the 15 elements in the Lanthanide Group in the Periodic Table with atomic numbers 57 to 71. Yttrium (39) and scandium (21) are often included in this group of elements as they both display chemical properties and behavior akin to REEs. REE elements are normally divided into two categories: (i) light rare earth elements (LREEs) comprising elements with atomic numbers ranging from 57 to 63; and (ii) heavy rare earth elements (HREEs) comprising elements with atomic numbers ranging from 64 to 71. Yttrium is categorised as an HREE. There are four main types of REE deposits, namely:

1. REEs present as hard rock deposits,
2. REEs associated with placer deposits,
3. REEs associated with ion adsorption clay deposits, and
4. REEs associated with deep-sea mud deposits.

The first three categories have already been mined commercially. However, offshore REE deposits in deep-sea mud deposits are still at the pilot-test stage. REEs have physical and chemical properties that make them suitable and critical for high-tech and green-tech applications. These properties include:

1. Chemical – unique electron configuration
2. Catalytic – oxygen storage and release
3. Magnetic – high magnetic anisotropy and large magnetic moment
4. Optical – fluorescence, high refractive index
5. Electrical – high conductivity
6. Metallurgical – efficient hydrogen storage in rare earth alloy

The potential for mining Offshore REEs deposits in Malaysia is yet to be studied. However, based on our knowledge of the offshore geology, especially in the Straits of Malacca, where the underlying bedrock is likely to be mainly tin-bearing granite, such as in offshore Perak, Negeri Sembilan, and Melaka, offshore deposits of REEs may be an important potential mineral resource soon.

2.3.1.8 Minerals in the Water Column

Seawater contains large quantities of valuable minerals, some of which are very scarce and expensive in their land-based form. However, only a few minerals, the ones in high concentrations, are currently mined from the sea. Due to recent problems associated with land-based mining industries resulting in depleted high-grade ores, sustainable water, and energy demand, and environmental issues, seawater mining is becoming an attractive option. A comprehensive and critical review of the current methods

of extracting valuable minerals from seawater and seawater brines generated in desalination plants, has suggested ways to overcome some of the limitations and challenges associated with the extraction process. The extraction methods discussed are solar evaporation, electrodialysis (ED), membrane distillation crystallisation (MDC), and adsorption/desorption as done by Loganathan et al. (2017).

Authigenic minerals are formed by in-situ inorganic precipitation on the seafloor and within the sediment column. Barite is the only mineral that has been reported so far to form in the water column. Some authigenic mineral reactions are bacterially mediated, where the bacteria modify the immediate geochemical environment, inducing mineral formation. The most important marine authigenic minerals are barite, francolite (carbonate fluorapatite), evaporites, especially anhydrite/gypsum and halite, and Mn-Fe-oxyhydroxide that occur as nodules or crusts. The most important mineral for the economy is francolite, which forms phosphorite deposits when the tectonic-oceanographic conditions are favourable (Kastner, 1999).

The economic gains from mineral extraction depend mainly on the concentration of minerals in seawater and the market price of these minerals. It rises with an increase in the concentration and the market price of minerals. Several methods have been used to mine minerals from seawater. Recent technological advancements in these methods have led to the more promising potential of mining minerals. There are four main mining methods: (i) solar or vacuum evaporation; (ii) ED; (iii) MD/MDC; and (iv) adsorption/desorption/crystallization. In all these methods, the mineral concentrations are increased to the level of supersaturation to enable their crystallization.

There are a lot more minerals in the sea as compared to those in land-based reserves. Given the difficulties facing land-based mining industries such as sustainable energy and water demands, the depletion of easily available high-grade ores, and environmental issues related to waste disposal and miners' health, mining minerals from the sea is becoming more attractive. The increasing demand for clean water has led to the installation of more desalination plants worldwide. This process generates enormous amounts of brine. The brine contains all the minerals present in the sea at nearly twice the concentration of those in seawater. Mining minerals from these brines can offset part of the desalination cost as well as solve the brine disposal problem.

2.3.1.9 Mining in the Area Beyond National Jurisdiction

A. Deep Seabed Minerals

There are three major groups of deep-sea minerals that are of very high value namely:

i. Polymetallic Sulfides

According to the ISA, polymetallic sulphide deposits usually occur at water depths of between 1,000 and 4,000 meters. These deposits contain copper, zinc, lead, gold, and silver, as well as trace metals such as indium, germanium, tellurium, and selenium. The main areas where they can be found are in the Central Indian Ocean, Southwest Indian Ridge, and Mid Atlantic Ocean.

ii. Manganese Nodules

ISA reported that manganese nodules are found on the seabed in water depths of between 3500-6500 meters. The nodules contain mainly the chemical elements: manganese, iron, copper, nickel, and cobalt as well as molyb denum, zinc, lithium, vanadium, and traces of rare earth. The areas where they can be found in abundance are in the Western Pacific Ocean (so-called Clarion-Clipperton Fracture Zone) and the Indian Ocean.

iii. Cobalt Crusts

According to the ISA, Cobalt crusts are found on the seabed at water depths of between 1,000 and 3,000 meters. They contain mainly manganese, iron, cobalt, nickel and platinum, and rare earth elements. The areas where cobalt crusts are most commonly found are in the Western Pacific Ocean, the Rio Grande Rise in the South Atlantic Ocean, and the Magellan Mountains in the Pacific Ocean.

Occurrences of these mineral resources are limited to the deep sea, far from the normal continental margins of the world. Exceptions are Small-Island countries whose EEZs are within the deep-sea realm. In Malaysia, prospective areas for deep-sea mining would be in the South China Sea, in areas beyond 200 nm from its baselines. These areas may fall within its continental shelf according to Article 76 of UNCLOS as submitted to the CLCS. Within the Malaysian EEZ, some areas off Sabah have deep water regions that may have the potential for deep-sea mineral resources but have yet to be investigated. The People's Republic of China is actively exploring and researching the regions of the Pacific Ocean, Indian Ocean, and Clarion Clipperton Fracture Zone. Beyond the limits of the continental shelf as per UNCLOS, seabed resource exploitation will be under the purview of the International Seabed Authority (ISA). ISA has given out licenses for commercial exploration and exploitation of deep-sea minerals in some areas beyond 200 nm, e.g. in the Western Pacific.

Malaysia's Interest in Deep Seabed Mining in the Area Beyond National Jurisdiction

On 14 October 1996, Malaysia ratified UNCLOS, and in relation to seabed mining, Malaysia signed Part XI concerning "The Area" on deep seabed mining on 2 August 1994. Signing the Convention signifies Malaysia's position as a State Party to UNCLOS and a member of the ISA. ISA was established to regulate exploration, exploitation, production policies, commercial production, profit sharing, distribution of benefits, and other related activities in the Area.

Although there has been no Malaysian involvement in deep seabed mining activities so far, there is a pressing need to venture into this industry. In today's era of modern technologies with high-tech appliances and digitalization, such as smartphones and LCD devices, offshore mineral deposits of commercial value could be harvested for precious elements including REEs, cobalt, and nickel that are needed to make them and meet the increasing global demand. Several countries have already been actively pursuing opportunities to secure mineral resources from the deep seabed mining areas. With the rising demand for marine minerals as an alternative to traditional energy and income sources, Malaysia should also consider moving in this direction, especially because of the economic benefits and added values that could potentially be gained from this venture for Malaysia and related industry players as well as to the scientific community.

To date, 30 contractors have secured the concession on deep-seabed mining from the ISA, with 18 contracts for exploration of polymetallic nodules in Clarion-Clipperton Fracture Zone (16), Indian Ocean (1), and Western Pacific Ocean (1). Seven contracts for exploration of polymetallic sulfides were awarded in the Central Indian Ocean, the Southwest Indian Ridge, and the Mid Atlantic Ocean. The other 5 contracts were awarded for the exploration of cobalt-rich crusts in the Western Pacific Ocean, Rio Grande Rise of the South Atlantic Ocean, and Magellan Mountains in the Pacific Ocean.

The Government of Malaysia has always encouraged innovation and the pursuit of knowledge as well as expertise among its population. Seabed mining could be an emerging Blue Economy and Malaysia could also, at this initial stage, have our scientific experts attached to the institutions that are involved in researching deep-sea minerals and seabed mining. This can be done through the ISA under the 'Contractor Training' and 'Endowment Fund' training programs.

State of Blue Economic activities according to the 9 sectors – current state, past performance (2010–2020)

According to the 2018 PETRONAS Annual Report, the O&G sector contributed RM57 billion to the government in 2018 including dividends, taxes, cash payments, and export duty. In addition, PETRONAS states that a "revenue forgone" to the tune of RM254.7 billion cumulative since 1997 due to the implementation of regulated prices for energy supply (gas) in the power sector and non-power sector (including commercial, industrial, residential, and NGV users).

PETRONAS lists one of its sustainability targets as to cap GHG emissions to 49.5million tonnes of CO_2 equivalent for our Malaysia operations by 2024. According to its Sustainability Report 2018, PETRONAS has managed to reduce GHG emissions by over 12 million tonnes of CO_2-equivalent between 2012 and 2018. In 2010, PETRONAS established its Corporate Sustainability Council to manage sustainability issues within its Corporate Sustainability Framework. The latter defines areas of focus, which include Natural Resource Use, Climate Change, Biodiversity, and Ecosystem Services, which are particularly relevant to the currently proposed blueprint.

The total mineral production value in 2020 is approximately RM2000 billion in revenue. The main minerals exported were metallic minerals which contributed about 71%, non-metallic minerals 12%, energy minerals at about 15%, and by-product minerals at about 2% (Malaysia Mining Industry, 2020). The major minerals exported during the year were iron ore, copper ore, zircon and concentrates, aggregates, limestone flux as well as fireclay and other clays (Ministry of Natural Resources and Environment Malaysia, 2013). According to the information from Jabatan Ketua Pengarah Tanah dan Galian Persekutuan (JKPTG), Ministry of Energy and Natural Resources, the offshore-sand mining sector contributed RM26.06million to the federal government from 2008 to 2019 from royalty. Also, from 2017 to 2019, the export of offshore sand brought in RM55.8 million for the state governments.

2.3.2 State of Ecosystem

2.3.2.1 Benchmark international strategies and policies to identify gaps and challenges for use in developing best practices for Malaysia.

The O&G industry operates under strict guidelines administered by PETRONAS, in conformity with the domestic laws and regulations (under PDA 1974, as well as related applicable laws such as Continental Shelf Act 1966, and environment-related laws). The industry is a global one and follows the norms and standards of international best practices.

Offshore sand and mineral mining operate under strict guidelines administered by the Ministry of Energy and Natural Resources and State Authorities, in conformity with domestic laws and regulations (under Continental Shelf Act 1966, National Land Code 1965, Geological Survey Act 1974, Mineral Development Act 1994, as well as related applicable laws such as environment and enforcement-related laws). The Malaysian Mineral industry is committed to sustainable development as agreed by the Johannesburg Plan of Implementation in the World Summit on Sustainable Development in 2002.

Ongoing efforts to promote sustainable mining in Malaysia through the implementation of best practices, policies, and legislations referred to international strategies and policies such as the United Nations Sustainable Development Goals (SDGs), as well as the Australian and Indonesian Offshore Mining Acts for benchmarking. Before venturing into deep seabed mining, Malaysia must comply with the legal requirements under UNCLOS as well as other international regulatory frameworks including the ISA Mining Code, IMO Regulations, etc. Article 139 of UNCLOS specifically provides for the responsibility of Member States venturing into seabed mining to ensure compliance and liability for damage, while Articles 208 and 209 require States to have rules and regulations to prevent, reduce or control pollution from seabed mining activities within and beyond national jurisdictions.

O&G exploration and exploitation on Malaysia's continental shelf within 200nm is fast approaching maturity and sooner will require going further in areas beyond 200nm, in particular in the South China Sea. PETRONAS as a multi-national oil company has also increased its exploration activities outside Malaysia to ensure its revenue stream from the oil & gas business. In addition to conventional oil/gas resources, it is also involved in unconventional resources both at home and abroad, such as coal-bed methane in Sabah and shale gas resources in Canada and Argentina. In terms of gas hydrate exploitation, it is still very early stage.

As yet no specific efforts have been made to harness this energy resource although some preliminary basic works have been done (Sharef et al. 2018). There is some ongoing research on gas hydrates at PETRONAS Research Sdn Bhd and Universiti Teknologi PETRONAS. PETRONAS also prepares itself for alternative energy sources, including investing in research on renewable energy. In January 2020, it announced that the company will apportion 5% of its capital expenditure (CapEx) for renewable energy. As part of its "carbon commitments", PETRONAS has a policy of using renewable energy technologies in all facilities and projects where it is operationally and economically feasible to do so (PETRONAS, 2018).

In the mineral sector, offshore sand and mineral resources mapping in Malaysia offshore will be completed by 2030 in offshores of Kelantan, Terengganu, and Sabah. Research, Development, and Commercialisation (R&D&C) on offshore sand and minerals will commence in 2021 by the Mineral Research Centre, JMG, and is targeted to achieve at least 5 Intellectual Property Rights, value-adding, create value, and replace import substitutes materials within 10 years. The Malaysian Mineral

Development Board will be established in 2021 to boost the mining industry in the country.

Issues and Strategic Interventions

1. Gaps in the ecosystem include:

i. Insufficient capable and skilled local talent in oil and gas, and deep-sea mining; highly reliant on expatriate talent.
ii. Most talents reside at the federal level, with limited talent at the state level.
iii. Negative perception of the mining industry in general and of offshore and deep seabed mining in particular
iv. Lack of legal framework for offshore and deep seabed mining, particularly in areas beyond national jurisdiction
v. While the O&G industry has launched the CCS technology (via the PETRONAS Kasawari CCS project), other industries have been slow to take up the challenge

2. Intervention strategies

i. Encourage industry shift towards more eco-friendly jobs
ii. Increase awareness of sustainable marine-based economic activities
iii. Apply the "Geopark" concept of sustainable economic development while protecting natural geoscience resources in marine/oceanic areas ("Marine geopark".)
iv. Apply technologies that can convert by-products into useful things (e.g. CO_2 byproduct from O&G production)
v. Improve the linkage between industry and academia
vi. Improve and introduce back of industrial grant scheme
vii. More coordination on the market demand and fundamental research
viii. Increase public awareness in Ocean Technologies
ix. Conduct training to help scientists and technologists communicate better with the public on science and technology issues of importance to society ("layman language").
x. Create multidisciplinary Working Groups to solve mutual concerns and problems
xi. Train more talent in science and technology at the state level
xii. Encourage an agile (flexible) management structure that is driven by data and facts
xiii. Ocean literacy – improved public knowledge and awareness of the oceans.

3. Flagship programmes and game-changers.

i. CCS - CO_2 capture and sequestration and related technologies

a) Leveraging on the initiative by PETRONAS in implementing its CCS programmes, other industries should follow suit in a concerted effort to mitigate the impact of CO_2 and other GHG emissions on climate change. Research and development on CCS have the potential to generate spin-off technologies that are beneficial to other industries and society at large.

ii. Deep Seabed Mining

a) A legal framework for offshore minerals and in particular deep-sea minerals should be established to make way for Malaysia's private sector or government-linked entities to venture into this industry.
b) The expertise and technologies needed to come from abroad during the initial stages, but capability development will be one of the main thrusts in this endeavor.

4. Quick Wins and longer term programmes

i. Quick Wins

a) Have Malaysian scientists attached to the institutions that are involved in researching on deep-sea minerals and seabed mining. This can be done through the ISA under the 'Contractor Training' and 'Endowment Fund' training programs.
b) Research on minerals extraction from seawater and its other uses
c) Conduct further investigation on the potential of offshore deposits of REEs in Malaysian waters
d) More detailed study of silica sand reserves and the potential for mining.
e) Detailed study of the offshore tin reserve

ii. Long Term programmes

a) Establish a collaborative platform to bring together various stakeholders and experts to share knowledge and ideas
b) Ensure all talent have multidisciplinary exposure to different skills sets, including entrepreneurial problem-solving skills
c) Conduct to help scientists and technologists communicate science and technical matters to the public in laymen's language
d) Better management of offshore sand mining and impacts on the environment
e) Improve structural governance and linkage between federal and state agencies in managing the activities in this sector
f) Collaboration between the industry and academia –market demand
g) Marine spatial planning (national ocean database
h) Research on the utilization of abandoned offshore installations as well as by products such as CO_2.
i) Research on CCS (or CCUS) and encourage spin-off technology development for use in other sectors

2.3.3 Issues, Gaps and Challenges

Table 6 Issues, Gaps and Challenges for Extractive Industries of Non-living Ocean Resources

Governance and Collaborative Platform	Industries Competitiveness	Talent	RDICE	ESG & Climate Change Issues
• Lack of legal framework for offshore and deep seabed mining, particularly in areas beyond national jurisdiction. • A gap in term of regulations between federal and state. • Slow uptake of CCS technology (except PETRONAS Kasawari CCS project). • Lack of public and industry awareness on offshore minerals and deep seabed mining. • Public perception and distrust on the technology (e.g., coal energy and desalination). • Political intervention consideration. • Shortage of water and equitable resources.	• Lack of comprehensive financial support system. • Lack of consultancy services and integration. • Lack of technical skills for the operations of advanced technology/ maintenance. • There is no balancing between the Federal government with income generation.	• Insufficient capable and skilled local talent in oil and gas, deep sea mining; highly reliant on expatriate. • Limited talents reside at state level. • Lack of coordination between technical people.	• Lack of natural resources assessment. • Lack of R&D in new technologies. • Research by university is too advanced but industry is not ready to accept/implement. • Lack of support from industry to implement a new technology. • Lack of the lab-to-market fund (pre-commercialisation). • Reluctancy to accept/ lack of confidence on local product. • Availability of other low-cost conventional technology and more competitive.	• Negative perception of mining industry in general and offshore and deep seabed mining in particular. • Low awareness of sustainable marine-based mining activities. • Increasing ESG requirement and standards will adversely impact the industry. • The industry also plagued by market volatility. • Brine effluent may impact sea water or environment.

2.3.4 Way Forward

Since 2013, PETRONAS has implemented a growth strategy against a backdrop of increasing energy demand and resource depletion towards exploring clean energy and adopting commercial renewable energy technologies that use solar and wind for power. Concerns for climate change have accelerated the push for cleaner and sustainable energy by establishing a new division called Gas & New Energy, which will lead the corporation in transitioning towards a low carbon future. Fossil fuels would remain as the core of its global energy source, but the company is actively pushing for the increased use of natural gas, as evidenced by its activities in Egypt, Canada, and Australia, as one of the top five LNG sellers in the world. Figure 18 illustrates the projected map for the O&G industry in Malaysia and figure 19 shows the projected roadmap for the Malaysian offshore minerals industry.

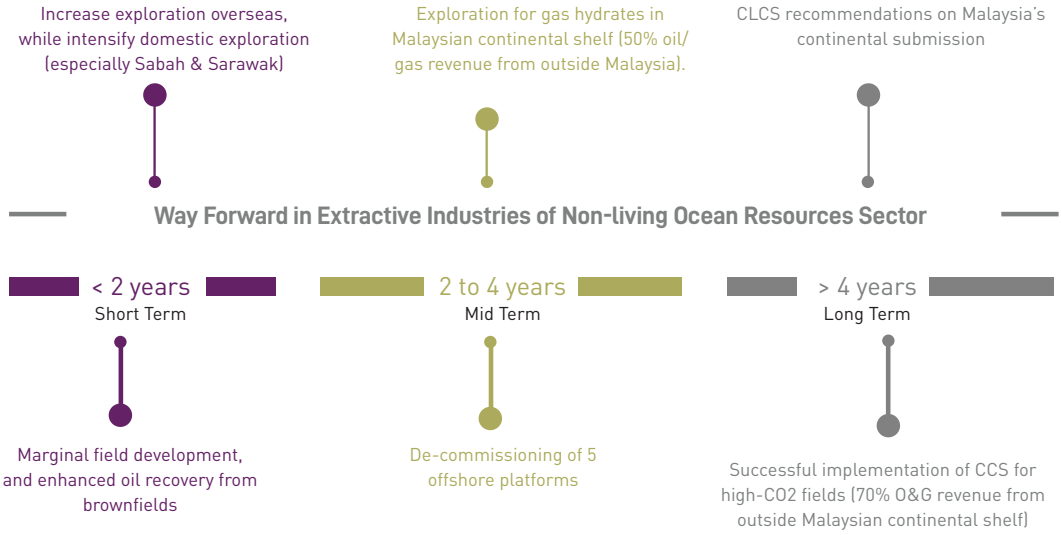


Figure 18 Projected Roadmap for the Malaysian O&G Industry

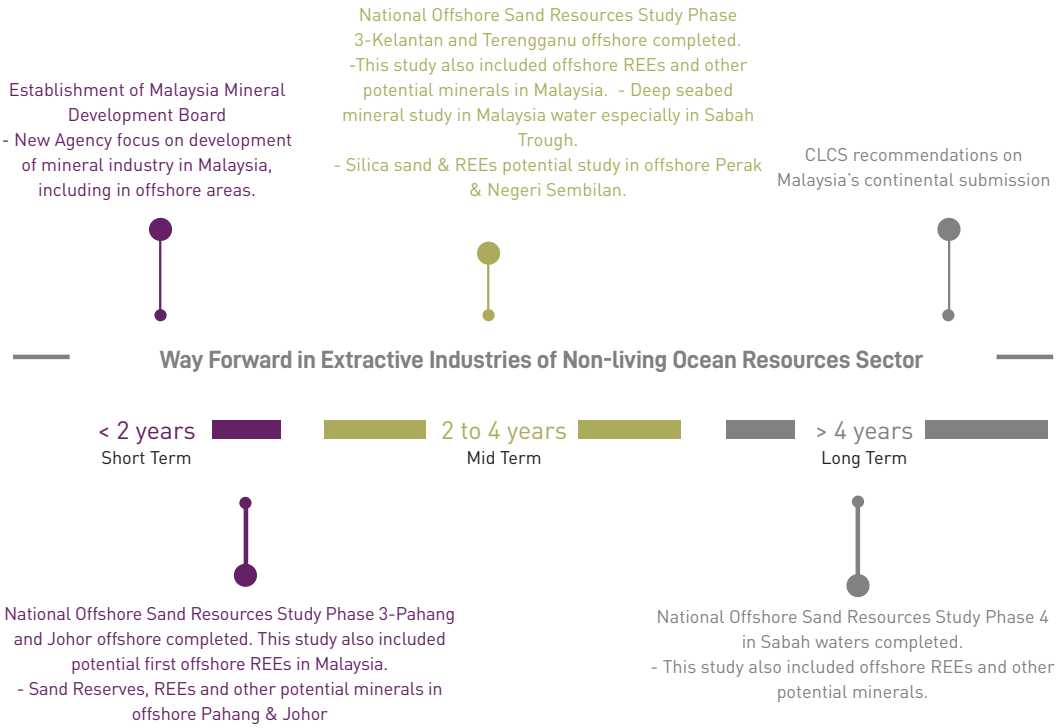


Figure 19 Projected Roadmap for the Malaysian Offshore Minerals Industry

2.4 Maritime transport, ports, and related services as well as shipping and shipbuilding

2.4.1 Introduction

According to the United Nations Conference on Trade and Development (UNCTAD), Malaysia is the world's fifth-best connected country in terms of shipping line connectivity, ahead of the Netherlands and the United States. Malaysia container transshipment hub in the region and a market leader in handling and exporting oil and gas products. Over the last ten years, Malaysian ports have recorded an average growth of 3% in compound cargo throughput. Following a drop in 2017 due to a change in the shipping line market and overall lows in global seaborne trade, cargo throughput recovered in 2018 totalling 568 million tonnes (Figure 20). About 70% of the cargo is containerised. With a total throughput of 26.2 million TEUs in 2019, Malaysian ports handled almost as many containers as the ports of Rotterdam and Antwerp combined (Figure 21). While the majority is transshipment, cargo that does not enter the country, Malaysian exports and imports accounted for respectively 4.5 and 4.4 million TEUs in throughput. Last but not least, as one of the world's largest liquefied natural gas (LNG) exporters, Malaysia is home to the first floating LNG port facility and the largest palm oil terminal in the world (IRO, 2019).

Halal logistics covers the entire supply chain process that adheres to a halal standard. The process encompasses several processes, such as the production and processing of the product, packaging, storage and warehousing process, transportation, inventory, scheduling and distribution, retailing, and delivery of the product to the consumer. In Malaysia, several ports such as Penang Port have been certified as Shariah-compliant ports and been promoted to be involved in the production of halal products for export (Mahidin et al., 2016). Penang Port is located along the Straits of Malacca, one of the busiest shipping lanes in the world. Penang Port is now a major halal port in Malaysia, also known as the second biggest halal port in the world following the footsteps of Rotterdam Port, which is considered the largest halal port in which halal traceability and Shariah-compliant logistics are the most trustworthy (Alserhan, 2017). Penang was the first port of discharge for ships sailing from Europe and India to the Straits Settlements during the colonial era. This historical advantage has been undermined by the growing size of vessels used in world shipping.

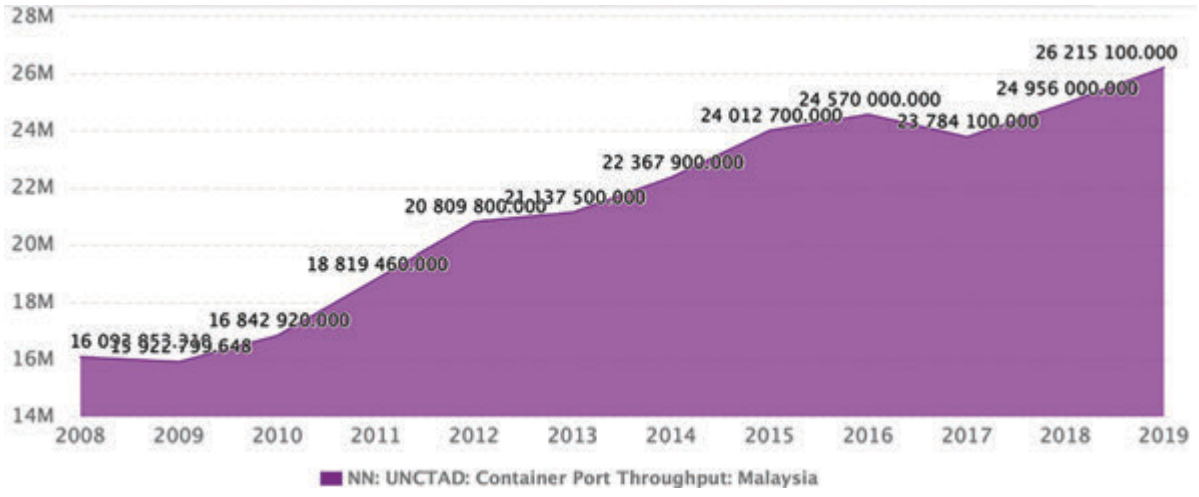


Figure 20 Cargo Throughput by Malaysian Ports

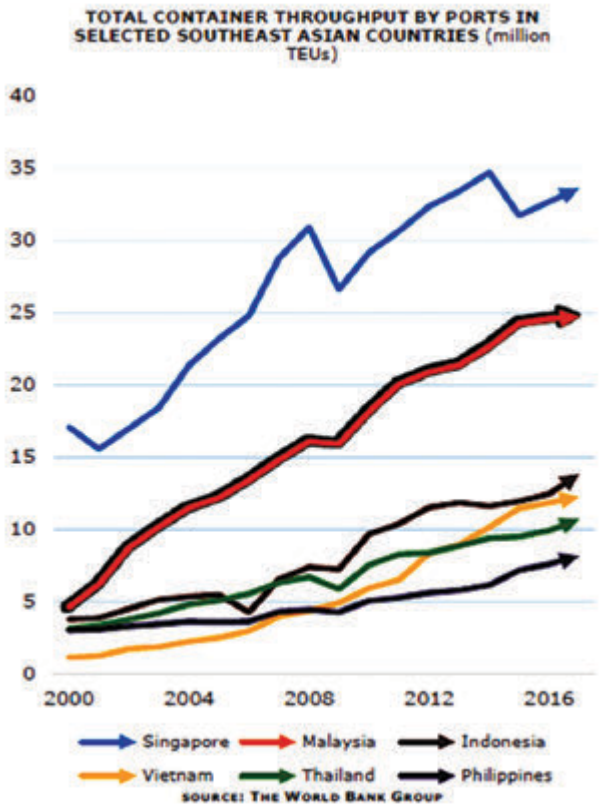


Figure 21 Total Container Throughput by Ports in Selected Southeast Asian Countries

Maritime Cluster of Malaysia: The Maritime of Tomorrow

The Malaysian Maritime Cluster consists of Maritime transport and logistics; ports and related services; and shipping and shipbuilding. The Maritime Cluster of Malaysia provides pragmatic and ready-to-use recommendations and a monitoring system to establish an effective ocean-policy platform to support the maritime cluster towards sustainable development. The Maritime Industry in Malaysia contributes about 40% of the country's gross domestic product (GDP) (MIDA, 2021). In an attempt to strengthen maritime sustainable development, the stakeholders have joined forces in a maritime cluster to increase innovation and business development. The initiative mechanism used is increased contact and collaboration between the maritime firms and research and provides a connection to innovation and maritime policies as well as the national maritime strategy. The long-term goal of all these efforts is growth in the maritime sector sustainably.

The maritime cluster is considered to consist of several interconnecting elements that relate to or are dependent upon the sea:

1. The maritime industries and associated services and infrastructures;
2. Government, defence and security;
3. The marine and coastal environment;
4. Maritime services;
5. Shipping;
6. Ports and terminals; and,
7. Maritime equipment and suppliers (shipbuilding ship repair – SBSR)

In addition, the SBSR industry is the activity of 'manufacturing' and repairing floating structures (vessels, etc.) comprising processes of engineering and design, procurement of material and equipment, construction, installations, testing and commissioning, and delivery.

Floating structures or assets, either propelled or non-propelled are included in the scope of the SBSR industry. These include fishing vessels, yachts, offshore supports vessels (OSVs), naval vessels, cargo ships, oil/gas/chemical tankers, and many other commercial vessels. The industry players are technology companies; shipyards and their supply chains; marine-related industries that supply materials and equipment; and services providers like ship designers and classification societies.

It is increasingly recognised that effective management of - or in - the maritime cluster is of necessity a multidimensional and complex process involving the interaction of communities, government and international organizations and conventions, the maritime industries player, and the marine environmental sciences. These elements are interrelated and interconnected (Figure 22):

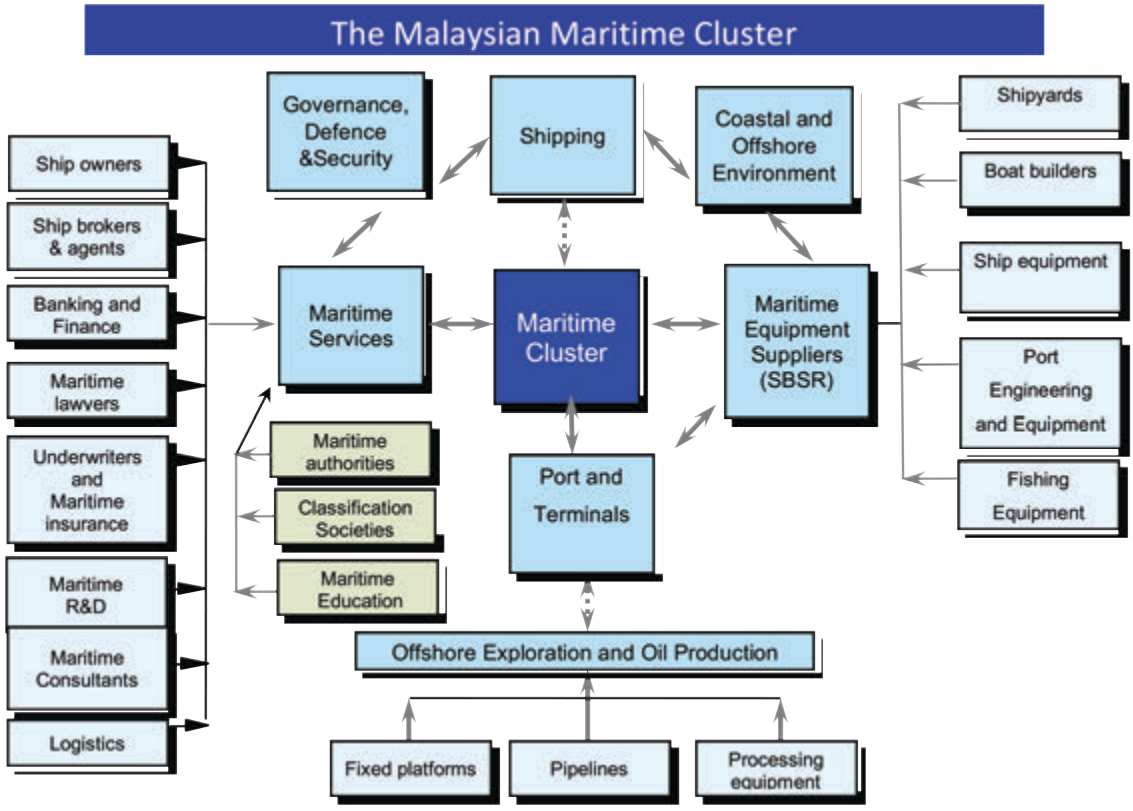


Figure 22 The Malaysian Maritime Cluster

2.4.2 State of Ecosystem

Malaysia has been investing in e-navigation technologies to facilitate the growing number of ships transiting the Malacca Straits via the country's various ports including Port of Tanjung Pelepas and Port Klang. In support of Sustainable Development Goal (SDG) initiatives, Malaysia plays an active role to promote green ports and shipping, whilst protecting the environment for future generations. One such effort is to reduce the CO_2 emissions from Malaysian ports and fleets. The maritime industry has lost billions of dollars annually through the supply chain due to the inefficient storage plans, poor vessel and voyage performance, lack of coordination from key stakeholders, insufficient port systems, and equipment breakdown. Thus, the digitalization of the maritime industry's ecosystem is crucial for improving operational efficiency, enhancing data gathering

and data analytics, empowering customer experience, and saving costs. In addition, the increasing vessel sizes and cargo volumes continue to pressure ports and terminals. This requires ports to maintain a competitive advantage by adopting digital mindsets and implementing smart-port technologies to stay productive, customer-friendly, and efficient. Modern ports are embracing the same digital breakthroughs that are disrupting other industries. Among those disrupters are connected platforms, cloud-based services, mobile devices and apps, sensors and other Internet of Things (IoT) technologies, augmented reality, autonomous transportation, blockchain technology, and big data.

Port Cities or port-based major cities need to operate sustainably to minimise their environmental impact. In addition to dealing with the challenges that confront midsize and large ports, leading global ports located in major city areas such as Shanghai, Hamburg, Singapore, New York, and Los Angeles should be conscientious stewards of the environment. This can be done by minimizing the pollution, noise, and traffic they create for their urban neighbours. For a major port and city to coexist as sustainably as possible, the port must monitor and reduce the local environmental impact of moving vast amounts of cargo. Smart digital port technologies can help to manage the wear and tear, and environmental impact of cargo-related traffic on city roads and infrastructures and meet increasingly stringent safety and security requirements. Among the technologies that have been adopted by port cities are to monitor traffic on port access roads (Singapore and Hamburg); and Port Klang introduced the Ucustoms, Port Klang Net, and e-Gateway (Business to Government (B2G), Business to Business (B2B). Other technologies monitor air and water pollution, employing a network of sensors like the system in the Port of Rotterdam. Data from these systems can be fed into port-wide platforms that aggregate and share information among port stakeholders. At ports in Hamburg and Antwerp, for example, such data platforms create additional operating efficiencies across the port ecosystem and are potential sources of data enablers services for port users.

The future potential game-changers in this industry are based on the de-carbonization and environmental awareness, challenging the way ships and ports are designed and operated, with future regulations requiring significant investment in ensuring compliance to the various environmental codes, for example, the Code for Approval of Ballast Water Management System. To comply with the IMO objective to cut 50% of total GHG emissions by 2050, efforts have been ongoing to increase energy efficiency and the development and use of alternative fuels regardless of trade growth. These challenges could potentially be best alleviated through a university-led strategy focusing on the quadruple-helix collaboration of university-industry-community-government that joins together the main players towards the implementation of SDG at the national level in the maritime industry inclusive of the Ship Building and Ship Repairing (SBSR) sector.

The Malaysian Ship Building and Ship Repairing (SBSR) sector started with the establishment of Brooke Dockyard in Sarawak (1912). Since then, vessels made by local shipbuilders are sold worldwide. However, the importance of the SBSR industry is underrated and misunderstood as belonging to the shipping sector. Hence it is placed under the Ministry of Transport, which focuses on shipping. The industry directly supports activities in the shipping industry, fisheries, oil & gas, ports operation, as well as tourism and creates job opportunities. Meanwhile, the advancement of its technological content is vital to its application in national security and defence. Globally shipbuilding is also recognised by Organization for Economic Co-operation and Development (OECD) as having strategic importance in terms of employment generation, industry capacity, technological capability as well as other benefits. As such, the SBSR industry needs a dedicated agency to nurture and oversees its growth. Globally, China, South Korea, and Japan are the top three countries in the SBSR Industry. They have about 92% share of the world's gross tonnage of shipbuilding. Closer to home, the Philippines (8), Singapore (9), Vietnam (13), and Indonesia (16) are ahead of Malaysia (20).

[Numbers in brackets refer to world ranking. (DNV-GL & Menon, 2018)]

Looking into the future, a dedicated agency to manage the maritime industry can be proposed, and aligning with the goals of the 2030 agenda for sustainable development, the maritime industry must work towards balancing the three dimensions of sustainable developments: the profit; the planet; and, the people, which were found to be imbalanced in the international maritime logistics and transport domain.

The Malaysian maritime industry is strongly influenced by national and international law and policy. The ports and shipping sector are placed under the purview of the Ministry of Transport. However, the SBSR sector is strongly influenced by national government policies and machinery. These ministries and agencies played significant roles in its growth or otherwise: Ministry of International Trade and Industry (MITI); Malaysian Industrial Development Authority (MIDA); Ministry of Home Affairs; Malaysia Maritime Enforcement Agency (MMEA); Ministry of Defence; Royal Malaysian Navy (RMN); Ministry of Transport; Marine Department; Department of Fisheries; Lembaga Kemajuan Ikan Malaysia (LKIM); Ministry of Finance; Royal Customs Department. One main reason for the lack of attention or focus on the SBSR industry by the government is that its domain exists in too many ministries. In summary, the key enabling factors are absent in the case of the SBSR industry.

Malaysia has been investing in e-navigation technologies to facilitate the growing number of ships transiting the Malacca Straits via the country's various ports including Port of Tanjung Pelepas and Port Klang. In support of Blue Economic activities and Sustainable Development Goal (SDG) initiatives, Malaysia plays an active role to promote green ports and shipping, whilst protecting the environment for future generations. One such effort is to reduce the CO_2 emissions from Malaysian ports and fleets.

The maritime industry has lost billions of dollars annually through the supply chain due to the inefficient storage plans, poor vessel and voyage performance, lack of coordination from key stakeholders, insufficient port systems, and equipment breakdown. Thus, the digitalization of the maritime industry's ecosystem is crucial for improving operational efficiency, enhancing data gathering and data analytics, empowering customer experience, and saving costs. In addition, the increasing vessel sizes and cargo volumes continue to pressure ports and terminals. This requires ports to maintain a competitive advantage by adopting digital mindsets and implementing smart-port technologies to stay productive, customer-friendly, efficient, and towards a new normal activity after the COVID-19 pandemic crisis is over. Modern ports are embracing the same digital breakthroughs that are disrupting other industries. Among those disrupters are connected platforms, cloud-based services, mobile devices and apps, sensors and other Internet of Things (IoT) technologies, augmented reality, autonomous transportation, blockchain technology, and big data.

The local SBSR industry is much dependent on the offshore industry and the government sector. The oil price slump in 2014 has affected the total revenue of the SBSR industry. For the year 2018, the revenue was RM 7 billion compared to an all-time high of RM 8.35 billion in 2013 since the launch of the SBSR Industry Strategic Plan 2020 in 2011. The oil price has remained low since then, especially during the COVID-19 pandemic crisis. The SBSR industry is in survival mode and government intervention is crucial in achieving success for this sector.

The future potential game-changers in the maritime industry are based on the de-carbonization and environmental awareness, challenging the way ships and ports are designed and operated, with future regulations requiring significant investment in ensuring compliance to the various environmental codes, for example, the Code for Approval of Ballast Water Management System.

To comply with the IMO objective to cut 50% of total GHG emissions by 2050, efforts have been ongoing to increase energy efficiency and the development and use of alternative fuels regardless of trade growth. These challenges could potentially be best alleviated through a university-led strategy focusing on the quadruple-helix collaboration of university-industry-community-government that joins together the main players in the implementation of the Blue Economy activities and SDG at the national level.

2.4.2.1 Benchmark international strategies and policies to identify gaps and challenges for use in developing best practices for Malaysia.

Maritime clusters including Seaport Cities or port-based major cities need to operate sustainably to minimise their environmental impact. In addition to dealing with the challenges that confront midsize and large ports, leading global ports located in major city areas such as Shanghai, Hamburg, Singapore, New York, and Los Angeles should be conscientious stewards of the environment. This can be done by minimizing the pollution, noise, and traffic they create for their urban neighbours. For a major port and city to coexist as sustainably as possible, seaports must monitor and reduce the local environmental impact of moving vast amounts of cargo. Smart digital technologies especially for seaports ecosystem can help to manage the wear and tear, and environmental impact of cargo-related traffic on city roads as well as infrastructures and meet increasingly stringent safety and security requirements. Among the technologies that have been adopted by seaport cities are Singapore and Hamburg to monitor traffic on seaport access roads; and Port Klang introduced the Ucustoms, Port Klang Net, and e-Gateway (Business to Government (B2G), Business to Business (B2B). Other technologies monitor air and water pollution, employing a network of sensors like the system in the Port of Rotterdam. Data from these systems can be fed into seaport-wide platforms that aggregate and share information among seaport stakeholders. At ports in Hamburg and Antwerp, for example, such data platforms create additional operating efficiencies across the seaport ecosystem and are potential sources of data that enable services for seaport users in the maritime cluster.

For the SBSR industry, top shipbuilder countries like China, Korea, and Japan create business models through joint ventures, private investments, new technology, and market exploration such as the blue ocean economy to ensure sustainable economic growth. The UK and Australia have implemented procurement reformation where the design, build, and integration work scopes for the new building of government vessels must be done locally, in collaboration with foreign partners if needed. Indonesia has enforced a cabotage policy that resulted in a 25% average growth of the local fleet annually since its implementation in 2008, according to INSA (Indonesia National Ship Owners' Association).

There are three main local services sectors that are directly related to the SBSR industry. These three that seem to operate independently are the security sector, fishing, and OSV (Offshore Support Vessels). The security sector is made up of the Royal Malaysia Navy (RMN), Malaysia Maritime Enforcement Agency (MMEA), the Royal Malaysian Customs Department, the Marine Police, Marine Department and others.

The total SBSR market value for these three sectors is estimated at RM 3 billion annually. Currently, these three sectors have one common parameter. All are operating in Malaysian waters and EEZ. The fishing and OSV sectors should act in a common interest to protect the country's sovereignty by collecting data and becoming the eyes of the nations. There are more than 200 OSVs and about 2000 fishing vessels. These 2200-plus fleet of OSVs and fishing vessels can function as 'RELA' at sea to complement the government vessels of about 200 only. Our

country's surveillance capacity would increase 10 folds at no additional capital expenditure except for training and other administrative costs. This is one major change in our business model to sustain the Blue Economy that would require policy and regulations to enforce it. The security of our ocean resources would receive better and wider coverage and protection.

The vessels for all these three local services sectors should be locally engineered and designed, and to be built by local companies at local shipyards, using locally produced material and equipment. This will create a sustainable ecosystem for the local SBSR industry.

Looking into the future and aligning with the goals of the 2030 agenda for sustainable development, the maritime agencies and industry must work together toward balancing the three dimensions of sustainable developments: the maritime economy; the ocean health; and the coastal community.

The new government after six decades provides Malaysia with the opportunity to reflect on and review its mechanism in positioning Malaysia as a true maritime nation and the high time in developing Malaysia's Comprehensive national Ocean Policy. It is also appropriate for Malaysia to take a more active role in regional economic integration, focusing on inclusive, Blue Economy growth and considering its role in the multilateral trading system. Malaysia must not only continue to maintain an open, liberal trade and investment environment, but more importantly, the country must ensure that its policies are relevant in the face of technological changes and demands as well as the implementation of the 2030 Agenda for Sustainable Development Goal that has been adopted on 25 September 2015 at a special UN summit. Thus, it is an opportune time for reviewing its maritime law and policies and making adjustments in line with the regional and global developments. A good place to start would be positioning Malaysia as a regional distribution centre, commitments at the regional and multilateral levels. This would give policymakers an appreciation of the gaps and provide clarity on the way forward.

A review of domestic law and policies should include trade facilitation, regulatory environment, digital connectivity, SME development, and capacity building. The maritime stakeholders including the policymakers should help the maritime industry to take a step back and look at the big picture to inform future investment portfolios. The opportunity to develop long-range technology, including science and technology plans should be welcomed and implementation of the new structure for sustainable management of the ocean should be prioritised. The management of ocean resources to facilitate sustainable economic development requires a cluster strategy based on sound information flow, cooperation between maritime industry communities, and the strength of the maritime industry sector.

The Maritime industry sector has been identified as having a significant role in achieving effective exploration and exploitation of the ocean areas through the provision of a new proposal on the governance structure that is appropriate for decision making toward sustainably managing the ocean areas. What is needed is the political will to effect a change to systems-centred thinking and planning of the future of the maritime industry sector by actively seeking to encourage the development of a competitive maritime cluster. If Malaysia wants to achieve the goals of industrialization and become a developed maritime nation with a knowledge-based economy, productivity-driven growth, and enhanced competitiveness, much will depend on how the ocean areas are managed and protected. A competitive and sustainable maritime industry is in Malaysia's long-term interest and essential to the nation's prosperity. Therefore, to position

Malaysia as a true maritime nation, ocean governance should be recognised via a national ocean policy, a dedicated maritime affairs minister and the adoption of a co-management principle are very important to maintain its maritime pre-eminence as a developed maritime nation.

Malaysia is seen as business-friendly and attractive to investments, both foreign and domestic. However, to maintain and improve its competitiveness in the face of global economic, technological challenges and environmental issues, and the latest global crisis (COVID-19 pandemic), Malaysia would do well to review its maritime policy regime, develop a comprehensive maritime policy for sustainable development and high time to explore the need for a national maritime agency, establishing a national coordinating entity is necessary to accelerate the emergence of "Malaysia as a truly maritime nation".

Issues and Strategic Interventions

Malaysia is a maritime nation located strategically, which makes it stand out on the map of maritime trade where 90% of trade is via shipping (MEPSEAS, 2020). With the country surrounded by an ocean virtually two times larger than the land area, Malaysia can increase its maritime global competitiveness. Its strategic location alone however is not sufficient to generate increased trade demand. Malaysia needs to develop several different sectors in port facilities, shipping, shipbuilding, and related services.

Nonetheless, Malaysia is already there for container shipping, but more effort is needed if it aims to become the region's number one in container traffic. Similarly, Malaysia being an oil-producing nation can improve its patchy and fragmented involvement in servicing this sector.

In addition, shipping is not all about containers or oil and gas only. Other sectors are equally lucrative and industrially sustainable, and if planned and shaped correctly based on the Blue Economy platform, could become a big economic driver and generate high-income activities.

Malaysian maritime policies also need to be improved. Currently, Malaysia has at least 15 federal laws and orders to manage its maritime industry, while the enforcement of these laws is entrusted to 31 maritime-related agencies from more than 10 ministries.

Another approach that will lead to increased maritime global competitiveness is by remaining open to ideas by the logistics players as well as the main contributor to Malaysia's Gross Domestic Product (GDP). The bottom line, as a maritime nation, Malaysia needs to undertake enough effort, strategic decisions, and policy revision to enhance the maritime sector that in turn will improve the nation's maritime global competitiveness.

With this awareness in mind, the 1st stakeholder engagement workshop organised by the ASM on 3rd October 2021 is to develop a resolution from the Blue Economy stakeholders. Initiated as a manifestation of ASM's role in developing a position paper for the Blue Economy and generation of the knowledge, skills, and practice in the ocean industry, the workshop gathered maritime industry players all over Malaysia. The main objectives of this workshop were as follows:

1. To address current critical issues and challenges from the maritime industry perspective,
2. To highlight new ideas inclusively from various stakeholders in enhancing the maritime industry to improve global competitiveness,
3. To propose resolutions based on the workshop's inputs for policy decisions and implementation.

The workshop discussed at length many issues and challenges concerning the government and collaborative platform, industry competitiveness, talent, SWOT analysis of the industry, Environmental Social Governance (ESG), and climate change issues as well as the recommendation of flagship initiatives for strategic interventions relating the Blue Economy in the maritime industry. The following are the summaries

a. Governance and collaborative platform

Due to the lack of coherent or comprehensive ocean policy, disjointed and overlapping the marine or ocean-related jurisdictions related to the seaports sector, shipping, and shipbuilding that contributed to issues of marine safety and security such as marine pollution, sea robberies, submarine cable (cabotage policy).

To overcome these issues, a strong centralised governance system is required:

i. With the effectiveness and better coordination with the industry stakeholder and enforcement agencies, the Blue Economy needs to be aligned with other national plans.
ii. Privatization of seaport policy has delayed some decision-making process, and bureaucracy issue has caused the seaport authority to lose its jurisdiction to control the entire process in a very efficient manner. It is important to retain the legislative power under seaport authority in ensuring smooth freight distribution in the supply chain. Thus, the establishment of the National Port Authority is important to effectively coordinate and cooperate with the seaport sector for developing stable infrastructure and sharing the resources towards the single window ecosystem.
iii. Since the 1980s, there have been unresolved debates on overcoming or reducing the overlapping tasks of various agencies. It is high time for all maritime-related agencies in the country to collaborate and consolidate necessary work processes and data through the setting up of a commission or a maritime ministry. Development of an ocean policy and the vehicle to carry out the ocean policy is through the establishment of an ocean authority (Lembaga) or Council chaired by the Prime Minister which is crucial for the sustainability of the ocean industry.

b. Maritime Industry Competitiveness: Seaports and Shipping Sector

All parameters concerning the qualitative aspect of the local maritime industry, such as customer-centric services, landside integration, value-added services, interoperability, and connectivity need to be equally treated as key factors for the maritime industry to be substantial nodes for global competitiveness. In addition, a complete and comprehensive financial support system should be provided in this industry.

The goal of Malaysia's cabotage policy is to safeguard and promote the domestic shipping industry. It is important to have relevant ministries and agencies investigate this matter seriously. MASA (including OSV, MOSV, and SSA) has highlighted that the government must consider a review of the policy, including restricting the exemption to international transhipment container trade in all ports of East Malaysia and subsea pipeline issues.

The issues such as data depository, sharing, and connectivity using a single-window or single unified system shall be introduced to achieve a competitive advantage in this industry. Thus, the strategic interventions have been introduced:

i. To review, communicate and share the industry KPI status with the stakeholders. Revisit the previous master plan and the status of the KPI achievement of this master plan. The knowledge can be shared with the stakeholders.
ii. The real data showing the contribution of the maritime industry to the nation's GDP economy should be developed and shared among industry players.

iii. Adopt digitalization and automation toward a lower carbon footprint.

c. Maritime Industry Competitiveness: Imbalances in the Shipbuilding Industry

Recognizing the impact of COVID-19 on the shipbuilding industry, there is a critical need to enhance the performance and competitiveness of the industry to avoid national income losses. Hence, intervention to support and promote the Malaysian shipbuilding industry is paramount. This industry has potential for further growth through a continuous effort by various parties in the areas of shipyard facilities and capability improvement. On the other hand, Malaysian local shipyards are capable of and competent in building and supplying the nation's ship demand.

The strategic interventions have been suggested:

i. Need to have transfer technology. The shipbuilders need to invest in the latest technology and advanced machinery.
ii. Due to the lack of vendors on ship's parts, machinery, and support services in the local ship service providers. Introducing the incentives to the manufacturers to set up their manufacturing facilities in the country and create more job opportunities (Malaysia as a regional Centre for commodity storage).
iii. Increasing the collaboration among local shipyards.
iv. Introducing the Maritime Fund to support the shipbuilding, ship repairs, and maritime support services to increase the competitiveness and sustainability in this sector as well as to increase and promote the local ship registration.

d. The Maritime Talent

Needs to improve and strengthen the maritime talent, especially at the degree level, and give an incentive to the employers to cooperate for developing the talents in this industry by providing high-impact and effective programmes that generate future holistic talents in the semi-professional and professional workforce in the field. This can be achieved by strengthening the framework and pathways involving the provision of skilled lecturers, and state-of-the-art facilities for teaching and research with full support from the government.

e. Environmental Social Governance (ESG) and Climate Changes Issues

Maritime threats include piracy, terrorism, drug trafficking, illegal migration, Illegal Unreported, and Unregulated (IUU) fishing, and climate change. Based on the notion of Blue Economics and Maritime Domain Awareness, management of Malaysia's seas should be based on balancing the need for continuous use of the sea for economic activities and the need to maintain the security and safety of the marine eco-system towards ESG. Thus, continuous financial support from the government in terms of incentives and subsidies is needed.

For the climate changes issues, we need to have more monitoring ocean system (sensors) installed in the ocean to monitor climate change and its impact on the local economy.

The ship and offshore structures recycling facilities in Malaysia have also been suggested to create a new opportunity in terms of new business for local industry.

f. Recommendation and Flagship Initiatives

The challenge in this industry comprises:

i. Lack of Political Will

It is crucial to consider all aspects of a major decision in the context of PESTEL, which includes

politics, economy, social, technology, environment, and legal expectations in exploring the blue ocean economy. We have segregated maritime governance in terms of maritime transport safety and regulations, enforcement issues, maritime security and sovereignty, environment, and foreign relations. There is no harmonization of rules and regulations between Peninsular and East Malaysia.

ii. Overlapping Agencies

Overlapping tasks in Malaysian government agencies have created difficulties for the industries, and this has slowed down the progress of the development of Malaysia as a maritime nation and exploring the ocean industry under the blue ocean platform. This is not conducive for the industry to move forward, especially for the shipping and shipbuilding sector. Thus, for the shipbuilding sector, the opportunities for new types of shipbuilding, like leisure boats and yachts, as a potential business for Malaysian shipbuilders need to be seized. Foreign ship imports mean a loss of income for the Malaysian shipbuilders. The vigorous action from the stakeholders to secure the projects on shipbuilding in Malaysia instead of ordering ships from foreign countries contributes to Malaysian economic deprivation. Thus, to be competitive internationally, we need to improve existing maritime-related policy implementation.

iii. The Need for Agile and Flexible Cooperation

The maritime sector is vast. The cooperation between the Ministry, Customs, Immigrations, and the other stakeholders has developed another dimension for the maritime industry to be agile and flexible in coping with the new trend (i.e., National Single Window System). This enables Malaysian to be more competitive in the global maritime industry.

iv. Public-Private Partnership (PPP)

It is time for a game-changing move, whereby the maritime industry needs to be revamped regarding its operating procedures and investment policies, especially via Public-Private Partnership (PPP). Furthermore, a new National Hinterland Policy must be developed.

The workshop discussed the various issues and challenges. The suggested Strategic programs or interventions that should be implemented based on the priorities are:

i. Establishing an authority or body (new entity) or Council that governs the whole maritime industry affairs (short term: 1-5 years);
ii. Developing the national single window (centralised data system) that can be shared among the stakeholders (short term: 1-5 years);
iii. Enhancing the Private-Public collaboration through incentives, investment in the new technologies (mid-term: 5–10 years); and,
iv. Follow through on the implementation of policies (short term: 1-5 years).

Besides the follow-through on the implementation of policies and centralised data system, the establishment of the new entity are most important to move this industry. To make Malaysia a dynamic, competitive maritime nation, a conducive ecosystem must be established. The workshop agreed that for increased efficacy and efficiency, it is important that Malaysia consolidate its various fragmented maritime agencies, either by setting up a focused ministry or a commission (or authority) on maritime affairs.

MINISTRY

The maritime industry players propose that a dedicated ministry – the Ministry of Maritime Affairs (MMA) – be formed. The proposed consolidated ministry will focus on the planning, execution, and monitoring of the country's maritime affairs. The ministry will be responsible for fulfilling the maritime agenda at the national, regional, and global levels, thereby ensuring

that Malaysia will be considered a model maritime nation. The proposed ministry will be tasked to do the following:

i. Consolidate and integrate all the maritime-related agencies under single governance.
ii. Formulate maritime governance for the nation in a planned, comprehensive, competitive, and progressive manner.
iii. Organise the previous agencies and departments to avoid duplication of powers and rights by redesigning the functionality of the department under the new maritime governance umbrella.
iv. Amend outdated and archaic legislations and policies to adapt to the latest maritime climate and streamline regulations to suit the needs and changes of the expanding maritime sector, technological and engineering viability, current maritime case studies, and new terms in the maritime sector.
v. Propose a new comprehensive and planned maritime governance that encompasses every governance role and power, finance, security and order operations, welfare, prosperity through maritime legislation, and policy towards a competitive maritime nation.
vi. Coordinate the various roles and responsibilities related to the country's maritime affairs.
vii. Oversee service providers, tariffs, prices, regulations, and imbalance practices in the maritime transportation industry.
viii. Integrate all ocean/land borne national and international transportation.
ix. Improve transport performance and trade facilitation, and boost Malaysia as the chosen logistics gateway.
x. Enforce compliance with all the Malaysian maritime rules and regulations.
xi. Protect the interests of all parties including exporters, importers, shippers, consumers, and all related stakeholders.
xii. Ensure the nation's maritime security through integrated policies.
xiii. Enhance the presence and visibility of the Malaysian maritime sector at the international level by becoming one of the council members in the international councils/bodies to support the goal of moving forward for maritime global competitiveness.

COMMISSION

A centralised Commission for Malaysian Maritime Affairs (CMMA) under the Prime Minister's Department will be similar to the Commission (FMC) in the United States of America. The new independent agency (structure of the Federal Maritime CMMA) will be tasked to do the following:

i. Coordinate the various roles and responsibilities related to the country's maritime affairs.
ii. Oversee service providers, tariffs, prices, regulations, and unfair practices in the maritime transportation industry.
iii. Integrate all ocean/land borne national and international transportation.
iv. Improve transport performance and trade facilitation and elevate Malaysia as the chosen logistics gateway.
v. Enforce compliance will all the Malaysian maritime rules and regulations.
vi. Ensure the nation's maritime security through integrated policies.
vii. Anticipate the dispute settlement processes, audits, and licensing activities.
viii. Ensure the high integrity of the various stakeholders.
ix. Protect the interests of all parties including exporters, importers, shippers, consumers, and all related stakeholders, and support the fact that they are moving forward together for maritime global competitiveness.

2.4.3 Issues, Gaps and Challenges

Table 7 Issues, Gaps and Challenges for Maritime Transport, Ports and Relates Services as well as Shipping and Shipbuilding

Governance and Collaborative Platform	Industries Competitiveness	Talent	RDICE	ESG & Climate Change Issues
• Malaysian maritime policies need to be improved - require greater coordination among various ministries. • Lack of ocean policy. • Disjointed and overlapping of the marine or ocean related jurisdictions. • Lack of regulations to address issues of marine safety and security such as marine pollution, sea robberies, etc. • Insufficient focus on ship-building.	• More effort is needed to become the region's number one in container traffic. • Lack of comprehensive financial support system. • No centralized data platform for maritime industry. • Technology, advanced machinery and facilities are not available. • Lack of manufacturer for ship's parts, machinery and more. • Lack of collaboration between shipyards.	• Limited degree level studies focused on port management or operation. • Lack of skilled workforce for this industry (especially in the use of green technologies for the sustainable management of the logistics and supply chain). • Lack of job opportunities in this sector.	• Lack of R&D in digitalization and automation. • Investment in green tech and eco-friendly innovation in the industry is low (e.g., use of renewable energy). • Difficulty in bringing technology developed by university to industry.	• Impact of climate change IUU, safety, are not currently addressed in management & decision making. • The local shipbuilding and repair industry are highly dependent on O&G industry and are susceptible to volatility in the industry. • Lack of data on ocean wave movement. • Lack of environmental monitoring system. • It is costly to implement law related ESG. • Ship recycling facilities are not available in Malaysia.

2.4.4 Way Forward

The maritime industry is more than just ports and ships and the provision of port and shipping services. The Malaysian maritime industry is supported by and in turn, supports other components of the maritime transport and logistics chain. Each component plays a role in determining the efficiency and competitiveness of the Malaysian maritime industry. Malaysia's geostrategic location at the heart of the economically highly dynamic ASEAN region has made it a hub of the maritime economy. Every year, more than 120,000 ships pass through the Straits of Malacca, which lies between the Malay Peninsula and the northeast coast of Sumatra. This makes it the busiest waterway in the world, and it already has a large number of shipyards, ports, and container terminals. Against the background of the enormous economic growth in Asia. Malaysia, therefore, offers optimal conditions for the rapid further development of the respective industries. Malaysia's maritime industry specialises primarily in the planning, engineering, construction, construction, repair, maintenance, and conversion of ocean-going and coastal vessels, as well as passenger and fishing vessels. It is about time the maritime industry initiates and invests in such a venture. With strong support from the government.

The Malaysian oil and gas industry estimated an income of more than RM140 billion a year, with globally operating companies, offers special potential in the field of offshore technology, as most of the deposits are located under the seabed. Thus, Malaysia has the opportunities to further develop its maritime industry to become a Green Bunker Hub for Marine Low Sulphur Fuel, with the support of maritime clusters such as the logistics services, shipyards, ports, and terminals, in addition to a strategic geographic location. Malaysia's maritime industry is putting an effort to ensure that Malaysia will be ready for IMO 2020. A sufficient supply of Gasoil is readily available should there be constraints on Ultra Low Sulphur Fuel Oil (ULSFO). Malaysia is putting efforts for the future by focusing on LNG bunkering to promote LNG as the primary source of alternative marine fuel for ship-liners in Malaysia and the global market. The oil storage and ship refueling site in the country's south has been identified as potentially becoming a bunkering hub for marine low sulfur fuel. Where the Re-Gas Terminal Sungai Udang. Melaka is a potential supply point for Western Peninsular LNG Bunkering, Re-Gas Terminal Pengerang, Johor is a supply point for Eastern Peninsular for LNG Bunkering, and Labuan Supply Base potential supply point for Eastern Malaysia Supply for LNG Bunkering. The LNG bunkering vessels are

the delivery vessel for Ship-to-Ship LNG bunker transfer positioned strategically in the waters of Johor Bahru Port Limit and become the ship-to-ship (STS) hub as well as Malaysia's Blue Economy gateway.

Malaysia has the infrastructure and expertise to be the bunker hub, language capability, labour, and connectivity are here. Thus, this is the high time to push for Malaysia to be a green bunker hub for the region. Governments are noting the importance of this role and have been doling out incentives to attract shipping lines to their facilities. The green bunker hub project would also be used to promote cleaner marine fuel following the International Maritime Organization (IMO) rules that will require lower sulfur content in shipping fuel from 2020 onward.

The local industry has lost millions of dollars annually through the supply chain due to the inefficient storage plans, poor manufacturing process, lack of coordination from key stakeholders, insufficient systems as well as equipment breakdown these elements need a set of characteristics and skills that enable and improve the efficiency and performance toward a new era of IR4.0 by using human capital as the greatest assets and key factor. The Malaysian human capital is young, educated, and productive, proving to be one of the best in the region. The Government's emphasis on human resource development ensures the continuous supply of manpower to meet the needs of the expanding manufacturing and services sectors. Thus, re-skilling, up-skilling, and maintaining the competency, especially, in the seaports, logistics, and maritime transport sectors towards digitalization of the industry's ecosystem is crucial for improving the operational efficiency, enhancing data gathering and data analytics, empowering customer experience, and saving costs.

The objectives of the roadmap for the SBSR sector are to arrive at holistic solutions benefitting all stakeholders and to maximise local contents in the design, building, and operations of vessels owned and operated by both the public and private sectors and/or those regulated by the government. These include the RMN, MMEA, Petronas chartered OSVs, and local fishing vessels. These vessels operate within Malaysia EEZ and thus share A common navigation area. The estimated total annual value of RM 3 billion can create a sustainable business eco-system comprising the complete supply and value chain for the SBSR industry. The collaborative efforts would bring many benefits in terms of shared prosperity by being cost-effective, creating more employment opportunities, reducing capital outflow, enhancing technology uptakes, and high-value incomes. The suggested steps are:

1. List out the programmes, projects, missions, visions, and objectives of each stakeholder in the Malaysian maritime cluster.
2. Compile issues and challenges of each stakeholder.
3. Identify solutions for each stakeholder.
4. Identify the commonality of all stakeholders (assets, operations, etc.)
5. Establish eco-systems based on the commonality of stakeholders. E.g. Security/defense; fishing industry; OSVs.
6. Specify the scope of collaborations between stakeholders
7. Formation of SBSR Corp to execute the strategies and plans as agreed, effectively, and with focus.

<u>What needs to be done</u>

In the immediate term, it is necessary to:

1. Work on the endorsement of the comprehensive and progressive National Ocean Policy comprises of Malaysia Shipping Master Plan, SBSR Industry Strategic Plan 2020, Logistics and Trade Facilitation Master Plan, and National Policy on Industry 4.0 (Industry4wrd) and Sustainable Development Goal (SDG) 2030. Thus, a new structure for Malaysian maritime strategic cluster thinking via proper management of the information flows, an integrated and centralised maritime-related knowledge

and information to guide external and internal sector management, correct incentives, and effective policies can be introduced to manage the maritime industry and ocean areas effectively; and,

2. Push for the completion of the Comprehensive National Ocean Policy and Malaysian Merchant Shipping Act (MSA) to renew the existing colonial law under MSO1952;

The following are other priority policy areas that should be considered. At the domestic level, Malaysia should focus on trade facilitation (Customs Clearance Procedures, Seamless Logistics), improving the regulatory environment, wider digital connectivity platform (e-commerce), SME development, and support for the services sector, investment policy, and capacity building (re-skill and up-skill in the digital era).

A competitive and sustainable maritime industry is in Malaysia's long-term interest and essential to the nation's prosperity. Therefore, to position Malaysia to become a true maritime nation, ocean governance should be recognised via a national ocean policy, a dedicated maritime affairs minister, and the adoption of a co-management principle very important to maintain its maritime pre-eminence and toward the developed maritime nation.

2.5 Renewable Ocean Energy

2.5.1 Introduction

Ocean energy is derived from ocean waves, currents, tidal movements, salinity gradient, and ocean temperature differences. Comparing ocean energy with other types of renewable energies, ocean energy is abundant, has a high-capacity factor, as well as posed minimal environmental impacts (Yaakob et al., 2016). Theoretically, the annual potential of marine/ocean energy is equivalent to 4-18 million tonnes of oil equivalent (Mtoe) per annum (Derakhshan et al., 2017). In addition, the global deployment potential of ocean energy can reach up to 337 GW, where more than 885 TWh of electricity can be generated annually (de Andres et al., 2017). Ocean resources assessment that able must differentiate between theoretical, technical, and practical resource viability and availability to assess the true potential of ocean energy.

Renewable costs are continuing to fall significantly with time, as much due to the continuing improvements in the energy conversion technologies as to its competitiveness relative to the increasing cost of oil and gas exploration and production. Clean energy opens more environmental acceptance and gaining wide attention. Global renewable energy power capacity has increased to 2,838 GW in 2020 (REN21, 2020). Furthermore, diversification of energy resources is significant to addressing energy security for a country. It is predicted that by 2050, 9.2 Gigatons of CO_2 are projected to be reduced, with $411.8 Billion net cost and - $1 Trillion savings through ocean energy (Hawken, 2017). To realise this projection, efforts towards accelerating the ocean energy to a full commercial scale in producing affordable and reliable renewable energy sources are significant. Energy conversion from an OTEC system into hydrogen energy offers a window for storing energy for further utilization. Thus, the ocean renewable energy ecosystem that addresses resource availability, technology adoption in combination with innovative knowledge, financial and investment support, effective planning, and implementation strategy are highlighted in the following sections.

Ocean thermal energy conversion (OTEC) technology used to be a laggard sector (ADB, 2014b). With an estimated 300 exajoules (EJ) per year or 90% of the global ocean energy potential, OTEC has the largest potential of the different ocean energy technologies (Lewis, et al., 2011). Extracting this energy would have no impact on the ocean's thermal structure. The total estimated available resource for OTEC could be up to 30 Terawatt (TW) with deployment up to 7TW would have little effect on the oceanic temperature fields (Rajagopalan & Nihous, 2013).

To date, only OTEC plants up to 1 MW have been built (IRENA, 2014). The deployment of OTEC is beginning to gain traction and several success stories such as the successful deployment of 100 kW OTEC plants located in Okinawa, Japan, and Kailua, Hawaii (Kim & Kim, 2020), and the latest being the commissioning of 1MW OTEC Plant that runs on R32 working fluid in Busan by the Korean Research Institute of Shipping and Ocean Engineering (KRISO) (Petterson and Kim, 2020). Wave energy technology was reported to possess a high energy potential of 8000–80,000 TWh/year (Khan et al., 2017) although its development is still lagging with regard to technology. Tidal stream technologies are closer to the maturity phase and innovation in the use of horizontal axis turbines, either mounted on the seafloor or attached to a floating platform (REN21, 2020). Salinity gradient technology has been estimated to produce energy of approximately 1650 TWh/year (Wilberforce et al., 2019) although its development stage is still within the lab scale.

The potential of ocean energy has been discovered during the Marine Survey of South China in 2006-2008, where a series of presentations to various agencies, institutions, and investors have been made (Academy of Sciences Malaysia, 2015). The study explored the ocean energy that can be regarded as future sustainable energy in Malaysia to benefit the remote communities i.e., rural areas/islands that are dependent on diesel generation for electrification systems. In the context of societal development, the implementation of ocean energy in Malaysia helps to create job opportunities and to accelerate economic growth. In addition, the ocean renewable energy contributes to the development of other new industries, such as aquaculture, bio-products, and other useful products.

Ocean thermal energy conversion (OTEC) leverages the temperature gradient between deep and shallow water for electricity generation. Greater temperature differences result in higher process efficiency. The warm seawater located at the sub-surface layer is used to produce steam that acts as a working fluid to drive turbines. The working fluid of an open system uses seawater while the closed system uses ammonia. OTEC provides electricity on a continuous non-intermittent basis, as well as cooling with a high-capacity factor of around 90%. Not only does OTEC-based technology produces clean energy, but also portable water and aquaculture products.
Wave energy or wave power can be converted to electricity. Tidal power includes tidal barrage power and tidal stream power. For tidal current also known as a tidal stream, the energy is derived from the flow of water, similar to that of hydroelectric power generation. In tidal power, water is used for energy generation.

The effects of global climate influence have profound impacts on both technologies where climate warming of sea temperature diminishes the temperature gradient between sub-surface and deep-surface seawater required by OTEC. On the other hand, wave/tidal currents technologies can serve as potential indicators of drastic weather patterns influenced by climate change.

As of 2019, growing efforts in activities relating to OTEC policy advocacy and promotion of investments have seen a significant rise from 20 to 143 OTEC-related activities by government agencies, companies, and local and international institutions after the inception of UTM OTEC in 2012. The feasibility study for the application of ocean thermal energy conversion (OTEC) in Kota Kinabalu, Sabah based on technical criteria and social responses was also proposed. The North-Borneo Trough (Sabah Trough) has an estimated water depth of 2,900 m with 3°C as compared to an average surface temperature of 29°C (Jaafar, 2012). In 2016, a Memorandum of Agreement (MOA) was signed between French group DCNS and OTEC Centre of Universiti Teknologi Malaysia (UTM OTEC) to investigate the potential application of Ocean Thermal Energy Conversion (OTEC) technology on the Malaysian island of Layang-Layang (UTM OTEC, 2016). In pursuance of this, UTM OTEC had also secured a 5-year project duration under Science and Technology Research Partnership for Sustainable Development (SATREPS) in 2019 in collaboration with local institutions and the Japanese government to develop an OTEC Malaysia Model

with an innovative hybrid ocean thermal energy conversion (H-OTEC) system.

Lim & Koh (2010) assessed potential locations of tidal currents for the generation of electricity in Malaysia where Sejingkat, Port Klang, Langkawi Island, Tawau, Kukup, and Johor Bahru were identified as the potential sites with 70% power availability. For tidal streams, four locations were indicated: namely, Sandakan, Pangkor Island, Melaka, and Port Klang, with Sandakan identified to have the potential to produce the highest power capacity of 80%. Nasir & Maulud (2016) explored the application of wave power potential in Malaysia and identified Kelantan, Terengganu, Pahang, Sarawak, and Kedah as the potential sites to derive wave power. In additio n, Chong & Lam (2013) proposed the Straits of Malacca as the potential site to harvest oceanic-based energies from tidal power and wave power to support the supply of electricity.

2.5.1.1 Governance & Collaborative Platform

In the context of renewable ocean energy, the challenge covers the availability, reliability, stability, and sustainability of the energy source. For instance, there is a lack of data on both tidal and ocean wave energy generation for which baseline data would be crucial for comparison with conventional energy generation methods. In addition, technologies that are reliant on local conditions need to be optimally adapted to fit specific Malaysian conditions. To address the problems, an assessment of the potential for renewable energy in Malaysia in terms of geographical factors by respective organizations (i.e., Sustainable Energy Development Authority Malaysia) is highly advised. This is pivotal given the uncertainty of energy providers (i.e., Tenaga Nasional Berhad) to commit to renewable energy due to inconsistency of the local geographic conditions i.e., monsoon season and weather patterns.

Another challenge that can be faced is the high upfront costs required for the equipment. Thereby, the Malaysian Investment Development Authority in collaboration with the Sustainable Energy Development Authority encourages the investment in green technology and has introduced an incentive in the form of a tax allowance. Furthermore, having a collaborative platform to facilitate technology transfer is an ideal option. To date, it has been observed that most companies opt for readily available technology in the market, rather than venturing into new R&D ventures due to the high capital investment required.

Thus, the establishment of a renewable energy consortium is a promising solution, where it can be a collaborative platform to facilitate technology transfer and coordinate the national renewable energy R&D efforts. The usual practice of technology development institutes to work in silo is the main hurdle toward meaningful progress in the renewable energy sector. This then results in an in-silo approach for renewable energy R&D and fragmented funding and investments, which prevent a significant breakthrough to be made.
Further, this consortium must also be appropriately empowered and backed by a strong political will to drive the renewable agenda forward. Through the consortium, a strong laboratory support network could be developed and sustained to tap the pool of experts leading to an efficient upscaling of design and processes through the facilitation of the centre on renewable energy. Further, having robust talent development will be a key factor for a successful technology transfer and investment. In addition, the industry players should be brought in at the early stage of R&D projects, to improve better understanding of their requirements in adopting the developed technologies. To supplement the involvement of industry players since the R&D planning stage, the provision of better communication will be ideal.
Other strategic interventions that can be adopted are through policy development, where it is suggested to include ocean-based energy generations in the existing Renewable Energy Act.

Better communication to respective stakeholders as well as public outreach shall be carried out to propagate awareness and adaptation of Ocean Renewable Energy.

2.5.1.2 Industrial Competitiveness

Till April 2021, Malaysian renewable energy has been monopolised by solar PV (269 GW), followed by large hydro (13.4 GW), bioenergy (3.6 GW), small hydro (2.5 GW), and geothermal (0.2 GW). Regardless of the MIDA's initiatives in setting up the matching grant, lack of interest from industrial sectors has become the main limitation, which is interrelated to lacking skilled talent, high capital investments, and insufficient technology that can be locally adapted to Malaysian conditions, information scarcity, among others. Therefore, in consideration of the high initial costs associated with renewable energy, it is crucial to identify the motivating drivers for the implementation of ocean renewable energy in Malaysia. Further, since the ocean-based renewable energy is overshadowed by other types of renewable energy such as solar and wind, the presence of a roadmap and strategy that integrates the supply and technology stability, as well as cost factor must be done to drive this renewable energy forward. Herein, the Renewable Energy Transition Roadmap which specifies the strategic framework to drive the renewable energy growth to 31% in the national energy capacity mix by 2025 will be launched in due time by SEDA. Moreover, the Economic Planning Unit is also currently finalizing the New Energy Policy that focuses on clean and sustainable energy sources. Other opportunities in terms of industrial competitiveness include the support/ incentives for local entrepreneurs such as that under the Malaysian Industrial Development Finance Berhad special funding scheme such as Sustainable, GreenBiz, and the Jana Graduan Hijau (Jaguh) programme under the purview of the Ministry of Environment and Water and Malaysian Green Technology Corporation. To be specific, RM1.95 million has been allocated for the first batch of the Energy Management (Jaguh Pengurusan Tenaga) stream, RM1.75 million for the Green Products (Jaguh Produk Hijau) stream, and RM1.85 million for the Urban Farming (Jaguh Pertanian Bandar) stream respectively.

Several strategic interventions have been outlined in driving the renewable energy ahead, including:

1. Introduction of artificial intelligence in harvesting renewable energy and integration of various types of renewable energies.
2. Development and accessibility to adaptive facilities to integrate renewable energy into the current conventional technology.
3. Development of highly specialised talents and in parallel to the market demands.
4. Development of Green Technology Park to link the green energy providers to the interested industries.
5. Establishment of a public domain portal in facilitating talent nurturing, information exchange, as well as promotion of technologies.

2.5.1.3 Talent

The presence of long-term plans on talent demand and supply that mapped against the skills to support the renewable energy sector is highly sought, given the current industries opt to import foreign technologies that necessitate the foreign expertise to operate. Following this, a consortium establishment is ideal to gather the relevant stakeholders to better understand the industrial talent demands and to close the gaps between the industry and academia. To date, the Malaysian Investment Development Authority (MIDA) has come out with a clause that emphasises industrial collaboration with local universities, and the employment of local

graduates to qualify them for the Government's incentives. Presently, MIDA has its dedicated section that focuses on talent development specifically for manufacturing, which can be further extended to cover renewable energy.

To sustain the renewable energy sector, the introduction of renewable energy in curriculum structure in local universities is a strategic intervention that can be implemented. On this note, the private sectors are recommended to be proactive in training and employing the local graduates. Other than that, integration of IR 4.0 and the Internet of Things is proposed to better equip the local talents on future technologies. Overall, revisiting the foresight studies that have been previously carried out i.e., ASM Science & Technology Foresight Malaysia 2050, should be emphasised to address the current gaps, subsequently to come out with the long-term planning on the talent demand-supply matching for renewable energy.

2.5.1.4 Research, Development, Innovation, Commercialisation, and Economy (RDICE)

In the context of RDICE opportunities in the renewable energy sector, the Malaysian Investment Development Authority (MIDA) has facilitated green technology advancement, through various promotional programmes including regular webinars and briefing sessions on renewable energy. Indeed, various manufacturing companies had ventured into Research and Development (R&D) under the facilitation of MIDA. Nevertheless, looking closely at the Malaysian companies' readiness for the ocean renewable energy, both local scenario and the readiness of local manufacturing industries to support the energy transitions need to be taken into consideration, as there is still an absence of specific ocean energy-related programmes. The continuous Government support is also expected to bring merits by linking the academia to the respective industries.

Another hurdle in renewable energy RDICE is due to limited incentives provided, hence it necessitates a greater role from the ministries and related agencies. With regards to this, regular engagement between industrial sectors and financial institutions is said to be a good platform to equip the industrialists with insights into the technology, along with the financing assistance for commercialisation. This is indeed beneficial as the current trend shows that the industrial sectors are less interested in technology development and prone to the adoption of readily available technology. Therefore, to address this issue, an establishment of scientific or technical pathways to demonstrate the commercial-scale application of the technology together with a feasible business plan for industrial buy-ins is essential.

Overall, as there are no regulatory roadblocks in terms of pursuing green technology and renewable energy projects, the mindset needs to be changed, to embrace investment criteria not only due to cost factors. With various breakthroughs over the years, the costs can be significantly reduced. Thus, openness and mindset change in committing to opportunities would be important values for furthering the renewable energy agenda.

2.5.2 State of Ecosystem

2.5.2.1 Current Status

In stakeholders' workshop 1, comprising of technical experts who are proficient in the renewable energy sector, nearly 50% of the panels collectively acknowledge the current key enablers are moderately weak and lack sufficient development in various blue ocean economy sectors. To transform the blue ocean economy into a strong national sector, 31.6% voted satisfactory status and 15.8% voted good to transform the blue ocean economy into a strong national sector.

The adaptation of the 8i Framework plays a very important role in strengthening the blue ocean economy. Collective feedback showed that all 8i elements (institutions, interaction, integrity, infrastructure, infostructure, intellectual capital, incentives, and internationalisation) have averagely performed slightly below satisfactory expectations. Both intellectual capital and institutions (governance bodies) were rated best while infostructure and internationalisation showed the lowest rate. Nevertheless, the panels collectively proposed the following top three (3) elements as Blue Economy enablers: namely institutions (governance bodies), integrity (governance system and regulatory framework), and interaction (collaboration network/ strategic partnerships), to be prioritised for the benefit of the blue ocean ecosystem. The key takeaway showed the need for a more aggressive top-down approach from governance bodies and to outline appropriate frameworks to advance the blue ocean economy further up the value chain.

Key Enabling Factors

Two key factors were identified for the sustainable deployment of ocean energy:

A. Aggressive innovative financing for technological research and development

In 2021, a study by the European Commission indicates that investment in ocean power is to be dependent on public funding, to reduce the risk of private investment. It has been reported that two-thirds of R&D activities were supported by developers and private sectors, while the remaining was from the European Commission as well as EU countries. Nevertheless, as of 2018, over €6 billion (USD 7.4 billion) had been invested in the project worldwide, of which 75% was from private financing (REN21, 2020). Furthermore, the available financial schemes in the EU to support the post-prototype demonstration technology of ocean energy farms includes the InnovFin Energy Demonstration Project (EDP) and NER300 (Ocean Energy Forum). In summary, aggressive funding to back R&D activities on ocean energy technologies must be mutually inclusive, where an innovative funding mechanism to be established collectively together with interested parties.

B. Current legislation acts and policies in support of ocean energy deployment-

In the Malaysian context, though there are no specific regulatory studies on the deployment of OTEC in the Malaysian waters to determine whether the currently available regulations are applicable and adequate, there are, however, sufficient provisions in the existing laws, namely, Exclusive Economic Zone Act 1984 (Act 311) and the Territorial Sea Act 2012 (Jaafar & Rahmat, 2017). Firstly, "ocean energy" is not listed under Renewable Energy Act 2011 where only four sources of renewable energy are highlighted, namely: biogas, biomass, small hydropower, and solar photovoltaic. Secondly, the current Feed-in Tariff (FiT) system only provides bonus rates for biogas, biomass, and solar photovoltaic sources. A policy change in the system will encourage extensive research activities for oceanic energy in the local

landscape. Nonetheless, should there be any excess electrical power not taken up, it could be converted into hydrogen fuel (Jaafar, 2015). Thirdly, the deployment of the OTEC plant may increase international fishing activities surrounding the area due to plankton enrichment that may raise transboundary issues due to the exploratory rights regarding high sea fishing freedom status. Finally, enacted Exclusive Economic Zone Act 1984 (Act 311) and Continental Shelf Act 1966 (Act 83) providing Malaysian sovereign rights including structure installations, marine scientific research, and protection and preservation of the natural environment are well-established for OTEC deployment in Malaysia. Nevertheless, the establishment of an appropriate Act for absolute authorization in governing OTEC activities should be considered in the future. Thus, Malaysia is proposing a new law concerning ocean thermal energy development (Jaafar, 2015).

C. Environmental, Social & Corporate Governance (ESG) and Climate Change issues

Both ESG and Climate change concerning the renewable energy sector are compulsory, where big industry players now have strategised to improve their business plans. Thus far, several strategies have been adopted concerning the ESG aspect, including (i) the development of the New Industrial Master Plan by the Ministry of International Trade and Industry (MITI) that contains specific policy thrusts addressing ESG in the manufacturing sector, and (ii) Bursa Malaysia who has mandated the ESG reporting in the annual reports.

Given the understanding of the impact of ESG on the Malaysian economy is low, more initiatives shall be performed by the Government and companies to ensure sound and inclusive socio-economic development, which include the following:

1. Presence of a political will in empowering the relevant Acts, policies, and ministries. agencies and the implementing bodies. Ministry of Environment and Water, Ministry of Energy and Natural Resources, and Economic Planning Unit shall be the focal point in ESG-related matters.
2. Government initiatives in conducting a comprehensive study on the impact of ESG implementations on the economy and willingness to bear the initial risks in developing new technologies to convince the industrial commitments.
3. Integration of Life Cycle Analysis (LCA) and Carbon Calculator by the technology provider. Following this, Malaysian Green Technology Corporation (MGTC) has also planned for National Carbon Calculator as well as National LCA Registry, allowing the technology providers to properly plan their ESG initiatives.
4. Proper demonstration of the feasibility and viability of technologies as suggested earlier is a must before committing to any investments.

Goals and targets for transforming Malaysia into a successful Blue Economy

i. The deployment of hybrid OTEC technologies in Malaysia on a larger scale.

iiii. Framework development for deployment of hybrid OTEC with spin-offs that sustainably integrate food and aquaculture industries, marine biomass renewables, hydrogen production, water desalination process, and/or solar photovoltaic technologies.

iii. Utilization of wave/tidal currents located at several local river mouths' locations in Malaysia with 70–80% availability and satisfactory flow speed at 0.5–4 m/s in certain regions.

iv. Establishment of comprehensive, accurate, and reliable data for the proper estimation of resource potential and identification of correct locations for the Renewable Ocean Energy devices such as through satellite altimetry that resolved limited coverage associated with field measurement and uncertainty in simulation models.

v. Development of local own endogenous devices suitable for local resources availability.
vi. Targeting local grids for remote coastal and island communities.

Shared Prosperity Vision target

i. Ocean energy deployment creates extensive career opportunities for interested parties individually or organizations to create highly skilled and marketable human capital in the ASEAN region.
ii. Renewable ocean energy technologies provide key economic growth activities, especially in Blue Economy and Renewable Energy contexts. For example, the utilization of OTEC technology can be spread across to produce energy, hydrogen generation, district cooling, water desalination, integration of aquaculture industry, and cultivation of high-value marine products (Jaafar, 2019).

Sustaining Ocean health for a sustainable Blue Economy

As of 2019, concentrations of CO_2 gases detected in the ocean that acts as the largest carbon sink on the planet are at their peak compared to the last two decades according to World Meteorological Organization (2019) giving rise to temperature in the ocean beds. Frozen caps of CO_2 and methane (hydrates) contained below oceanic beds are gradually melting as an after effect of the continuous absorbance of heat and carbon emissions by the ocean to induce subsequent chain reactions to offset GHGs concentrations even further.

The application of OTEC technology can be applied to remove heat energy from the surface ocean to counter ocean and atmosphere warming, where surface heat is transferred to the deeper ocean without inducing a sudden spike in deep water temperature. The cycle continues as heat from deep waters is sequestered back to the surface during overturning circulations, thus mitigating the negative effects of climate changes such as ocean and atmospheric warming (Rau & Baird, 2018). In a sense, OTEC continuously provides zero emissions while delivering intended renewable energy generation. However, a 100 MW OTEC system functions to deliver an average 300–400 m^3/s intake and discharge water that could prevent entrainment of planktonic eggs and larvae surrounding the area as well as consideration of salinity, acidity, temperature, and nutrient mixing changes locally (Hammar, 2014). Furthermore, the material used for foundations and mooring is likely to contribute more towards various environmental impacts such as eutrophication and ecotoxicity.

Wind/tidal current technologies produce substantial movements underwater to convert hydrokinetic energy mainly into electrical energy. Concerns on the day-to-day operational impacts of such devices or systems especially on marine lives should be emphasised. A study carried out by the US Department of Energy-funded Pacific Northwest National Laboratory concluded their findings for wave and tidal energy setups blades in endangering marine wildlife at low risks and cited construction and maintenance of these systems are more likely to pose a disruption to marine lives instead (Skibba, 2018).

Given this, further investigations are required to further understand the effects and impacts of such technologies in the local marine ecosystem scenario. The use of intensive adaptive management for environmental management is required to identify current known and unknown stressor indicators for a better ecosystem-based spatial planning approach to minimise irreversible detrimental effects on the marine ecosystem. In addition, consideration of biomimetic designs to improve process technologies may considerably reduce harmful damages to marine life and its surrounding.

In Malaysia, private energy farms, as well as funding for R&D renewable energy in universities/institutes, should be initiated jointly by the government and private sectors. Such funding with incentives (Incentives) is important for the progression of ocean energy since this sector is still at an early stage. As of present, the only available OTEC plant available in the ASEAN region is located in Okinawa, Japan, which operates within 100 kW capacity (Infrastructure) while deployments of wave/tidal technologies are not readily deployed at large in Malaysia. Capitalizing on the potential of ocean energy technology deployment in Malaysia, this provides the capability to deliver highly skilled and marketable human capital force (Intellectual Capital) such as specialised engineers and research scientists from various local universities (Institutions) to create and pilot technical know-how (Infostructure). In essence, early exploitation and understanding of this technology can serve as a platform to champion Malaysia's position in the global landscape (Internationalization). Nevertheless, strategies/actions are still required to fully explore the potential of ocean energy, especially OTEC and wave/tidal current technologies. These include:

a) Identify several locations that can be suitably used for OTEC and wave/tidal technologies. These locations should satisfy the minimum requirements of each respective technology to function optimally.
b) Exploring the possibilities of integration with local industries, such as aquaculture industries, water desalination, and high-value marine product cultivations, to further boost the economic landscape.
c) Enhancing research and development activities to further improve the efficiency of production of renewable energy.
d) Integration of other renewable technology processes such as the generation of hydrogen by water electrolysis and/or algae technology for H2 or lipid generation (Poh et al., 2020)
e) Solar photovoltaic panel installations in OTEC plants.
f) Producing graduates with relevant skills and knowledge through R&D in local universities (e.g., HICoE or COE) and providing a structural academic cohort in the ocean energy sector.
g) Building local industrial capacity in manufacturing sub-components required by ocean energy technologies to meet both local and overseas demand.

2.5.3 Issues, Gaps & Challenges

Table 8 Issue, Gaps, and Challenges for Renewable Ocean Energy

Governance and Collaborative Platform	Industries Competitiveness	Talent	RDICE	ESG & Climate Change Issues
• Ocean-based energy generation industry is not well addressed in existing Renewable Energy Act. • Lack of leadership in renewable energy sector.	• Lack of comprehensive financial support system for the renewable industries to be viable.	• Insufficient initiatives to attract students. • Lack of public acculturation among the on the use of renewable energy (nurturing an ESG-mindset).	• Lack of baseline data for development of new sources of renewable energy. • Lacking development of in-house technologies to adapt to current condition. • Lack of platform for technology transfer. • Lack of academia-industry research collaboration. • Lack of funding for experimental R&D related to renewable energy technologies.	• Low public understanding the impact of ESG to the Malaysian economy. • Low level of knowledge technology transfer between local institutions/ industry/foreign institutions/industry. • Most Malaysian firms are dependent on foreign technology and operate at the lower-end of the global value chain.

2.5.4 Way Forward

Table 9 highlights the proposed roadmap for ocean energy technology by National Oceanography Directorate (NOD). The proposed timeline and action plan are highlighted in Figure 23 and Figure 24 respectively.

Table 9 Proposed roadmap on the ocean energy technology by NOD (Lim and Lam, 2014)

Components	Current	Short term (2011–2012)	Mid Term (2013–2015)	Long Term (2016–2020)	Beyond 2020
Potential projects, grants and collaborations network	• Wave/wind/current mapping (Marine atlas) • Ocean temperature profiling • Chemical, geological, physical and biological oceanography study covering regional seas	Implementation of testing facilities for demo of small scale (pilot project) ocean energy conversion devices	Make ocean energy part of the hybrid system especially for islands To install 500 kW conversion device	Use the ocean energy to generate hydrogen for remote islands (for use in dual cells)	To install 6 units 10 MW conversion devices
		Implementation of numerical modelling for the ocean energy system	Detail physical and numerical modelling of potential sites	To install 10 MW conversion device	
		Development and testing of 20 kW ocean energy generation	Potential demonstration facilities/marine laboratory	Niche market for indigenous technology for the equatorial belt countries	

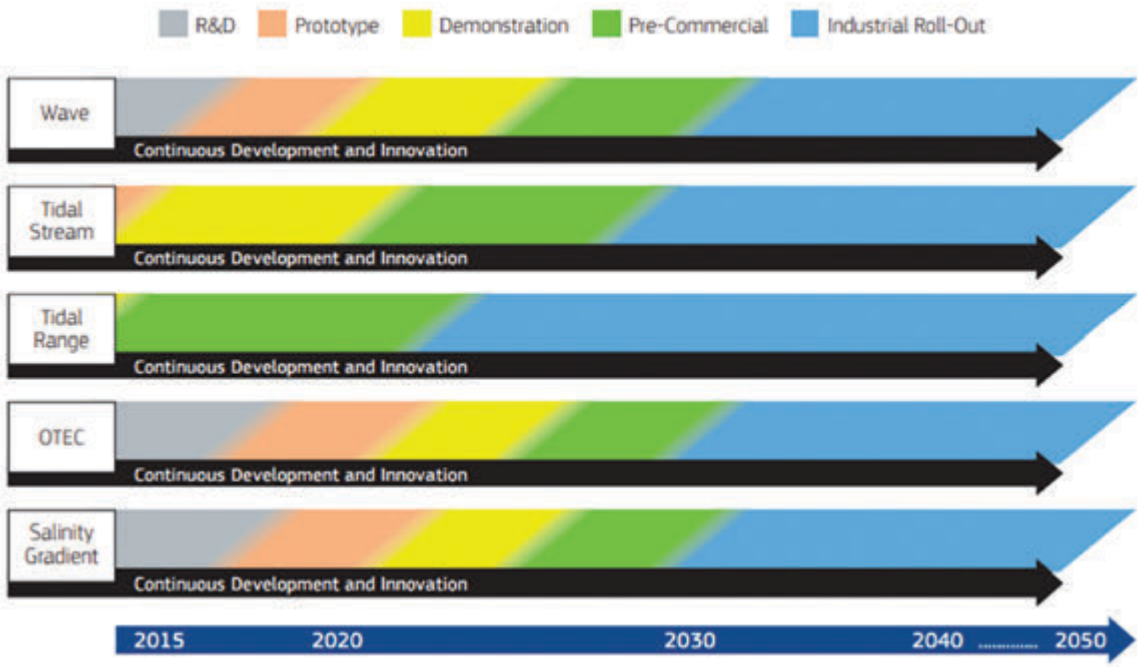
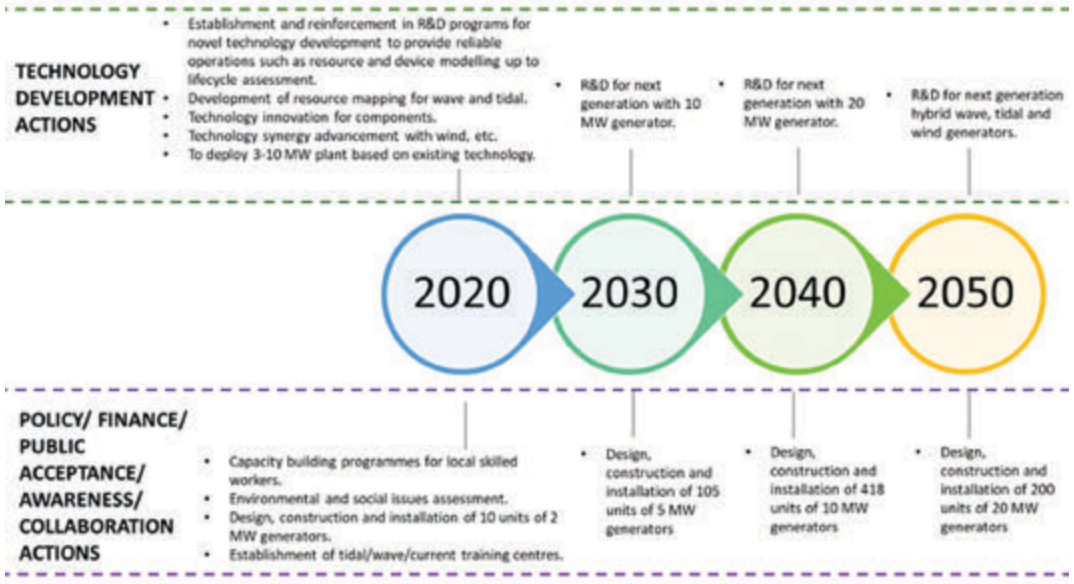


Figure 23 Timeline for the development phase of ocean energy technologies

(a)



(b)

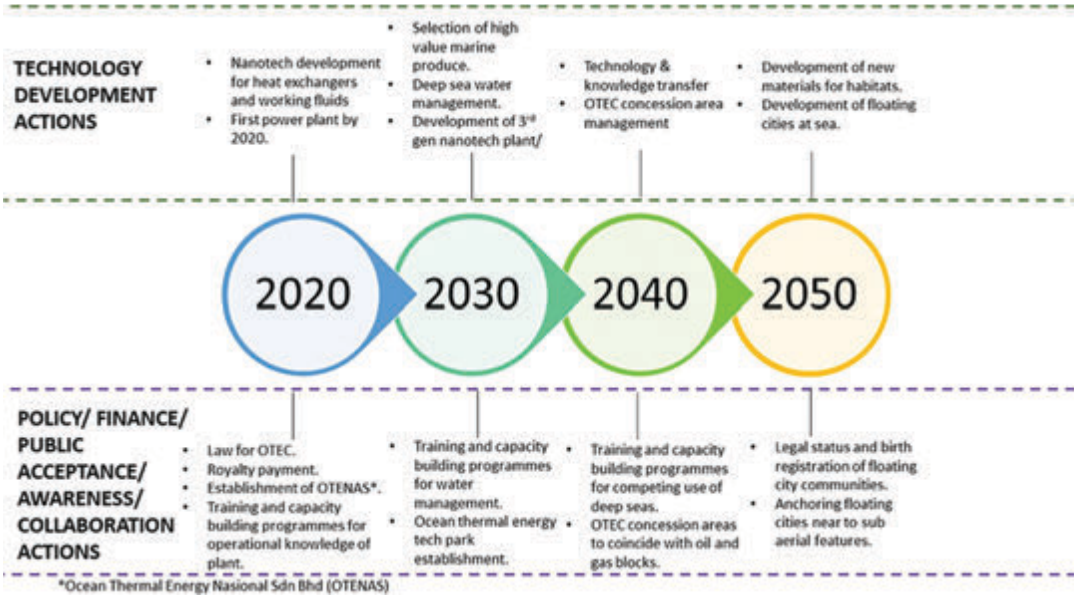


Figure 24 Proposed action plan and time frame for (a) OTEC development and (b) wave/tidal current developments by 2050. Adapted and modified from (Academy of Sciences Malaysia, 2015)

In addition, other Quick Wins initiatives that would be most important to spearhead the renewable energy sector is as summarised in Table 10.

Table 10 Renewable Energy Sector Quick Wins Initiatives

Recommendations for Quick Wins Initiatives (Attainable within 1-2 years)	
1.	Communications/Outreach plan on Ocean-based REs and Blue Ocean Economy to various stakeholders to improve overall awareness and understanding.
2.	Collective vision in introducing ocean-based REs into the energy mix, based on inputs from the government, academia, industry, and civil societies.
3.	Communication platform to facilitate collaboration among all the key players.

2.6 Marine Biotechnology & Bioprospecting

2.6.1 Introduction

Marine biotechnology alludes to the use of science and technology to explore the potential of marine organisms (at the whole, cellular, or molecular level) for the development of new or improved bioproducts as a solution to today's problems, and to advance the understanding and accessibility of marine biological material (Deborah, 2012; Jang et al. 2013). It was reported that the potential of marine organisms first came to notice with the discovery of nucleic acid material encoding the unusual sugar arabinose in the Caribbean sponge Tethya crypta in the 1950s (Carroll & Crews 2009), and this biologically active marine natural product was first discovered and formally reported by Bergmann, Watkins & Stempien in 1957.

The development of new materials and substances using land-based bio-resources has reached a bottleneck in terms of the dwindling numbers of subjects. This, in turn, has led to a recent trend in advanced economies and coastal countries, to gradually shift their focus on bio-material development from land-based to marine bio-resources (Jang et al. 2013). Marine organisms inhabit a completely different environment from land-based ones and differ in many ways in terms of their physiological and metabolic processes to adapt to conditions of extreme pressure, salinity, temperature, and others. For instance, secondary metabolites from marine bacteria gave rise to novel anti-inflammatory agents such as topsentins and manoalide, anticancer agents like bryostatins, discodermolide, and sarcodictyin, and antibiotics like marinone (Global Marine Biopharmaceutical Market report-2027, 2021). For this reason, it is believed that there is a great potential for harnessing novel structural and functional chemical compounds. Marine bio-resources have drawn particular attention as an alternative to land-based ones thanks to their great variety and the knowledge that around 80%—some 300,000 species—of all organisms on Earth dwell in the sea (Kim S.K., 2019). Figure 25 showed the distribution of marine organisms used in pharmaceutical and food applications of marine biotechnology, by publication.

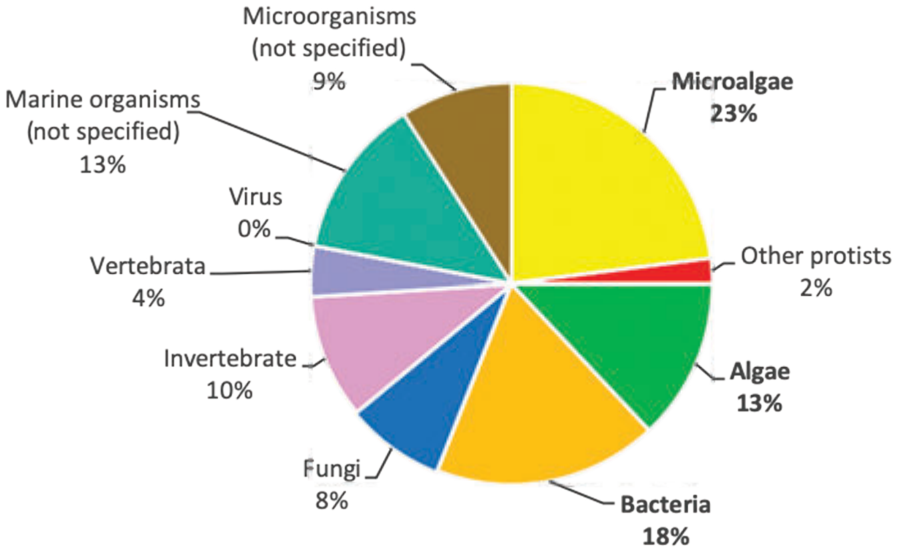


Figure 25 Distribution of marine organisms used in pharmaceutical and food applications of marine biotechnology, by publication (Daniotti & Re, 2021)

The rich biodiversity in the marine ecosystem allows the discovery of a broad range of unique new compounds with more than 13,000 molecules described from these marine bio-resources, and 23.08% (about 3000) of them are found to have active properties with great potential to be further developed in the marine pharmacology industries (Vignesh et al., 2011). Currently, more than seven drugs of marine

origin are approved for human use globally, but many marine compounds are reported at different stages of clinical trials as well as a large number of marine-derived compounds/ molecules (e.g. halichondrin B, soblidotin, and tetrozotoxin) are still in the preclinical testing pipeline (Ruiz-Torres et al., 2017; Ghareeb et al., 2020). The current and potential market value of these marine bioproducts is substantial. Thousands of unique bioproducts have been identified from a relatively small number of the ocean's biochemical diversity (Ireland et al., 1993) and at one-in-6000, the success rate for product development from marine materials is more than twice as high as the one-in-13,000 rate for land-based biological materials, suggesting that research is also high in efficiency (Kim S.K., 2019).

Within the marine biotechnology sector, drugs and health supplements derived from marine resources contributed to more than USD 21 million in the year 2021 and are forecasted to exceed USD 33 million in the year 2027, growing at a CAGR of 6.74% over the forecast period. The revenue and growth rate from the global marine biopharmaceuticals industry has been showing a promising and steady increase since 2015 with a sharp decline in the year 2020 (Figure 26) as a result of the COVID-19 pandemic, but the industry is expected to recover in the next few years. Marine drugs constitute 76.77% while marine nutraceutical products as health supplements also represent a large portion, 23.23%, of the global marine biopharmaceutical market (Global Marine Biopharmaceutical Market report-2027, 2021). Marine drugs such as ziconotide are based on a natural 25-amino acid peptide v-conotixin MVIIA, originally extracted and purified from the venom of a marine snail, Conus magus. Ziconotide is now produced as a synthetic molecule and approved as an analgesic by FDA. The marine collagen market is expected to project encouraging growth with a CAGR of 7.9% in the forecast period of 2021 to 2026 and is expected to reach USD 1,137 million by 2026 from USD 778 million in 2021 (Market and Market 2021-2026). A new trend of adopting a healthy lifestyle and increased consumption of health products are likely the driving factors for this market.

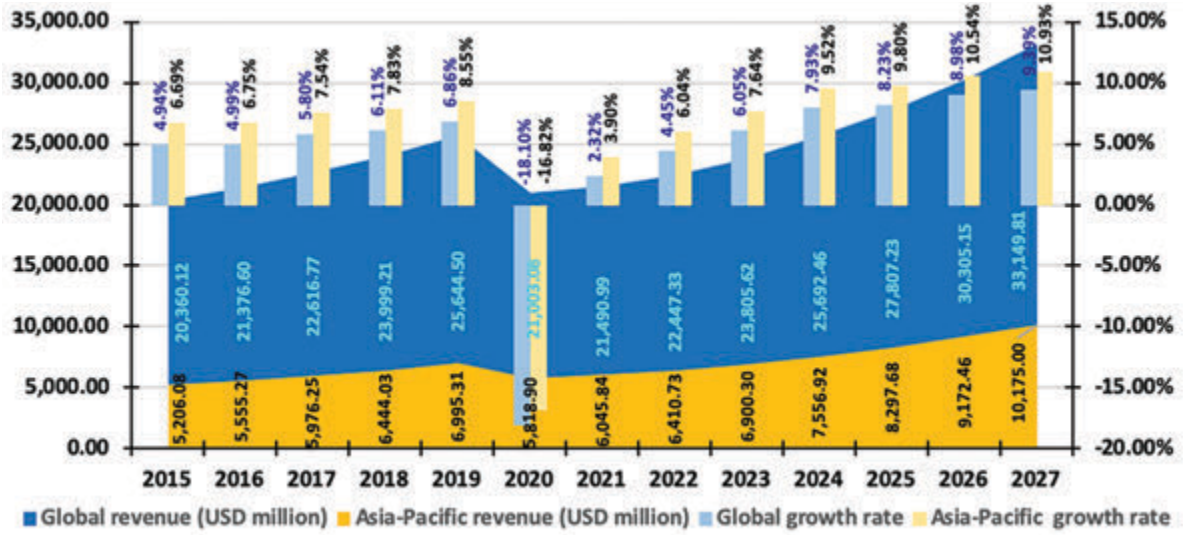


Figure 26 Global vs Asia-Pacific marine biopharmaceutical market revenue (USD million) and growth rate (2015-2027)

Among the various sectors of the Blue Economy, marine biotechnology is relatively new in Malaysia, but it has great potential in contributing to sustainable economic growth, generation of new jobs (OECD, 2013), and sustainable use of ocean resources via a circular economy. Globally, marine biotechnology plays an important role in meeting societal challenges and in supporting economic growth by applying recent advances in marine science and technology (European Science Foundation, 2010; Al-Belushi et al. 2015). Its global market value is expected to grow from $3.84 billion in 2015 to $5.9 billion by 2022 (Ninawe & Indulkar, 2017). The nation's long coastline (home to many coastal communities) and vast sea area of 614,159 km2 (ADB, 2014a) which is almost double its landmass present us with

ample opportunities and the advantage to tap into the rich marine bioresources through marine biotechnology and bioprospecting. Malaysia's marine ecosystem is blessed with high productivity and rich biodiversity, which includes many unique and diverse species of marine microorganisms, sponges, corals, algae, fungi, and invertebrates among others. In particular, biodiversity hotspots are potential areas for the sampling of novel marine organisms with the potential to support the development of marine biotechnology products. Nevertheless, many of the nation's marine resources have so far not been intensively investigated for their biotechnological potential. The discovery of new materials is in line with the Industry4WD: National Policy of Industry 4.0.

The rising incidence of chronic diseases such as cancer and diabetes is one of the drivers for the marine biopharmaceutical market as the demand for pharmaceutical drugs grows, especially for high-priced patented drugs. A sedentary lifestyle, the increasing habit of fast-food consumption, and the growing geriatric population worldwide, especially in the developed countries, have led to an increase in the number of chronic disease patients and consequently the surge in demand for the medication (Global Marine Biopharmaceutical Market report-2027, 2021).

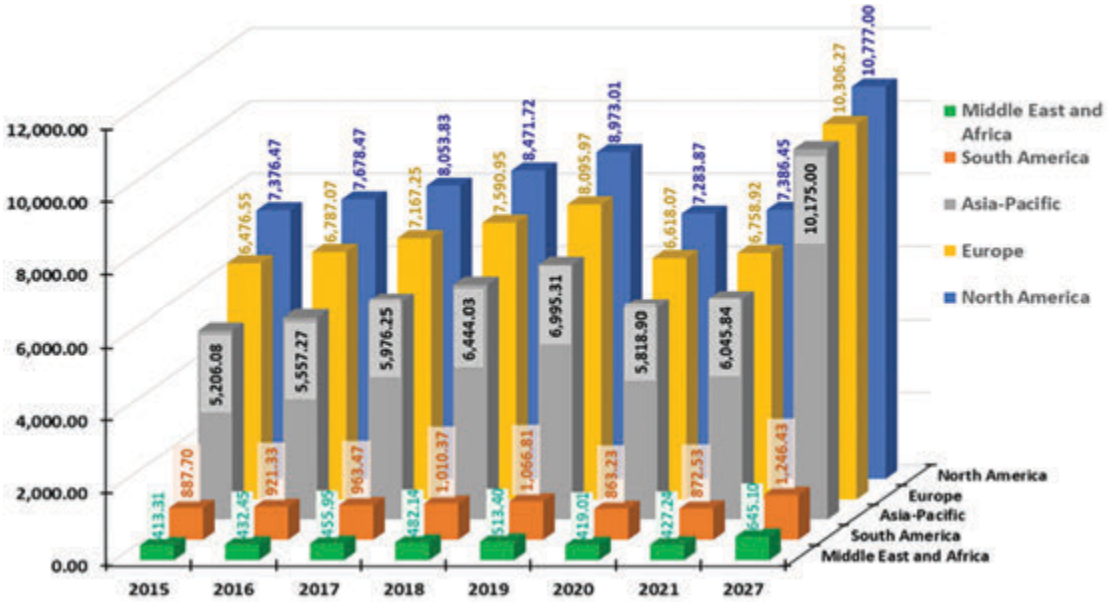


Figure 27 Global marine biopharmaceutical market revenue (USD million) by region (2015–2021 vs 2027)

Globally, North America accounted for a significant market share of 34.37% (or USD 7,386.45 million) followed by Europe with a 31.45% stake in 2021 (Figure 27). Key players in the marine biopharmaceutical market are largely dominated by those from Europe and North America (Seagen Inc., DSM, BASF SE, Amway Corp., GlaxoSmithKline, Pfizer Inc.) and some from Japan (Eisai Co. Ltd., Takeda Pharmaceutical Company Ltd.) Nonetheless, industry players in the Asia-Pacific region are catching up with a steady rise in market revenue and growth rate since 2015 (Figures 27 and 28), and market players in this region are led by those from China, Japan, South Korea, and India (Figure 29). Countries in the Southeast Asia region are collectively ranked 5th behind India with no breakdown in the composition of producing countries. There is a huge opportunity to develop the marine biotechnology sector in Southeast Asia and of course Malaysia, particularly where biodiversity is rich and abundant near the Coral Triangle.

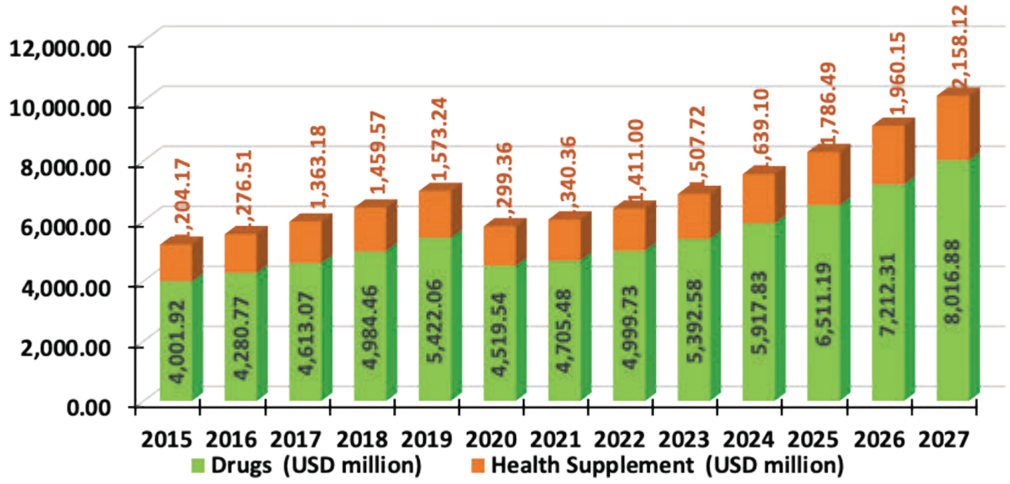


Figure 28 Asia Pacific marine biopharmaceutical revenue (USD million) by type (2015-2027)

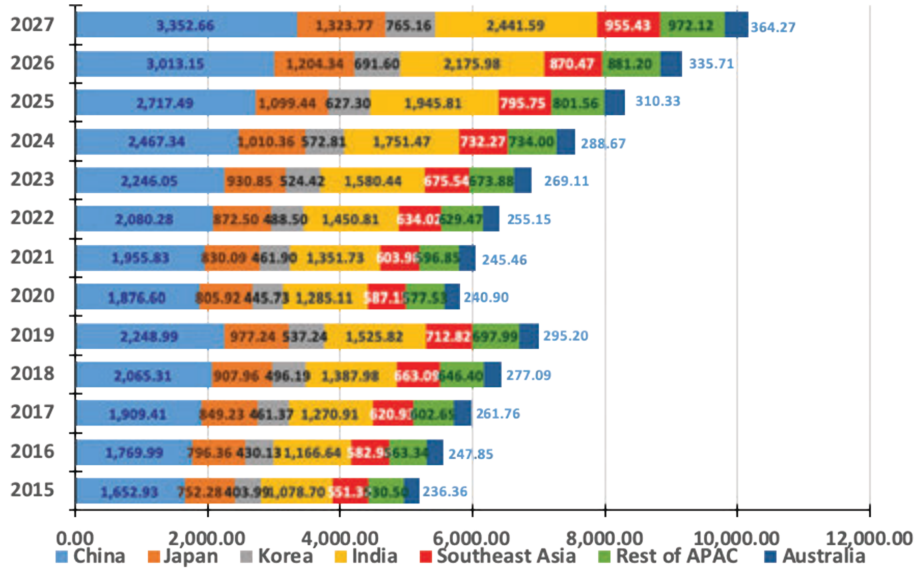


Figure 29 Asia Pacific Marine Biopharmaceutical Revenue (USD Million) by Countries (2015-2027)

The global rush in investing in marine biotechnology and the increasing number of patents based on marine bioresources, particularly genes, signals the need to enhance our capacity to explore, utilise and benefit from these resources through intellectual property rights. Within the marine biotechnology sector internationally, several countries have developed policies to aid its development. In one of the most rapidly industrializing nations, such as South Korea, marine biotechnology is the focus of the Blue-Bio 2016 Plan which identifies four key areas and fifteen sub-areas (Jang et al. 2013):

i) Marine organism-based tech: Marine bio-resources development and utilization, marine organism genome utilization, omics analysis, and utilization, marine bio-mechanism identification
ii) Marine organism production: New marine organism cultivation, marine disease control, and monitoring, mass production of marine bio-resources, marine bio-safety assessment
iii) New materials development: Natural drug discovery, new industrial materials, new health supplements, renewable bio-energy
iv) Conserving marine ecosystem: Environmental change monitoring-forecast, marine pollution control, species diversity maintenance, ecosystem preservation, and recovery

The marine biotechnology sector is currently promoted as one of the driving forces for economic growth in the next generation in India. Ireland has set integrated policies for the development of its maritime sector which includes marine biotechnology. It has set itself the target of becoming an international centre for research into ocean-related technology by the year 2020 (Marine Institute, 2007). Through industrial collaboration, Norway has also established an industrial R&D programme for marine biotechnology in Northern Norway (MABIT) (Isaksen & RemØe, 2001) to increase 'added value' in the fishery, aquaculture, and biotechnological industries in Northern Norway. About 30 companies have been involved in this programme with total funding of about 6 million euros. Norway's economy has in the past been dependent on oil and gas but has since diversified as oil production has been falling steadily since the 1990s. Norway has since invested significantly in marine biotechnology, including aquaculture which is considered world-leading (Al-Belushi et al. 2015).

European Union also considered Blue Biotechnology or Marine biotechnology as one of the emerging sectors in the Blue Economy. EU defined marine biotechnology as using a group of identified marine organisms: algae (macro and micro), bacteria, fungi, and invertebrates which can be commercially exploited and biomass application using non-conventional approaches. The hundreds of new compounds being discovered yearly showed great potential in this sector. Besides, new technology is continuously being enhanced to improve the quality and reliability of the new compounds. To support the growth of this sector, it is estimated that €262 million of research funds have been provided through the European Regional Development Fund (ERDF) and Horizon 2020. (European Commission, 2021).

The number of publications related to marine biotechnology in Malaysia is relatively low in comparison with other developed countries as shown in Table 11. At the same time, the number of patents related to Marine Biotechnology is also rather low (Figure 30). This indicates that there is much room for progress and improvement, particularly in boosting research related to marine biotechnology and bioprospecting in Malaysia, before making a significant contribution to the Blue Economy agenda.

Table 11 Marine Biotechnology Related Research Publication published by Malaysia compared to Other Countries - Web of Sciences Database

No	Topic	Total No. of Article	World Ranking	Asia Ranking
1.	Marine Natural Product	12,631	1. USA 27.91% 2. China 11.56% 3. Japan 9.78% **16. Malaysia 0.66%**	1. China 11.56% 2. Japan 9.78% 3. India 6.25% **10. Malaysia 0.66%**
2.	Marine Drugs	5,361	1. USA 23.93% 2. China 13.84% 3. Japan 10.31% **27. Malaysia 1.05%**	1. China 13.84% 2. India 10.31% 3. Japan 6.01% **8. Malaysia 1.05%**
3.	Marine Bioactive Compounds	2,728	1. India 13.78% 2. USA 13.27% 3. China 12.06% **16. Malaysia 1.94%**	1. India 13.78% 2. China 12.06% 3. South Korea 6.30% **16. Malaysia 1.94%**
4.	Marine Biotechnology	1,102	1. USA 13.70% 2. China 8.89% 3. Italy 8.80% **22. Malaysia 1.63%**	1. China 8.89 2. India 7.99% 3. Japan 5.71% **5. Malaysia 1.633%**
5.	Marine Bioresources	304	1. USA 14.80% 2. France 13.16% 3. Australia 9.868% **15. Malaysia 3.29%**	1. China 9.21% 2. India 8.88% 3. Japan 3.98% **5. Malaysia 3.29%**
6.	Marine Bioenergy	177	1. USA 24.29% 2. South Korea 11.86% 3. England 10.17% **15. Malaysia 3.95%**	1. South Korea 11.86% 2. China 9.61% 3. India 6.78% **4. Malaysia 3.95%**

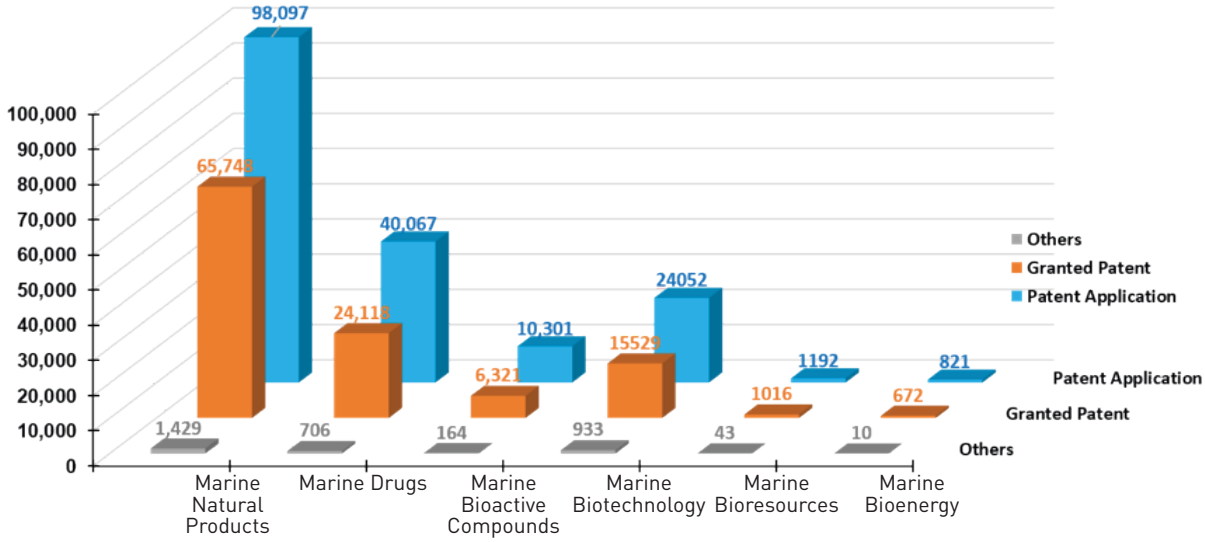


Figure 30 Marine Biotechnology related International Patents Filed/ Granted for the Year 1900 - 2020

2.6.2 State of Ecosystem

2.6.2.1 Current Status

In stakeholders' workshop 1, cvmprising of technical experts in Marine Biotechnology and Bioprospecting sector, more than 60% of the panels collectively acknowledge the current key enablers are weak or moderately weak and lack sufficient development in various blue ocean economy sectors. To transform the blue ocean economy into a strong national sector, 33.3% voted satisfactory status and 4.2% voted good to transform the blue ocean economy into a strong national sector.

The adaptation of the 8i Framework plays a very important role in strengthening the blue ocean economy. Collective feedback showed that all 8i elements (institutions, interaction, integrity, infrastructure, infostructure, intellectual capital, incentives, and internationalization) have performed averagely. Both interaction (collaborative network & strategic network) and integrity (governance system and regulatory framework) were rated best while infostructure showed the lowest rating. Nevertheless, the panels collectively proposed the following top three (3) elements as Blue Economy enablers: namely interaction (collaboration network/strategic partnerships), incentive (fiscal and non-fiscal), and infrastructure (physical and natural), to be prioritised for the advancement of the blue ocean ecosystem. The key takeaway showed the need for a more aggressive top-down approach from governance bodies that create an environment that fosters the development of new marine biotechnology through collaboration from various stakeholders with incentives and also infrastructure.

Despite the announcement of Malaysia's New Biotechnology Policy (NBP) in 2005 which is valid until 2020, the focus was generally on agricultural, medical, and industrial biotechnology but not marine biotechnology per se. This had led to the stagnant growth of marine biotechnology-based industries within the country. The high cost of production and R&D of bioproducts from marine organisms involves huge capital investment, and this has restrained the development of the marine pharmaceutical market (Global Marine Biopharmaceutical Market report-2027, 2021). Malaysia was reported to have dedicated almost USD550 million to developing the industry from 2006 to 2010 (Marine Biotechnology ERA-NET, 2020).

2.6.2.2 Governance and Collaborative Platform

The main obstacle to the development of this sector is the unclear governance structure. Currently, the Access and Benefit Sharing of bioresources is under the purview of the Ministry of Energy and Natural Resources under the Act of the Access to Biological Resources and Benefit Sharing 2017 (Act 795 / the Act), while regulations and permit to access bioresources is generally under state control. In East Malaysia, biodiversity centres have been tasked to govern the access to bioresources for the past few years, but this isonly starting to be implemented in Peninsular Malaysia. In general, there is a lack of information on who are the stakeholders of this sector, what are the aspects of the research being done, and who are the funders. There seems to be no single overarching body that oversees this sector which led to several complications such as the threat of biopiracy, a lack of guidance on funding agencies available to bridge the gap between research and pre-commercialisation to actual commercialisation, and a lack of communication and interaction between the different stakeholders and agencies although many researchers are looking into marine bioproducts. Industry players find it challenging to identify the governing body for various marine resources, while researchers face issues in obtaining research permits from various government agencies. Suggestions were made to set up Marine Network Platform that functions as a one-stop centre comprising multiple agencies based on the disciplines, goals, and industries which are expected to be more conducive and flexible, as compared to a single governing body. There is also a lack of policies related to this sector, for example, the National Ocean Policy is currently available only as a draft, and MOSTI is currently refining the National Biotechnology Policy which should look into where marine biotechnology can fit into one of the three core focus areas i.e. healthcare, agriculture and industrial.

2.6.2.3 Industries Competitiveness

Currently, not many marine-related products can be offered to the market as most are still in the pipeline. At this stage, we are lagging in terms of competitiveness as there is an insufficient volume of biomass (e.g. carrageenan from seaweeds) and the capacity and manufacturing capability of local companies are still low. Some key challenges include contrasting expectations between industry players (more realistic to go for lower hanging fruits which take less time and lower technology to develop) and funders (aiming for more sophisticated products), sharing of intellectual properties, higher costs of local manpower, lack of innovative financial solutions or incentives such as ocean-risk insurance or results/KPI based loans to assure investors of their ROI, TLR levels (what can be done to facilitate researchers to go beyond pre-clinical stages for new products) and the funding landscape in Malaysia is more biased toward conventional funding rather than capital venture or impact funding as in the developed countries.

2.6.2.4 Talent

In general, there is a lack of awareness of the employability of graduates in this field, which led to less interest and enrolment from the wider public. Our public universities currently do not offer any undergraduate programmes which focus on marine biotechnology. To move forward, nurturing a pool of experienced and young researchers that are well trained in current technologies in the related field is very important. There is a need to develop a scheme of knowledge and technology transfer that can prevent brain drain, where students are sent overseas to be trained in the latest development and technologies and upon graduation, bring these skills back to serve the local sector. To this end, grants are essential to expedite the capacity building of human capital for the development of this sector.

2.6.2.5 Research, Development, Innovation, Commercialisation, and Enterprise (RDICE)

There are some initiatives from local universities and research institutes in researching bioprospecting of marine organisms, but these are generally conducted at a laboratory scale without much scaling-up and the approaches used are rather conventional. There is a need to identify new sources of marine

bioproducts, develop novel screening technologies, provide a sustainable source of supply, and optimise the production and recovery of the bioproducts. The identification and application of novel, marine-derived pharmaceuticals, cosmetics, nutritional supplements, enzymes, and pigments have already been realised. Continued discovery and development of marine resources will depend on several factors: identification of new bioproducts, sustainable use of the product, optimization of production, and efficient product recovery. Successfully addressing these challenges will require the integration and collaboration of multidisciplinary teams of oceanographers, biologists, chemists, and engineers. To this end, industry players require assistance in R&D on fundamental aspects of research such as extraction of active ingredients from a cocktail of crude materials or converting hydrophilic compounds to hydrophobic or vice versa before we even venture into cutting-edge technology. Other challenges include the lack of expertise in certain research areas, lack of studies on upstream activities such as culturing or sustaining a live culture of microbes and other marine organisms which are sources of valuable products, and lack of funding for pre-clinical and clinical testing. A platform or network is needed to enable pairing between researchers who have the knowledge and industry players who are better informed on the market needs and to coordinate and resolve conflicts related to intellectual property.

More than 200,000 international patents relevant to this sector have been filed although further information with regards to their actual commercialisation is lacking (www.lens.org). Factors such as the surge in healthcare spending; growing geriatric population; implementation of the UN Nagoya Protocol which provides access, benefit-sharing, and revenues; the challenge of ever-increasing antibiotic resistance in the pathogens, complemented with the call by WHO and several governments in searching for targeted R&D efforts; are expected to help boost the marine biopharmaceutical market. With the current hype on Blue Economy, this is a golden opportunity to revive and further develop the marine biotechnology-based industry in Malaysia.

Environmental Social Governance (ESG) and Climate Change Issues

For this sector to be viable, a vast and sustainable marine resource is the fundamental requirement, hence a healthy and sustainable ocean is vital for the development and success of Marine Biotechnology and Bioprospecting in the Blue Economy. In this regard, relevant legislation is needed to prevent the over-exploitation of marine resources for Blue Economy development. Wild harvesting of marine resources with the potential to be further commercialised is not sustainable in the long run, and thus sustainable supply through aquaculture or bioreactors should be encouraged. Despite having clear guidelines on sample collections from Marine Parks, there is currently no regulating body to monitor sample collections beyond the jurisdiction of Marine Parks. In addition, the current legal interpretation of wildlife appears to be limited to the terrestrial organisms but does not unambiguously encompass their marine counterparts, which hampered the conservation efforts of the latter. Several key issues related to the preservation of ocean health include mitigation of threats to ocean health and transboundary issues, mitigating impacts of Climate Change, promoting the concept of variety creates wealth – "bio" diversity as the key to sources of higher-value-added products from marine living resources, sharing of profits between investors and the coastal communities to encourage collective responsibilities in ensuring the sustainability of the ocean resources and implementation of "rest period" for any activities related to the ocean (e.g., 3 months per year for the recovery of the ocean). The COVID-19 pandemic has demonstrated that with a short break (2-3 months), the degraded environment can recover.

Key Enabling Factors

Despite its long history and rapid development in many parts of the world, marine biotechnology and bioprospecting are relatively new sectors in Malaysia. To date, commercial-scale production of local marine biotechnology-based products is insignificant and very limited (if any). There is great potential for the development of the marine biotechnology sector in our country given the rich marine resources; however, the major stumbling block lies in the lack of existing information, intensive exploration, and innovation concerning their potential applications. Some of the enabling factors include:

1. **Intellectual Capital (Talent).** There is a need to identify niche area(s) for talent development. National Marine Institute to train highly skilled local workers which can avoid over-reliance on foreign labour and provide more attractive salaries to local workers and incorporate marine-related courses in the school curriculum. Besides, public universities should also develop Marine Biotechnology & Bioprospecting undergraduate programmes in addition to strengthening the ongoing post-graduate programmes. Setting up an advisory council for marine biotechnology with experts in academia and industries as council members to provide guidance and consultation when required by the public. Ministry of Education/ Ministry of Higher Education to enhance research capability in the form of scholarships or research funds to support postgraduate students in the field of Marine Biotech & Bioprospecting; Fellowship for Post-doctoral researchers; Financial assistance such as research grants for marine biotechnology-based related industries.

2. **Infrastructure.** Enhancement of R&D capability and capacity such as a designated Marine Biotechnology Institute/Park with basic facilities and infrastructure to support the small and medium industries. Higher visibility and usage of the National Scientific Facilities & Equipment (NSFE) portal by MOSTI which a national inventory database for scientific facilities and equipment is available in both government and private sectors, helps to encourage sharing of resources and reduce the cost of infrastructure among STI communities.

3. **Incentives.** Innovative financing and investment-friendly environment such as establishing results/KPI-based loans to ensure ROI for investors and encourage impact funding as in the developed countries, which incorporates elements of environmental sustainability governance (e.g. seaweed aquaculture for carbon trading). Ministry of International Trade and Industry to provide a special incentive for Marine Biotechnology and Bioprospecting related industries and take proactive steps in attracting foreign investors. Given the relatively high risks related to the industry, insurance schemes to safeguard sea farming for entrepreneurs and their workers is necessary for the development of the industry.

4. **Interaction.** Integrative academic-industry collaboration, especially to address the gap between research areas and addressing market needs, sharing of intellectual properties, and transfer of technology (begin with fundamental extraction processes before venturing into cutting-edge technology) from the academia to the industry. The Researcher-Industry Scientific Exchange (RISE) platform is a good avenue to foster more interactions and collaborations between academia and the industry. Ministry of Science, Technology, and Innovation to provide research grants, and initiate a blueprint for Marine Biotechnology Industries.

5. **Institution (Governance).** Formulate national policy frameworks and governance structures (including clear jurisdictions of the competent authority/governing body to oversee related matters, such as permit applications) for marine resource access and management and biosafety at both the state and federal levels.

6. **Infostructure.** High-speed internet and a large capacity of server database are required to store a huge amount of data to be generated from omics research. Centralised information platform to enhance and facilitate the collaboration between research experts and industries as well as a one-stop centre to explore patents or products that can be commercialised by the industries.

7. **Internationalization.** Collaboration with other countries to foster technology transfer is essential for the country. Additionally, foreign investment is needed due to the large capital needed for marine resource exploration.

8. **Integrity system.** The government and stakeholders of the industry should promote public awareness and acceptance of marine biotechnology-derived products through education and marketing to strengthen the value chain. It is also important to ensure that the products meet international standards and regulations by implementing traceability of the source.

Goals and targets for transforming Malaysia into a successful Blue Economy

1. Instead of exporting raw marine-based products, Marine Biotechnology and Bioprospecting Industries should be the key economic sectors for Malaysia.
2. Omics-driven technologies and marine organisms as model systems to understand and manipulate the intricate system biology, especially concerning the production of secondary metabolites.
3. Bioprospecting for new sources of marine bioproducts such as through deep-sea exploration.
4. Diversification and innovation in the use of existing and newly explored marine resources (e.g., algal pulp and fibre for paper and as battery composite material, algal biomass waste for degradable bioplastics and biofuel).
5. Development of novel screening technologies through joint R&D cooperation between private and public sectors.
6. Cultivation or bioprocess technology instead of wild harvesting: Develop methods for sustainable use of marine biological-based raw material in commercial production without disrupting the ecosystem or depleting the resource via academic-industry collaborations.
7. High throughput tools: Optimization of production coupled with downstream processing and recovery of the marine bioproducts (process development) to meet the need for bulk production.
8. Sustainable aquaculture for food security via marine biotechnology approaches such as improved strain selection, early detection and prevention of diseases with probiotics and reduced use of antibiotics, improved feed, post-harvest improvement, and innovation for value-added products from marine resources.
9. Active monitoring and bioremediation of marine pollution using naturally occurring marine organisms (generally microbes) for a healthy ocean to ensure the sustainable supply of marine resources.
10. A national register of indigenous marine resources (e.g. DNA sequences deposited in the global public repository) and the relevant stakeholders is proposed for transparency and to minimise the risk of exploitation by foreign parties. Nonetheless, it is equally important to ensure that effective legislation is in place to protect endangered and threatened indigenous marine species as relatively less attention has been given to the marine species (only a small section under the Fisheries Act) and marine ecosystem with regards to assessments and baseline data, compared to their terrestrial counterparts (Wildlife Conservation Act).

Shared Prosperity Vision Target

1. Marine biotechnology & bioprospecting-based technology will provide a sustainable income and livelihood for the coastal communities as well as promote advanced technology-based industries in Malaysia, hence positively impacting the nation's Gross Domestic Product (GDP). This will create new opportunities for small, medium, as well as large industries. In other words, this sector is a broad-based developing industry that will bring economic gains to entrepreneurs, their employees, the communities in which they establish their facilities, and indeed to the entire nation (Balint et al. 1998).

2. Proper mechanisms and regulations need to be put in place to ensure equity and access-benefit sharing with the coastal communities instead of biopiracy or monopoly by large corporations and entrepreneurs. Some host countries or entities enter into benefit-sharing agreements with established foreign companies in return for royalties from any resulting commercial products and technical training or assistance.

3. Improving the quality of life through the discovery of novel and functional bioproducts (e.g., functional food and beverages, dietary supplements, novel drugs, treatments, health, and personal care products) as an alternative to terrestrial-based biological resources.

4. Provide wider options of raw biomaterials (e.g., enzymes, biopolymers, and biomaterials) for use in various industries, at the same time reducing the heavy reliance on depleting conventional raw materials.

5. Development of biotechnological approaches, mechanisms, and applications to address key environmental issues for a healthy and sustainable marine or ocean environment.

6. Conservation of designated marine protected areas where indigenous marine resources are distributed, in particular where the resources are rare or under threat. It is also important to ensure that biosecurity measures are implemented to avoid genetic pollution by non-native strains introduced for cultivation or bio-invasion by alien species.

2.6.3 Issues, Gaps, and Challenges

Table 12 Issues, Gaps, and Challenges for Marine Biotechnology & Bioprospecting Sector

Governance and Collaborative Platform	Industries Competitiveness	Talent	RDICE	ESG & Climate Change Issues
• Weak governance; no National Ocean Policy. • Fragmented coordination among the key players. • Key institutions managing biotechnology sector have not given adequate focus on developing this field.	• Lack of ready-to-market products. • Contrasting expectations between industry (go for lower hanging fruits) & investors (aiming for higher tech products) • Lack of market mechanism to increase the demand and supply of high quality marine-derived procceses/ products.	• Lack of interest in marine biotechnology due to poor career opportunities. • Lack of expertise to develop cutting-edge and multidisciplinary technological convergence to highlight the importance of this field. • Poor entrepreneurial skillset, especially venturing into competitive global markets.	• Low investment in R&D, especially fundamental and translational R&D. • The R&D is not in line with the needs of industry. • Low commercialization activities due to unclear pathway. • Low academia industry collaboration. • High dependence of foreign technology.	• Poor understanding on global best practices in the field. • The technology and knowledge transfer between local institutions and industry global leaders are patchy. • No clear guidelines on access and benefit of sharing marine resources, leading to over-explotation & biopiracy. • Malaysian firms operate at the lower-end of the value chain.

2.6.4 Way Forward

Figure 31 shows the way forward in the marine biotechnology and bioprospecting sector.

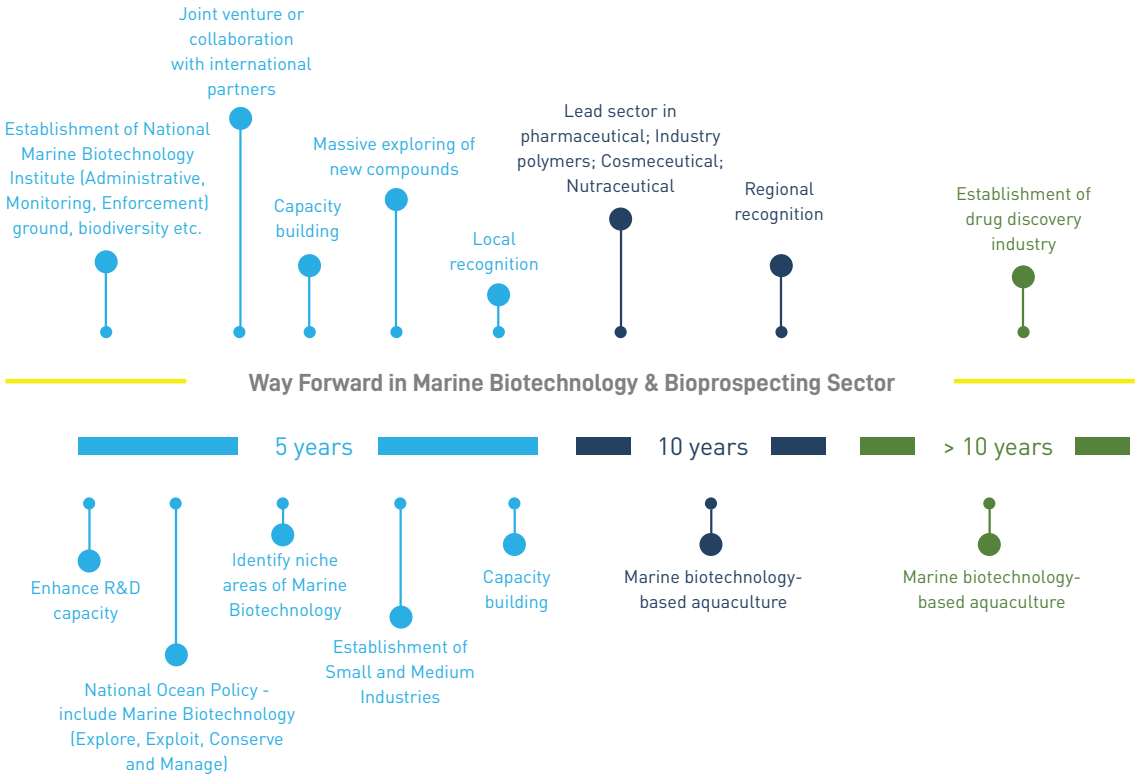


Figure 31 Way Forward in Marine Biotechnology & Bioprospecting Sector

2.7 Desalination for Freshwater Generation

2.7.1 Introduction

Supply of raw water extracted by source, Malaysia, 2014 and 2018

In 2019, the supply of raw water extracted from rivers and storage dams increased by 1.2% compared to 2018. Meanwhile, the supply of raw water extracted from the storage dam and groundwater decreased by 0.1% (Table 13).

Table 13 Raw Water Sources 2018-2019

Source	2018		2019	
	Volume (mld)	Proportion (%)	Volume (mld)	Proportion (%)
Surface Water	12,138	80.5	12,498	81.3
Dam	2,730	18.1	2,669	17.4
Ground Water	209	1.4	202	1.3
Total	15,077	100	15,369	100

Source: Suruhanjaya Perkhidmatan Air Negara Annual Report 2019

Freshwater is predicted to be an invaluable resource in the new future. The oceans are a reservoir for this resource. Desalination is a process that removes the excess salt and other minerals from saline water to obtain fresh water that is fit for human and animal consumption, as well as for irrigation.

Desalination of seawater can serve as a sustainable remedy to account for water issue as more than 97% of the water available on the earth exist as brine water and the sea covers more than 70% of the earth's surface. Globally, desalination has been acknowledged as an essential alternative for conventional water reclamation technologies to tackle water shortage issues in many arid and water-stress regions. The rapid booming of desalination on a global scale is majorly contributed by the capability of this technology to provide a reliable climate-independent source of high-quality product water. Over the past decade, the dependency on desalination for clean water has been steadily increasing where a great momentum has been observed in the expansion of desalination industries. Currently, various seawater desalination technologies, which can be generally categorised into thermal-based and membrane-based processes, have been established. Membrane-based processes in particular account for more than half of the newly constructed desalination plants in the world. As of 2018, it has reached 96 million cubic meters per day. It has been estimated that the number and size of the global desalination market are growing at a fast pace of 5-6% per year, corresponding to the production of an additional 3.0-4.0 million m^3/day of freshwater from these newly installed desalination plants (Statista, 2018).

On average, Malaysians' water usage per person is over 201 litres per day (Suruhanjaya Perkhidmatan Air Negara SPAN, 2020). Hence, the constant exploitation of natural resources by agricultural users also leads to the need for desalination in the country. Worsening, with the climate change and occurrences of the El Nino phenomenon, Malaysia increasingly faces prolonged drought and drier weather, which also means that the country receives less rainfall. Hence, this resulted in a higher probability of water supply shortages and disruptions as the reservoirs and dams dried up. In this regard, desalination could serve as an attractive approach to rendering reliable water supply against prolonged periods of droughts.

Seawater desalination has been used for decades and it is a reliable method to produce high-quality freshwater. Seawater is almost an inexhaustible source to produce fresh water through desalination, so even in times of droughts, there will be sufficient access to freshwater supply. Promoting the ocean as a long-term water supply will be helpful to increase the awareness of protecting our oceans. The largest consumer of desalinated water is primarily water utilities with significant drinking water demands and long-term investment horizons, making the cost to produce water a primary driver for new technology and water supply adoption. The total dissolved solid concentration of seawater is more than 200 times that of river water, hence much greater energy is required for the water treatment process. Although costs for these large desalination systems are greater than typical water supply sources (i.e., surface water or groundwater), desalination becomes economically viable as other water sources become less abundant. Utilities are interested in desalination to establish control and reliability of water supply, provide drought resistance, and diversify their resources. Because of the high cost of these systems, water utilities expect the long-term operation to provide maximum pay-out. Currently, the desalination market is negligible to the total Malaysian water consumption. Desalination is still an energy-intensive process and the high electricity costs have similar economic implications to fuel or other operational costs that cannot be amortised over the life of the project. The ability to bypass these energy costs could potentially be critical for development.

Reverse osmosis is a common method for seawater desalination. The quality of seawater including the temperature, pH, and total dissolved solid has a significant impact on the performance of the reverse osmosis process and the quality of the final product water. Thelifespan of the membrane is also strongly dependent on the characteristics of wastewater. The presence of undesired biological components, such as algal blooms can cause significant operational issues that result in increased chemical consumption, increased membrane fouling tendency, and in the worse scenario, a plant to be taken off-line. Therefore, understanding the compositions that are present in the ocean is an important

condition for the proper design of the desalination plant. It emphasises the need for pre-treatment steps to remove the contaminants in treatment that will interfere with the desalination process. The desalination process has been done minimally in Malaysia due to its dependency on surface water collected using dams in several locations across the country. Currently, Malaysia has one full-scale seawater reverse osmosis desalination plant located in Pantai Senok, Kelantan. This seawater desalination plant which was commissioned in Feb 2018 can produce 500,000 litres of treated water every day to meet the water demand of the people living nearby. The project was initiated by the Higher Education Ministry through the Translational Research Grant Scheme (TRGS) under the ministry's Sustainable Water Resources Strategic Research Action Plan. The project was said to benefit 3,300 people in the village.

2.7.2 State of Ecosystem

2.7.2.1 Benchmark international strategies and policies to identify gaps and challenges for use in developing best practices for Malaysia.

The international strategies and policies by other countries such as Maldives, Malta, and the Bahamas implement desalination routes to cope with the water needs. In Saudi Arabia, about 50% of its drinking water comes from desalination. Institute for Water, Environment, and Health at the United Nations University (UNU-INWE) reported almost 16000 desalination plants operating in 177 countries (2019). However, the toxic brine increases the risk of food contamination due to the dumping in the sea.

Brine production and high energy are the areas that need to be addressed to close the gap in practicing desalination. Disposal brine is both costly and giving a negative impact on the environment. It is estimated brine is produced at around 142 million m^3/day (Jones and Edward et al., 2019). Many researchers suggest that brine also could be an economic opportunity such as commercial salt, metal recovery, and fish production systems. This was clearly stated in the policy by China in Fujian province which stated Regulations regarding the municipal water supply and water saving in Xiamen, Fujian Province. This policy emphasises the development of wastewater products.

Despite that, desalination also suffers from high energy consumption. The waste heat discharged by the seawater desalination process increases the seawater temperature and results in harmful algal blooms that can cause blockages and cause the power generation capacity of the power plant to decrease. Therefore, it makes sense to combine seawater desalination and energy system utilisation to reduce energy lost.

This practice had been shown by Saudi Arabia's "Shoaiba III factory" where the world's largest solar desalination plant. It shows how a plant can reduce its dependency on energy, instead of generating its energy. Additionally, it also could provide lower costs. Energy coast accounts for a significant fraction of all operational costs. An increase in energy prices leads to an increase in the production cost of water and leads to an increase in the water price. Therefore, a smart move is to have renewable energy equipped for a desalination plant. This was stated in the Vision 2030 and the birth of Saudi solar energy, which emphasises solar energy in every sector possible.

For the USA, every state has its authority related to seawater desalination. For example, in California, their agencies have the authority to create policies or administer regulations governing seawater desalination. The State Lands Commission (SLC), State Water Board,

and the California Coastal Commission have regulatory control over seawater desalination projects. The SLC has regulatory authority over public trust lands, including tide and submerged lands (land under navigable waters), and it has authority to "exclusively administer and control all [public trust lands]" to "lease or otherwise dispose of such lands, as provided by law." A private company or a public entity must apply to the SLC to use sovereign lands for any public trust use. Applications "must include an outline of the proposed project, supporting environmental data, and payment of appropriate fees." The State Water Board is the designated state water pollution control agency under the Federal Water Pollution Control Act. In conjunction with the Regional Water Boards, it is authorised to issue Waste Discharge Requirements and National Pollutant Discharge Elimination System (NPDES) permits. The State Water Board also has the authority and duty to regulate seawater desalination intakes.

A few strategies and policies can be practiced in Malaysia such as:

1. Utilise brine as a source of the economy instead of dumping it in the sea. Few applications could profit from brine because brine as it contains numerous types of minerals. One example is lithium extraction from brine.
2. Support and fund research and technology development related to desalination- material development, brine management, coastal protection, life-cycle assessment, and sustainability.
3. Improve the freshwater recovery rate through research and development of the plant, for example through membrane design and system optimization. This could help reduce the loss of freshwater.
4. Reduce energy costs by integrating renewable energy into the desalination plant such as solar energy and integrate with low-grade heat to reduce the operational cost.
5. Seawater serves as a reliable source of freshwater through sustainable desalination. The implementation of zero-liquid discharge strategies using advanced technology can reduce the negative environmental impact of desalination.
6. Involvement of the government in promoting 'drought-proof' freshwater source: Seawater desalination becomes the major choice of freshwater production technology, particularly in coastal areas with water shortage issues, especially where no other options are available.
7. Human capital development. Provide sufficient training to increase the skills of the operator. This also can improve the confidence of the public in the relatively new desalination technology to be implemented in Malaysia.
8. Perform a thorough life-cycle analysis to achieve balanced water-energy-environmental development through seawater desalination.
9. Attractive scheme and incentive to recognise the growing desalination market and to attract investors.

Shared Prosperity Vision target

1. Desalination technology as a sustainable alternative can promote more efficient use of diversified water resources through seawater harvesting; hence, positively impacting water resources assessment and utilization.
2. Sustainable desalination benefits the public, particularly the residents along the coastal regions, which include municipalities, water associations, municipal companies- job creation (jobs on-site and contracts awarded for plant installation, operation, and post-installation services), and new opportunities for small and medium local business (brine recovery and tourism).

Investment and Financial Implications

Desalination has great development potential on a global scale. This is attributed to the fact that, from

among the 71 largest cities that do not have local access to new freshwater sources, 42 are located along coasts. Out of the entire world population, 2,400 million inhabitants, representing 39% of the total, live at a distance of less than 100 km from the sea.

Other than the fact that desalination may be the only option for particular countries, there are driving forces behind its development potential, making it more favourable compared to conventional resource development. Being independent of climatic conditions, rainfall, etc., a primary force is its identification as a secure source of supply. Desalinated seawater is truly a "sustainable" water source and has an essentially unlimited capacity, not subject to sustainability criteria, although perhaps limited by energy production. When desalination started in the late 1850s, the cost was not as important since the primary challenge was to produce fresh water from seawater for boilers and drinking purposes in ships. Later in the 1960s and early 1970s, desalination technologies (thermal processes) were widely available for commercial production, but the cost was still too high. Membrane processes began to compete in the 1970s and started the trend toward cost reduction. As late as 1975, seawater desalination costs were quoted in planning documents as being about USD2.10/m^3. The expansion of the desalination market has attracted many organizations and companies to improve desalination technologies to reduce costs. Tremendous decreases in desalination costs were continuously achieved in the last decades causing the water price to reach USD 0.50/m^3 for large-scale seawater reverse osmosis (SWRO) plants and specific local conditions and below USD1.00/m^3 for multi-stage flash desalination (MSF). Technological maturity, system integration, and competition combined to cause the reduction of desalination costs in the last 20 years.

Similarly, technological improvements in membrane design and systems integration have also decreased the desalinated brackish water cost by over half in the last two decades. In some systems, the amount of energy required to produce 1 m^3 of freshwater decreased by over 64%. It is more difficult to estimate brackish water cost because of water quality and quantity changes from site to site, and sometimes even at the same site. But the cost of brackish water is always lower than SWRO, mainly due to lower salinity feedwater which requires lower applied pressure and allows higher recovery. This thus causes a lower energy consumption per unit volume of water produced, and a substantially lower investment cost. Low-cost portable water quality from a brackish water source can also be achieved by electrodialysis reversal (EDR) technology. A very large-scale brackish water desalination plant, with a total capacity of 200,000 m^3/d and using EDR technology, was built recently in Barcelona, Spain. Typically, EDR is selected over reverse osmosis (RO) for systems that have a particular water chemistry issue, such as a high sulfate to chloride ratio in the raw water (Marine Impacts of Seawater Desalination, 2019).

Although desalination is expensive compared to the conventional treatment of freshwater, the cost of desalination, particularly RO, is decreasing, while the costs for developing new freshwater sources of potable supply are increasing, or no longer possible. Membrane prices have significantly dropped in the past few decades. Prices of thermal processes are also falling, attributable to material improvements, process innovation, and increasing competition. Also, as technological developments cause a reduction in the cost of equipment, the overall relative plant costs are expected to decline. This trend has made desalination, once a costly alternative to the provision of potable water, a viable solution and economically competitive with other options for water supply. RO desalination cost includes all the treatment steps including pre-treatment and post-treatment processes but excluding water distribution costs. The overall decline in cost trend may significantly decrease or could reverse based on current, substantial increases in conventional energy production costs.

2.7.3 Issues, Gaps, and Challenges

Table 14 Issues, Gaps, and Challenges for Desalination for Freshwater Generation

Governance and Collaborative Platform	Industries Competitiveness	Talent	RDICE	ESG & Climate Change Issues
• Weak governance. • Fragmented coordination between state and federal jurisdiction.	• High capital costs. • Lacking incentives to attract investors to expand the desalination market. • The market tariff system is not competitive to attract private sector participation and FDIs.	• Lack of acculturation of good water management practices among consumers and firms. • Lack of local talents to develop and adopt locally-developed technology. • Lack of investment in human capital development in the water sector, especially in seawater desalination. • Lacking CEPA, hence talent is not aware on the potential of this sector.	• Low investment in R&D hence there is high dependence on foreign technology. • Low academia-industry collaboration - low translational research outcomes and training of next-generation talent for the industry. • Low commercialization activities of local technology.	• Lack of awareness on global best practices of freshwater desalination. • Lacking technology and knowledge transfer between local and foreign institutions and industry.

2.7.4 Way Forward

Figure 32 shows the way forward for the desalination for freshwater generation sector.

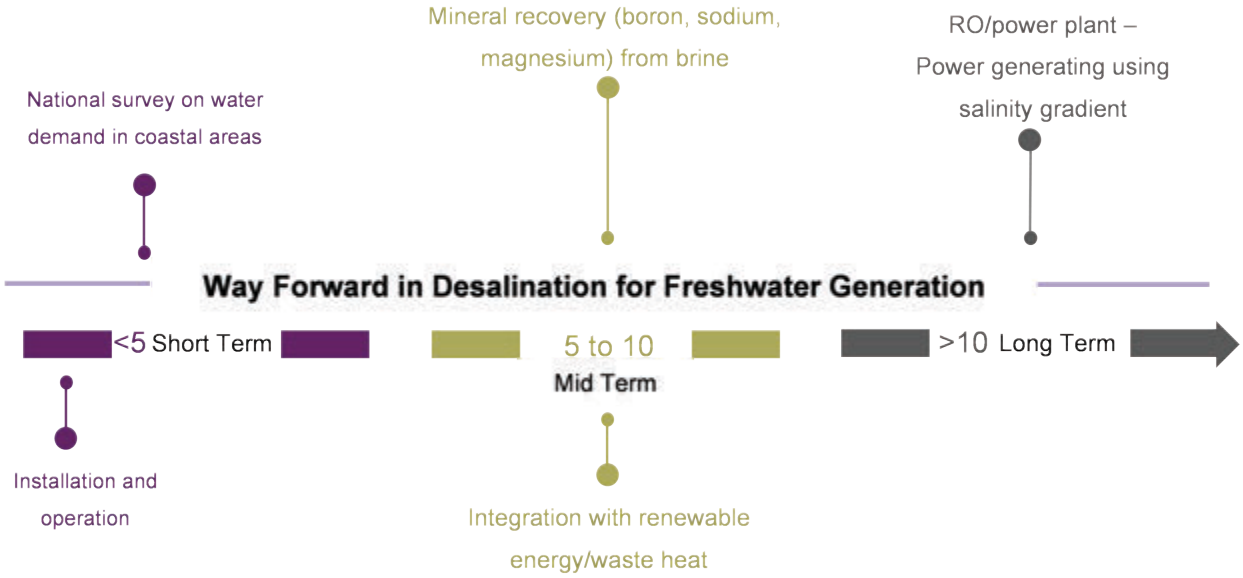


Figure 32 Way Forward in Desalination for Freshwater Generation

2.8 Waste Disposal Management

2.8.1 Introduction

Marine debris has become a more alarming issue in the last decade, with the ever-increasing reports and publications about marine pollution. Though scarce and incomplete, the available data and reports indicated the critical situation of coastal pollution due to improper waste management. The dominant component within the marine debris stream is plastic comprising more than 60% of the total waste stream by weight followed by cigarette butts, paper, and metal. In 2010, Malaysia is labelled to be

among the top contributors of plastics to the world ocean, ranking at number eight. The issue was not solved but continues to escalate by reports of the increasing tonnage of plastics and marine debris collected each year during the International Coastal Clean-up events (Table 15). Recent publication highlights Malaysia to be among the top three countries that contribute to marine plastic pollution (Table 16).

Table 15 Coastal Clean-up (ICC) Report on Collected Marine Debris (2012-2020)

Year	Weight (kg)	Covered area (Km)	Average item collected per Km	Average weight (Kg) collected per Km	Most abundant item
2012	400.06	2.25	-	177.80	Not available
2013	36.93.15	6.44	4,193.22	573.47	Food wrappers (candy, chips) @1690
2014	1277.77	11.27	1,050.48	113.38	Cigarette butts @2,477
2015	926	14.6	1,138.01	63.63	Cigarette butts @1,582
2016	345	12.5	543.04	27.6	Plastic grocery bags@648
2017	5,274	114	675.45	46.26	Plastic beverage bottles @23,664
2018	17,649	1,768.2	196.34	9.98	Plastic beverage bottles @50,699
2019	41,884	2,415.5	359.36	17.34	Plastic beverage bottles @200,797

(Source: Fauziah et al., 2021)

Table 16 Top 50 Countries with the Most Plastics in The World's Ocean

Rank	Country	% Share
1	Philippines	36.4%
2	India	12.9%
3	Malaysia	7.5%
4	China	7.2%
5	Indonesia	5.8%
6	Brazil	3.9%
7	Vietnam	2.9%
8	Bangladesh	2.5%
9	Thailand	2.3%
10	Nigeria	1.9%
11	Turkey	1.5%
12	Cameroon	1.1%
13	Sri Lanka	1.0%
14	Guatemala	0.7%
15	Haiti	0.7%
16	Dominican Repub	0.6%
17	Venezuela	0.6%
18	Tanzania	0.6%
19	Algeria	0.6%
20	Panama	0.5%
21	Cote d'Ivoire	0.5%
22	South Africa	0.4%
23	Ghana	0.4%
24	Argentina	0.4%
25	Sierra Leone	0.4%

Rank	Country	% Share
26	Trinidad and Toba	0.4%
27	Mexico	0.4%
28	Papua New Guine	0.3%
29	Liberia	0.3%
30	Mozambique	0.3%
31	Myanmar	0.3%
32	Egypt	0.3%
33	Honduras	0.2%
34	United States	0.2%
35	Guinea	0.2%
36	Jamaica	0.2%
37	Japan	0.2%
38	Morocco	0.2%
39	Suriname	0.2%
40	Benin	0.2%
41	Albania	0.2%
42	Nicaragua	0.1%
43	Guyana	0.1%
44	Ecuador	0.1%
45	Cambodia	0.1%
46	Uruguay	0.1%
47	Iran	0.1%
48	Libya	0.1%
49	Pakistan	0.1%
50	Angola	0.1%

Source: Meijer et al., 2021

Despite global recognition of plastic as a pervasive contaminant, plastic marine pollution is still a growing environmental threat that affects marine biota and ecosystems (Fauziah et al., 2021; Wright et al., 2013; Zarfl et al., 2010). Global plastic production is increasing and surpassed 368 million metric tonnes (MT) in 2019 (Statista, 2022). Between 4.8 and 12.7 million MT are estimated to enter oceans annually (Jambeck et al., 2015).

The World Economic Forum projects that in 2050, the dumping of plastics into oceans will be over 8 million tonnes per year and result in more plastics than fish in the ocean. While International Union for Conservation of Nature in 2021, reported that there are 14 million tonnes of pieces of plastic debris in the ocean, making up 80% of all marine debris found from surface waters to deep-sea sediments. Adding to that, the UNEP (2006) estimated that every square mile of ocean contains 46,000 pieces of floating plastic. It is worrying to note the fact that plastic debris causes the deaths of more than a million seabirds every year, as well as more than 100,000 marine mammals. It is an undeniable fact that there is no place on earth that is devoid of plastics and their products (Shahul Hamid et al., 2018; Jambeck et al., 2015).

Malaysia has always promoted sustainable development by balancing economic growth with environmental protection in line with the United Nation's Sustainable Development Goals. Malaysia plans to address single-use plastics by encouraging the plastic industry to transition to eco-friendly products, supported by the Malaysia Roadmap towards Zero Single-use 2018-2030, launched by MESTECC in 2018 (Fauziah et al., 2021). This will ensure the industry thrives by adapting green technologies while the environment is safeguarded. Therefore, national and international commitments, cooperation, and implementation, through practical measures integrating circular economy principles, should be used to address the challenges of halting marine debris. This will provide solutions that benefit the environment, society, and the economy.

Waste management has been included as a priority area on national and international agendas since this sector has a tremendous impact on climate change and loss of biodiversity (Gopinath et al., 2020) Waste management has been included as a priority area on national and international agendas since this sector has a tremendous impact on climate change and loss of biodiversity). Malaysia generated nearly 37,560 tonnes of Municipal Solid Waste (MSW) per day in 2019, which is equivalent to approximately 1.17 kg per person per day (Liew, 2020). Landfills and open dumps, being the absolute opposite of sustainable waste management, received about 80% of this generated MSW. Waste collection is on a par with developed nations, and almost all urban MSW is being collected for disposal. However, illegal dumping still occurs sporadically, and it can account for 10% of the total MSW generated. Illegal dumping resulted in the leakage of waste, particularly plastic waste into the environment and eventually ends up in the ocean. Hence, Malaysia is facing a stiff challenge in reducing the amount of waste sent to landfills and adopting sustainable waste management.

Waste disposal is an important component of the Blue Economy. In the past, communities around the world used the ocean for waste disposal, including the disposal of chemical and industrial wastes, radioactive wastes, trash, munitions, sewage sludge, and contaminated dredged material. Minimal attention was given to the negative impacts of plastic waste disposal on the marine environment and even less attention was focused on socio-economic opportunities to recycle or reuse such materials.

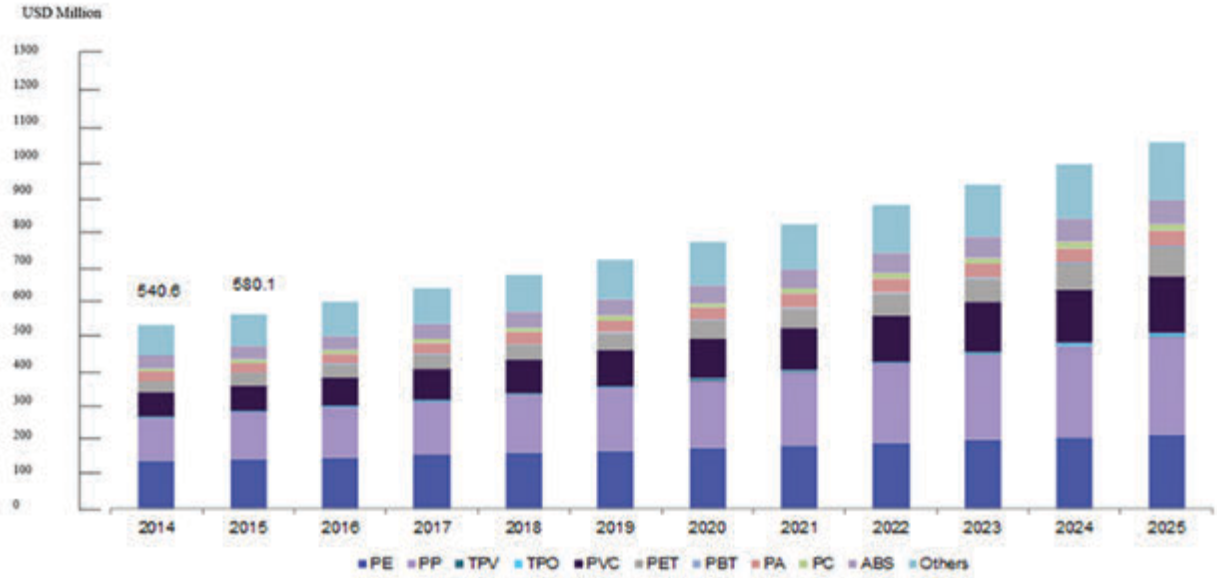
Plastic wastes were frequently dumped in coastal and ocean waters based on the assumption that marine waters had an unlimited capacity to mix and disperse wastes. The impacts of marine plastic debris are far-reaching, with serious consequences for marine habitats, biodiversity, human health, and the global economy.

For instance, marine ecosystems worldwide are affected by plastic waste and microplastics that intentionally or unintentionally end up in the ocean and along the coast. Plastic debris in oceans and seas is an aesthetic problem to Blue Economy, it incurs considerable costs and can have severe impacts on marine organisms and habitats. The fact that 80% of marine debris is land-based, it is very essential that waste, particularly plastics is properly managed since its generation is not going to be on a reducing trend. In 2020, World Wildlife Fund reported that the annual per capita generation of household plastic consumption in Malaysia topped other countries including China, Indonesia, Thailand, Vietnam, and the Philippines, at 16.78 kg (WWF, 2020). In Klang Valley alone, the total plastic consumption increased by 16% over the last decade from 121 thousand tonnes in 2010 to 141 thousand tonnes in 2019 (Fauziah et al., 2021). Hence, appropriate plastic waste disposal is crucially needed to address this alarming state and prevent its intrusion into the marine environment.

The existence of plastics in the marine environment presents several challenges that hinder economic development. Stranded plastic along shorelines creates an aesthetic issue, which has negative impacts on tourism (Jang et al., 2014). It has been identified as a major global conservation issue with implications for maritime industries, tourism, marine life, and human health (Napper & Thompson 2020). Economic losses are associated with reduced tourism revenues, negative impacts on recreational activities, vessel damage, impairment in marine environments, invasive species transport, and damage to public health (Hardesty et al., 2015). Stranded shoreline plastic also negatively impacts shipping, energy production, fishing, and aquaculture resources (Shahul Hamid et al., 2018; Barnes et al., 2009). A conservative estimate of the overall economic impact of plastics on marine ecosystems is approximately 13 billion USD/year (Raynaud, 2014), although the true environmental costs are difficult to monetise. Similar challenges are faced by Malaysia concerning the economic loss due to ocean pollution. However, as reported by the Maritime Institute of Malaysia (MIMA) (Kaur & Jaabi, 2017), the actual estimates of the loss are not available due to the lack of data on ocean pollution.

An effective and consolidated approach to waste disposal management in safeguarding a cleaner and healthy ocean will further highlight the need for a long-term responsible, sustainable, inclusive, and cross-sectoral approach in addressing marine debris and pollution at the source to realise the full potential of Blue Economy in Malaysia. A preventive approach should be prioritised along the chain of operations to avoid the unnecessary burden on waste treatment costs.

Malaysia is a global player in the plastic industry with currently about 1,300 plastic manufacturers. As of 2016, our exports amounted to RM30 billion which saw a 2.26 million metric tonnes of resin utilised to produce plastics (MESTECC, 2018). Figure 33 illustrates the Malaysia plastic compounding market products from 2014.



PBT: Polybutylene Terephthalate; PA: Polyamide; PC: Polycarbonate; ABS: Acrylonitrile Butadiene Styrene

Figure 33 Malaysia Plastic Compounding Market by Product, 2014–2025 (USD Million)

Source: Grand View Research, 2020

The projected increases highlight the urgent need for appropriate and effective plastic waste management to prevent further threats to the marine ecosystem. The increase in the local production and consumption of single-use plastic carrier bags has led to an increase in the volume of mismanaged plastic waste. The mismanaged plastic waste directly contributes to land and water pollution which has resulted in an enormous amount of plastic waste accumulation in our landfills and marine environment. Subsequently, the demand for environmentally friendly alternative products has also been increasing gradually in Malaysia and also in many other countries around the world. In addition to that many state governments in Malaysia such as Selangor, Penang, Wilayah Persekutuan, and Johor have also been trying to promote alternative options to curb the environmental problems in their respective regions. However, there is a misalignment in the policy in various states where each of the states decided to use their respective mechanism to curb the environmental problems.

2.8.2 State of Ecosystem

2.8.2.1 Benchmark international strategies and policies to identify gaps and challenges for use in developing best practices for Malaysia.

Governments have struggled for decades to reduce marine plastic debris (Rochman et al., 2015). The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) was signed in 1973, although a complete ban on the disposal of plastics at sea was not enacted until 1988. Even though 134 countries agreed to eliminate plastic disposal at sea, research has shown that the problem of marine debris has worsened since MARPOL 73/78 was signed. This may be because the marine debris problem is related to the incorrect disposal of waste on land.

Many non-governmental organizations (NGOs) conduct monitoring research on marine debris to increase awareness (Pettipas et al., 2016). For example, the 5 Gyres Institute and the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection engage in awareness campaigns. The Ocean Conservancy oversees the International Coastal Cleanup (ICC). The ICC encourages other NGOs and volunteer groups to engage in mitigating marine debris by cleaning up coastal areas across the globe. The Honolulu Strategy outlines strategies for the prevention and management of marine debris (Shevealy et al., 2012). The Honolulu Strategy has been adopted across the globe to meet the specific needs of different regions, such as Canada and the U.S. (Pettipas et al., 2016). Two strategies from the Honolulu Strategy are of particular interest. One focuses on market-based instruments (e.g., levies on new plastic bags) for minimizing waste. A second strategy creates policies, regulations, and legislation to reduce marine debris (e.g., imposing bans on microbeads and/or single-use plastic bag production).

However, the approach toward integrated waste management should be implemented holistically, not only focusing on plastic waste. This is necessary to minimise the impact on the environment due to increasing waste generation and disposal. For sustainable management, several issues that could become stumbling blocks include, but are not limited to the following:

- **Implementation of Circular economy.** More comprehensive and sustainable waste management policies are needed Improve resource efficiency and productivity throughout the entire life cycle. Apart from that, the proper incentive should be given to the manufacturers and industries, as well as the introduction of the pollution pay principle, packaging law, e-waste management, and deposit refund systems.
- **Lack of database on waste generation.** The provision of data on waste generation in Malaysia is rather inadequate, along with the poor accessibility to the latest data. Moreover, the system for documentation of the waste data collected in Malaysia is not consolidated, especially for industrial and commercial waste. This is reflected in the inaccuracies of some waste data obtained. The agency concerned should be more transparent when supplying the data.
- **Inadequate infrastructures and facilities.** The lack of treatment infrastructures and facilities may be due to the low acceptance of adopting the appropriate available technology. Inability to provide good research and development, as well as poor initiatives on technology and innovation, exacerbate these issues.
- **Low awareness of the public on 3Rs initiatives.** Although recycling campaigns were carried out to initiate the implementation of 3Rs, the lukewarm acceptance and nonchalant attitudes of the public failed. The existing policies and regulations, which lack enforcement together with insufficient material recycling facilities became a hindrance, due to a lack of incentive to entice consumers to recycle. A circular economy approach should adopt to enhance and strengthen 3Rs and separation at source initiatives.

- **Enforcement of Regulations.** Although the enactment of laws is in place, what seems to be lacking is the implementation of a circular economy. Enforcement is not stringent, particularly concerning illegal dumping by factories and scavenging activities at landfill sites. The imposition of fines and compounds, under the Solid Waste and Public Cleansing Management Act 2007 (Act 672), for not separating waste at the source is rather relaxed. The concern act could be seen where not all the states in Malaysia approved and implemented Act 672.
- **Littering and Illegal dumping.** The coastal pollution and coral degradation are due to issues such as littering and illegal dumping. Although the Roadmap towards Zero Single-Use Plastics was launched in 2018 to reduce the usage of plastic and littering, without prior shifting the public mindset on unrestrained littering, the roadmap will become standstill. The concern about the effectiveness of regulations in preventing littering is quite challenging. Apart from littering, illegal dumping is also becoming prevalent, particularly in out-of-the-way areas such as inaccessible forests or unoccupied lands. The incident, for example, Sungai Kim Kim in 2020 should open the eyes to the need to have appropriate measures in curbing illegal dumping. Stringent enforcement and diversified management approaches are needed to prevent further tragedy from occurring.

  More than 60 countries worldwide have introduced some measures to curb single-use plastic waste such as imposing bans and levies. Some countries have imposed direct bans on single-use plastics but according to a UNEP report, the bans have not been effective to curtail plastic pollution. The report also highlights other countries have taken a phased approach and, in some cases, complemented with economic instruments. For example, India is planning to phase out single-use plastics by 2022. Taiwan and European Union plan to phase out single-use plastics by 2030. Plastic pollution is a global problem that needs to be addressed sustainably.

Blue Economy in Malaysia should be able to consider several best practices on waste management from other countries. For example:

1. US Act to Prevent Pollutions from Ships;
2. Marine Debris Research, Prevention and Reduction Act;
3. Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA): by United Nations Environment Programme (UNEP);
4. Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal (Malaysia is a member of this multilateral agreement)

Requirements

1. Infostructure, Intellectual Capital, Integrity, Incentives, Institutions, Interactions, Internationalization)
2. Infrastructure: resilient and sustainable infrastructure should be in place to address land-based marine debris at the source to upscale access to recycling infrastructure at identified designated areas/zones and leverage blockchain technology to stop plastic waste from entering into oceans.
3. Infostructure: a central coordinating agency or body should be assigned accordingly among the stakeholders of Blue Economy in collating, documenting, reporting, and analysing data which includes real-time data monitoring in-sync with the latest IR4.0 instrumentations. This is an important measure to address data disaggregation and standardization. These data should be taken up as part of the national statistics.
4. Incentives: provision of relevant research grants and scholarships to foster academia-industry linkages to take up research on waste disposal management. Another one would be the provision of a sustainable incentivised and rewarding ecosystem to attract more investors among waste sectors and international partners.

5. Interactions: all relevant stakeholders, especially at a higher level (ministerial) should work in synergy to address the issue of waste management which involve multi-stakeholders and a multisectoral approach. Relevant industries must be identified and be part of the initiative to provide real feedback and input on the implementation of waste disposal management to propel Blue Economy's transformation in Malaysia. These are important steps to reaching a common understanding of the Blue Economy.
6. Internationalization: Blue Economy in Malaysia requires local, regional, and international collaboration on research, policies, industries, and inter-governmental participation to expedite sharing of best practices and minimise unnecessary waste of time, resources, and effort. Strategic cooperation with regional and international partners is vital to provide critical and honest external input and advice to minimise risks of failure at all stages of planning, governance, monitoring, evaluation, and continuous improvement of the Blue Economy ecosystem. Blue Economy should be linked closely with Sustainable Development Goals (SDGs) for all respective sectors and other international agreements.

Strategies

- A global impetus for action on plastics and marine debris: Support the implementation of existing global commitments on marine debris.
- An efficient waste management system is vital for moving toward a more circular economy. A circular economy could be fostered as a framework for change across governance levels by promoting sustainable consumption and production; promoting the transition to a circular economy to create a plastics system that works in the long term, with enhanced system effectiveness, increased resource productivity, and drastically reduced marine debris.
- Enhancing and committing to a national road map for action on single-use plastics and marine debris. Hence, introducing regulations on single-use plastic such as banning single-use plastics and microbeads.
- Ensuring collaboration and coherent approaches with other processes such as SDGs.
- Implementation of mandatory rule for Polluter Pay Principles. Ban the imported waste/restrict the industry.
- Capacity building and knowledge enhancement in terms of implementing agencies. Educate the agency on enhancing knowledge in terms of proper segregation or identifying the waste. Extensive adoption of solid waste management on recycling approaches and strategies should be implemented to ensure that all the required recycling plan targets are achieved.
- Strengthen the act/policy that has been adopted – fine/imprisonment.
- Adoption of Act 672 to all states in Malaysia for consistency and effective National Strategy implementation.
- Coordinating a centralised platform to comprehensively address sustainable waste management. Central Ministry/agency coordinating all efforts – draw up a comprehensive policy with corresponding regulations. Provide a real-time database on waste (e.g. volume of biomass). Provide training and technology development in Malaysia.
- Strong front-end community-based 3R programme (everyone separates their waste). A good consolidation plan to minimise waste and improve existing 3Rs initiatives should be employed by the local authorities.
- Incentives (e.g. grants, green discounts, etc.) for SME industries to motivate and promote waste minimization, waste recycling, upcycling and circular economy.
- Promote MRF in the industry (Separation of waste – long term and start education system to the norm).
- Increase the infrastructure in the local community areas (e.g., recycling bins). The consumer should be educated, from the young to the old age, to empower them on issues of sustainable

waste management. A strong understanding of current recycling and waste disposal activities as well as knowing the key industry players across Malaysia would help to strengthen the effort for recycling and waste minimization activities.

- Agencies like Standard Institute of Research and Innovation Malaysia (SIRIM), Malaysia Productivity Council (MPC), Malaysia Global Innovation & Creativity Centre (MAGIC), and Malaysia Board of Technologies (MBOT) cooperate as a team to develop the product/green technology/introduce or train local industry.
- Enhance the development of the Green Technology financing scheme.

Requirements in Sustaining Ocean Health for a sustainable Blue Economy

Waste Separation at Source (SAS) is one of the vital key initiatives to address the issue of marine debris both land and ocean-based. Another initiative could be the introduction of more inclusive and holistic approaches. The focus should be directed toward the need to improve resource efficiency and promote a comprehensive life-cycle approach to effectively prevent and reduce land-based waste discharge into the ocean. These approaches will focus on land-based sources in particular, and pursue action including environmentally sound waste management, clean-up of marine debris including plastic debris, and prevention and reduction of plastic waste generation and debris. The Action Plan will also promote the deployment of innovative solutions, in cooperation with existing international/regional initiatives and fora as well as cooperation to enhance national capacities.

Further, the monitoring and evaluation framework will define the methodologies to measure progress based on suitable indicators, as well as a further description of responsibilities and required resources for realizing this action plan.

Several key strategies should be in place to strengthen the effective implementation mechanism of waste disposal management:

1. **A national baseline** on the status and impacts of marine debris in Malaysia is to be compiled by a special task force or working groups. The working groups assess information and data gaps and identify possible interventions to bridge the gaps, as well as establish a national marine debris inventory and continuously update the national recycling rate.

2. **Policy development** by working with other relevant international, regional, or organizations and utilization of available scientific information by taking into account all existing global, regional, and domestic action plans and frameworks on marine debris. Policy coordination should be inclusive by establishing strategic engagement with the private sector and Civil Society Organizations (CSO) while addressing financing gaps for waste management infrastructure and inter-agency policy coordination mechanisms on marine debris and waste management. Effective policy instrumentation should also be able to address the issue of leakage of waste from land and sea-based sources at all respective government levels.

3. **Research and innovation** focusing on innovative solutions to marine debris – shifting towards environmentally sustainable alternative materials, exploring start-up incubator's potential. Highlights should be given towards encouraging research on environmentally sustainable waste disposal management which should support research arms on land and sea-based sources; including potential impacts on human health.

4. **Capacity building** on macro and microplastics monitoring methodologies and best available technologies (BAT) to reduce the release of plastic waste while continuous engagement in consumer awareness activities and education.

2.8.3 Issues, Gaps, and Challenges

Table 17 Issues, Gaps, and Challenges for Waste Disposal Management

Governance and Collaborative Platform	Industries Competitiveness	Talent	RDICE	ESG & Climate Change Issues
• Lack of institutional leadership to address the waste management issue. • Weak and fragmented governance with multiple players, hence lots of turf wars. • Poor enforcement of policies; e.g. management of marine plastic debris.	• No incentives for SMEs to motivate them to develop & implement waste minimization, recycling, upcycling and circular economy. • Low priority on waste management.	• Lack of coordination to motivate local talents in waste management technology development. • Poor understanding in getting better ROV from waste management.	• Low investment in R&D activities. • Lack of investment to develop sustainable waste management systems and viable commercial products. • Weak academia-industry collaboration.	• Imbalance between explotation and economic-driven activities. • Negative impact of marine pollution (human and marine life). • Lack of understanding and adoption of global best ESG practices in waste management.

2.8.4 Way Forward

Table 18 Way Forward and Suggested Actions on Marine Debris Prevention and Mitigation

Phase	Goals	Actions
Phase 1	Compile national base line data on the status and impacts of marine debris in Malaysia	1. Review and analyse material flow data and impacts of marine debris in Malaysia to develop a national baseline report. 2. Assess information and data gaps and identify possible interventions to bridge these gaps. 3. Benchmark with regional and international experts as well as keep abreast with developments in the above-identified areas. 4. Establish a national marine debris inventory and national recycling rate. 5. Assess national marine debris hotspots. 6. Display information on the publicly accessible platforms and update regularly to provide the public with the latest information on the scale of marine debris pollution 7. Update digital and hard-copy data entry reporting for (i) voluntary national actions addressing land-based sources of marine debris; (ii) voluntary national actions addressing sea-based sources of marine debris; and (iii) voluntary national actions addressing education and outreach on marine debris. 8. Organise expert exchange platforms and/or study-trip programmes

		for schools and tertiary institutions. 9. Establish an information platform for NGOs and youths to exchange information and share innovative solutions and best practices. 10. Establish an official governmental agency to coordinate and be responsible for all matters about marine debris.
Phase 2	Policy development and implementation	1. Establish a National Marine Debris Monitoring Expert Group to streamline and socialise regional/ global findings with national stakeholders and actions. 2. Adopt, where possible, international laws and agreements related to waste management into national platforms with guidelines to facilitate successful implementation on the ground. 3. Establish dedicated inter-agencies working group to streamline the implementation of national actions on addressing marine debris. 4. Review and formulate a national legal framework for addressing marine debris. 5. Review of the National Action Plan to assess the effectiveness and incorporate emerging developments and measures. 6. Organise webinars, workshops, seminars, forums, and other suitable platforms for discussion and collaborations to address related issues and challenges. 7. Develop and implement a robust and progressive strategy to combat marine debris, including having comprehensive integrated waste management systems to prevent marine debris pollution through circular economy approaches. 8. Develop/strengthen upstream as well as downstream policies for mismanaged waste leakages such as single-use plastic, ghost nets, and abandoned fishing gears, including other sectors which cut across manufacturing, wholesale and retail, tourism as well as shipping, and logistics. 9. Promote multi and inter-sectoral initiatives and collaboration to effectively address marine debris through various relevant ASEAN-led mechanisms. 10. Explore the formation of a dedicated working group on the new plastics economy and Extended Producer Responsibility (EPR).

Phase 3	Enhance scientific knowledge, transfer marine technology and promote innovative solutions to combat marine debris.	1. Support research and sharing of scientific knowledge, technology and innovation development, including by engaging research institutions, public and private sectors, international partners, and other relevant stakeholders. 2. Promote cooperation and partnership across research institutions to collect and exchange data and information and develop collaboration on combating marine debris including through national and international events/meetings, and exchange visits. 3. Enhance research/study on marine debris, including plastics and microplastics. 4. Explore the possible development of a network for sharing marine debris data and information via a National Inventory for Marine Debris Monitoring Efforts and Data Collection Hub. 5. Promote efforts to identify and replicate innovative solutions implemented by cities for combating marine debris. 6. Promote a science-policy interface to enhance interaction between scientists and policy-makers, and accessibility to scientific information. 7. Disseminate scientific knowledge through various communication channels such as peer-review publications, conferences/meetings, and mass media. 8. Encourage participation among Malaysian scientists in policy-making processes, when appropriate, to provide evidence-based inputs to the policy. 9. Encourage scientists to incorporate multiple points of view, especially from policymakers, into study design, delivery, and communication. 10. Cooperate with other countries to develop technology, innovation, and new standards to tackle source-to-sea plastic pollution, recognizing the transboundary nature of the issue.
Phase 4	Deployment of Technologies, Innovation, and Capacity Building	1. Implement and enforce mandatory segregation at source in all sectors with mandatory reporting guidelines. 2. Engage the private sector in capacity building and campaigns where programmes on the circular economy, product life-cycle management, sustainable consumption and production, and "3R" approaches are being taught and practiced.

		3. Promote private sector investment and innovation to redesign products/packaging, using credible solutions backed up by international standards, enabling materials to return to nature if they enter the environment. 4. Mainstream private sector support to develop research and innovation such as through project funding and prioritising ESG activities on combating marine debris. 5. Engage value chain stakeholders to establish enabling mechanisms /infrastructure to increase waste recovery and recycling. 6. Develop open access traceability schemes for packaging and other forms of solid waste. 7. Explore existing funding mechanisms from MOSTI to support research on marine debris priority areas. 8. Collaborate with mass media (national and private) and engage media agencies to create engaging content on marine debris issues for the public. 9. Explore/Encourage mandatory segregation at source in workplaces (offices and factories) with voluntary reporting guidelines in collaboration with relevant Ministries. 10. Engage multi-stakeholders including youth, environmentalists, celebrities, influencers as well as public and private sectors, and government agencies in advocacy programmes and outreach activities on combating marine debris. 11. Create incentives and reward programmes with businesses such as retailers and F&Bs in Malaysia to encourage the public to take part in combating marine pollution in exchange for attractive returns at their business premises. 12. Develop communication materials on the status and impacts of marine debris by incorporating science-based information. 13. Disseminate the information/materials to the general public via advanced communication platforms, mass media, and public events.

2.9 Ocean Ecosystem Service and Ocean Health

2.9.1 Introduction

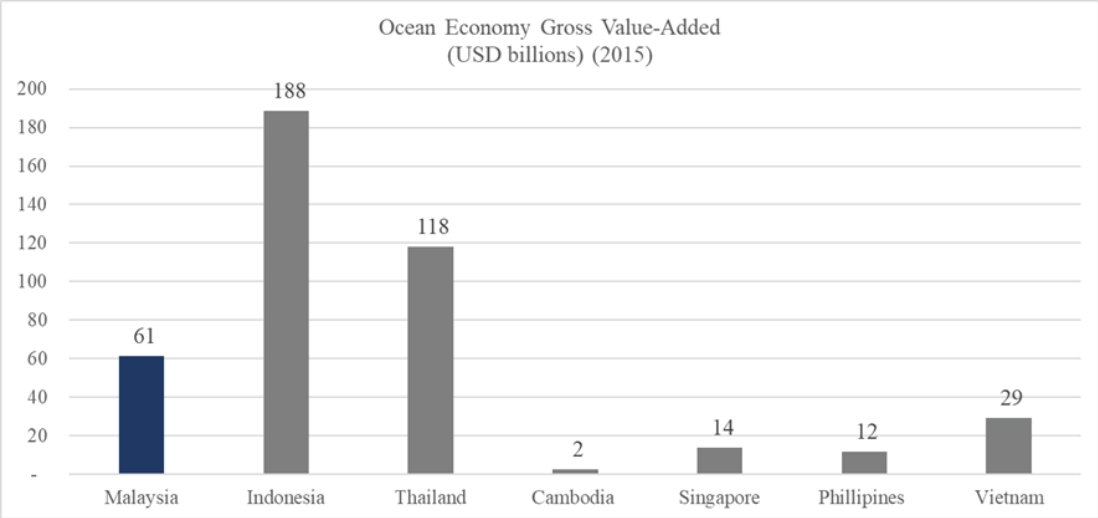


Figure 34 Ocean Economy in the East Asian Seas (PEMSEA 2021)

Blue Carbon Value in the East Asian Seas:

- Mangroves - USD111 billion
- Seagrass - USD75 - USD95 billion

In Malaysia, the value of a coral-reef related business is estimated to be USD635 billion annually in the form of food, fisheries, tourism, and pharmaceuticals (Kaur, 2015a).

Fisheries, aquaculture, offshore renewables, oil and gas exploration, seabed mining, blue biotechnology, marine, and coastal tourism – the uses of global seas are becoming increasingly complex and of increasing economic importance to a range of sectors and countries. The United Nations (UN) is encouraging this development as part of its push for "blue growth" and the advance of a Blue Economy, one that acknowledges that seas and oceans are essential drivers for the economy and have the potential for further – sustainable – innovation and growth.

Meanwhile, available data shows that the marine environment is in a poor and most respect deteriorating state. Many countries have therefore agreed on several ambitious objectives, including effectively managing a well-connected network of 10% of their marine waters as marine protected areas (MPAs), achieving the good environmental status of its seas, and halting the loss of marine biodiversity. Increased exploitation of the seas may put already fragile marine ecosystems under additional stress and aggravate the timely achievement of these important goals. If the Blue Economy fails to develop sustainably, it may also ultimately undermine the foreseen 'blue' economic growth potential as many of the relevant sectors are directly or indirectly dependent on the long-term quality and resilience of the oceans.

For the Blue Economy to be truly sustainable, it must have a framework and processes in place that recognise and accommodate nature's different values that underpin our social and economic wellbeing. The concept of ecosystem services (ES) is often explored to bridge this divide and allow the application of conventional economic thinking to emphasise the various values of nature. Ecosystem

services are already relatively widely integrated into policies and laws that govern the conservation and use of marine and coastal areas and related natural resources in the European Union, providing a legal imperative for the Member States to apply it in practice. This legal imperative and obligation are amplified by the commitments made by the EU – together with the rest of the world – to achieve the 2030 Agenda for Sustainable Development and the 17 Sustainable Development Goals (SDGs) adopted at the UN General Assembly in 2015.

While primarily designated for the protection of biodiversity values at a specific site, Marine Protected Areas (MPAs) can indirectly support and provide a range of socio-economic benefits by improving the delivery of different marine and coastal ES. Marine and coastal ES include, for instance, food provision, climate regulation, and biodiversity conservation, with implications at the local, regional as well as global scale. MPAs are a conservation tool that provides an opportunity to use ES in practice and encourage a shift towards a "greener" blue economic model for marine sectors, for the potential benefit of both biodiversity and people and beyond.

Ocean health is key to the Blue Economy. The concept involves sustainable management of oceans for now and future generations. Healthy seas are key not only for the health of our environment, but also to accelerating economic growth, creating jobs, and fighting poverty. Recognizing the great potential of the Blue Economy, world leaders and scientists united for strategic talks about the future of our oceans at the first Sustainable Blue Economy Conference held in Nairobi, Kenya, in November 2018. The world can improve the health of the oceans, seas, lakes, rivers, and ecosystems they support which are under increased threat and decline across the globe. At its core, the Blue Economy sets a framework for the international community to actively work on conserving its ocean resources and develop more sustainable habits to protect ocean ecosystems. The Blue Economy is a source of economic growth – not just a way to protect the environment but also a source of food, jobs, and water.

The United Nations has recognised the importance of the Blue Economy and its important role in a sustainable future for the world's oceans. Sustainable Development Goal 14, aims to "conserve and sustainably use the oceans, seas and marine resources." The UN seeks to prevent and reduce marine pollution of all types by 2025, and sustainably manage, conserve, protect, and restore coastal and marine ecosystems over the next 5 to 10 years. In addition, SDG 14 aims to conduct greater scientific research into ocean health and marine biodiversity, particularly in small island developing states (SIDS) and least developed countries (LDCs). The inclusion of oceans as an SDG is a signal to help small island developing countries thrive economically through the sustainable use of marine resources, driving tourism, and better fisheries management.

Malaysia is located in the Indo-Pacific region with its coastlines bordering the Andaman Sea, Straits of Malacca and Singapore, Gulf of Thailand, South China Sea, Sulu Sea, and Sulawesi Sea. The coasts and seas are part of the nation's social, economic, security, cultural and natural parameters, which are interlinked and influenced by internal as well as external factors. These sectors are dynamic and continuously changing, providing goods and services and in turn, being affected by their utility.

The seas surrounding Malaysia contain productive and diverse habitats with the major ecosystem being mangroves, coral reefs, and seagrasses, among others. These are productive natural ecosystems that contribute significantly to human, food, economic and environmental security.

Malaysians benefit from the coastal and marine areas in various ways. The local communities are dependent upon healthy ecosystems and habitats which supply many species of plants, animals, and microorganisms that provide food, medicines, and other products for use daily. This, in part, explains

why the Government has become a party to several multilateral environmental agreements such as the Convention on Biological Diversity.

Various studies focusing on the valuation of ecosystem services have been conducted to justify the interest in biodiversity protection on economic grounds. For instance, total economic valuation studies have been carried out in the major national marine protected areas, with the values recorded to be between RM39.6mil and RM3.6bil. The total value of ecosystem services for the country is projected to be about USD17.7bil (Lim & Repin, 2017).

The contribution of the ocean economy to the country's GDP was valued at 23% in 2015 alone, with about 4% of the total employment share in the ocean sector. Just a decade ago, the same was reported to be only about 13% of the country's GDP (Kaur C.R., 2015b).

The Blue Economy concept also focuses on the development of the existing ocean sectors to further generate employment, promote entrepreneurship in new areas of economic activities, facilitate the inter-connectedness of the regional economy, and contribute to sustainable development and climate change mitigation. Major priority areas identified include fisheries and aquaculture, ocean energy, ports and shipping, oil and minerals exploitation, and sustainable tourism activities through various platforms at the national and regional levels.

The ocean sector, which is crucial to Malaysia's economy through its resources and ecosystem services that support trade and industries, requires proper management and conservation strategies to achieve maximum economic, environmental, and social outcomes. This will involve participation from the relevant stakeholders and assessment of the physical and human resources required; investment in research, science, and technology; collaboration; and review and formulation of policies.

Some of the initiatives that could be undertaken include developing a Blue Economy profile and conducting pilot studies of the ocean to help define and refine Malaysia's conception of a Blue Economy and promoting the use of ocean economy data in marine planning at the national level to facilitate further engagement by Malaysia with other countries in the region on related areas.

It is envisaged that Blue Economy initiatives would further drive sustainable development at the national level. The overall management of Malaysia's seas should hence focus on balancing the need to continue or perpetuate the provision of goods and services from the sea while allowing for sustainable development.

2.9.2 State of Ecosystem

Better ocean data and scientific understanding of our marine ecosystem is much-needed confidence to understand the importance of ocean health in the Blue Economy metrics. Current approaches to valuing the ocean economy have underestimated its contribution, particularly the value of non-commercial goods and services. Ecosystem benefits such as the protection of coasts offered by coral reefs, or carbon sequestration are some of the many services offered by the ocean for our essential safety and security. Despite improvements in accounting methods and techniques for valuing this natural capital, there remain gaps in the data and information required to price ecosystem benefits accurately. Thus, more data and understanding of the ecosystem must be improved at the level where the information can be used to better inform policy and investment decisions.

Our major challenges are the role of governments in implementing laws, regulations, institutions, and planning tools to govern our EEZs in an integrated manner. If this can be provided properly managed,

this should greater certainty, transparency, and stability that will encourage new investment. This will certainly add a new dimension to the established ocean industries on how they should transition to more environmentally responsible practices.

In Malaysia, for the past 10 years, the aspect of a marine ecosystem has produced several notable investments in ocean health. Some of these were implemented in the framework of ocean science research and adaptation and mitigation activities. Among the important works under the ocean, scientific research is national scientific cruises, ocean monitoring and forecast, coral reef health monitoring, marine endangered species studies, and ocean pollution research i.e., invasive species and microplastics.
Meanwhile, the adaptation and mitigation efforts include marine protection infrastructure and services, artificial reef deployment, marine conservation and preservation, mangroves replanting, and marine pollution monitoring.

The ocean environment is subject to a complex range of pressures, especially on ocean health. Unsustainable use of the ocean and its resources threatens the basis on which much of the world's welfare and prosperity depend. Our investments in these scientific ocean observations, measurements, forecasts, and adaptation-mitigation efforts play a fundamental role in underpinning the scientific basis for national and international legislation to regulate the use of the ocean and protect the ocean environment.

Table 19 The Components of the Ocean Economy

Type of Activity	Ocean Services	Established Industries	Emerging Industries	New Industries	Drivers of Future Growth
Harvesting of living resources	Seafood Marine Biotechnology	Fisheries	Sustainable Fisheries Aquaculture Pharmaceuticals Chemicals	Multi-species	1. Food Security 2. Demand for nutrient R&D in healthcare and industry
Extraction of non-living resources generation of new resources	Minerals Energy Freshwater	Seabed Mining Oil and Gas	Renewables Desalination		Demands for mineral Demand for alternative energy resources Freshwater shortages
Commerce and Trade in and Around the Ocean	Transport and trade Tourism and Recreation	Shipping Post-Infrastructure and Services Tourism Coastal Development	Eco-tourism		1. Growth in seaborne trade. 2. International regulations Growth of global tourism Coastal Urbanization Domestic regulations
Response to Ocean Health Challenges	Ocean monitoring and surveillance Carbon sequestration Coastal protection Waste disposal		Technology and R&D Blue carbon (i.e coastal vegetated habitats) Habitat protection, restoration	Assimilations of nutrients solid waste	R&D in Ocean Technologies Growth in coastal and ocean protection and conservative activities

Table 19 shows the components of the ocean economy, emphasizing the existing industries facing the transition to more environmentally sustainable practices, or for new and innovative investments, where technologies and business models and innovations are focused on promoting or restoring ocean health.

The term "Blue Economy" has been coined to describe how ocean-based economic activities can be developed sustainably to optimise the benefits and minimise the negative impact on the environment and society. Discussions on the Blue Economy are typically focused on high-tech innovations, large-scale aquaculture systems, and mining of the ocean's depths, which together form an increasingly relevant element of the Blue Economy. However, the immediate impact of the Blue Economy comes from a greater focus on integration, coordination, planning as well as adding value to existing systems, sectors, and tools to ensure sustainable development.

Fisheries, aquaculture, tourism, shipping, biotechnologies, maritime security, mining, oil and gas, renewable energy, and ecosystem services all compete for coastal and ocean space. Understanding the different economic, social, and environmental costs and benefits, as well as the risks of each sector in sustaining and conserving aquatic resources, is necessary for making meaningful inter-sectoral trade-offs.

The Blue Economy aims to achieve this through various tools and assessments that incorporate the real value of the ocean's natural capital into all aspects of economic activities. By reflecting the real value of the ocean's environmental services, the Blue Economy approach optimises the benefits while minimizing the costs between different sector activities in the oceans.
Approaches to be used include:

- Ecosystem-Based Management (EBM) is an approach that acknowledges the importance of healthy and functional ecosystems in maintaining essential ecosystems and takes into account an array of impacts and interactions in an ecosystem – including humans.
- Marine Spatial Planning (MSP), also known as Ocean Use Planning, is an approach that aims at allocating different human activities within specified marine areas on different scales and, by doing so, balancing ecological, economic, social, and political interests and minimizing the conflict between different activities.
- Ocean Health Index (OHI) is the first-ever framework that assesses the health of the ocean by evaluating how successfully and sustainably humans are obtaining the range of benefits that the ocean can deliver.
- In addition to improving data collection and disseminating such information appropriately to facilitate inclusive collaboration and decision-making processes, adequate regulatory and legal frameworks are essential in the transformation to Blue Economy.

A major issue with fast-tracking the development of the Blue Economy is the overexploitation and poor management of the ocean's resources that inevitably results in lost opportunities, heightened food insecurity, and diminished economic opportunities for some unfortunate communities by the coast, e.g. traditional fishermen.

Other major threats to the marine ecology surrounding Malaysia's coastal ecosystem include increases in exotic invasive species; poorly planned and regulated coastal development; unsustainable extraction of natural resources such as sand mining for construction; and the increasing intensity of storm surges and extreme events that provide severe impact on coastal erosion.

Climate change will lead to an increase in the cumulative impact of these factors. The consequence of these impacts will include loss of livelihood, economic opportunities such as fisheries, and loss of natural protection to the coastline.

The natural world is made up of the physical environment, it's mineral components, and biodiversity at all three levels (genetic, species, ecosystem) is intrinsically interconnected, and the more diverse and productive the natural system, the greater the degree of interconnectivity. The ecosystem approach must underpin all aspects of the Blue Economy incorporating inter-relationships, knock-on effects, externalities, and the true costs and benefits of activities in terms of the natural blue capital. Issues of priority include the following:

- Sustainable use of biodiversity
- Food security
- Unsustainable Fisheries
- Climate change and managing carbon budgets.

- Marine and coastal tourism.
- Pollution and marine debris.
- Governance and international cooperation.

Amongst national initiatives that can address these challenges are:

- Integrated Coastal Zone Management: This will serve as the overall framework to guide decisions and lead actions on the sustainable use and development of resources within the coastal zone in the short and long term. Marine Spatial Planning (MSP) approaches to map, zone, and allocate resources that promote a balanced mix of conservation and utilisation. These approaches will help to identify and minimise the impacts that climate change is having on our ocean.
- National Ocean Policy: Provide a guide to short and long-term adaptation and mitigation to climate change. This must ensure a well-integrated and well-coordinated approach to climate change adaptation and mitigation by fostering the development of appropriate administrative and legislative mechanisms in alignment with national sectoral policies and adaptation plans.
- SDG 14 or Ocean Decades 2021-2030: Put forward global initiatives for ocean conservation and sustainable use in the nation's adaptation and mitigation framework. Implementation of best practices and regional or G2G collaboration between countries will help reduce the strain on transboundary-related issues such as invasive species and microplastics.

2.9.3 Way Forward

These recommendations will necessarily require the definition of immediate, medium, and long-term actions across a broad range of sectors as well as require fundamental changes to the traditional institutional arrangements that exist to support marine sector resource management.

Monitoring and evaluation of performance are of extreme importance because the progress needs to be measured and decide whether we are on course towards set objectives.

A coordinated, whole of Government approach is a necessary condition for the successful implementation of the Blue Economy. A Blue Economy Department needs to be established to oversee the completion and implementation of the Strategic Policy Framework and Roadmap domestically and internationally. The Government's ultimate goals in developing the national Blue Economy Roadmap should include:

- Economic diversification & resilience to reduce economic vulnerability and reliance on a small number of sectors and increase the GDP derived from marine sectors.
- Shared prosperity through the creation of high-value jobs and local investment opportunities;
- Food security and well-being;
- The integrity of habitats and ecosystem services, sustainable use, and climate resilience.

The successful and sustainable implementation of the Blue Economy Strategic Framework and Way Forward will ultimately deliver the following outcomes:

- Effective protection of ocean space and resources through better coordination across different sectors, application of protective measures, and greater use of surveillance and enforcement tools;
- Increased investment in the diversification of existing ocean-based economic sectors (particularly fisheries, tourism, and ports) to realise greater value and efficiency from the existing resource base;
- Reduced vulnerability to economic and environmental shocks and dependency on energy and food imports;
- New research, innovation, and generation of knowledge about ocean space, resources, and management needs;
- Exploration and feasibility of new and emerging maritime sectors (for example marine-based aquaculture, renewable energy, offshore petroleum, and marine biotechnology);

- Improved prevention of ocean/Blue Economy risks including illegal, unreported, and unregulated (IUU) fishing, marine pollution, and climate change through integrated approaches to effective regional cooperation on maritime security;
- Capacity for effective ocean management and for taking advantage of the opportunities the Blue Economy offers today and in the future;

Immediate Approach - Research and multi-disciplinary approaches

The most effective approach to managing oceans is to understand the ocean much better than we do now, which remains a major challenge as there still are so many knowledge gaps and unknowns about our ocean. Only about 5% of the ocean has been thoroughly studied, and there are still vast unknowns and uncertainties about emerging challenges like acidification, melting polar ice, and the impact of microplastics.

Moreover, we need to shift from the prevailing compartmentalised, single-sector economic and management approaches, which promote little collaboration across different entities, toward multi-sector, comprehensive systems. Within this complexity, a Blue Economy approach may provide incentives for establishing and supporting better-integrated collaboration and linkages between and across sectors, even among those with competing interests.

- Resources (financial, human capacity, and technical) for implementation projects of the Blue Economy Strategic Framework and Roadmap, need to be identified and secured.
- Strategic partnerships between government and relevant partners including, but not limited to development agencies, private sector organizations, and marine research institutes, need to be established and maintained.

Advancing and applying marine science and sharing it with less-developed states; putting an end to illegal fishing; and extending protection to vulnerable, pivotal ocean areas.

For decades, scientists have been calling for marine protected areas to cover at least 20% of the ocean. The world met them halfway with the Aichi Biodiversity Target to achieve 10% protection by 2020. But, just two years from the deadline, still only 7% of the ocean is protected.

There are six "recovery wedges," or actions to be taken to restore valuable ecosystems:

1. Protecting species
2. Harvesting wisely
3. Protecting spaces
4. Restoring habitats
5. Reducing pollution
6. Mitigating climate change

CHAPTER 3: POLICY GOVERNANCE AND REGULATORY FRAMEWORK

Chapter 3: Policy, Governance, and Regulatory Framework

3.1 Introduction

Chapter Three sets out the policy, governance and regulatory framework for a Blue Economy Position Paper. It highlights the current government ministries related to ocean management, and the laws, policies, and strategies that inform this framework. In the absence of a single regulatory institutional framework for ocean governance in Malaysia, many government ministries are involved in the proposed Blue Economy framework. This chapter reviews the mandates of the Ministries and areas of evaluation necessary for Malaysia's transition to a Blue Economy. The mandate of the Ministries focus on involvement of the National Security Council, the Department of Statistics Malaysia, which is directly under the Prime Minister's Department, the Ministry of Foreign Affairs, the Department of Fisheries under the Ministry of Agriculture & Food Industries, the Marine Department under the Ministry of Transport, the Ministry of Energy and Natural Resources, the Department of Environment under the Ministry of Environment and Water, Tourism Malaysia under the Ministry of Tourism, Arts and Culture, the Malaysian Armed Forces under the Ministry of Defense, and the Malaysian Maritime Enforcement Agency under the Ministry of Home Affairs.. The Chapter evaluates the strengths, weaknesses, gaps, challenges, and priorities in the Mandates of the current and immediate past Governments at the federal, state, and district/town levels on coastal and ocean governance for all nine sectors of the Blue Economy and benchmarking them against suggested international best practices. Further, the adaptation of enabling policies, strategies, and laws to translate the scientific study results into community-based solutions, and to adopt a viable, robust, and yet adaptable national ocean policy for the Blue Economy, as we set out cautiously to industrialise the oceans, are considered.

3.1.1 Sector Analysis

3.1.1.1. Fisheries and Aquaculture

The Department of Fisheries under the Ministry of Agriculture and Food Industries is the stakeholder in the fisheries and aquaculture sectors. A new commission under the Prime Minister's Department as a coordinating body is needed to strengthen effective collaborations and strong partnerships between Government Agencies, Universities, Industries, and Stakeholders, locally and internationally. The urgent need for partnerships to bridge the knowledge gaps, share up-to-date technologies, improve talent, and enhance resource management to accelerate the sector forward is crucial. The competitiveness of the sector needs to be enhanced by improving the supply chain, certification, traceability, application of best practices, and use of innovative technologies for sustainable production. The natural ecosystems and resources should be well protected and managed for sustainable harvests, to support the blue communities and their livelihoods. Networking with regional and international organizations, such as the Food and Agriculture Organization of the United Nations (FAO), the Southeast Asian Fisheries Development Centre (SEAFDEC), the Network of Aquaculture Centres in the Asia Pacific (NACA), and the World Fish would enable the country to learn from the experiences of other countries. The transfer of effective technologies from collaborating countries to improve sustainable local production is needed. Strategic alliances with renowned regional and international aquaculture research centres need to be nurtured for mutual benefit. To accelerate the performance of the fishing and aquaculture sectors, the government must provide financial and non-financial assistance, as well as other interventions to improve competitiveness and mitigate the effects of climate change. Similarly, a new authority is needed to oversee the proposed fish sanctuary.

3.1.1.2. Tourism

At present, the governance of coastal and maritime tourism is under the purview of the Ministry of Tourism, Arts and Culture, State Governments, and Local Authorities.

3.1.1.3. Extractive Industries

To support the growth of the extractive Industries of Non-Living Ocean Resources, the Mineral Development Act (MDA) (1994), the National Water Research Institute of Malaysia (NAHRIM), and various State Mineral Enactments, depending on where the mining operations are located, govern the regulatory landscape of mining operations in Malaysia. The MDA is governed by the Ministry of Natural Resources and Environment, whereas the various SMEs are governed by various state agencies. The federal government works jointly with the relevant state land and mine offices to govern the mining landscape in Malaysia. The Environmental Quality Act of 1974, the Occupational Safety and Health Act of 1994, and the Factories and Machinery Act of 1967 govern various environmental, safety, and health aspects of mining operations.

3.1.1.4. Shipping, Ports and Related activities

Maritime Transport, Ports, and Shipping-related Activities are under the purview of the Royal Malaysian Navy (RMN), the Malaysian Maritime Enforcement Agency (MMEA), the Royal Malaysian Customs Department, the Marine Police, and the Marine Department to oversee the safety and security of the sector. Ports and Shipping activities are under the Ministry of Transport. Besides, the Ministry of International Trade and Industry (MITI), the Malaysian Industrial Development Authority (MIDA), the Ministry of Home Affairs, the Malaysian Maritime Enforcement Agency (MMEA), the Ministry of Defence, the Royal Malaysian Navy (RMN), the Ministry of Transport, the Marine Department, the Department of Fisheries, the 'Lembaga Kemajuan Ikan Malaysia' (LKIM), the Ministry of Finance, and the Royal Customs Department work jointly to enhance the Malaysian Shipbuilding and Repair (SBSR) sector. A dedicated agency to manage the maritime industry can be proposed and aligned with the goals of the 2030 agenda for sustainable development. The maritime industry must work towards balancing the three dimensions of sustainable development: profit; the planet; and people, which currently are found to be imbalanced in the international maritime logistics and transport domain.

3.1.1.5. Renewable Ocean Energy

Renewable Ocean Energy is currently under the purview of the Ministry of Science, Technology, and Innovation (MOSTI), the Malaysian Meteorological Department (MMD), the Marine Department of Malaysia (MARDEP), and the Department of Environment. For the future, it is proposed that a National Oceanography Directorate (NOD) under the MOSTI and the Malaysian Meteorological Department (MMD) be set up.

3.1.1.6. Marine Biotechnology and Bioprospecting

The Marine Biotechnology and Bioprospecting sector is not under the purview of any Ministry or agency. In this regard, it is essential to ascertain (1) which government body would have the regulatory authority and expertise over the wide range of marine bioproducts and processes involved in this sector; and (2) the Lead Agency for Marine Biotechnology with cooperation and partnership from all agencies.

3.1.1.7. Desalination

For Desalination for Freshwater Generation, the agencies involved in governance are the Ministry of Health, the Ministry of Environment and Water, the Ministry of Science, Technology, and Innovation, and the Water Supply Department. Besides these Ministries, the National Water Services Commission, a technical and economic regulatory body for the water supply and sewage services in Peninsular Malaysia and the Federal Territories of Putrajaya and Labuan (SPAN), the State Water Operators, the Indah Water Consortium, the National sewerage, and State water providers such as Hijrah Water are also involved.

3.1.1.8. Waste Disposal Management

Waste Disposal Management is under the Ministry of Higher Education (MoHE), the Ministry of Environment & Water, the Ministry of Housing & Local Government (KPKT), the Ministry of Science Technology and Innovation (MOSTI), the Ministry of Transport (MOT), the Ministry of Health (MOH), the Ministry of Tourism, Arts and Culture, the Department of Marine Park, and the Department of Environment and Marine Department Malaysia. The latest agencies include the Maritime Institute of Malaysia (MIMA) with its respective Centre for Ocean Law and Policy (OLAP) and Centre for Coastal and Marine Environment (CMER).

3.1.1.9. Ocean Ecosystem Services and Ocean Health

Unfortunately, activities related to Ocean Ecosystems Services and Ocean Health are still not under the purview of any agencies. New tools and approaches to ocean governance include Marine Spatial Planning and Marine Evidence-Based Management.

3.2 Policies applicable to all nine sectors

In the absence of a national ocean policy and a single governance mechanism, the establishment of a related National Ocean Policy and the National Institute of Oceanography are the two key new strategies proposed to complement existing policies related to ocean and coastal management in Malaysia. The term 'policy' is used here to cover international treaty regimes, policy instruments, strategies and action plans, including inter-governmental and non-governmental action plans. The existing policy refers to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, which covers 27 dangerous wastes except for radioactive waste and garbage from ships. In addition, the Coordinating Body on The Seas of East Asia (COBSEA) oversees the implementation of the East Asian Seas Action Plan. This regional intergovernmental mechanism brings nine countries of East Asia to the development and protection of the marine environment and coastal areas of the East Asian Seas in addressing the Aichi Target on the Convention of Biological Diversity (CBD). In addition, the Sustainable Development Goals (Number 14: Life below Water), the National Policy on Climate Change, the National Forestry Act, and the National Biodiversity Act assist governance in the nine sectors.

3.2.1 Fisheries and Aquaculture

The National Agro-food Policy (NAP 2011-2020) and the Aquaculture Industrial Zone (AIZ) are the existing policies associated with Fisheries and Aquaculture. In addition, the National Plan of Action (NPOA) on the Conservation and Management of Fishing Capacity, the Malaysian National Plan of Action for the conservation and management of sharks (NPOA Sharks, NPOA Dugong NPOA Sea Turtle, and NPOA Sea Cucumber) developed by the Food and Agriculture Organization of the United Nations (FAO) under voluntary implementation, Malaysia's National Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (Malaysia's National Plan of Action NPOA-IUU), the FAO Code of Conduct for Responsible Fisheries (CCRF) and the Regional CCRF are additional steps taken to support the growth of fisheries and aquaculture sector.

3.2.2 Tourism

In support of Coastal and Maritime Tourism, policies under the Ministry of Tourism and Culture (MoTAC) are in alignment with related national policies. In support of progression in this sector, the identification of an Institutional Framework and the empowerment of a Lead Ministry/Agency for Blue-Economy, the establishment of a National Consortium under MoTAC, and support for the role of local communities in coastal and maritime tourism industries are beneficial. Furthermore, to ensure successful implementation, the development of a detailed action plan with various related agencies, is among one of the management instruments proposed. Further, enhancement of national networking can be an instrument of strengthening collaboration among national and international agencies. This could be a major consideration in ensuring a sustainable marine ecosystem, i.e., coral reef, protecting biodiversity and aquatic ecosystem resilience. These can be released through sustainable resource management, prevention of habitat destruction and pollution, and enhanced research.

3.2.3 Extractive Industries

Under the sector on Extractive Industries of Non-living Ocean Resources, the related policies are the National Mineral Policy 2 of 2009 compared to Mineral Development Act 1994, the Sea Sand Export Ban Imposed by the former Ministry of Water, Land and Natural Resources (KATS), the Mining policies, the practice in the grant of licenses issued by States in consultation with the Federal Department of Minerals and Geosciences (DMG), and the regulatory oversight of the Department of Environment (DOE). Equally important for this sector, is the reestablishment of The National Mineral Council (NMC) 1998 as outlined in the National Mineral Industry Transformation Plan (TIM) 2020-2030.

3.2.4 Shipping, Ports and Related Activities

The Maritime Transport, Ports, and Shipping Related Activities Sector is governed by the National Transport Policy 2019-2030, the Malaysian Shipbuilding/Ship Repair Industry Strategic Plan 2020, the Logistics & Trade Facilitation Master Plan 2015-2020, the Malaysian Shipping Master Plan 2017-2022, and the "Dasar Keusahawanan Nasional 2030". The strategy to promote innovation in and sustainable growth of the maritime ancillary services includes the evaluation of the Cabotage Policy. There is a need to examine and develop a comprehensive maritime policy regime for long-term development, as well as investigate the need for a national maritime agency and the establishment of a national coordinating entity. Other areas of evaluation, include the Malaysia Shipping Master Plan, the SBSR Industry Strategic Plan 2020, the Logistics and Trade Facilitation Master Plan, and the National Policy on Industry 4.0 (Industry4WRD) followed by the Sustainable Development Goals (SDG) 2030. Likewise, the adoption of a Comprehensive National Ocean Policy and Malaysian Merchant Shipping Act (MSA) that covers (Customs Clearance Procedures, Seamless Logistics), improving the regulatory environment, wider digital connectivity platform (e-commerce), SME development, and support for the services sector, investment policy, and capacity building (re-skill and up-skill in the digital era) are necessary.

3.2.5 Renewable Ocean Energy

The policies of the Renewable Energy sector include the National Petroleum Policy 1975, the National Energy Policy 1979, the National Depletion Policy 1980, the Four Fuel Diversification Policy, the Fifth Fuel Diversification Policy 2001, the National Renewable Energy and Action Plan 2009, the National Green Technology Policy 2009, the National Biofuel Policy, the Green Technology Financing Scheme (GTFS) 2011, the National Renewable Energy Policy, the Green Technology Master Plan Malaysia 2017-2030, and action plans that support the policies.

Sustainable development of renewable energy requires comprehensive policies, action plans, and institutions that focus on energy efficiency, financial and business model structure, legal regulations for innovation, robust data gathering, and reporting framework, as well as awareness and capacity building programmes (IRENA, 2018). Further, policy intervention assists in consolidating the related agencies in promoting ocean renewable energy. The proposed policy on marine renewable energy involves the participation of several stakeholders and the adoption of Marine Spatial Planning for OTEC. Proposed strategic actions include identifying local government institutions and governance in authorizing and specifying procedures for desalination plant planning (site and land usage), operation, utilization, and long-term management; and facilitating the issuance of regulatory permits required for desalination plants at various levels of government (federal, state, and local), and the scope of law and policy to incorporate desalinated water into the water supply.

3.2.6 Marine Biotechnology and Bioprospecting

The policies of the Marine Biotechnology & Bioprospecting sector are the New Biotechnology Policy 2005-2020 (limited to agricultural and industrial biotechnology) and Industry4WD: National Policy of Industry 4.0 (Table 20). Moving forward, it is proposed to avoid complicated and unreasonably strict regulations that will deter potential investments. Establishing a regulatory framework that includes investment guidelines and a one-stop licensing center and developing policies for the development of a Blue Economy based on a risk-benefit science study. In addition, there is a need to impose moratoriums on activities related to the ocean. As benchmarking, Korea's Blue-Bio 2016 Plan identifies four key areas and fifteen sub-areas (Jang et al. 2013) concerning Marine Biotechnology and Bioprospecting.

Table 20 Key areas and sub-areas of Marine Biotechnology & Bioprospecting

i)	Marine organism-based technology	Marine bio-resources development and utilization, marine organism genome utilization, omics analysis, and utilization, marine bio-mechanism identification
ii)	Marine organism production	New marine organism cultivation, marine disease control, and monitoring, mass production of marine bio-resources, marine bio-safety assessment
iii)	New materials development	Natural drug discovery, new industrial materials, new health supplements, renewable bioenergy
iv)	Conserving marine ecosystem	Environmental change monitoring-forecast, marine pollution control, species diversity maintenance, ecosystem preservation, and recovery

3.2.7 Desalination

A policy that governs desalination for freshwater generation is highlighted under the Green Technology Master Plan Malaysia 2017-2030. A new policy is proposed to be inclusive of the following items: Identification of local government institutions and governance in authorizing and specifying procedures for desalination plant planning (site and land usage), operation, utilization, and long-term management; facilitation of the issuance of regulatory permits required for desalination plants at various levels of government (federal, state, and local); the scope of law and policy to incorporate desalinated water into the water supply distribution network to deliver water for residential, commercial and industrial consumption; the establishment of drinking water standard based on WHO that is tailored to desalinated water condition; to provide guideline related to procedure and elements of environmental impact assessment to address environmental concern in order to facilitate the design and installation of the desalination plant; the establishment of Water-Food-Energy Nexus policy framework for comparative study of several countries, e.g. Saudi Arabia and many others. Policies related to the

responsibility of the water operator at the state level with the minister should be created in Malaysia, as the water supply is handled by the state. The Ministry can be a host in standardizing policy between states, especially related to the discharge from a desalination plant. Policies should be emphasised on the subsidies given by the government to consumers of freshwater from desalination. Tax reduction to water operators who install desalination plants as an alternative to conventional water purifying replacing approaches. Encourage the water operator to supply freshwater using the desalination plant to remote areas first, via tax reduction and education. It is necessary to identify areas that require freshwater from desalination, i.e., areas that are always struck by draught.

3.2.8 Waste Disposal Management

For the Waste Disposal Management sector, the policies and cross-referring strategies and action plans include the Road Map on Zero Single-use Plastic 2018, the National Solid Waste Management Policy 2016 (KPKT) (land-based), the Green Technology Master Plan Malaysia 2017-2030 (strategies for resource-efficient society), the Green-Waste to Wealth (land-based waste at source), the National Environment Policy 2002 (coasts and seas), the National Policy on Biological Diversity (NPBD) (2016-2025), and the Strategic Plan for Biodiversity (2011-2020, International commitments).

Progressing further, a joint effort with other relevant international, regional, or organizations and the utilization of available scientific information by taking into account all existing global, regional, and domestic action plans and frameworks on marine debris, policy coordination that is inclusive through establishing strategic engagement with the private sector and civil society organizations (CSO) while addressing financing gaps for waste management infrastructure and inter-agency policy coordination mechanisms on marine debris and waste management are proposed. Effective policy instrumentation should also be able to address the issue of leakage of waste from land and sea-based sources at all respective government levels, such as a group of independent scientific experts that provides advice to the UN system on scientific aspects of marine environmental protection (GESAMP), the United Nations Environment Programme (UNEP), the United Nations Development Group (UNDG) and others.

3.2.9 Ocean Ecosystem Services and Ocean Health

Current Policies on ocean ecosystems services and ocean health focus on Ocean economy assessment: a common framework for the ocean economy-environment assessment.

Ecosystem services are classified along functional lines within the Millennium Ecosystem Assessment (MA), using categories of provisioning, regulating, cultural, and supporting services. There are no Strategies and Resources. Thus, to support, Ocean Ecosystem Services and Ocean Heath, a National Ocean Policy and the Alignment of related national policies are proposed. National Carbon Inventories and National Determined Blue Carbon Contributions are needed.

3.3 Strategies and action plans

3.3.1 Fisheries and Aquaculture

Issuance of the Malaysian Aquaculture Farm Certification Scheme (SPLAM) and Good Aquaculture Practices (GaqP) prevent or minimise the risks of aquaculture production linked to food safety, animal health, and welfare, and environmental integrity and socio-economic aspects associated with the aquaculture. Some additional measures necessary for better governance may include the following recommendations, for example, current legislation/enactments/ordinances require review as some

could be outdated, and too segmented for effective implementation and enforcement by the authorities. Certification of aquaculture practices needs to be increased to enhance product competitiveness internationally. Improving traceability and implementing an anti-dumping policy are also necessary to protect local produce and the country's export quality. Establish a collaborative platform (advisory council or commission) and have more engagements between institutions, governance bodies, and farmers to improve practices through the application of new technologies and increase production, both in terms of quality and quantity. Interventions by authorities (champions and strong leadership) to address the Environmental Social Governance (ESG) & Climate Change Issues. Next, by improving the image of the sector from a low-paying labour-intensive sector to one with money-generating activities would attract more graduates to join the Fisheries and Aquaculture industries. Effective management plans to protect the natural environment and resources should be effectively implemented and enforced.

3.3.2 Tourism

There are several Maritime and Coastal Tourism strategies that may be adopted for improved governance in the transition to a Blue Economy. These include, for example, an increase in fish production and shelter, based on advice from local fisherman as needed, policies to focus on Blue Economy demonstration zones, and for Intellectual Capital: policies focusing on the needs of local resources and clear jurisdiction. There is also a need to ensure effective waste management and disposal in the tourism sector, as well as clear land-use planning and development to be incorporated into tourism policies. It is important to explicitly address the impact of tourism on the environment and local communities and for; policies to address the Blue Silicon Valley institute; to create a research facilities centre specialised in various departments such as climate, biotech, genetic, environmental, and take into account the potential impact of climate change and adopt and implement adequate disaster risk reduction policies and practices in order to increase the resilience of tourism sector. In addition, there could be policies to look at the Open gate strategy; strategies to increase stakeholders engagements and open to economic liberalization, engagement of various stakeholders in tourism planning and development that are integral to the social and environmental sustainability; policy to adopt a Blue Economy demonstration zone; strategy to build the country into a strong maritime power and to expand Malaysia's emerging 'Blue Economy'- that stresses on innovation and which influences international regions. China's 13th Five-Year Plan is proposed as a reference.

3.3.3 Extractive Industries

The main strategies of the Extractive Industries of Non-living Ocean Resources' include leveraging on the initiative by PETRONAS in implementing its CCS programme. Other industries should follow suit in a concerted effort in transitioning towards a low carbon future. Apart from that, the R&D on CCS has the potential to generate spin-off technologies that are beneficial to other industries and society at large. As for deep seabed mining, a legal framework for offshore minerals should be established to make way for Malaysia's private sector or government-linked entities to venture into this industry as it can generate income for the country. Malaysian scientists attached to the institutions that are involved in researching deep-sea minerals and seabed mining should be trained for capability development in this area funded by ISA. Other elements such as methane hydrate, tin, silica sand, and rare earth elements (REE) provide an opportunity for Malaysia to become a centre for the manufacturing of rare earth permanent magnets, phosphors, lasers, and oil-refining catalysts. However, a more detailed study needs to be carried out on the mining technology and environmental impact analysis. To increase awareness of sustainable marine-based economic activities, a quadruple collaborative platform should be established by bringing together various stakeholders and experts to share knowledge and ideas and also to improve structural governance and linkage between federal and state agencies in managing the activities in this sector.

3.3.4 Shipping, Ports and Related Activities

Existing strategies and action plan that govern the Maritime Transport, Ports, and Shipping related activities relate to the Transport SBSR Industry Strategic Plan 2020 that was crafted at LIMA 2011, with the vision and objective to become a shipbuilding/ ship repair nation by 2020. It concerns the SBSR Industry Strategic Plan 2020, published by MIGHT in 2011. The Strategies aim to implement the smarter and more efficient use of existing infrastructure and in developing new infrastructure through optimising existing assets and adopting automation, to optimise the use of government-owned infrastructures under ('Lembaga Kemajuan Iklim'Malaysia) LKIM to facilitate the growth of the ship repair sector and maintain river draft to allow unrestricted vessel movements around shipbuilding/ ship repair clusters in Miri, Kemaman, Kuala Linggi, and Seberang Prai. Further, an evaluation of the current laws, subsidiary regulations, and compliance is proposed.

3.3.5 Renewable Ocean Energy

Under the Renewable Ocean Energy sector, the action plan includes a short-term plan (2011-2012) related to the Implementation of numerical modelling for ocean energy systems and a Mid-term plan (2013-2015) focused on detailed physical and numerical modelling of potential sites. Other actions include resources - preliminary assessment on the potential location of tidal current in Malaysia, Digital infostructure, Acoustic Doppler Current Profiler, and the Geographic information system technology (GIS) under the Malaysian Meteorology department. Another strategy was the inception of UTM OTEC in 2012. The next step of action includes the adoption of Marine Spatial Planning for OTEC, especially in the Straits of Malacca.

3.3.6 Marine Biotechnology and Bioprospecting

The Marine Biotechnology and Bioprospecting sector is to be listed as a priority area for R&D and to be the Key Industry. The first and immediate infrastructure is to have the National Marine Institute serve as a one-stop centre for R&D in Marine Biotechnology. In addition, a research vessel for deep-sea exploration is needed for exploring new resources with valuable compounds, and a policy framework should be designed concerning two important conventions i.e. the Convention on Biological Diversity and the United Nations Convention on the Law of the Sea.

3.3.7 Desalination

For the Desalination sector, there is a Sustainable Water Resources Strategic Research Action Plan to realise the Desalination for Freshwater Generation strategies. To strengthen the sector, development of wastewater products, utilization of brine as a source of the economy instead of dumping in the sea, (nutrient and valuable resource recovery such as lithium extraction), improvement of the freshwater recovery rate through research and development of the plant, implementation of the renewable energy to the desalination solar plant to keep the operational cost low, integration of the desalination plant with a sewage treatment plant to reduce treatment cost, disposal of compressed solid waste in an eco-friendly way and reduction of the carbon footprint of desalination process are equally relevant. Some insight may be gathered from the Perth, Australian experience.

3.3.8 Waste Disposal

Existing policies associated with Waste Disposal Management can be cross-referenced with the Road Map on Zero Single-use Plastic 2018, National Solid Waste Management Policy 2016 (KPKT) (land-based), Green Technology Master Plan Malaysia 2017-2030 (strategies for resource-efficient society: Green - Waste to Wealth (land-based waste at source), National Environment Policy 2002 (coasts and seas) and National Policy on Biological Diversity (NPBD) (2016-2025) and Strategic Plan for Biodiversity (2011-2020, International commitments). For the future, it is proposed to introduce commitments to

reduce levels of marine litter as previously, marine litter contribution was not studied and this sector was not integrated with wider objectives on resource efficiency and terrestrial waste management.

3.3.9 Ocean Ecosystem Services and Ocean Health

In support of Ocean Ecosystem Services and Ocean Health, new proposed strategies are associated to balance the needs to continue or perpetuate the provision of goods and services from the sea while allowing for sustainable development. Further, it is seen advisable to develop strategies to promote studies on the Economics of Ecosystems and Biodiversity and on Wealth Accounting, on Valuation of Ecosystem Services to meet the needs of policymakers by strategic planning and policy analysis to identify more sustainable development paths. Better economic data and science are essential elements in assessing progress in the Blue Economy by recognizing, demonstrating, and capturing the values of ocean sectors for use in planning and management. In addition, to create a broader set of ecosystem services provided by vegetated coastal ecosystems and to develop and implement a marine environmental monitoring system.

3.4 Laws applicable to all nine Sectors

3.4.1 Fisheries and Aquaculture

The Fisheries and Aquaculture sector is regulated by the Fisheries Act 1985, related legislation and subsidiary legislation, the Waters Act 1920, the Environmental Quality Act 1974, the Sabah Inland Fisheries & Aquaculture Enactment 2003, the State Fisheries Ordinance 2003 (Sarawak), and the Biological Resources and Benefit Sharing Act 2017.

3.4.2 Maritime and Coastal Tourism

The Maritime and Coastal Tourism sector is regulated by laws across Immigration, Customs, Sewage, and Garbage Regulations.

3.4.3 Extractive Industries

The regulatory instrument of the Extractive Industries of Non-living Ocean Resources sector is described in The National Mineral Policy 2 of 2009 and it is proposed to have a new law to cover offshore non-living resources and minerals policy.

3.4.4 Shipping, Ports and Related Activities

For the Maritime Transport, Ports and Shipping Related Activities sector, the Merchant Shipping Ordinance 1952 and all related legislation, subsidiary legislation cover all types of vessels and contribute to prevention of marine pollution. The evaluation of the strait regimes and the safety of navigation in the Malacca Strait will need to be carried out frequently as is already practised by the relevant department. Better governance requires a review of changes in the regulatory environment and institutional structures; and strengthening Malaysia's role in bilateral, regional, and multilateral fora in the maritime domain. At least for the foreseeable future, regulation of ocean activities is expected to continue to be largely sector-driven, with efforts focusing on the integration of emerging ocean industries into existing and fragmented regulatory frameworks. The number of countries and regions putting in place strategic policy frameworks for better ocean management within their exclusive economic zones (EEZs) has increased in recent years in response to growing pressures. Other relevant measures needed, are to announce in a Gazette of national non-convention regulations for domestic shipping that also apply to Sabah and Sarawak, and the establishment of an agency dedicated to SBSR industry development, e.g., SBSR Corporation.

3.4.5 Renewable Ocean Energy

Under the Renewable Ocean Energy sector, the OTEC legal issues are mainly involved in jurisdictional and regulatory issues, namely National-International issues, Federal-National issues, and environmental considerations. These cover the Federal Constitution, the Renewable Energy Act 2011, the Energy Commission Act 2001, the Sustainable Energy Developing Authority Act 2011, the Exclusive Economic Zone Act 1984, the Territorial Sea Act 2012, the Baseline of Maritime Zones 2006, the Continental Shelf Act 1966, the Electricity Supply Act 1990, the Gas Supply Act 1993, the Atomic Energy (Licensing) Act, the Petroleum Development Act 1974, and the Biofuel Industry Act 2007. For the future positing of the sector, a legal framework for renewable energy related to blue ocean energy should be established. An act governing all OTEC activities should be considered in the future.

3.4.6 Marine Biotechnology and Bioprospecting

The law related to the Marine Biotechnology and Bioprospecting sector, is the Convention on Biological Diversity (CBD) 1992, which is the international legal instrument that covers biodiversity at all levels, inclusive of an ecosystem, species, and genetic resources related to Marine Biotechnology and the Law of the Sea Convention 1982. New marine biotechnology laws on intellectual property and patents; laws on consumer awareness of new biotech products; new insurance laws for the biotechnology industry; new labour laws; new laws governing Artificial Intelligence; and new laws on marine pollution are proposed. Proper mechanisms and regulations need to be put in place to ensure equity and access-benefit sharing with the coastal communities instead of a monopoly by large corporations and entrepreneurs. We would also need to examine bilateral/multilateral benefit-sharing agreements with established foreign companies in return for royalties from any resulting commercial products and technical training and assistance. Legislation to ensure there is no over-exploitation of marine resources for Blue Economy development is necesary A sustainable strategy is also required, for example, for marine resources that have the potential to be further commercialised, instead of being continuously harvested from the ocean, and sustainable supply through aquaculture or bioreactors should be encouraged. Proper legislation and regulations with input from various stakeholders should be in place. This coupled with regular monitoring of standards and quality control by the relevant authority, will be instrumental in cultivating public acceptance of marine biotechnology products.

3.4.7 Desalination

For the Desalination sector, the laws applicable are the Water Services Industry Act 2006 (Act 655) and the National Commission on Water Services (Surahanjaya Perkhidmatan Air Negara) Act 2006. Further, proposed new acts include the Desalination Water Act, Standards of Safe Drinking Water from Desalination, and Regulations of Brine Discharge to Coastal Waters.

3.4.8 Waste Disposal

Existing Solid Management law applies to the ocean Waste Disposal Management sector. A new Legal Framework for Single-Use Plastics and Regional Marine Debris is proposed in support of waste disposal management sector.

3.4.9 Ocean Ecosystem Services and Ocean Health

The Biodiversity Act and related legislation pertain to the Ocean Ecosystem Services and Ocean Health sector. Existing policies focus on ocean economic assessment and ecosystem services within the Millennium Ecosystem Assessment; the Digital Ocean; the Strategy of Blue Carbon; the National accounts of an ecosystem; the Measuring and Valuing ocean industries and integrating them into national accounting via satellite accounts. The policies focus on Marine Spatial Planning (MSP) and Ecosystem-Based Management (EBM), with strategies to include better identifying and measuring the benefits of public investment in sustained ocean observation systems. In moving forward, the adaptation of MSP is proposed.

3.5 Stakeholders

Table 21 lists the stakeholders associated with the Blue Ocean Economy. Stakeholders play a significant role in the growth of the blue ocean economy and ensuring progress towards sustainability of the nine sectors, namely fisheries and aquaculture, coastal and marine tourism, extractives industries of non-living ocean resources, marine transport, ports, and shipping related activities, renewable ocean energy, marine biotechnology and bioprospecting, desalination for freshwater generation, waste disposal management and ocean ecosystem services, and ocean health.

Table 21 List of stakeholders associated with the Blue Ocean Economy

Sectors	Stakeholders
Fisheries & Aquaculture	Government Departments: Ministry of Agriculture (MOA), Department of Fisheries (DOF), Malaysian Fisheries Development Authority (MFDA), NGOs: Malaysian Fisheries Society (MFS); Malayan Nature Society (MNS); Malaysian Society of Marine Sciences (MSMS), Malaysian Aquaculture Development Association (MADA); Marine Fish Farmers of Malaysia (MFFM), Aquaculture Farms – Hatcheries, Grow out, Fisheries Associations in Malaysia – (Persatuan Nelayan)
Coastal & Marine Tourism	State Govt. Local Authorities, MoTAC, National/state Museum, National Security Council (NSC), NGO/ Funding, Tourism management, Coastal village tourism groups, Coastal ecotourism, Tourism business agencies, Hotels, Restaurants, Travel agencies, Tour operators and foreign investors.
Extractive Industries of Nonliving Ocean Resources	Department of Minerals and Geoscience, all State Governments, River Authorities
Shipping, Ports and Related Activities	MOE, MOF, MITI, MOSTI, DOF, LKIM, MOT, MARDEP, PETRONAS, MOSVA (ship owners Assoc), Entrepreneurs and communities, Ministry of Maritime Affairs (Blue Economy), National Institute Oceanography (NIO, new SBSR Corporation (shipbuilding and Recycling).
Renewable Ocean Energy	National Oceanography Directorate (NOD), Malaysian Meteorological Department (formerly abbreviated as MMD and now MetMalaysia) under the Ministry of Environment and Water, (MEWA), Marine Department, Institute of Oceanography (INOS), Department of Environment (DOE), National Oceanography Data Centre (MyNODC) through National Oceanography Directorate (NOD) under the Ministry of Science, Technology, and Innovation (MOSTI).

Marine Biotechnology & Bioprospecting	MOE/MOHE, MITI, MOSTI, Entrepreneurs, and communities.
Desalination for freshwater generation	MoH, Ministry of Environment & Water, MOSTI, SPAN, JBA, MACC, Private: State water providers, Hijrah Water, Malaysia Water Association (MWA), Malaysia Membrane Society (MyMembrane). Companies: Aquakimia Sdn Bhd, Kubota Kasui Malaysia Sdn Bhd, and Aliran Ihsan Resources Berhad (AIR).
Waste disposal management	Ministry of Housing and Local Government, Ministry of Environment and Water, Relevant corporations (Indah Water, AlamFlora, etc.).

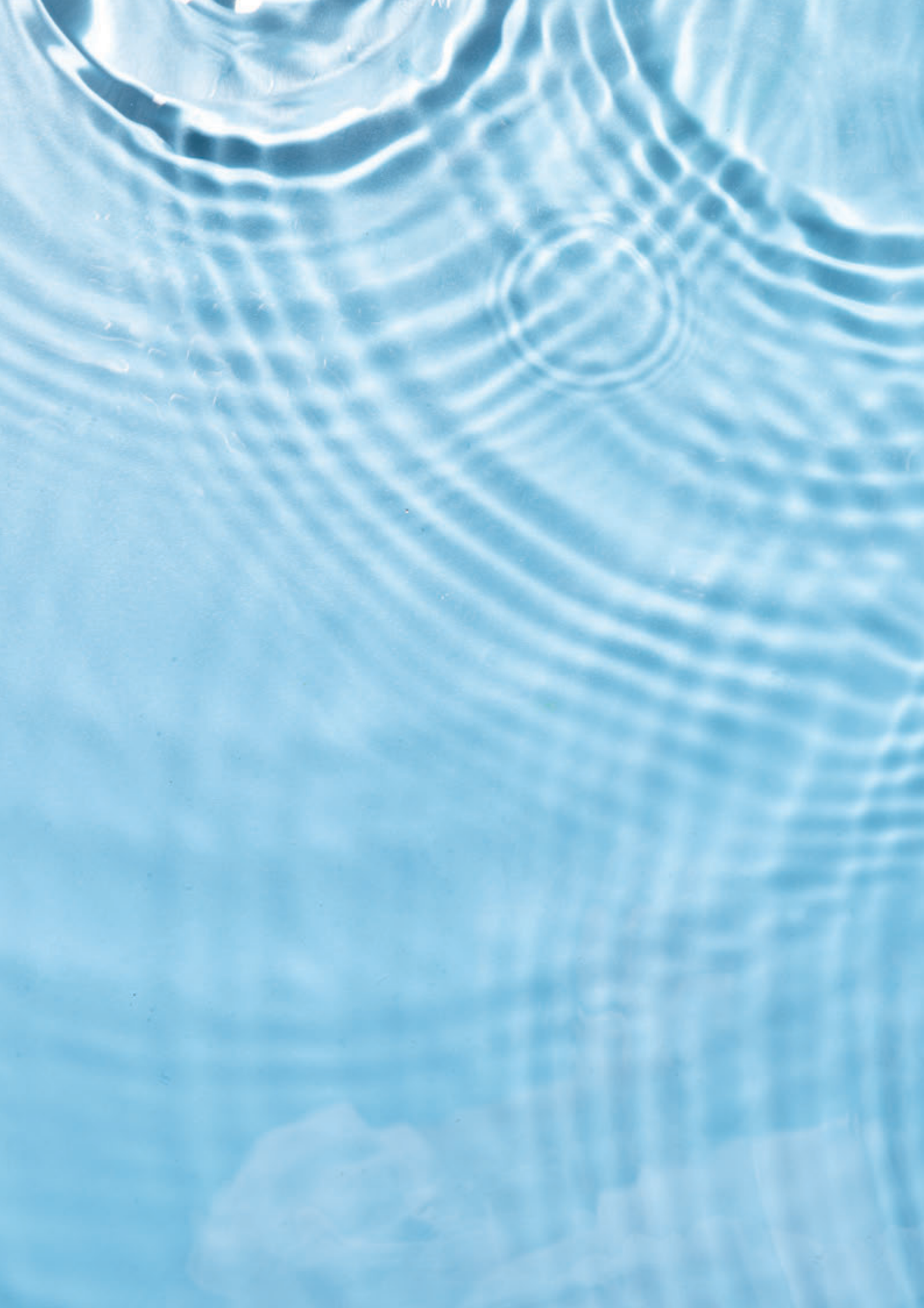
3.6 Conclusions (Governance Ecosystem)

Frequent changes in ministerial mandates can be unsettling for ocean governance unless it is to consolidate the matter. The major outcome of this policy and governance position paper is the repeated call across several sectors to adopt a national ocean policy. There is no national ocean policy in Malaysia. The status quo of piecemeal solutions to ocean policy cannot be the way forward. For Malaysia to lay claim to its seafaring and coastal nation status, and its role as a major trading partner and coastal State, both regionally and internationally, as well as to legitimise its claims to maritime resources, boundaries and features systematically and sustainably, the country needs to implement such a national policy. Such a policy must apply to Malaysia, East and West. The application of the National Ocean Policy to East Malaysia must be carefully crafted within the terms of the Malaysia Agreement 1963 and other legal documents in force. The decision to engage in the nine sectors of the Blue Economy, absent a national ocean policy, is unwise, to say the least, as transition to and management of the Blue Economy must be based on sound scientific and equitable principles while preserving the ecosystem health of the coastal belt and the seas. The contents of a national ocean policy or framework have not been hypothesised here.

The problems in Malaysia in the context of ocean governance and evidence-based management are first, the conflict between Federal and State powers over jurisdiction over territorial resources
Secondly, policies are not tested for their validity and data is often missing for time series evaluation and forecasting of trends. Thirdly, there is a need for adaptable policies for the benefit of the coastal community. The defects and weaknesses of existing tools, policies, strategies, and action plans must be studied. Fourthly, management tools, such as the Integrated Coastal Zone Management and Marine Spatial Plan must be adopted. Finally, the secrecy regarding data and information makes it very hard to acquire and interrogate data. A national ocean policy that addresses data availability, use, management, and proftection is long overdue. Protection of official secrets need not be undermined under the national ocean policy.

Security and defence of the Malaysian seas with peculiar geographical and legal traits deserve better management from ecological and security perspectives. Humanitarian laws and policies regulating unsafe migration by sea should also be covered. These measures are important because they create a safe and secure marine environment for marine scientific research, amongst others.

Adherence to international commitments needs to be carried out holistically. Absent an international treaty on this matter, Malaysia could be the champion for bioprospecting in areas of national jurisdiction and beyond national jurisdiction. Finally, municipal laws need to be tested for delivery in line with the sustainability goals.



CHAPTER 4: A NEW FRAMEWORK FOR CHARACTERIZING THE BLUE ECONOMY

Chapter 4: A New Framework for Characterizing the Blue Economy

4.1 Introduction

Effective management of the Blue Economy is critical for addressing issues related to climate change and ensuring the socio-economic sustainability of communities across the globe. The Blue Economy is an important contributor to the Malaysian economy, as it provides food security, employment, and income for the nation. The well-being of the oceans is inextricably linked to the social fabric of coastal communities in Malaysia. Poor management of the oceans will have a long-lasting impact on the health, environmental and socioeconomic wellbeing of these communities and the Malaysian economy.

In this chapter, we highlight that the management of the nation's Blue Economy must take an ecosystem approach, as there are multiple sectors and players involved in the well-being of the oceans and the communities that are dependent on the oceans for their livelihood and way of life. Here, we propose a new framework for characterizing the Blue Economy ecosystem, which incorporates a Nature-Centric Philosophy and clearly defined enablers of the Blue Economy ecosystem. Using this new framework, we will identify key strengths and gaps in the Malaysian Blue Ecosystem. Key strategies to close these gaps will be discussed in the following chapter.

4.2 Characterizing the Blue Economy Ecosystem

The ocean and coastal environment, which form the Blue Economy, covers an extensive part of Malaysia and is a significant source of opportunity for our nation. The growth in these sectors, which provides mankind with many benefits, such as food, energy, and transport, among other essential products and services, serves as a foundation for sustainable development. However, there is often a fractured relationship between marine and coastal development and biological and ecological preservation. The marine and coastal environment is affected by both anthropogenic and natural factors. Anthropogenic factors such as ocean governance and poorly planned coastal development, marine pollution, overexploitation of biodiversity and marine resources, coupled with natural factors, such as climate change with frequent floods, ocean acidification, and blue carbon, threatens the ocean. As such, it is pertinent that the protection of ocean space is given priority in the development plans for a sustainable and resilient ocean economy.

In this context, this study assesses the state of the Blue Economy ecosystem, which comprises the marine and coastal environment. This ecosystem is home to many biological marine plants and animals that are unique to Malaysia. The Blue Economy ecosystem has significant potential for generating socio-economic and environmental value for communities. However, there are weaknesses in the enablers of the Blue Economy ecosystem. In this study, we assess the state of the Blue Economy from an ecosystem perspective by incorporating the 8R-Nature-centric Blue Economy (8R-NCBE) philosophy (Respect marine and coastal environment, Rethink the value of marine and coastal resources, Reduce wastage, Reuse marine resources to reduce wastage, Recycle waste, Restore biological marine plants and animals; Repurpose biodiversity for higher-value use; and Revitalise marine and coastal resources) across socio-economic activities taking place in the region[1] . The philosophy is outlined below and summarised in Figure 35.

1. **Respect:** Recognise and inculcate an appreciation for marine and coastal ecosystems to ensure the effective management of resources in the ecosystem to protect the biodiversity and unique biological marine species.

1 This philosophy was adapted from Nair, Ahmed, and Vaithilingam (2022a and 2022b) and Sibaud and Gaia Foundation (2013). It has been modified to address planetary health initiatives. The Lancet Commission defines Planetary Health as "the understanding that human health and human civilisation depend on flourishing natural systems and the wise stewardship of those natural systems" (Whitmee, et al., 2015, page 1974). A detailed analysis of 8R analysis can be found in the Nair, Ahmed and Vaithilingam (2022b).

2. **Rethink:** Entails rethinking the oceans as waste streams to resource streams that value adds to the Blue Economy. This requires a mindset shift of people, industry, and nation-states from being profit maximisers to purpose maximisers, to transition from unsustainable practices that pollute and destroy the biodiversity of the oceans to building strong, resilient biodiversity conservation efforts and sustainable ocean practices. This will require a rethink of existing approaches and the introduction of more creative and innovative approaches to ensure the environmental and economic sustainability of the oceans.

3. **Reduce:** Reduce our climate and environmental impact for all Blue Economy sectors by minimising human activities and harmful economic practices (e.g., marine pollution such as disposal of chemicals and waste such as releasing harmful waste by-products through waste outlets, reducing the discharge of plastics) into ecological ecosystems as a way to protect biodiversity and endangered species.

4. **Reuse:** Develop materials and products to stimulate a circular economy to maximise socio-economic and ecological Return on Value (ROV) from ocean resources. This reduces the demand for resources from the Blue Economy ecosystem and reduces the amount of waste that ends up in rivers, oceans, and landfill sites, thus reducing the adverse impact on the ocean and coastal environment and communities.

5. **Recycle:** Ensure that fewer products are discarded by recycling or recovering all forms of waste (biodegradable and non-biodegradable) to support a Circular Economy. Recycling is a strategy for resource end-of-life management that allows resources to re-enter the product cycle, improve environmental performance, and reduce waste generation. This will reduce pollution of the ocean and coastal environment.

6. **Restore:** Increase blue carbon initiative work to restore marine and coastal habitat ecology to ensure that there is an adequate 'carbon sink' to balance human activities that contribute to carbon emission.

7. **Repurpose:** Develop new uses for marine and coastal resources and waste through creative and innovative ways to increase the ROV from the biodiversity of the marine and coastal ecosystems. This includes creating nature-centric socio-economic drivers to reduce the depletion of vital resources.

8. **Revitalise:** Increase investments for the revitalisation and conservation of marine and coastal resources which includes biological species within their natural habitats, creating a spillover impact on coastal communities and key economic sectors.

Figure 35 8R-Nature Centric Blue Economy Philosophy (8R-NCBE) – adapted from Nair et al. (2022a and 2022b)

The Blue Economy can be characterised by multiple players across the continuum of the supply chain, and the key players are described below:

- *Upstream* – management of the ocean and resources therein.
- *Downstream* – consists of the following:
  - *The primary sector* (upstream) includes mineral extraction and the harvesting of marine resources.
  - *The secondary sector* (downstream) includes food, energy, medicine, biotechnology, bioprocessing, and treated water.
  - *The service sector* includes water desalination plants, tourism, waste disposal, and transportation.

The 8R-NCBE will form the foundational conditions necessary for a circular economy (for both the upstream and downstream Blue Economy sectors), where marine and coastal life are valued and respected. It can nurture a population that recognises the potential threats to the country's marine and coastal resources and the importance of sustainable marine biodiversity conservation practices. The 8R-NCBE philosophy is people-centric and must be embedded across all the enablers of the Blue Economy ecosystem (the 8i Innovation Framework). This is to enable the transformation of the current weak and fragmented Blue Economy ecosystem to a vibrant and dynamic economic sector of the country. The marine and coastal environment is essential for our survival, and activities that use marine resources must continue. However, conservation processes should be developed in such a way to ensure that the 8R-NCBE philosophy is embedded in all national development plans and education and training programmes that are rooted within a circular economy framework. The next section will discuss the key enablers of the 8i Innovation Framework, which are comprised of 8i enablers that provide a systematic way of strengthening the 8R-NCBE.

The definitions of the eight enablers in the 8i Innovation Framework are provided below, and a summary of them is shown in Figure 36:

- ***Infrastructure –*** the state of the natural and physical infrastructure of the Blue Economy to deliver

quality marine resources to the various stakeholders in the economy. These include technology and knowledge-intensive ports, distribution networks, logistics supply chains, laboratories, testing centres, and other infrastructure that facilitate the extraction of marine resources in sustainable ways and the movements of goods and services within the economy. These include the state of oceans, waterways, and coastal ecosystems.

- ***Infostructure*** – the state of the digital infrastructure in the Blue Economy; that is, the use of advanced digital and industry 4.0 technologies to manage the marine resources in this sector efficiently. This includes innovative technologies such as artificial intelligence, big data, advanced data analytics, sensor technology, and autonomous systems to transform the Blue Economy. In addition, seamlessly integrated digital systems across the upstream and downstream industries to ensure allocative efficiency and productive efficiency in the industry. They also include integration across multiple physical infrastructures, institutions, and regions to ensure continuous tracking of the performance of the sector using evidence-based decision-making approaches.
- ***Intellectual Capital*** – the state of the talent stock (general and specialised skill sets and core competencies) in the Blue Economy sector. These include talent with basic competencies, specialised skills, technical capabilities, researchers, entrepreneurs, and technopreneurs; and leadership skills to foster a knowledge culture in the sector.
- ***Integrity systems*** – the governance systems at the federal, state, and municipal levels (governments, industry associations, community organisations, institutions of learning, and research institutes) that ensure seamlessly integrated information flow, implementation of policies and strategies to enhance efficiency and maximum economic value for all stakeholders in the Blue Economy sector. They include business and environmentally friendly policies. Other governance systems include the use of technology to develop systems that enable tracking of key performance indicators; effective implementation and enforcement of regulations and policies; and providing market intelligence that assists effective decision-making processes.
- ***Incentives*** – the quantum and quality of fiscal and non-fiscal incentives to enable the industry to not only be a significant generator of economic and societal transformation but also ensure sustainable management of marine resources. Among the key support systems are research and development funds, innovation grants, access to state-of-the-art research facilities, expertise, tax incentives and subsidies, and other incentives that drive local innovations in the sector. Some of the incentives are the development of nature-centric infrastructure and eco-friendly-driven firms in the upstream and downstream Blue Economy sectors.
- ***Institutions*** – the quality of the institutional leadership and institutions (government, industry associations, tertiary institutions, and community organisations) that play important catalytic roles to transform the sector to be more knowledge- and technology-intensive, and environmentally friendly. The institutions provide leadership and direction to other stakeholders to enable the Blue Ocean economic sectors to continuously move up the innovation and economic value chain in a sustainable way.
- ***Interaction (smart partnerships)*** – characterises the state of collaboration, cooperation, knowledge, and technology sharing among key stakeholders in the sector. These include sharing best practices and adopting new innovative systems and processes to create multiple spillover socio-economic impacts in the sector and across other sectors of the economy.
- ***Internationalisation (building global network and partnership)*** – characterises the depth of international collaborations with other countries to ensure sustainable management and security of the oceans. These include being part of the international knowledge networks, regulations, treaties, trade policies, and the development of effective enforcement mechanisms to ensure sustainable management of the marine resources and security of the waterways in the region. It also captures the global reach of local innovation, technology, products, and services within

this sector. A key feature of the knowledge networks is to ensure the local industry can benefit from the knowledge and technology transfer from pace-setter countries and adhere to global best practices and standards.

Internationalisation

Participation in the development, formulation and adherence to international laws, treaties and engagements that ensure sustainable management according to the Blue Economic sectors aligned to global best practices and **8R-NCBE**. These include the depth and breadth of engagement with global knowledge networks, institutions of governance and supply chains.

Interaction

Level and quality of cooperation, collaboration and knowledge sharing among all stakeholders in the Blue Economic sectors.

Institutions

Institutional leadership and quality of the institutions to lead the sustainable development of the blue economic sectors aligned to the 8R-NCBE Philosophy. Quality of institutions of governance (at the federal, state and local council), including regulatory and standard bodies that ensure transparency, accountability, efficiency of the sector and observes the **8R-NCBE Philosophy**. It also includes industry associations, community organization, institution of learning and research institutes.

Incentives

Fiscal and non-fiscal incentives to encourage the creation and adoption of new technology, innovation and systems to enhance the competitiveness of the sector and to ensure adherence to the **8R-NCBE Philosophy**.

Infrastructure

Quality of the physical and natural infrastructure to support the sustainable development of Blue Ocean economic sectors aligned to the **8R-NCBE**.

Infostructure

Digital infrastructure that provide seamless integration of multiple digital and data analytic systems to provide seamless flow of information for strategic decision-making within the Blue Economic sectors.

Intellectual Capital

The development of talent stock for the Blue Ocean Economy to nurture the **8R-NCBE**.

Integrity Systems

Governance systems that oversee the adherence to the **8R-NCBE Philosophy** to manage the sector efficiently and raise the ROV for all stakeholders.

Figure 36 Framework to characterise the Blue Economy ecosystem: 8i-ecosystem analysis

Adapted from Nair (2011); Notes: The 8i-ecosystem was adapted from Nair (2011) and a detailed analysis can be found in Nair et al. (2022b), forthcoming.

The assessment of the 8i-model will provide valuable insights into the enablers of the Blue Economy ecosystem and the impact on the performance of key marine-based economic sectors. The impact on the enablers of the Blue Economy (i.e., the 8is) is examined in terms of the dynamic capability, competitiveness, and economic value of this sector to the national economy. The dynamic capability component in this model is defined as the ability of the firms in the industry to build strong absorptive, adaptive, and innovative capabilities.[2] On the other hand, the competitiveness of this sector is defined as the ability of the firms to enhance their productivity. Here, productivity captures the following: process improvement; product development; business model innovation; and the generation of intellectual property, such as patents, copyright, and trademarks, that generate new economic value for the firms. The economic value generated by this sector is captured by the following: income, as a proportion of the gross domestic product; jobs; brand value/positioning; and improving the quality of life of the 'rakyat' (health and wellbeing). Thus, it is necessary to identify the value of ocean resources to maximise economic growth. This framework shows the state of the Blue Economy ecosystem when it intrinsically combines to create dynamic capabilities within the sector to enhance productivity and economic value generated by this sector and thereby contribute to the overall wealth of the country. As shown in Figure 37, sustainable development of the nation's Blue Economy will mean the ability of the industry to generate economic wealth and to continuously invest in and develop the Blue Economy ecosystem.

2 Dynamic capabilities is made up of three components and they are: (i) absorptive capabilities - ability of an organisation to identify new external information and knowledge, and to be able to integrate them into the organisation to create value for the organisation and other stakeholders; (ii) adaptive capabilities – ability to respond to external knowledge and information absorbed and adapt them to changing or emerging needs based on market conditions in a timely manner; and, (iii) innovative capabilities – ability of an organisation to use innovative behaviour to develop new products and or markets. For more details on Dynamic Capabilities, refer to Wang and Ahmed (2007).

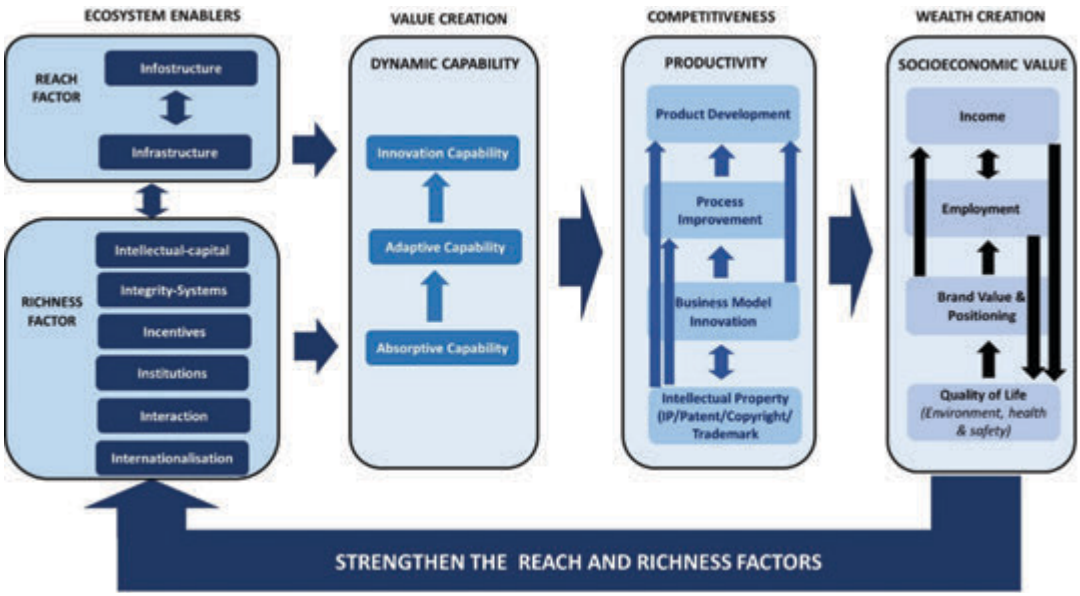


Figure 37 Value chain for the Blue Economy ecosystem [Adapted from Nair (2011) and Nair et al. (2022a)]

More recent studies have incorporated a values-based development model, where a planetary health mindset (8R-nature centric philosophy) is integrated into the enablers of the Blue Economy ecosystem, as shown in Figure 38 (Nair et al., 2022a and 2022b). Here, an integrated and sound 8R-8i Blue Economy ecosystem model is envisaged to enhance the dynamic capabilities of the Blue Economy industry. All of which will increase the Return on Value (ROV) to the nation. The ROV include the following:

- nurture creative talent for the Blue Economy industry (both ensuring the supply side to meet with the demand of the industry) and a talent stock that continuously improve the process and new product development;
- generate new innovations and discoveries that will raise the competitiveness of the local Blue Economy industries;
- develop strong knowledge networks and value chains to foster knowledge and technology transfer; and continuously strengthen the domestic, regional and global BE supply chains;
- contribute to creating high-income jobs, employment opportunities, improve the competitiveness of the local Blue Economy industry and increase the contribution of the Blue Economy sector to the wealth (GDP) of the country;
- contribute to societal development of coastal communities by ensuring strong nexus between health of the planet (ocean and marine life) and health of the people; thus, increasing their standard of living and quality of life for the current and future generations in the coastal regions across the country; and,
- a sound 8R-8i driven Blue Economy ecosystem will brand the nation as a leading regional and global player in developing new innovations, products and services from the nation's ocean and marine resources – this will attract high-end foreign direct investment into the Blue Economy sector.

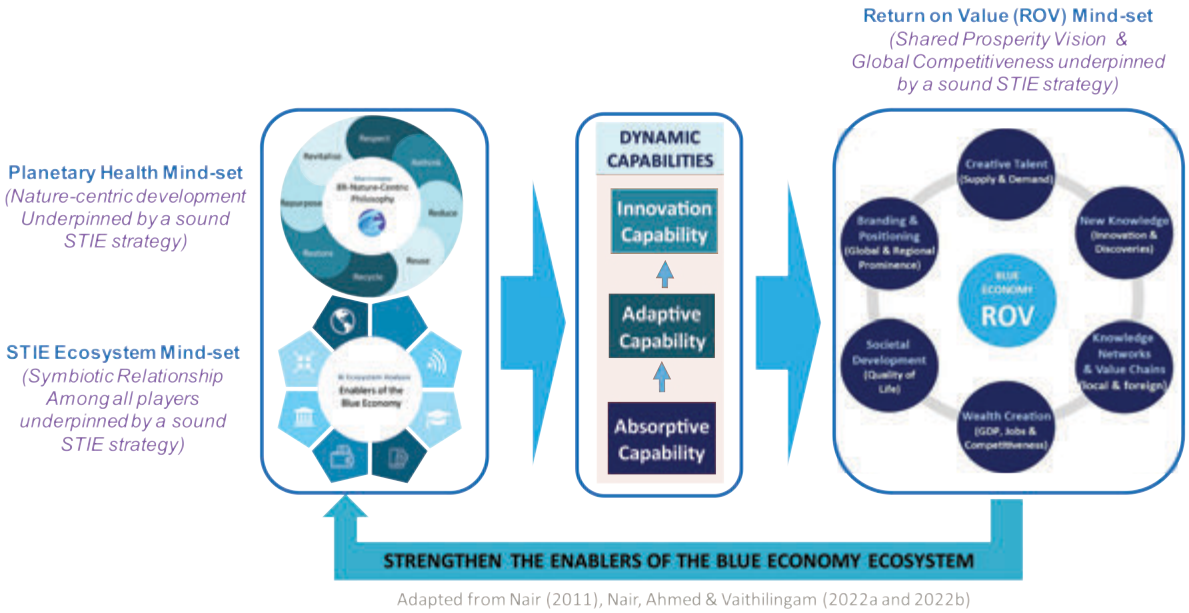
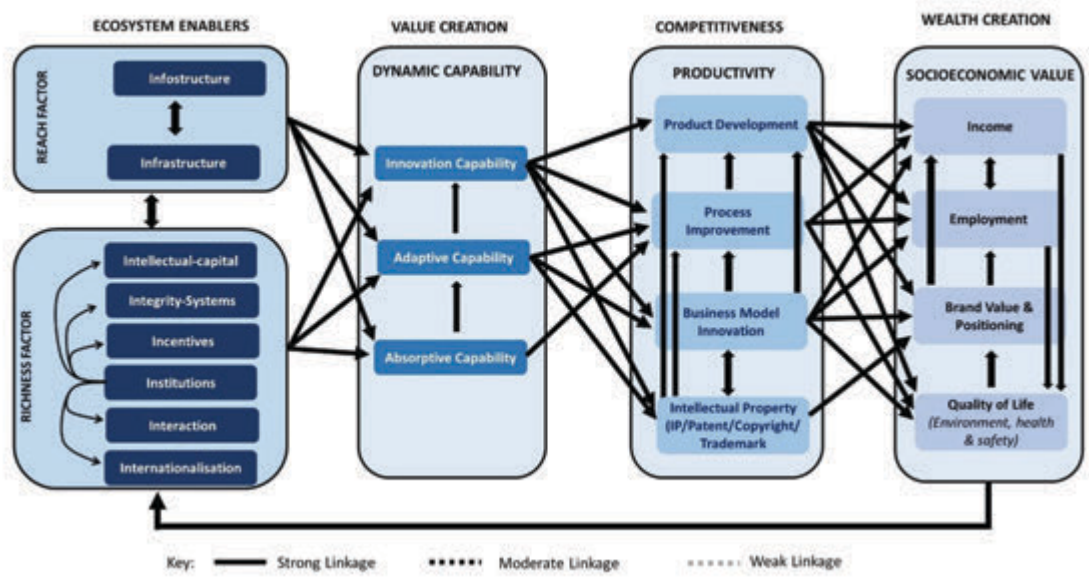


Figure 38 Building sustainable dynamic capability, ROV and competitiveness of the Blue Economy sectors (Adapted from Nair et al. 2022s and 2022b)

Based on Figure 37 and content analysis on the Blue Economy ecosystem, the ecosystem for developed economies is postulated as in Figure 39, where the enablers play a key role in not only increasing the absorptive capability but also the adaptive and innovative capabilities. That is, the ecosystem enablers spur holistic development of the dynamic capability of the Blue Economy in these economies. Strong dynamic capability enhances the development of intellectual property, business model development, process improvement, and product development. As firms in these economies increase their productive capacity, they will increase the income level, create high-paying jobs, and create brand value for the sector. Further, the use of sustainable management practices driven by sound science, technology, and innovation will also ensure safe, efficient, and sound environmental management of this important commodity. All of which contribute positively to improving the quality of life of all stakeholders in the economy.



Adapted from Nair (2011).

Figure 39 Postulated Value Chain of the Blue Economy Ecosystem for an Advanced Economy

Note: Model adapted from Nair (2011). The linkages were postulated using the analysis outlined in MyKE-III, EPU (2016a & 2016b) for an industrial ecosystem for advanced economies.

In the Malaysian context, based on the analysis from MyKE-III (EPU, 2016a), the knowledge content and innovation mapping (see Figure 40) show that four key sectors related to the Blue Economy are in different stages of development. For example, the fishery is classified as a laggard industry, shipping as an imitator industry, tourism as an adapter industry, and energy (oil and gas) as a pace-setter industry.

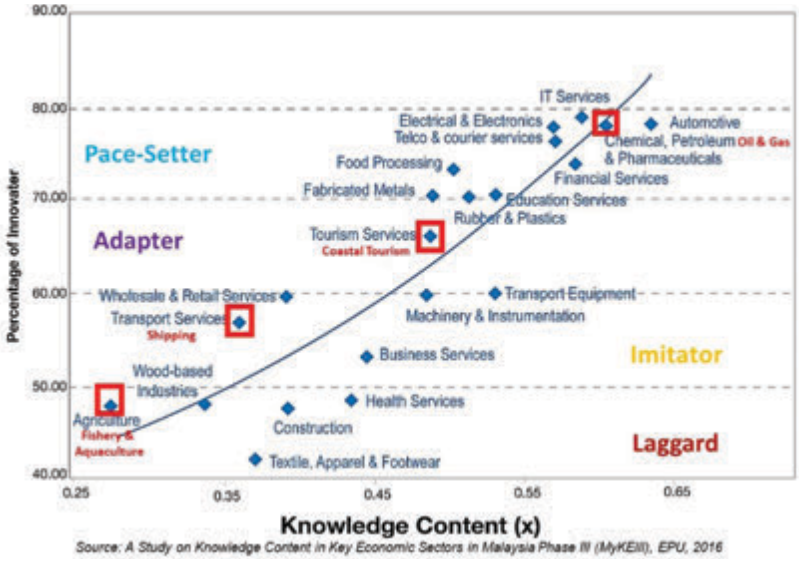


Figure 40 Industry Knowledge Content and Innovation Mapping

As a laggard industry, the fishery industry had the lowest percentage of innovators and knowledge content among the four key sectors related to the Blue Economy. The industry has struggled to reinvent itself and suffers from a high dependence on traditional, low-efficiency operations. The slow pace of modernisation also limits the attractiveness of the industry for new talent, exacerbating the lack of capabilities within the industry to transform into modern high-tech operations. Though there are pockets of innovators in the industry, the enabling factors of the fishery industry's ecosystem are not strong enough to move them up the value chain. As fish stocks decline globally, there is a significant need for better practices that focus on environment, sustainability, and governance in order for local firms in the fishery industry to penetrate regional and international markets.

As an imitator industry, the shipping industry had the second-lowest percentage of innovators and knowledge content among the four key sectors related to the Blue Economy. While the industry has had some success in keeping pace with global standard practices, most of the operators are still dependent on advancements made in other markets before adopting them for local use. This role as a second adopter limits the innovation potential of the industry as firms will always be playing catch-up to the pacesetters. Furthermore, the Southeast Asia region has some of the busiest shipping lanes in the world, with strong competitors in Singapore, Indonesia, and the Philippines. Maintaining the role of imitator in the regional industry may cause the Malaysian shipping industry to gradually lose its competitive advantage in Southeast Asia's increasingly crowded shipping space, especially with the rise of Vietnam and Thailand.

As an adapter industry, the tourism industry, particularly coastal tourism, had the second-highest percentage of innovators and knowledge content among the four key sectors related to the Blue Economy. This indicates that the tourism industry can bring incremental innovations to existing developments in the industry. Building on the natural assets of Malaysia, the tourism industry has had success in developing the tourism ecosystem to attract high-value-added tourists into the country.

In addition, the industry has diversified beyond the traditional idea of tourism into other sectors such as medical tourism, education-related tourism, and ecotourism. Malaysia's rich culture and history offer a strong foundation for the tourism ecosystem. To transform into pacesetters in the regional and global tourism industry, the local tourism ecosystem needs to curate and present a unique package that offers a tailored experience that no other country in the region can provide.

As a pacesetter industry, the energy (oil and gas) industry had the highest percentage of innovators and knowledge content among the four key sectors related to the Blue Economy. As one of the key producers in the Asia-Pacific region, the energy industry has been a key sector in Malaysia's economy. The industry has constantly seen significant investments in its development and regularly attracts the top talents in the country. It has led to key innovations that have been adopted beyond the local industry. However, with the recent shift in political and societal focus on climate change issues, the energy industry needs to rapidly transition to renewable energy sources to stay competitive.

Using the MyKE-III data and the evaluation of the enablers of the Blue Economy ecosystem detailed earlier, the impact of the state of the enablers of the ecosystem on dynamic capability, productivity, and economic outcomes is shown in Figure 41.

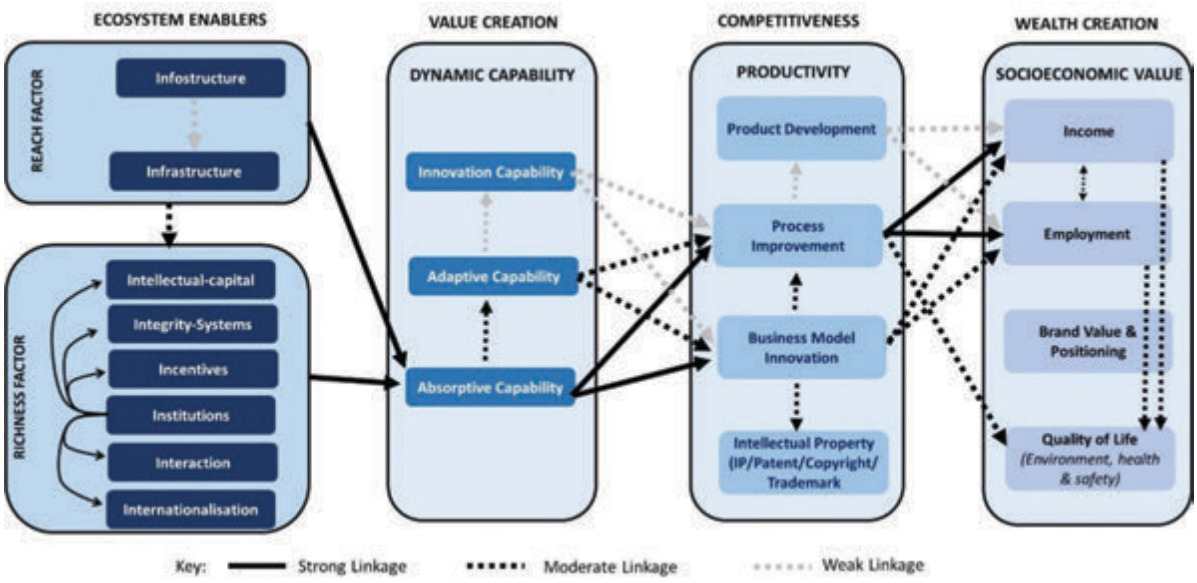


Figure 41 Postulated Value Chain for the Blue Economy Ecosystem for Malaysia

Note: The linkages were postulated using the analysis outlined in MyKE-III, EPU (2016a and 2016b) for industrial ecosystems in Malaysia. These analyses were based on interviews of close to 189 industry captains, of which, 55 were from the agriculture (fishery), transportation services, tourism, and petrochemical industries – all of which are related to the Blue Economy. In the MyKE study, a survey of 2458 firms was conducted in phase 1 and 4438 firms in phase 2; of which, 545 were from the blue ocean economic sectors in phase 1 (23%); while 1059 were in phase 2 (24%).

Based on the analysis from MYKE-III (Phase 1 and Phase 2) for the key sectors that are related to the Blue Economy (energy, petrochemical, fishery, transportation services, and tourism), institutions (government agencies, industry associations, and universities) play a key role in developing the other enablers of the ecosystem. However, institutions do not play a significant role in developing the dynamic capabilities of the industries directly. The enablers (both the reach and richness factors) are seen to be developing the absorptive capabilities of the industry but do not impact adaptive and innovative capabilities significantly. The analysis also shows that the transition from absorptive to adaptive capabilities has moderate linkage, while the linkage from adaptive to innovative capabilities is weak.

Much of the industry's dynamic capabilities are focused on developing process improvements to keep the industry cost-competitive. Most Malaysian firms remain low-cost producers of goods and services, and this is an important factor for income generation and job creation in this industry. Hence, many of the firms in the subsectors of the Blue Economy remain at the lower end of the value chain compared to their counterparts from more developed economies. The impact of income and employment on improving the quality of life in many of the coastal communities remains moderate. However, in some coastal communities, the percentage of those on low and uncertain income is high. The above analysis highlights that the weakness in the Blue Economy ecosystem in Malaysia and the low understanding and adoption of the 8R-8i Blue Economy ecosystem approach has resulted in the industry not being able to capture the full ROV for the nation.

The Blue Economy is an important source of socio-economic development for the country. While the sector is an indispensable revenue earner and employment for the economy, preliminary analysis shows that several subsectors of the Blue Economy operate below their potential. The Blue Economy Blueprint for Malaysia comes as a timely development as ocean economies need to leapfrog into industries that have strong dynamic capabilities and global competitiveness. This is also to ensure that this sector creates high-income jobs and contributes to higher wealth of the country (GDP). To achieve this objective, there is a need for the industry to take a more holistic approach in incorporating a planetary health (nature-centric) STIE approach in developing stronger dynamic capabilities of the local Blue Economy industries and deriving better ROV from them for the nation. This is critical to ensure the long-term sustainability of the industry.

4.3 Assessment of the Enabling Environment – 8i Framework

4.3.1 Current State of Play of the Malaysian Blue Economy Ecosystem

The state of the Blue Economy ecosystem is analysed using both, content analysis of the MyKE study and focus group discussions among key stakeholders in the sub-sectors. Based on a detailed ecosystem analysis from the EPU (2016a & 2016b) study on the Malaysian Knowledge Economy Study (MYKE-III), which examined the knowledge ecosystems of 21 industries, four of the sectors from the MYKE-III study are related to the Blue Economy (fishery, transportation services, tourism, and energy sectors) and were discussed in the previous section.

In addition to the MyKe study, this study also conducted focus group discussions (FDGs) to draw a comprehensive understanding and insights into the state of the enablers of the Malaysian Blue Economy ecosystem from key stakeholders. The focus group is a qualitative method to collect information and has been widely used in the social sciences for its inherent participatory approach but has recently gained popularity in natural resource management (Kumer & Urbanc, 2020). While there are many ways to characterise an ecosystem, in this study we characterise the Blue Economy ecosystem by eight enablers adapted from Nair's (2011) 8i framework as described in the previous section. The FGDs conducted were based on a series of questions related to the enablers of the Blue Economy ecosystem.

The stakeholder engagement was conducted in two stages. The first stage is to gauge the stakeholder perspective using SWOT analysis of the state of the enablers of the Blue Ocean economic ecosystem and also to identify key gaps in the ecosystem. The second stakeholder FGD was to confirm the findings from the first stage and also to come up with policy recommendations and intervention strategies for policymakers, tourism stakeholders, and other relevant institutional players. Both stakeholder engagement sessions were conducted with a combined total of 527 participants (369 and 158 participants, respectively). The discussion below and Figure 42 highlight the findings[3] from the FGDs based on the enablers that characterise the Blue Economy ecosystem:

3 Detailed 8i ecosystem analysis for each sector can be found in the appendix.

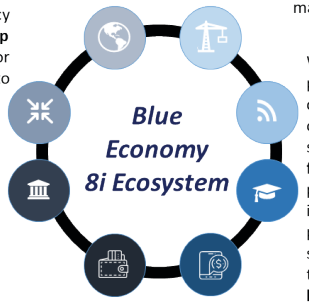
Blue Economy Gaps – 8i Ecosystem Analysis

Internationalisation
Local industries remain **slow to catch up** with fast-changing global trends (particularly sustainability) due to shallow depth and breadth of international linkages and two-way knowledge and technology transfer. Factors such as lack of adherence to global best practices, local certifications **not meeting international standards**, and poor mutual international agreement/communication will present significant **non-tariff barriers** towards globalisation.

Interaction
Level and quality of engagement and collaboration remains **fragmented and superficial**. Stakeholders often work in **silos**, thus causing a mismatch between research projects and available funding, industry and investor expectations, and low rates of commercialisation. Lack of **formal collaborative platform** for industry and community participation in policy design and implementation. Weak **inter-sectoral partnership and coordination** for end-to-end supply chain solutions. Poor **knowledge sharing** culture between industry players due to larger player need for market share dominance.

Institutions
Poor coordination between stakeholders (government, industry, academia, NGOs) and **fragmented policies** and governance have led to lack of cohesion and long-term vision for the Blue Economy, as well as confusion among stakeholders regarding sector direction. There is lack of a nationwide ocean policy. Existing policies and initiatives are **not cross-sectoral or sufficiently inclusive** (i.e., subsectors being excluded in national vision). Lack of **sectoral champions** to lead sectors towards a sustainable maritime economy with only DOE at its helm. **Fragmented governance structure** creates gaps, disjoint, and overlap in jurisdiction (e.g., poor clarity between governing bodies).

Incentives
Limited fiscal and non-fiscal support and incentives for investment into sustainability, research and commercialisation, and technology adoption. There is **insufficient funding for research** leading to **unattractive IPs** and uncompetitive/low-quality products and services. Additionally, industry remains risk-adverse due to **high costs** associated with investment into sustainability, ESG practices and implementation and existing subsidies that promote existing unsustainable practices. Further, low barriers for foreign players have allowed them to **outcompete local industries**.



Infrastructure
Mature physical infrastructure limited to major ports/zones (e.g., Port Klang, Tanjung Pelepas) and subsectors (e.g., O&G) while a majority of subsectors reported lacking **infrastructural support** to enable upscaling and investment into emerging technologies. This subsistence on weak infrastructure has led many of these subsectors to rely on **legacy technology**, both of which pose as barriers for the adoption of more advanced technologies.

Infostructure
Lack of key enabling **digital infrastructure** such as coastal and marine high-speed/internet connectivity compounded by weak **data collection and sharing** has led to low-level usage and adoption of data-driven technologies (e.g., marine environmental monitoring system).

Intellectual Capital
Weak subsector ability to **retain and attract talent**, due in part to negative perception, poor remuneration and career progression/opportunities, and better prospects in other sectors or abroad (**brain-drain**); thus leaving subsectors relying on an **ageing workforce** and **cheap foreign labour** who lack the skill set for more advanced processes and technologies. **Low awareness** among industry and communities regarding ESG, SDGs, marine protection, and potential of new technologies or subsectors (e.g., renewable energy) stifle progress towards a sustainable Blue Economy. Further, there is **limited research** into sustainability and key areas for growth due to poor research funding, research conducted in silos (creating gaps or duplication), and **limited industry participation** in research and commercialisation.

Integrity
Governance systems and current legal and regulatory framework have room for improvement (i.e., weak, fragmented, not contemporary, **clashing State and Federal laws**, and limited for some such as offshore mining, marine bioprospecting). **Lack of measurable targets**, monitoring of KPIs, **transparency**, and **accountability** measures impede effective implementation of existing plans, policies, and initiatives. Illegal imports, exports, and practices (e.g., sand mining, contraband, oversea waste) allowed to run rampant due to **weak enforcement**.

Figure 42 The 8i Ecosystem Analysis of the Gaps in the Blue Economy

Infrastructure

Although there has been much advancement over the years, physical infrastructure support for the Blue Economy remains limited for many subsectors. Many sectors have seen significant development over the years in the natural and physical infrastructure for the Blue Economy sector (oceans, waterways, coastal ecosystems, ports, logistic supply chain, desalination plants, R&D laboratories, testing platforms, and other key related facilities). However, these major developments and supporting physical infrastructure have been limited to major players, subsectors, and locations, whereas nascent subsectors and more rural regions are not so well-equipped to pursue similar levels of advancement as incumbents. For instance, in the case of maritime transport, only major ports (e.g., Port Klang, Tanjung Pelepas) enjoy mature infrastructure to support the adoption of an e-navigation system, while in extractive industries, it is limited to oil and gas. This is the case for many subsectors, with much of the natural and physical infrastructure and facilities across the country remaining underdeveloped, especially in rural coastal areas. A cascading effect then occurs, whereby industry players are left relying on legacy technology and an inability to adopt emerging technologies to catch up, thus resulting in services that are fragmented, experiencing bottlenecks, lower productivity and efficiency, and an inability to upscale.

Infostructure

Digital infrastructure and data availability are key enablers for the adoption of emerging technologies for sector competitiveness. There has been significant improvement in the digital infrastructure in the country and the sector over the last two decades. However, the quality of bandwidth, coverage, and

affordability of services, especially for rural coastal communities and SMEs, remain key challenges. Additionally, data collection and sharing between stakeholders (public-public and public-private) remains limited and fragmented, which impacts both data availability (scarce and scattered) and data quality. Lack of open-data and data sharing policies stifle the pursuit and adoption of data-driven digital technologies among stakeholders. This limits evidence-based decision-making processes, particularly in the management of marine ecosystem health, disasters, and climate change.

Intellectual Capital

Malaysia has a pool of established marine and maritime-related institutions and organisations that are engaged in good research, but research efforts remain limited to niche areas, nascent sectors, and sustainable development (e.g., marine bioresources, waste recycling, circular economy). Sectors often contribute to lagging research efforts due to low quantum in research funding; lack of data availability (i.e., collection, quality, and sharing); low industry participation associated with a mismatch between research and market needs; high initial capital; and high risks. Low industry participation vis-a-vis adoption of emerging technology, implementation of ESGs/SDGs, and low entrants in nascent sectors may be attributed to low awareness of the potential of these factors in creating long-term added value and competitiveness.

Another major challenge is the Blue Economy's inability to attract and retain institutional memory and build specialised skill sets in key areas. The current talent pool has strong, broad-based skills, and there are several institutions training students for these sectors. However, the industry lacks talent with specialised skills in various key areas, as well as technical skills, especially in the mid-level workforce. Additionally, levels of entrepreneurial skills remain relatively low, and a large part of the sector is dependent on government support and services. Much of the industry is dependent on an unskilled foreign workforce that subsists on low wages. These sectors also involve long working hours, low remuneration, high turnover rates, and weak career opportunities and pathways. Pervasive negative perception plagues some industries, attributed to the inability to provide a good career, financial stability, and association with climate change. These issues have become strong factors for brain drain as graduates gravitate towards more lucrative subsectors, overseas prospects, or non-maritime sectors, thus leading to a talent deficit within the Blue Economy. This inability to attract and retain talents with the necessary specialised skills has resulted in an aging workforce, reliance on low-skilled foreign labour, and the gradual depletion of institutional memory.

Many of the education and training programmes in the sector are suited for the old economy (a production-based economy). Few train and educate the next-generation talent with appropriate technical skills and entrepreneurial acumen to transform the ecosystem into a vibrant and competitive economic sector. Some of these high-end courses and training are expensive and beyond the reach of SMEs and the workforce in the rural coastal townships. The level of use of digital technology and Industry 4.0 technology is relatively low in this sector, especially industries and workforce in the rural coastal townships.

Integrity System

Policy design and implementation have room for improvement. There are numerous policies on managing the Blue Economy, but not a single integrated and cohesive national ocean policy. These policies are piecemeal and fragmented, and often lack measurable targets and mechanisms for transparency, accountability, and monitoring of the progress of KPIs. Due to the fragmentation of the different policies and strategies, there is significant duplication of resources, which dissipates the efficiency and productivity of the subsectors in the Blue Economy. As such, many of the Blue Economy

systems (upstream and downstream), across different industries and localities are not seamlessly integrated.

A sound and adaptive governance system that is supported by contemporary and relevant legal and regulatory frameworks are necessary for seamless policy implementation. Tracking and monitoring policies, strategies, and development initiatives can be challenging without a sound governance ecosystem. Low levels of use of governance systems underpinned by weak technology strategies, especially among rural coastal communities and SMEs, also limit their ability to obtain valuable insights and data-driven market intelligence to enhance their competitiveness. This also hinders effective decision-making processes which impact maritime security and, in some areas, encourages rent-seeking behaviour. Lack of coherence in the governance systems also tends to lead to weak enforcement, allowing unsustainable economic and industrial practices to go unmonitored at the expense of environmental degradation and over-exploitation of marine resources.

Incentives

While the government has invested significant resources in developing this sector through various incentives schemes (research and development funds, tax incentives, subsidies, and business-friendly policies), much of the incentives are targeted at a production-based Blue Economy, as opposed to transforming this sector into a knowledge- and technology-intensive sector. These incentive schemes are primarily targeted toward building absorptive and some adaptive capabilities of firms and the workforce and less towards supporting the research, development, and adoption of new science, technology, and innovation (STI) that meet the needs of a modern, competitive, and sustainable Blue Economy sector, i.e., to build strong adaptive and innovative capabilities of all players in the sector. Additionally, these incentives are also insufficient in addressing the barriers that both research institutions and industries face. Research institutes struggle to conduct research (particularly in niche areas) and bring prototypes to market due to a lack of research funds and industry co-investment. This lack of industry participation may be attributed to their risk-averse nature as fundamental research (particularly new technologies and processes such as waste management disposal and recycling and marine biotechnology) involves high initial capital, risk of failure, and a long duration between research and commercialisation.

Lack of a focused and strategic approach to developing frontier local STI has hindered the potential of higher innovative capabilities among firms. Hence, there is a lower propensity for frontier innovations in the sector thus, leading to an over-reliance on foreign STI in this sector. Additionally, the culture of "lock-in" is prevalent, which can "crowd-out" local innovation and development in the sector. Meanwhile, regional players with higher production efficiency and cost competitiveness are squeezing local players out of both global and local value chains.

Institutions

The government has had many policies for managing the Blue Economy, but fragmentation in institutional governance and poor coordination of stakeholders render federal policies ineffective in transforming the sector into a vibrant and globally competitive economy. This existing fragmentation in institutional governance and the lack of effective stakeholder collaboration in policy design (i.e., citizen participation) has weakened institutional authority and state trust in federal policies. Furthermore, this disconnect between state and federal governments creates inconsistencies and gaps in legislation and regulations, as is the case for offshore mineral mining, whereby the subsector's expansion hinges on limited state laws and an absence of federal laws. The lack of a central coordinating body, as well as a national ocean policy, has left stakeholders unguided and confused in the direction of the Blue Economy.

There are several government institutions (federal, state, and local councils), government-linked companies (GLCs), industry associations, community organizations, and institutions of learning that support the development of the Blue Economy. However, most of these institutions are more suited for a production-driven Blue Economy ecosystem as opposed to a more STI-driven economy. Many of the institutions do not have an advanced STI ecosystem that seamlessly integrates multiple systems across the upstream and downstream sectors and the multiple ecosystems across the country. The interface between the Blue Economy ecosystem and other economic sectors is fragmented due to a lack of a robust and transparent governance system. The MyKE-III study (EPU, 2016a; 2016b) showed that for key Blue Economy sectors such as fishery, transportation services, and tourism, the relevant institutions lack the technological sophistication and expertise to directly influence the dynamic capability (absorptive, adaptive, and innovative capabilities) of firms in the sector. Hence, the knowledge content in many of the Blue Economy subsectors remains low, and its contribution to economic development remains below its full potential.

Interaction (Smart and Strategic Partnerships)

Smart partnerships among the key institutions are critical to ensure that strategies formulated and implemented meet the needs of all stakeholders in the sector and ensure sustainable development of the sector. One of the major challenges faced by the sector is that the level and quality of engagement and collaboration remain fragmented and superficial. There is a lack of a formal collaborative platform for industry and citizen participation and a coordinating body to delegate the roles of each stakeholder. These factors, combined with an already weak governance ecosystem, put the Blue Economy at risk of poor cohesion between policies, uncoordinated research done in silos, a mismatch between supply and demand of talents, low industry-academia R&D collaboration, weak CEPA, and slowed developments for a sustainable economy.

These problems are further exacerbated by overlapping responsibilities among the various institutions (across different jurisdictions) and a lack of role clarity, which leads to 'turf-wars' among key players in the sector (e.g., large incumbents maintaining the status quo and market share dominance). Lack of coordination and harmonization between the multiple systems in the sector also lead to unproductive practices and low private-public and private-private partnerships for knowledge and technology sharing, which hinder the sustainable development and competitiveness of the Blue Economy.

Internationalisation

Malaysia has also built strong international partnerships and linkages in some key sectors, such as the energy sector (oil and gas). These strong international networks and partnerships have resulted in strong knowledge and technology transfers from more advanced economies to Malaysian corporations. This has yielded a significant positive spillover impact in the form of increasing the dynamic capabilities of the energy sector. This stronger dynamic capability position has allowed the energy sector to be an important contributor to the Malaysian economy. Similar international partnerships and linkages are not prevalent in other subsectors of the Blue Economy. Further exacerbated by comparably lower innovative capabilities, many sectors struggle to compete with advanced developed countries and highly efficient developing economies (e.g., waste recycling, marine biomass, renewable energy), thus resulting in the poor presence of Malaysian maritime industries in the global value chain. Hence, there is a lot of room for improvement to raise the dynamic capabilities of these Blue Economy sectors through the fostering of strong international partnerships and collaboration. Sound international collaboration with countries and multilateral institutions within and outside ASEAN will be important to ensure that Malaysia establishes itself as a key player in the global supply chains of Blue Economy products and services.

Multilateral cooperation is vital in maintaining Malaysia's continued access to the global supply chain. Disagreements and lack of adherence to international standards and best practices can often pose significant non-tariff barriers. One such case involves the requirement for certified sustainable palm oil and palm-oil-derived products (e.g., biofuel) to be exported to Europe, thus impacting the export revenue of both the renewable energy and agricultural sectors. Additionally, Malaysia is surrounded by oceans that are shared by other regional economies with competing interests. While Malaysia is a signatory of many international treaties to ensure the safe, secure, and sustainable use of marine resources and free access to the waterways for transportation, there are still 'hotspot' areas where countries in the region have unresolved territorial disputes. These disputes require a resolute approach by institutions to create holistic solutions that benefit all parties involved.

4.3.2 Comparative Analysis of the 5 Pillars with the 8i Blue Economy Ecosystem

The 5 pillars (discussed in chapter 2) show the main themes of the gaps highlighted in the stakeholder engagements. The themes range from governance and collaboration issues to struggles with competitiveness and capacity building. These 5 pillars are broad categories, and by mapping these themes onto the 8i Blue Economy Ecosystem framework, the 8is present a more granular perspective and targeted approach to developing interventions that will strengthen the ecosystem. The 8 enablers in this framework are mapped to these 5 pillars as shown in Figure 43.

The governance and climate change issues primarily map onto the foundation enablers of the 8i ecosystem, where integrity, institutions, and interaction play a critical role in setting the stage for a dynamic Blue Economy ecosystem. These foundation enablers are the necessary precursors that will guide the development of the supporting enablers where the resources needed to enhance industry competitiveness and capacity building can be found. These supporting enablers, such as infrastructure, infostructure, incentives, intellectual capital, and internationalisation, are key ingredients for thriving public and private participation in the development of the Blue Economy. They enable strong research and development processes that lead to innovation and commercialisation of ideas that have a positive impact on the economy.

In many studies, a secondary mapping of the five pillars has been used by policymakers and others to characterise the ecosystem. In this study, the five pillars can be linked to the 8i-enablers, as shown in Figure 43. Information was gathered for the five pillars from two stakeholder engagements, which provided valuable insights on the state of the Blue Economy in the country for all the Blue Economy subsectors. The analysis suggests that strengthening the Blue Economy ecosystem requires an integrated systemic approach to transform the Blue Economy ecosystem into a dynamic one. That will require a systems approach that strengthens every aspect of the 8i enablers of the ecosystem.

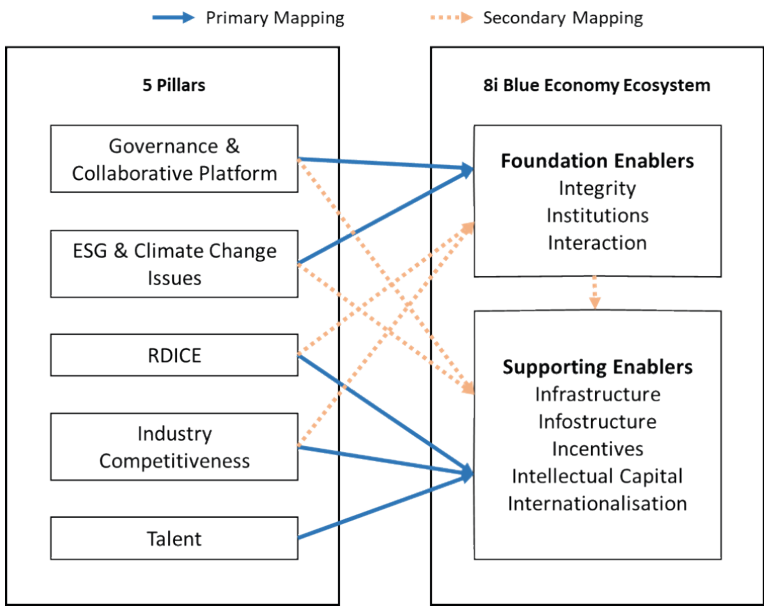
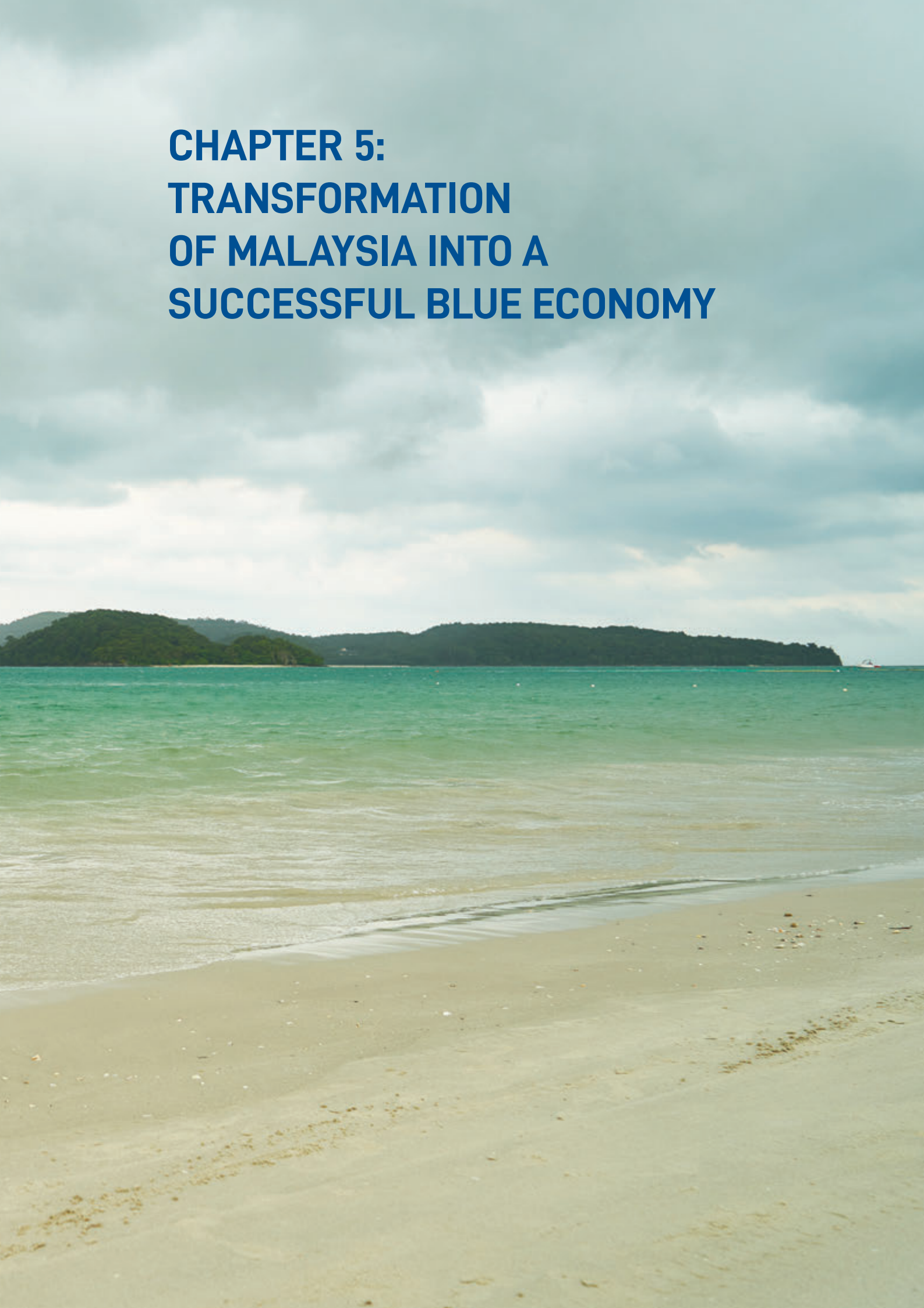


Figure 43 How the Five Pillars Map onto the 8i Blue Economy Ecosystem

4.4 Conclusion

Local firms and institutions remain low in the global value chain due to a heavy reliance on absorptive capabilities, leading to weak innovative capabilities. Additionally, fractures in the key enablers are impacting their progress moving forward. Through analysis of the Blue Economy based on the 8i ecosystem framework, the key gaps within the Blue Economy lie in the weaknesses within governance systems and collaboration, which are wrought with fragmentation, poor coordination, weak implementation, and lack of accountability. These key weaknesses have had a negative knock-on effect on all 8 enablers and have stifled the growth of the Blue Economy. Gaps in supporting physical, digital infrastructure, skilled talent pool, data collection and sharing must be addressed to create a conducive environment for effective multistakeholder partnerships and adoption of emerging technologies to transform the sectors into a vibrant knowledge- and technology-driven, globally competitive Blue Economy. Chapter 5 will elaborate on the way forward to overcoming some of the gaps in the 'quadruple-helix' model (partnership among government, industry, institutions of learning/research, and community organisation) within the Blue Economy.

CHAPTER 5: TRANSFORMATION OF MALAYSIA INTO A SUCCESSFUL BLUE ECONOMY



Chapter 5: Transformation of Malaysia into a Successful Blue Economy

5.1 Introduction

A successful Blue Economy boosts economic growth, trade and investment, and employment, and contributes to food security, poverty alleviation, the provision of energy and fuel, water, new medicines, minerals, and enhanced maritime connectivity. The practice of sustainable Blue Economy principles in the restoration and management of the ocean ecosystem will ensure the sustained services that the oceans provide in terms of resources and their role in climate management.

Though the ocean economy and Blue Economy are not interchangeable terms and concepts[4], there is limited global data on the gross value-added of a country's Blue Economy. Therefore, current estimates and measurements using the ocean economy likely underestimate the full long-term sustainability value of a dynamic Blue Economy. Examining the latest ocean economy data available in 2015, Figure 44 shows that Malaysia has the third-highest gross value-added ocean economy in the Southeast Asia region at USD 61 billion (PEMSEA, 2021). However, this does not consider the physical size of the ocean in comparison to its respective output. Using each country's exclusive economic zones (EEZs) as a proxy of the physical size of their ocean economy, Figure 45 shows how productive each country's EEZs are in terms of their ocean economy's gross value-added per square kilometre.

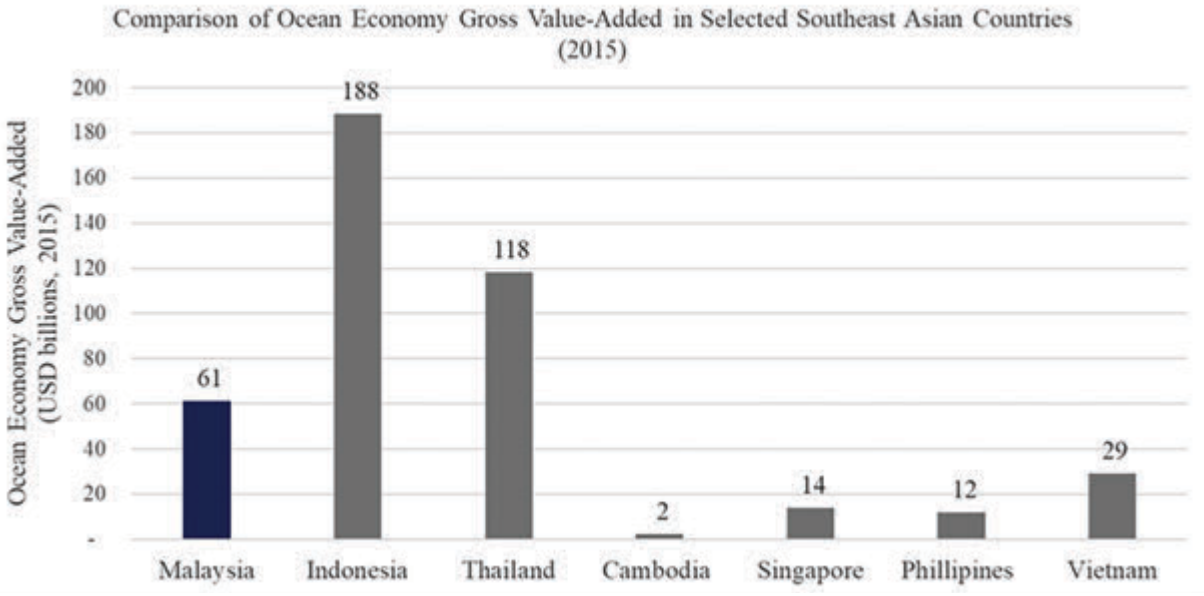


Figure 44 Ocean Economy Gross Value-Added Amount in Southeast Asia in 2015

Source: PEMSEA (2021)

4 Ocean economy refers purely to the extraction and use of ocean resources for economic value, while the Blue Economy focuses on the sustainability aspects of environmental, social, and economic growth of ocean-related activities. For more details, refer to PEMSEA (2015).

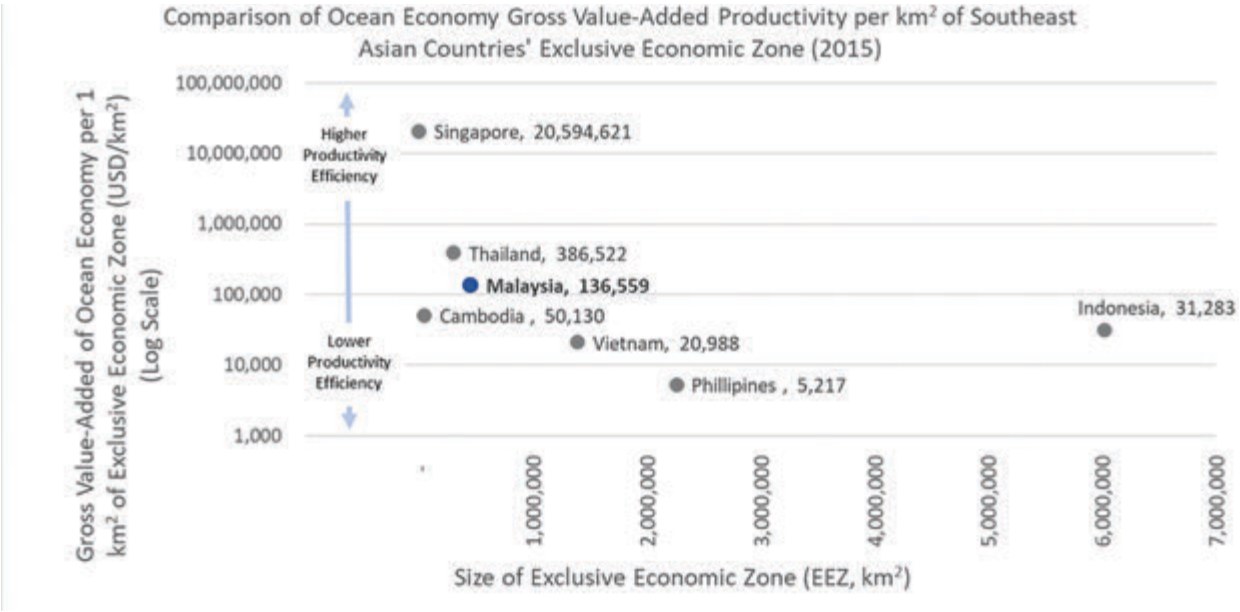


Figure 45 Comparison of Ocean Economy Productivity in Southeast Asia in 2015

Source: Pauly et al. (2020)

When looking at Southeast Asia's respective ocean economies' productivity measures, Singapore leads the region by creating just over 50 times (USD 20.6 million/km²) the gross value-added per square kilometre of EEZ of the next most productive country, Thailand (USD 0.39 million/km²). Malaysia has the third most productive ocean economy (USD 0.14 million/km²), less than half of Thailand's ocean economy productivity, despite having a similar-sized EEZ of around 300,000 to 450,000 square kilometres (Zeller and Pauly, 2015). With only 673 square kilometres of EEZ, Singapore has managed to position and develop itself into a leading global shipping hub, with its shipping and ports, and coastal and marine tourism sub-sectors of its ocean economy contributing the majority of the gross value-added. Nevertheless, Singapore has also embarked on its Blue Economy strategy, aiming to transition its ocean economic activities into sustainable practices. Given the size of Malaysia's EEZ, there is a lot of potential and room for improvement to increase the ocean economy's productivity while transitioning into a sustainable Blue Economy at the same time to stay competitive in the region. This successful transformation will require the right policies and initiatives to strengthen the 8i enablers of the Blue Economy ecosystem.

5.2 The Way Forward

The Blue Economy is a complex, interconnected ecosystem that has multiple linkages across many economic, environmental, and social sectors. The effective development and management of a Blue Economy lie in a systems approach to addressing the gaps and issues of the existing ocean and coastal economy. These gaps are described within the 8i ecosystem framework in Section 4.3.1, showing issues with the current state of the Blue Economy ecosystem. To successfully strengthen the ecosystem, gaps in each aspect of the 8i need to be tackled comprehensively for the strategies to be effective. Figure 46 shows a summary of the way forward for the 8i Blue Economy ecosystem, followed by a detailed description of the way forward for each of the 8i enablers .

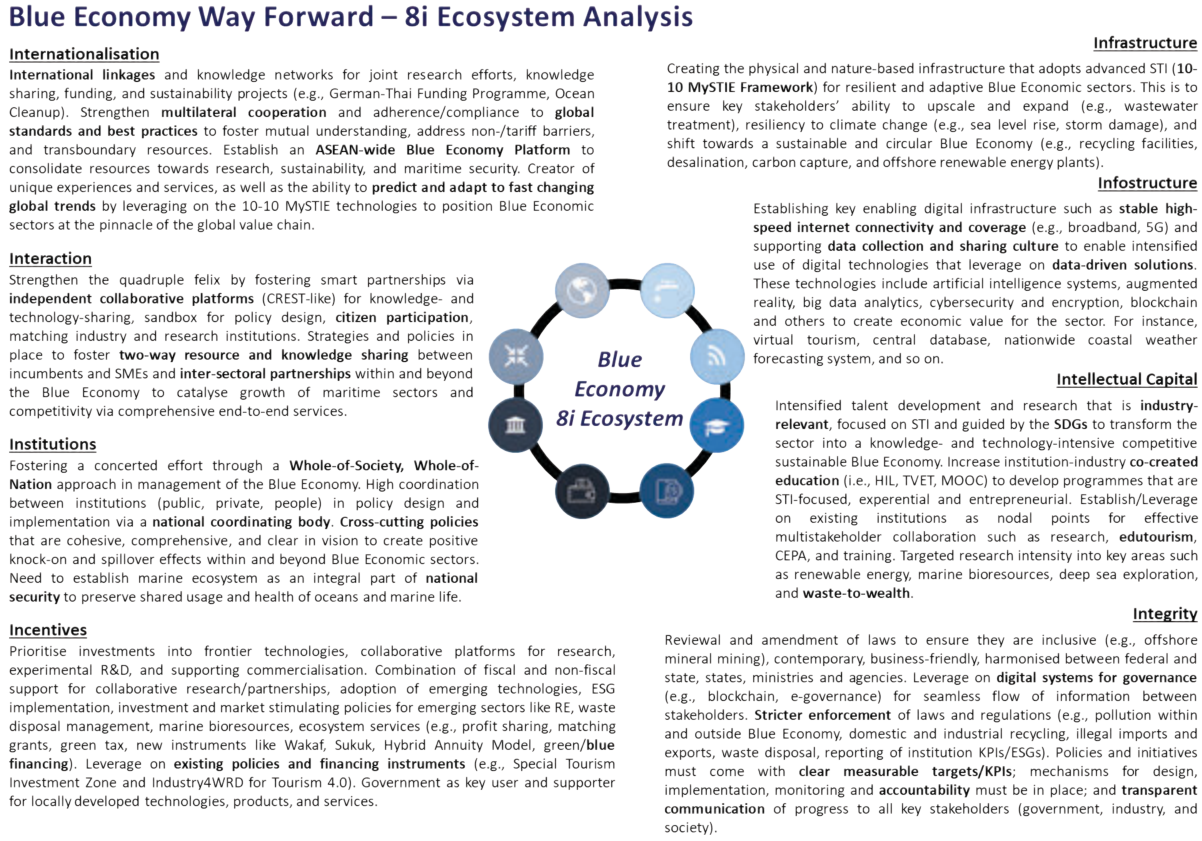


Figure 46 The 8i Ecosystem Analysis of the Way Forward in the Blue Economy

Infrastructure

Major upgrading works are required to improve current infrastructure as well as equip rural and under-developed regions with the necessary supporting infrastructure to meet current needs and future-proof the Blue Economy. This will require major capital investments into infrastructure such as roads, shoreline barriers, and so on to address current difficulties faced by local firms. As it stands, the current infrastructure is not at a level where the industry can contemplate adopting more advanced technologies. For instance, weak coastal waste management systems, wastewater treatment for aquaculture, and insufficient basic infrastructure for marine biomass products are among the problems. Delaying upgrades to infrastructure and maintaining the current conditions will only stifle firm progress and further widen the gap between local firms and foreign competition. Moving forward, newly constructed infrastructure should allow the adoption of frontier and emerging technologies such as cell towers and high-speed cables to support high-speed internet connectivity (coastal or offshore). Examples of the use of advanced technology to upgrade the infrastructure in the Blue Economic sectors (using the 10-10 *My*STIE framework) are discussed in Section 5.2.1)

Ocean and coastal policies should also consider the long-term impacts of climate change and the potential damage coastal and maritime industries may incur in the face of destructive weather patterns. The Intergovernmental Panel on Climate Change (IPCC, 2021) predicts Southeast Asia to be one of the most vulnerable regions to worsening weather events and rapidly rising sea levels, with damage expected to cost in the billions. At present, coastal communities and tourist spots struggle with downtimes caused by damage from floods and typhoons. Infrastructure design and disaster risk management will need to be comprehensively integrated to protect coastal and offshore infrastructure such as maritime transport, mining rigs, tourist zones, and coastal fishing communities.

Further resiliency of the Blue Economy could be strengthened by increased investment into infrastructure to support sustainability and circular maritime sectors. There has been insufficient investment into areas such as renewable energy, waste recycling, desalination, and carbon capture due to the immense initial capital required – a sum most industry players cannot afford. This form of investment will require strong government support in the form of fiscal and non-fiscal incentives for research and construction of contextualised facilities, as well as market stimulating policies to encourage industry buy-in, which could come in the form of matching grants, green tax exemption, research funding, and leasing of public facilities for research.

Infostructure

Establishing a facilitative digital ecosystem will be key to enabling the greater adoption of digital technologies by the Blue Economic sectors. These include technologies such as artificial intelligence systems, data analytic tools, and blockchain technology. This should be supported by digital infrastructure (high-speed internet) and a data collection and sharing culture. There is a need to address the siloed approach of collecting and storing data by institutions through a comprehensive open data and data sharing policy. Additionally, a national data repository should be set up to act as a one-stop hub for Malaysian data. In doing so, any gaps, overlaps, and issues in data format can be addressed, and this opens up avenues for the creation of data-driven solutions. Establishing and collecting data on key marine indicators will enable better tracking of pollution sources, fish stocks, marine ecosystem health, and the development of vital coastal and marine forecasting systems. In terms of maritime transport, there should be a national digital navigation system set up to help with port congestion and vessel schedules, as well as to deal with cargo rollover and blank sailing rates. Examples of the use of digital technology in the Blue Economy sectors (aligned to the 10-10 *My*STIE Framework) is discussed in Section 5.2.1.

Intellectual Capital

A multi stakeholder approach is required to address existing issues in research, commercialisation, and intellectual capital development. Many sectors are opined to be experiencing a talent deficit due to poor remuneration, career opportunities, and harsh working conditions affecting sector employability. Institutions should adopt a co-creation approach to the design of educational programmes and career pathways to better align education with industry needs. Programmes will need to be experiential, entrepreneurial, and STI-enabled to create talents with specialised skills, while industry players will need to adopt frontier technologies to create high-value jobs and automate labour-intensive tasks. Industry-academia collaboration should also extend towards research efforts to address the mismatch between research and industry requirements and improve commercialisation rates.

Integrity Systems

The current legislation and governance structure is outdated and lacks clarity. A review and amendment system is required to review and update laws and regulations to ensure they remain contemporary and provide the necessary framework for emerging and niche subsectors (e.g., offshore mineral mining, marine bioresources, renewable energy). There are many policies and initiatives tied to the Blue Economy (whether directly or indirectly), but implementation and monitoring of progress are just as vital as the policy itself. Many subsectors have opined a lack of follow-through of existing policies, a key area for improvement. Systematic mechanisms for policy design, implementation, monitoring, and reporting should be established. Additionally, measurable hard targets and clear communication of policy progress through publicly accessible progress reports will improve stakeholder trust and allow citizens to hold institutions accountable for public funds. Government governance should leverage digital technologies, such as e-governance and blockchain.

Incentives

There is a need for greater government support through fiscal and non-fiscal incentives for research, industry participation, and improving local firm competitiveness. Due to the nascent nature of some sectors (e.g., renewable energy, offshore mineral mining, waste disposal management), the costs associated with pioneering them remain strong barriers to industry players, particularly SMEs. These subsectors that lack incumbents and existing facilities will require additional support for research by means of increasing existing research funding. Greater government support in the form of market stimulating policies, matching grants, green tax exemptions, subsidies for technology adoption, and collaborative research can help alleviate the strain of high initial costs. Similar incentives should also be applied to encourage business investment into technologies and processes relating to sustainability, ESG implementation, and the circular Blue Economy. Comprehensive economic and financial incentive schemes can play a key role in nudging all stakeholders in the ecosystem to adopt the 8R-nature centric approach to managing the blue economic sectors (see Figure 47). These include the following incentives outlined below[5].

- Removal of harmful subsidies that have an adverse impact on the oceans. These include subsidies for the agriculture, fishing and other economic practices that are not environmentally-friendly and have adverse impacts on ocean and marine resources.

- Blue Economy Investment risk management include voluntary and mandatory investment risk management standards, regulations, fiduciary duties and tools, which investors and financial institutions put in place to inform and review risk development projects that can pose a threat to the environment and the oceans. Investment risk management is core to approval and valuation of all development projects that can potentially have adverse impact on the oceans and marine ecosystems.

- Blue Economy biodiversity offsets are measures taken to compensate for environmental degradation or biodiversity loss to the oceans and marine life due to unavoidable development initiatives. Resources generated from the biodiversity offsets are utilised to improve the environmental condition and biodiversity of the ocean and marine ecosystems.

- Blue Economy Biodiversity taxes, levies, and fees are revenue generated from the use of marine and ocean resources and ecosystem services. The revenue is channelled towards maintaining the quality of marine and oceans ecosystems across the country.

- Blue Economy nature-based financing is financial support provided for the development of nature-based infrastructure, technology and innovation that mitigate environmental risk to the oceans and marine resources, including mitigating risks associated to climate change that can adversely impact coastal communities.

- Blue Economy financing market instruments such as the blue bond markets are instruments used to finance sustainable management of the marine and ocean resources of the country. Blue bond is a debt instrument issued by governments, corporations and financial institutions to support investments in blue economic sectors and sustainable management of the oceans and marine resources. Income derived from the ocean and marine resources are used to repay investors,

5 More detailed discussion on the economic and financial instruments for biodiversity conservation are given in Deutz et al. (2020) and OECD (2020). Blue bonds are financial instruments that are designed to manage the oceans resources in sustainable ways aligned to the 8R-philosophy. Examples of blue bonds include the Seychelles Sovereign Blue Bond, which raised close to US15 million to manage the small island ocean resources (Ahmed, 2019). Another is "Nordic-Baltic Blue Bond", which raised SEK 2 billion to manage water related pollution, adaptation to climate change and wastewater treatment (Ahmed, 2019). For Blue Carbon Sink, refer to National Oceanic and Atmospheric Administration, USA (2022)

while at the same time enable them to meet their social obligations to preserve the health and biodiversity of the oceans for future generations.

- The Blue Economy carbon sink market is a market instrument to attract investment in the preservation and expansion of marine plants such as tidal marshes, mangroves, seagrass, and other marine plants that capture and sequester carbon. The blue carbon markets can leverage and complement existing carbon credit markets.

- Blue Economy Official Development Assistance (ODA) programmes are aids provided to developing and under-developed countries by other wealthy countries or international development institutions to ensure that development assistance for the less developed countries adheres to global best practices in managing the marine and coastal ecosystems. The assistance programs are in the form of financial support, grants and technical assistance for these countries to adopt nature-based solution (8R-Nature-centric philosophy) to create sustainable and economically vibrant coastal communities.

- Blue Economy supply chains include the development of knowledge systems, business and environmental policies, and regulatory architecture to ensure seamless integration and flow of information, goods, and services across multiple Blue Economy sectors and regions. All of which lead to the smooth flow of high-quality goods and services from the oceans to consumers, delivered using sustainable environmentally friendly supply chains.

- Blue Economy Biodiversity Sovereign Fund is a fund primarily established to support projects that contribute to sustainable ocean and marine ecosystems. These include resources to increase ocean and marine protected areas, enhance governance and derive better ROV from the Blue Economic sectors[6]. There is also increasing recognition among global sovereign funds on the importance and economic opportunities in protecting the biodiversity of the environment, in particular the oceans[7].

6 An example of this financial instrument is the Sovereign Blue Bond launched by Seychelles in 2018 to get better ROV from its ocean resources. Refer to World Bank (2018), https://www.worldbank.org/en/news/press-release/2018/10/29/seychelles-launches-worlds-first-sovereign-blue-bond

7 Reuters (2018) state that Norway's sovereign wealth funds is intensifying sustainable initiatives to address plastic pollution in the oceans.

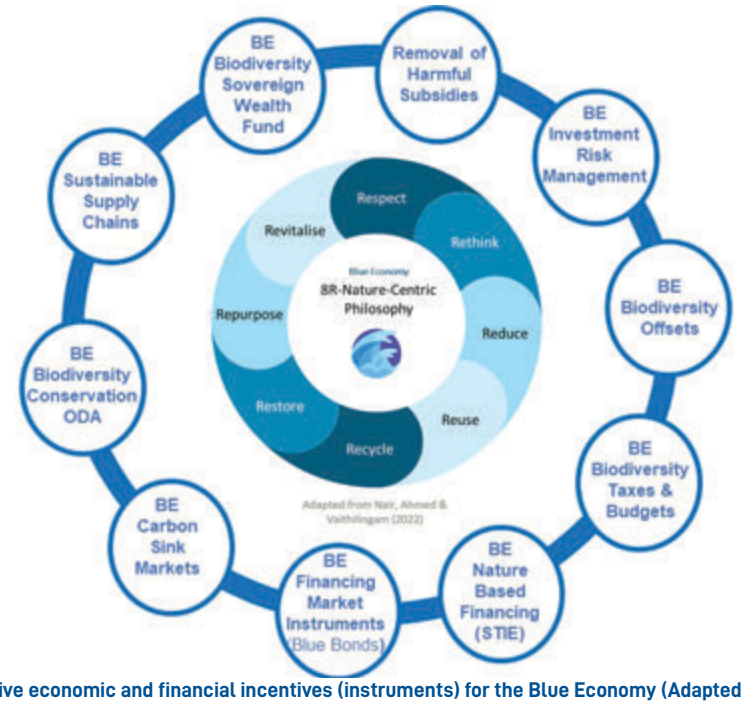


Figure 47 Comprehensive economic and financial incentives (instruments) for the Blue Economy (Adapted from Nair et al. (2022b))

Institutions

The scale of the Blue Economy is huge and will require a strong guiding entity – a "Champion with Clout" – supported by a Whole-of-Nation approach. Strong leadership is vital in steering the direction and vision of the sectors involved, via a comprehensive and cohesive national ocean policy. The Blue Economy is a broad spectrum spanning numerous sectors, portfolios, and policies. It remains vital that a coordinated and concerted effort be taken in the implementation of policies. Sector stakeholders have opined their agreement on the matter and that a national coordinating body under the Prime Minister's department to be employed. In a similar vein, due to the expansive nature of the Blue Economy, it encompasses numerous agencies and ministries of differing portfolios, thereby causing overlaps and gaps in governance and responsibilities. Therefore, institutional governance structures and ministry/agency portfolios will need to be harmonised and consolidated. Specifically, this involves ensuring greater harmonization in the design and implementation of policies between the federal, state, and local governments.

Interaction

The successful transformation of the Blue Economy hinges on effective collaborations, not siloed efforts. A nationally trusted partner such as CREST or i-Connect will facilitate the Whole-of-Nation approach by bringing all actors together to build smart partnerships for research, innovation, investment, and policy decision-making in the different blue economic sectors. Additionally, it provides a platform for discussion of challenges and ideas, offering an opportunity to empower stakeholders. This creates a more inclusive Blue Economy through citizen participation and develops innovative ideas. Smart partnerships can also be leveraged to consolidate research efforts and resources, particularly investments into high capital projects such as renewable energy facilities, desalination plants, and offshore mineral extraction rigs.

Internationalisation

Institutions will need to take the lead in establishing international linkages to pave the path for industry players to tap into the global value chain. Strong global networks are gateways towards two-way

technology and knowledge sharing, joint research programmes, global funding schemes, and training programmes to improve local innovative capabilities and establish Malaysia as a Blue Economy hub. Currently, Malaysia is playing catch up with other developed and developing economies in terms of market reach and richness in blue economic products and services. To transition the Blue Economy sectors up the global innovation value chain will require global technology and trend scanning, strong innovative capabilities, and adherence to global best practices and standards to improve production efficiency and the creation of uniquely Malaysian products, services, and experiences. Doing so not only puts local institutions and firms on par with global competitors but also reduces the risk of facing non-tariff barriers due to poor compliance. Creating an ASEAN-wide Blue Economy platform could also help consolidate regional resources and solve marine and maritime challenges.

5.2.1 Transforming the Blue Economy into a Knowledge-Driven Sector: Application of the 10-10 *My*STIE Framework

Blue Economy sectors are important economic drivers for Malaysia. To remain globally competitive, it needs to become more knowledge-intensive, underpinned by a sound technology plan. Under the 12th Malaysia Plan, the government introduced the 10-10 *My*STIE Framework, which integrates 10 global science and technology drivers with 10 socio-economic drivers, as shown in Figure 48. One of the socio-economic drivers is the environment and biodiversity of the nation, which is critical for ensuring sustainable development of the ocean and marine biodiversity. Sustainable development of the ocean and marine resources will have a significant spillover impact on the other nine socio-economic drivers, from energy to education. An example of the spillover impact and interlinkages between the blue economic sectors such as energy, water and food, agriculture and forestry, and tourism are shown in Figure 49. Hence, national and industrial policies, strategies, and regulatory reforms should be implemented to support the creation of a vibrant and competitive Blue Economy, underpinned by the 10-10 *My*STIE Framework[8] and adherence to global best practices and standards. In select areas within the Blue Economy, Malaysia should endeavour to lead some of the innovation, global best practices, and standards. Hence, a carefully curated 10-10 *My*STIE ecosystem, anchored on the 8R-NCBE philosophy and 8i-ecosystem, will lead to technology and economic spillovers. These new recombinant innovations, discoveries, and technological developments are envisaged to increase economic multiplier impact across the different blue economic sectors. All of which will increase economic wealth and high-income job opportunities for the nation.

8 The 10 Key Technologies and 10 Key Socio-economic Drivers (10-10) Science, Technology, Innovation, and Economic (STIE) framework is a national frontier policy strategy and research project that addresses the middle-income trap that has hitherto hindered Malaysia's socio-economic growth towards an advanced economy. This 10-10 STIE Framework was derived from a technological foresighting study undertaken by ASM after consulting various stakeholders, including industry, local and international experts and government agencies.

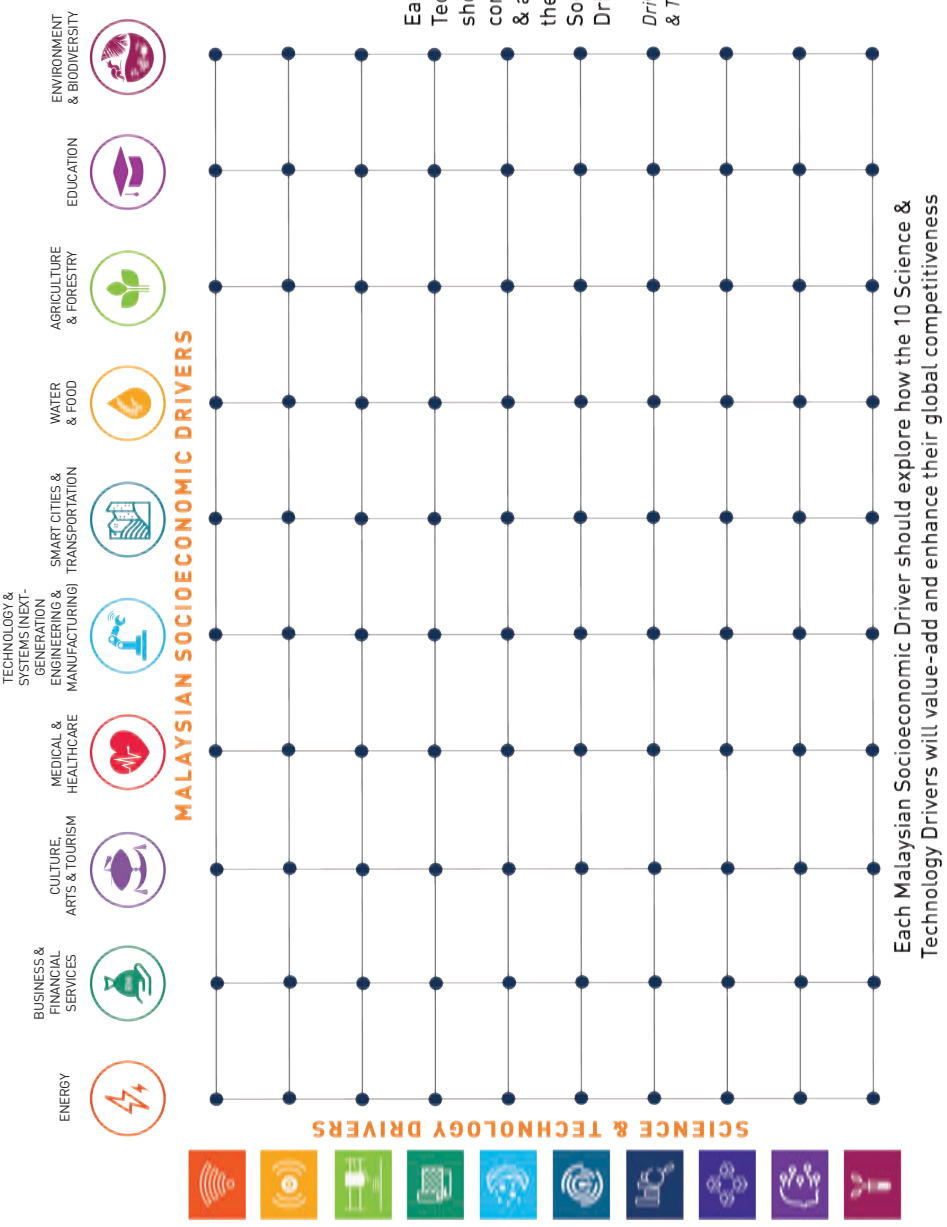


Figure 48 The 10-10 Malaysian Science Technology Innovation and Economy Framework

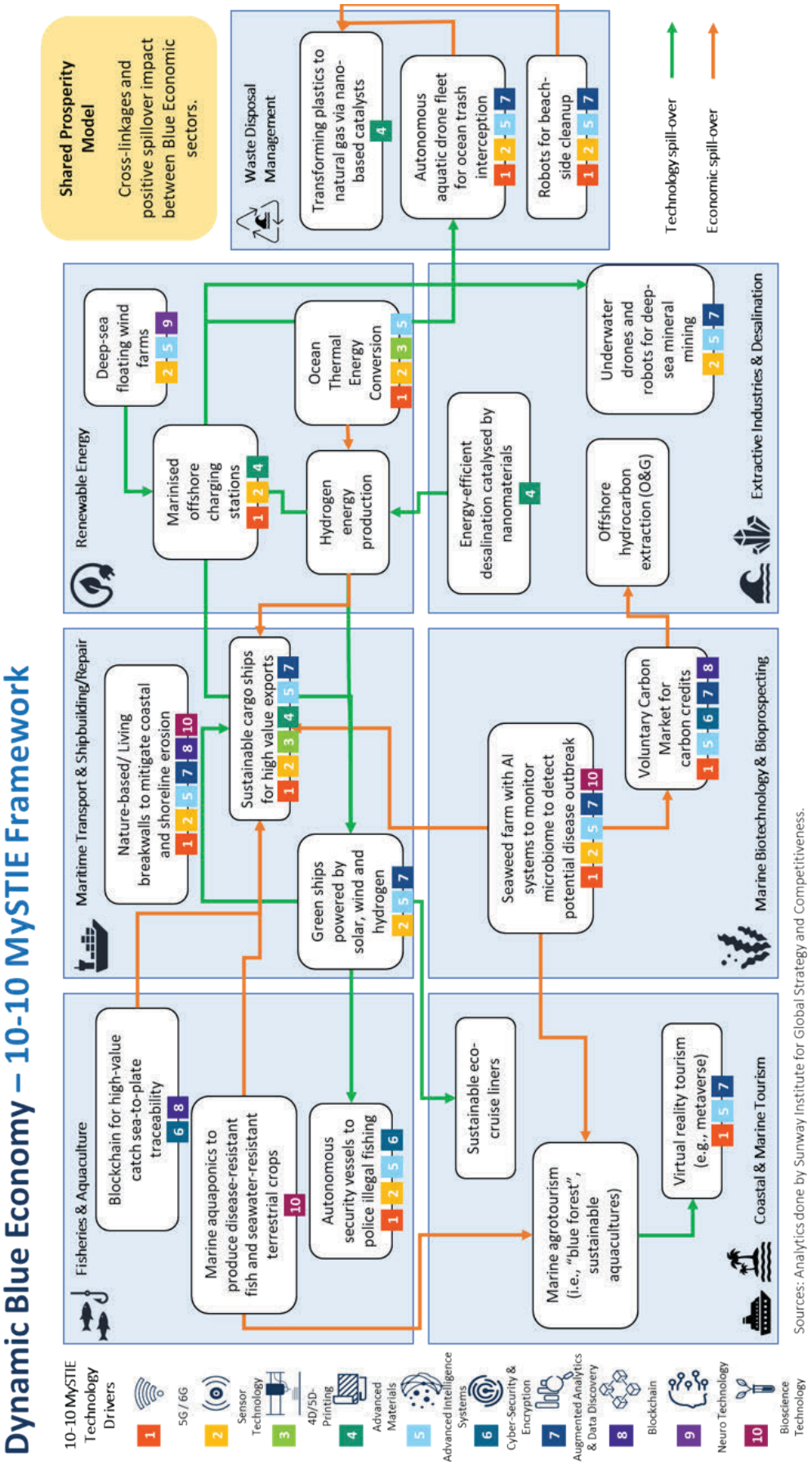


Figure 49 A dynamic Blue Economy that leverages the 10-10 *My*STIE Framework to create intersectoral spillover

A key feature of the 12th Malaysia plan (2021-2025) is to ensure that wealth is distributed equitably across multiple regions in the country. In this context, to raise the socio-economic well-being of the different communities in the various localities in the country, especially the rural and coastal communities will require the use of 10-10 *My*STIE technology to raise the ROV for these communities, and the Blue Economy sectors. This will require a 'Whole of Government and Whole of Society' approach in adopting the 8i Research, Development, Innovation, Commercialization and Economy (RDICE) ecosystem framework in each of the coastal and ocean localities across the country and ensuring that they are well networked to the other sectors of the economy and the region. Figure 50 shows coastal communities and economic activities across the various selected localities in Peninsular Malaysia and East Malaysia. The figure also shows the institutions of learning (knowledge enablers) that are present in these localities. Many of the Blue Economy sectors in these localities are underdeveloped due to weakness in the enablers of the ecosystem, as highlighted in the previous section of the report. These have a major impact on the socio-economic development of communities living in these localities that are dependent on marine resources. Due to gaps in the enablers of the ecosystems and low-income levels, many of the communities living in these localities use unsustainable business practices, which further adversely impact the quality of life for these coastal communities.

Figure 51 shows that if the 8R-NCBE philosophy (8R-Nature Centric Blue Economy Philosophy) forms the basis of strengthening the enablers of the ecosystem (8is) in these respective localities using the 10 global technologies identified under the 10-10 *My*STIE framework, the potential for increasing the ROV and ROI from the ocean and coastal natural resources will be very high. Many of the traditional and unsustainable Blue Economy practices can be transformed into vibrant and sustainable economic sectors that are aligned to the planetary health philosophy for the Blue Economy (8R-NCBE). These ecosystems are supported by the various institutions of higher learning (IHL) and government research institutions (GRIs) that become key 'knowledge enablers', working closely with industry, government agencies, and community organizations to nurture a vibrant RDICE ecosystem in the respective localities.

The RDICE ecosystem can play a catalyst role in enhancing the multiplier effect and positive network externalities within their respective blue-economy localities but also across the different localities in the country. These network externalities will enable economic agents to share best practices and sustainably complement their economic activities. This is aligned with the Shared Prosperity Vision 2030, where the country's wealth from its rich ocean resources is shared equitably among people of different socio-economic statuses across the country[9]. Figure 52 shows a leapfrogging trajectory (underpinned by the 8R-NCBE philosophy, 8i-ecosystem, and 10-10 *My*STIE) that is predicted to potentially increase the contribution of marine and ocean resources in 2030 to 31.5% of the GDP, as compared to 21.3% of the GDP if the Blue Economy ecosystem was to continue operating at status quo. The cumulative net gain from 2020 to 2030 of such a vibrant Blue Economy could increase contribution by RM 1.4 trillion GDP with an investment of 3.7% of GDP per annum in 2020. A summary of the ROV of STIE-driven Blue Economy sectors is given in Figure 53.

9 Refer to Ministry of Economic Affairs (2019).

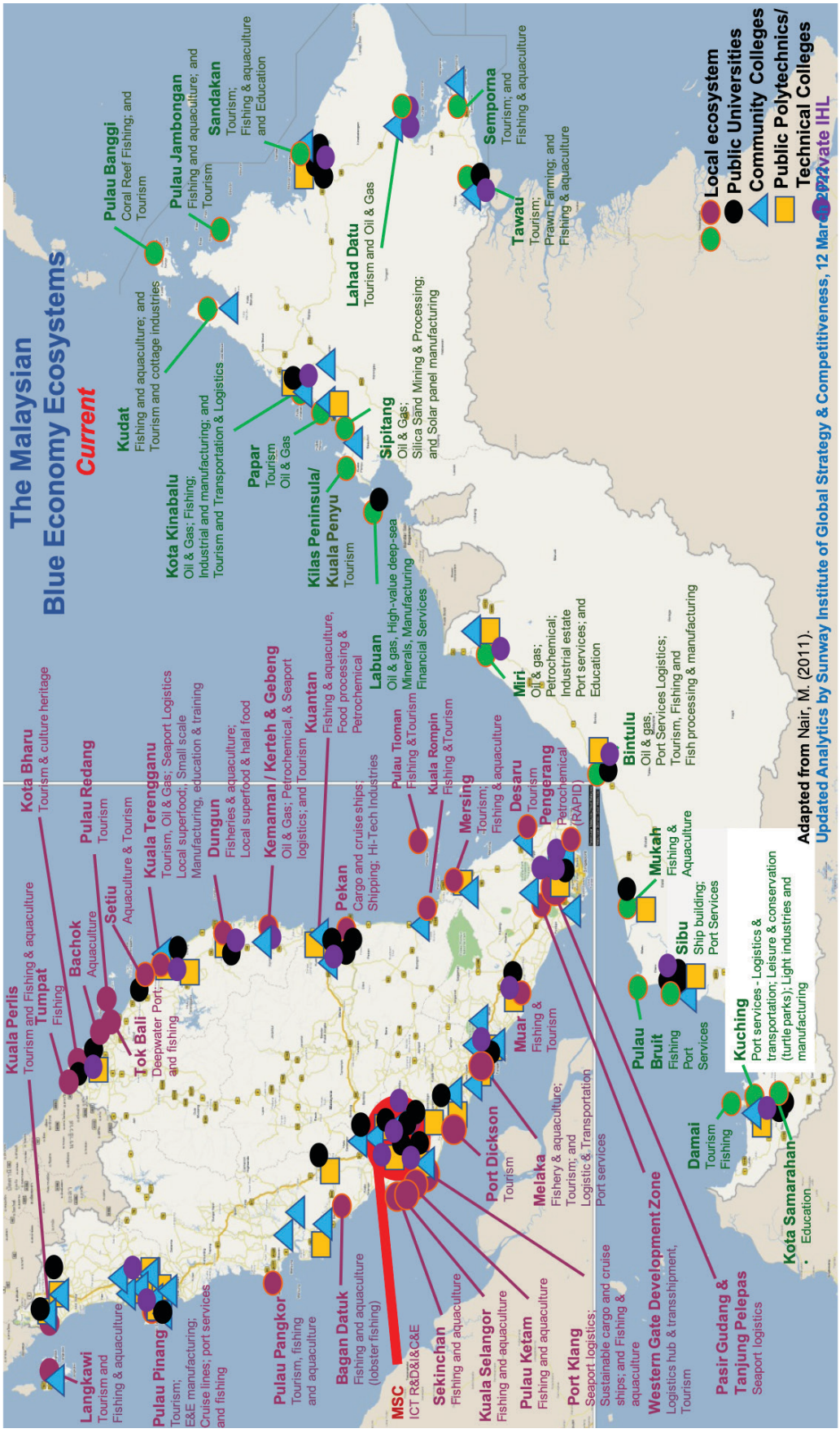


Figure 50 Current Blue Economy Ecosystems Across Malaysia

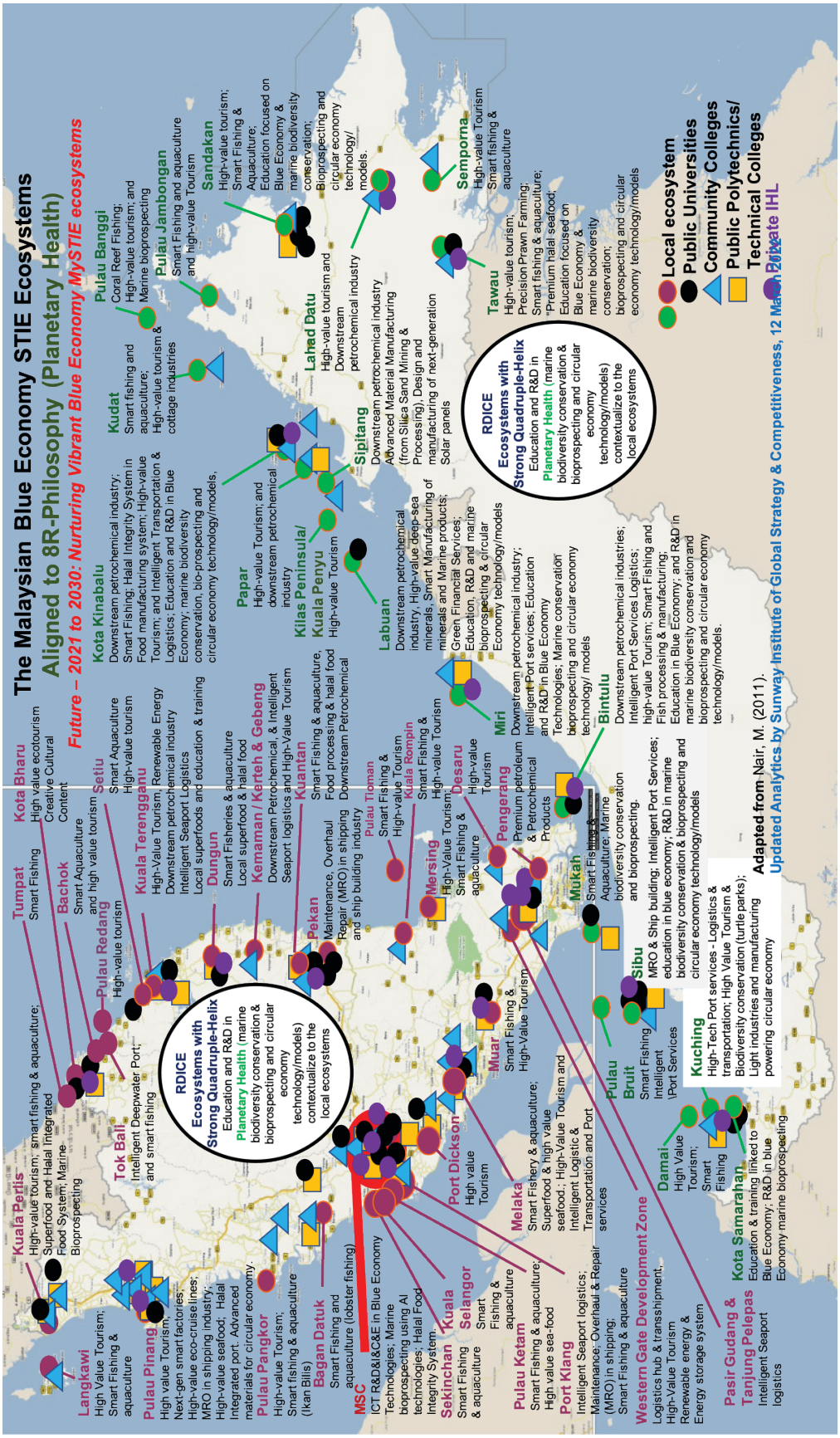
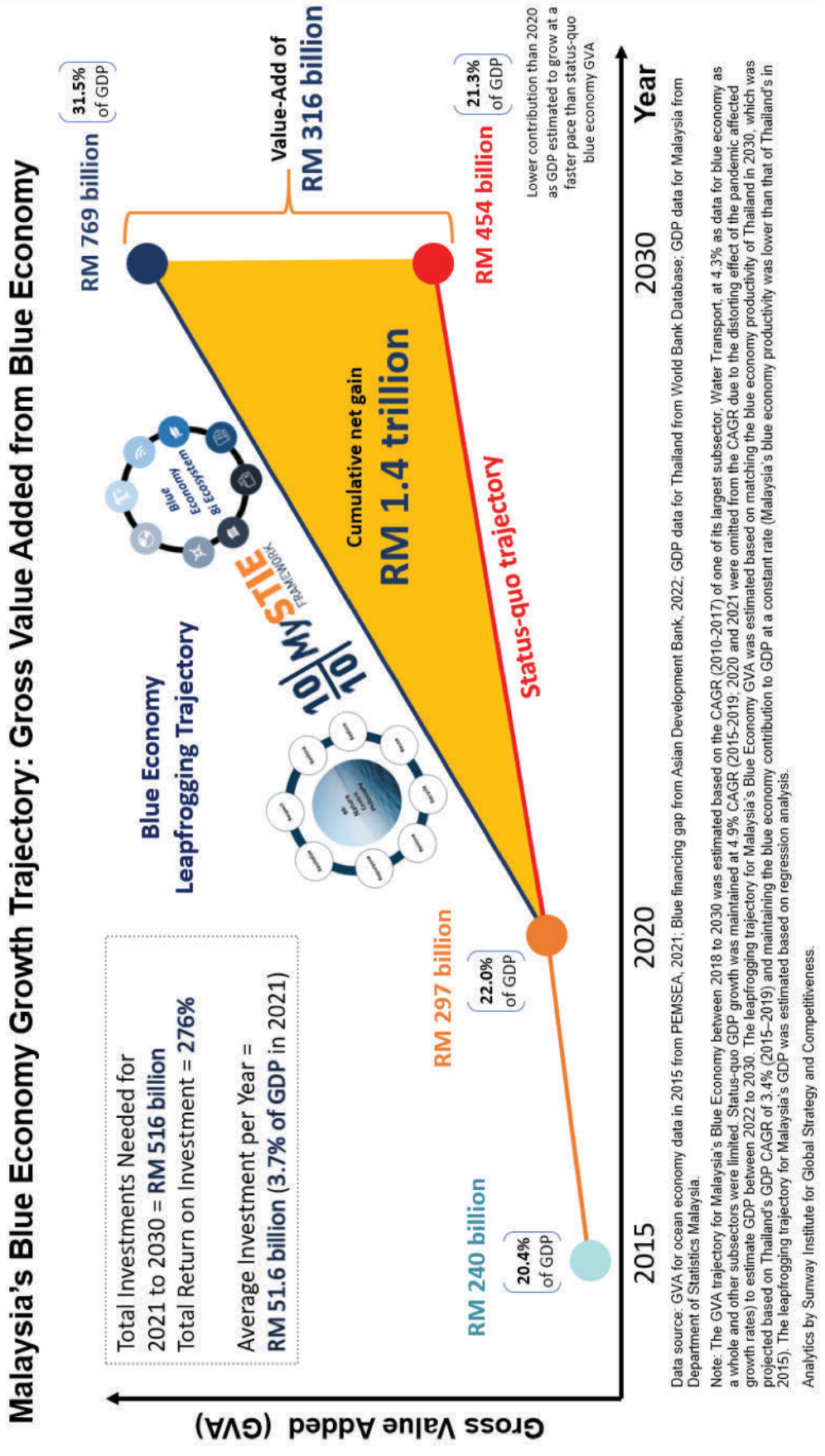


Figure 51 Future Blue Economy Ecosystems Across Malaysia (2020-2030)



Data source: GVA for ocean economy data in 2015 from PEMSEA, 2021; Blue financing gap from Asian Development Bank, 2022; GDP data for Thailand from World Bank Database; GDP data for Malaysia from Department of Statistics Malaysia.

Note: The GVA trajectory for Malaysia's Blue Economy between 2018 to 2030 was estimated based on the CAGR (2010-2017) of one of its largest subsector, Water Transport, at 4.3% as data for blue economy as a whole and other subsectors were limited. Status-quo GDP growth was maintained at 4.9% CAGR (2015-2019; 2020 and 2021 were omitted from the CAGR due to the distorting effect of the pandemic affected growth rates) to estimate GDP between 2022 to 2030. The leapfrogging trajectory for Malaysia's Blue Economy GVA was estimated based on matching the blue economy productivity of Thailand in 2030, which was projected based on Thailand's GDP CAGR of 3.4% (2015–2019) and maintaining the blue economy contribution to GDP at a constant rate (Malaysia's blue economy productivity was lower than that of Thailand's in 2015). The leapfrogging trajectory for Malaysia's GDP was estimated based on regression analysis.

Analytics by Sunway Institute for Global Strategy and Competitiveness.

Figure 52 Malaysia's Blue Economy Growth Trajectory: Malaysia's Blue Economy Potential Contribution to the National GDP from 2020 to 2030

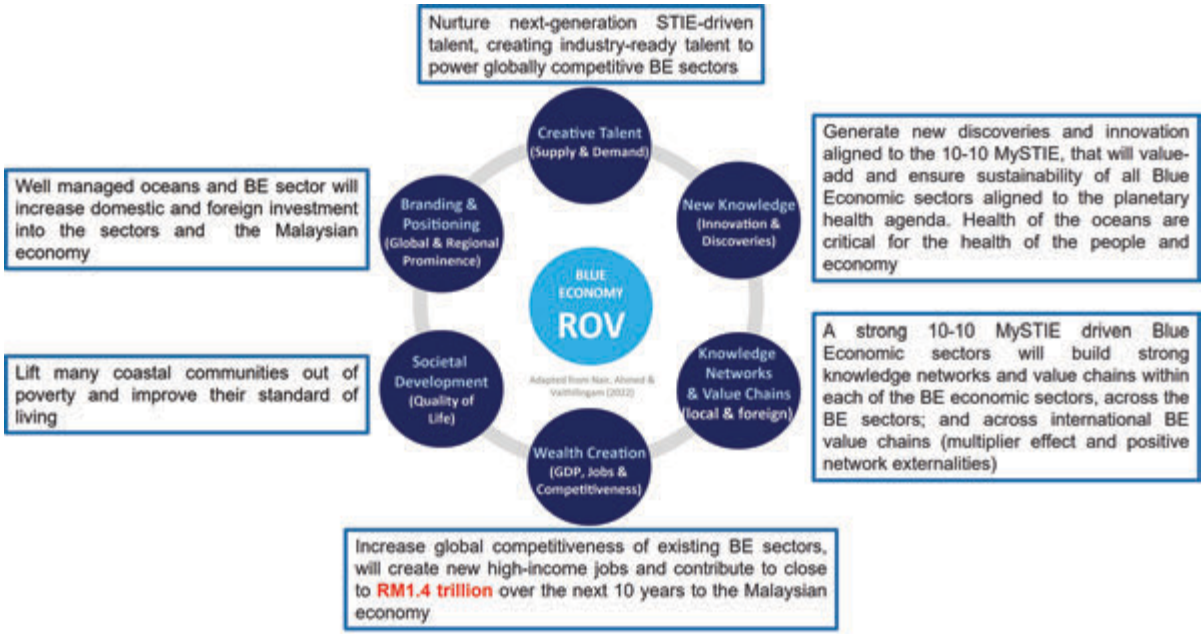


Figure 53 The ROV from an STIE driven Blue Economy ecosystem

5.2.2 Envisioned State of the Blue Economy – A South Korea Case Study

In this section, the Korean Blue Economy is presented (Figure 54). The analysis suggests that the Blue Economy sector is an important contributor to the Korean economy, and careful co-development policies and strategies were put in place to strengthen the Blue Economy ecosystem (the 8i-enablers – refer to the 8i ecosystem analysis of the Korean Blue Economy ecosystem in Figure 55). These have a significant economic impact on several economic sectors, as shown in Figure 54.

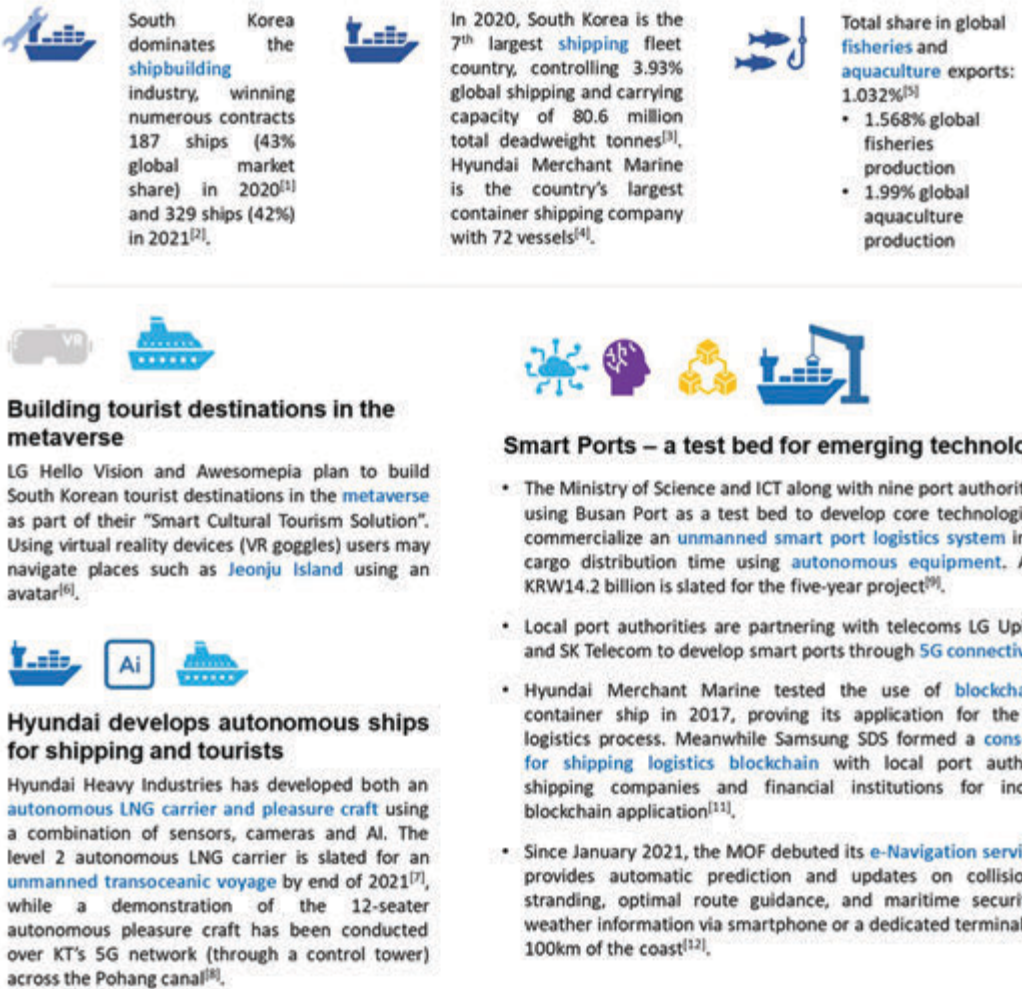


Figure 54 Economic impact of a conducive 8i ecosystem on the South Korean Blue Economy[1]

1 References: [1] Hellenic Shipping News, 2021 | [2] Shen, 2021 | [3] USGI, 2021 | [4] Marine Insight, 2021 | [5] OECD, 2021 | [6] Um, 2021 | [7] Song & Lee, 2021 | [8] The Maritime Executive, 2021 | [9] Park, 2020 | [10] DIT, 2021 | [11] DIT, 2021 | [12] MOF, 2021

South Korea – 8i Ecosystem Analysis

Internationalisation

International cooperation through multilateral initiatives such as the New Southern Policy with India and ASEAN[1]. Among top 5 largest providers of **official development assistance** (ODA) in 2019, at around USD194 million, of which USD120 million goes to sustainable ocean economy efforts[2]. Strengthen evidence-based ocean observation and climate change by providing training for ocean observation and hydrographic surveying to countries in Asia and Africa via ODA (e.g., Philippines, Indonesia, Bangladesh, Senegal)[3,4].

Interaction

Public-driven public private partnerships for research and innovations (e.g., smart ports with 5G and blockchain)[5,6,7]. Private-academia collaborations facilitated by industry associations (e.g., KSA, KOSHIPA, KOMEA, KOSIC) with institutions such as Korea Maritime Busan, Korea Marine Equipment Research Institute (KOMERI) and Society of Naval Architects of Korea (SNAK)[8]. Several **technology parks** near major ports/coastline and Korea Technopark Association to facilitate collaboration and communication between public, private and academia. **Collaborative hubs** such as Open Square-D that allow open data start-ups to use open government data for commercial purposes[9].

Institutions

Strong leadership and forward-thinking national plans that help build the necessary foundations for current growth (e.g., digital policy, high-speed internet and 5G, early major public R&D investments, 4IR)[10,11]. **Comprehensive maritime strategies** that are cross-sectoral (e.g., "K" strategy that focuses on digitalisation and sustainability of maritime industries such as K-Ship, Korean New Deal)[12,13].

Incentives

Strong public investments tied to key priority areas across maritime industries, primarily in research, infrastructure and innovation. Fiscal and non-fiscal incentives tied to long-term national policies to encourage sustainability and IR4.0 (e.g., harmful vessel buyback programme, deposit fund system for eco-friendly fisher gear and buoys)[14], quadruple annual budget for controlling port pollution (from KRW31.2 trillion to KRW119.3 trillion)[15]. **Public-private co-investment initiatives** for large scale infrastructure and research (e.g., project to build 12 new smart ports and introduce IoT, 5G and AI into ports)[16].

Infrastructure

Major investments outlined for **improving aging infrastructure** and the construction of **smart ports**, offshore **renewable energy plants** and **facilities for marine biology** products (e.g., KRW43 trillion project to develop 12 smart ports by 2040, 12GW target for offshore wind power[17], Wando's Marine Biotech Cooperation Research Center[18]).

Infostructure

Prevalence of high-speed internet and **5G network coverage** strong enablers for **digitalization of government services** and integration of data-driven technologies such as IoT location sensing, blockchain[19], and e-Navigation system at ports[20]. This is further supported by public-driven support for digital policy, **open government data** and **data sharing platforms** [21].

Intellectual Capital

Strong early support for basic-research capabilities[22], **human capital development**[23], **R&D programmes** related to shipbuilding and marine[24]. Strong proportion of GERD contributed by BERD highly emphasised on **experimental research**[25]. Industry leading players establish inhouse research institutes and academies for research in emerging areas (e.g., autonomous ships). Public policies assisting in attracting talents into maritime industries through hiring and training incentives, flexible working visas, and insurance payments[26]. Early introduction to maritime industry through **elective high school curricula**[27]. Marine Bio Bank database housing 7,600 ocean-derived biomaterials run by National Marine Biodiversity Institute of Korea.

Integrity

Strong investment and push for **digital government** through use of digital systems for public services (e.g., GICOMS - open data on maritime security and ship data, MEIS – marine environment information)[28] as well as designing **legal framework** for emerging areas of development (e.g., autonomous ships, smart ports). Policies and initiatives with clear measurable targets, ministries in charge and future trajectories. Inclusion of sustainability targets for maritime industries such as data on key fish stock levels, standards and regulations to combat air pollutions at ports[31].

Figure 55 The 8i Ecosystem Analysis of the South Korean Blue Economy[1]

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5.2.3 Quick wins and long-term programme

Two stakeholder engagements have identified intervention strategies, quick wins, and long-term strategies to strengthen the Blue Economy ecosystems. The summary below highlights the key intervention strategies highlighted by most blue economic sectors, while sector-specific suggestions are listed in Table 22. From these findings, the recommendations are presented in the next section of the report.

Key Intervention Strategies

- **Whole-of-society/Whole-of-nation** approach.
- Establishing the national level advisory council/commission under the Prime Minister's department to act as a **coordinating body** for national ocean policies.
- **Independent collaborative platform** to facilitate smart partnerships between stakeholders for effective cooperation and collaboration (e.g., citizen participation).
- Promote research, innovation, and adoption of frontier/emerging technologies through integration of the **8R-NCBE philosophy, 10-10 *My*STIE Framework**, and extension of 4IR policy to cover maritime industries.
- Improving talent development through academia (i.e., MOE, HIL, TVET) and industry co-created education, training, and career pathways that embed STI, entrepreneurial, and experiential learning.
- Improving **CEPA** for marine awareness that is aligned to the 8R-NCBE philosophy.
- Strong fiscal and non-fiscal government support to provide the foundation and incentives for private investment, research, innovation, and talent development.
- Cross-cutting, comprehensive, and cohesive **national ocean policy** that integrates marine spatial planning.
- Policy implementation mechanisms and **accountability** measures (i.e., measurable targets, public-access progress reports) that leverage **digital systems for governance.**
- Strict enforcement of laws and regulations and implementation of the "**polluter pays principle**".
- Establish a **national data repository** and **open-data policies** to create a data-sharing culture and facilitate data-driven solutions.
- Reviewal system for maritime legislation and regulations to harmonise laws between State and Federal, and to create a supportive legal framework for emerging subsectors.

Table 22 Sector Intervention strategies, quick wins and long-term goals

Sector	Intervention Strategies	Quick Wins	Long-term Goals
Fisheries and aquaculture	• Improving local aquaculture/fishery efficiency by intensifying R&D for seeds, fish nutrition, and fish health, establishing a disease-resistant broodstock domestication programme, and incentivizing increased technology adoption. • Establishing internationally recognised and compliant Sustainable Fisheries Standards for Malaysia, and incentives/advisory to encourage farmer application. • Integrating food security to national nutrition and environmental conservation objectives. • Conducting scientific assessments into determining trends (market, fish production, fishing pressure, stocks) to improve species diversity.	• Sustainable Fisheries Standards for Malaysia that meet international standards and are globally recognised. • Encourage farmers to adopt Recirculating Aquaculture Systems (RAS). • Stricter enforcement to combat illegal imports, practices, fraud, and pollution. • Leverage existing institutions to establish a strategic alliance between industry, academia, and government (e.g., SEAFDEC, World Fish). • Financial support for targeted research and farmer/fishery adoption of emerging technologies and upscaling.	• Predictive modelling for climate and weather effects on species stock management. • Integrating blockchain for fraud prevention.
Coastal and marine tourism	• Investigation and adoption of virtual or hybrid tourism to supplement physical tourism. • Improve promotion and marketing of coastal and marine attractions. • Enhance nature tourism awareness and education by leveraging grassroots knowledge and expertise. • Payment for ecosystem services to encourage coastal and marine clean-up. • Increase the number of marine protected areas.	• Promoting local underwater and coastal attractions. • CEPA through citizen science programmes and collaboration with local/indigenous groups to facilitate marine ecotourism. • Blue financing for ecosystem services. • Promote and market coastal and marine attractions (e.g., Biorock, Reefball). • Increased monitoring of marine protected areas. • Improving high-speed internet coverage and stability in coastal areas.	• Virtual/hybrid tourism. • Marine ecotourism. • Automated marine patrol boats to guard marine protected areas.
Extractive industries,	• Effective industry-academia collaboration to improve market demand for marine minerals. • Review, amend, and harmonise legislation and regulations for offshore mineral mining.	• Intensify research into deep-sea mineral extraction, potential offshore deposits, and reserves.	• Exploration and implementation of carbon sequestration for alternative hydrocarbon resources.

Including desalination	• Intensify research into cost-efficient desalination and upcycling of brine effluent.	• Industry-linked sabbaticals via ISA (e.g., endowment fund training programmes).	• Conversion of abandoned offshore installations as a research platform for deep-sea mineral extraction. • Mature deep seabed mining industry to support E&E industry. • Coastal desalination treatment plants.
Maritime transport and shipbuilding	• Harmonisation of government portfolios, laws, and regulations about maritime transport, security, and foreign relations. • Centralised data system for the coordination of maritime transport (i.e., national single window). • Smart partnerships for end-to-end and holistic services (e.g., finance, insurance).	• National single window/ Centralised data system for maritime transport. • Smart partnerships for end-to-end/holistic services (e.g., finance, insurance).	• E-Navigation system for vessel scheduling.
Renewable energy	• Greater government fiscal and non-fiscal support for renewable energy research, plants, supporting energy grid, and usage by maritime and non-maritime sectors (e.g., electric vehicles). • Intensify research to improve the cost-efficiency of renewable energy.	• Communications/ Outreach plan on Ocean-based REs and Blue Ocean Economy to the various stakeholders to improve awareness and understanding • Collective vision on introducing ocean-based REs into the energy mix based on inputs from the government, academia, industry, and civil societies • Communication platform to facilitate collaboration between all the key players.	• Increased renewable energy mix through hybrid ocean thermal energy conversion, and wave/tidal energy harvesting.
Waste disposal management	• Addressing supply chain gaps in waste disposal management (e.g., collection and delivery to the facility). • Social enterprises to promote sustainable and integrated management (e.g., The Ocean Cleanup). • CEPA through citizen science and community outreach programmes that are aligned to the 8R-NCBE philosophy. • Fiscal and non-fiscal incentives such as grants and green discounts to encourage industry investment for a circular economy (e.g., waste minimization, recycling, upcycling).	• Implement and enforce the "polluter pay principle" and separation at source. • Adoption of Act 672 (solid waste and public cleansing nationwide). • Collaboration with stakeholders (public, private, NGOs) for CEPA (e.g., citizen science programmes) and tackle marine waste management (e.g., The Ocean Cleanup).	• Central body to oversee ocean and marine ecosystem health (e.g., previously National Oceanography Directorate) and to address sustainable waste management. • Cess fund and compulsory contribution by all industries for waste disposal R&D. • Local councils are held accountable for coastal management, source pollution, and clean-up within their respective jurisdictions. • Increasing waste recycling and upcycling facilities.

Marine biotechnology and bioprospecting	• Establishing a National Marine Biotechnology Institute to coordinate talent development and capacity building, identification of niche areas, advisory on national ocean policies, support regional and international collaborations (e.g. joint venture), sustainable research funding, etc. • Marketing and promoting strategies on marine biotechnology products to improve local, regional, and global recognition of indigenous products, services, and SMEs.	• Establishing a National Marine Biotechnology Institute. • Improve marketing and promotion of marine bioproducts to local and foreign markets.	• Deep-sea bioprospecting for new marine bioproducts. • Lead in marine-based pharmaceutics, industry polymers, cosmeceuticals, and nutraceuticals. • Establish marine biotechnology-based aquaculture and drug discovery industry.

5.3 Recommendations

To create an optimal path to achieve a sustainable Blue Economy, the gaps identified in the 8i Blue Economy ecosystem in the aforementioned chapters need to be addressed. This position paper proposes three key recommendations as suggested below, based on the gaps identified in the Blue Economy ecosystem.

Recommendation 1: Government to formulate a National Ocean Policy and Ministry of Science, Technology & Innovation (MOSTI) in collaboration with relevant ministries and central agencies to formulate a Blue Economy Policy based on science, technology, innovation and economy (STIE) to strengthen governance and provide direction for Blue Economy in Malaysia towards an integrated, effective and sustainable ecosystem by unravelling the potential of this sector.

Malaysia has yet to launch an Ocean Policy, while regional competitors have had one in place since 2017 (Indonesia). The National Ocean Policy should recommend the establishment of an independent commission to oversee the Blue Economy ecosystem. The Blue Economy ecosystem management should be strengthened and transformed through a cohesive national effort, that is, through a Whole-of-Society and Whole-of-Nation approach to address the current fragmentation and to optimise plans, initiatives, and distribution of resources. This requires seamless planning and coordination of the Blue Economy ecosystem by the government and the industry. Further, involving society in decision-making will foster collaboration and enhance the process of engagement and subsequent buy-in from the people. With that goal in mind, a champion is needed at the national level for the Blue Economy to be fully realised for Malaysia and our natural resources optimised for competitiveness and sustainability.

MOSTI as a leading ministry in ensuring a robust STIE ecosystem is proposed to spearhead the Blue Economy, particularly in the research, development, innovation, commercialisation, and economy (RDICE) context. This would forge relevant synergy and STI-based action toward socio-economic advancement and environmental sustainability. This would also serve as continuity for MOSTI, who previously helmed the National Oceanography Directorate (NOD) in November 2000, intending to develop the national oceanographic and marine science R&D policy and agenda. At least ten marine and oceanographic research centres established at various universities in Malaysia were recognised as Centres of Excellence (COE) under the NOD. Of these, the Institute of Oceanographic Studies (INOS), Universiti Malaysia Terengganu (UMT), and the Institute of Ocean and Earth Sciences (IOES), Universiti Malaya (UM), became the Higher Institution Centre of Excellence (HICoE), in the Ministry of Education. The NOD commissioned and launched the Malaysian National Oceanographic Data Centre (MyNODC) in 2010. In 2014, the second phase, MYDAS — "An Integrated Malaysian Oceanographic Data and Information Management System for Ocean Modelling and Forecasting" were initiated. Up till 2016, the NOD was Malaysia's voice in the Intergovernmental Oceanographic Commission (IOC) under the auspices of UNESCO, Coral Triangle Initiative (CTI), Regional Working Group on Tsunami Warning and Mitigation in the South China Sea Region of ICG/PTWS, Intergovernmental Panel on Harmful Algae Bloom (IPHAB), serving as the Chair. After 2016, the NOD was replaced by a unit under the Technology, Strategic, and Application of S&T (TSA) in MOSTI. In 2018, oceanographic and marine science affairs were placed under the Unit on Sustainable Ocean Management Unit in MESTECC. The current MOSTI is the agency most closely associated with oceanography, and hence the Blue Economy, due to its historical involvement.

Recommendation 2: To drive the eight strategic sectors of Blue Economy in Malaysia to align with 8R-Nature-centric Blue Economy (8R-NCBE) philosophy towards value creation, socio-economic growth, and to be embedded in the National Planetary Health Action Plan.

To enable the transformation of the Blue Economy ecosystem from the current weak and fragmented ecosystem to a vibrant and dynamic economic sector, there is a need for the sector to adopt an integrated 10-10 *My*STIE Framework, 8R-NCBE philosophy, and 8i ecosystem approach. This integrated approach provides the necessary conditions to develop and drive innovations and processes for a vibrant and sustainable ocean and coastal environment. All of which will create a blue ocean RDICE ecosystem that will enhance nature-based solutions, thus creating higher return on value (ROV) and return on investment (ROI) from the nation's ocean and marine resources.

A key feature for transforming the Blue Economy sector into a sustainable contributor to the Malaysian economy is communication and education to all stakeholders. Communication and education are critical to raising greater awareness among the people on the value of ocean and marine environment that will help to boost the socio-economic growth. Though public awareness and concern about the ocean and coastal environment are growing, there is still much to be done to intensify greater awareness, appreciation, and affinity towards ensuring the oceans are free from contamination, pollution, and preservation of marine diversity. Effective communication is still a challenge, and it is proposed that a wide range of capacity building through Communication, Education, and Public Awareness (CEPA) programmes that are focused on the 8R-NCBE philosophy be conducted to address the lack of knowledge and understanding of the Blue Economy among the people.

Given that Malaysia shares the oceans with other countries in the region, there needs to be concerted effort to work closely with neighbouring countries to manage marine resources for effective conservation and sustainable development of the ocean and coastal environment Malaysia should collaborate with regional neighbours for an ASEAN-wide Blue Economy Platform. This is to address maritime-related issues to gain a better ROV through the sharing of resources, knowledge, and know-how in the ASEAN region. A united front would allow Malaysia to better address regional challenges associated with a shared resource (i.e., the ocean) and form effective collaborations towards addressing the following: marine litter; algal blooms associated with anthropogenic effluent; developing knowledge-sharing platforms or networks for combined research efforts towards frontier technologies; deep-sea exploration; establishing a regional data repository; and joint effort towards protecting ASEAN waters against encroachment.

Recommendation 3: To establish the RDICE Matching Fund Scheme for Blue Financing towards enhancing public and private participation in empowering Blue Economy.

Strengthen collaboration between key stakeholders by incentivising through a blue financing mechanism to encourage and foster public-private partnerships in ocean and coastal development programmes. To enhance the efficacy of public-private partnerships, there is need to involve civil society, community groups, and NGOs to oversee the implementation of projects and ocean-related conservation activities.

When financing activities related to the Blue Economy, the 8R-NCBE philosophy should be applied to ensure incentives are only allocated to projects that mitigate risks associated with climate change, minimise carbon footprint, and ensure sustainable ocean and coastal development.

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APPENDIX
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APPENDIX

Group 1: Fisheries and Aquaculture Gaps – 8i Ecosystem Analysis

Internationalisation

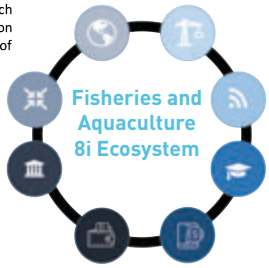
Weak international cooperation for two-way knowledge and technology transfer for indigeneous SMEs to move up the global value chain. Coupled by low adoption of emerging technologies, and low adherence to global best practices, local SMEs struggle with playing catch up to compete with price-competitive neighbours and global leaders in fishing and aquaculture (e.g., China, Indonesia, Norway).

Interaction

Weak collaboration between stakeholders (institutions, NGOs, farmers). Disconnect and poor information exchange between government, research institutions and industry. However, taking small steps in the right direction (e.g., MoU on Geospatial Data Sharing between JUPEM and DoF). Lack of knowledge sharing culture within the sector.

Institutions

Lack of a strong 'Champion' that can lead the transformation of the industry into a technology- and knowledge-intensive sector. Sufficient foundation of legislation, policies, and institutions (e.g., DoF, LIKIM, NGOs) but lacking cohesion and long-term vision. Lack of champion for ESG, being primarily driven by DoE. Lack of direction in incorporating/leading ESG in the industry resulting in an industry that is predominantly focused on economic growth that leads to unsustainable culturing of homogenous species, lack of climate change in management and decision making, and uncoordinated fisheries and farms in species prioritisation.



Incentives

Available research funding insufficient, leading to IPs that cannot attract industry interest and market populated with uncompetitive/low-quality products. Difficulty scaling up/ adopting newer technologies due to high electricity tariffs (up to 30-40% of direct costs). Strong competition from neighbouring countries outpricing local products (e.g., Thailand, Indonesia). Subsidies are promoting unsustainable fisheries. Lack of fiscal and non-fiscal incentives that promote technology adoption.

Infrastructure

Use of legacy technologies (30-40 years behind) that are still environmentally destructive and difficult for native licensed fisherman to compete with hobbyist equipped with more advanced gear. Lacking supporting infrastructure poses barriers for upscaling such as wastewater treatment for aquaculture waste, efficient post-harvesting processing, etc.

Infostructure

Low level use of digital technologies and data collection and analytics. Weak supporting digital infrastructure to promote use of emerging technologies such as IoT, cloud computing, etc.

Intellectual Capital

Negative perception of fishery and aquaculture, poor remuneration, and tough working conditions make it difficult for the industry to attract and retain talents. This subsequently causes the industry to subsists on foreign labour that can operate on lower wages and legacy technology, thus continuing the negative cycle. Education on sustainability and environmental impact awareness for farmers weak (only limited to those with MYGAP certification). Poor stock management contributed by lack of scientific assessment on local fish stocks.

Integrity

Regulatory architecture and enforcement within the fishing and aquaculture is fragmented and weak. Weak enforcement by authorities to limit/stem off illegal imports and contrabands. Lacking measures to ensure institutional accountability for policy and initiative implementation. Resulting lack of trust between stakeholders and in the institutions. Current legislation, enactments, and ordinances are not contemporary that aligned to a technology & knowledge-intensive fishing industry. Weak governance systems has led to rent-seeking behaviour in the sector.

Group 1: Fisheries and Aquaculture Way Forward – 8i Ecosystem Analysis

Internationalisation

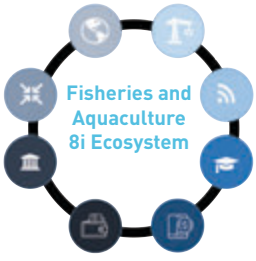
Local certifications and standards on par with international requirements for competitive local products and globalisation of indigeneous SMEs (e.g., Sustainable Fisheries Standards for Malaysia, Good Aquaculture Practice Certification). Encourage local innovation and technology transfer by facilitating strategic global partnerships between public, private and academia through MoUs (e.g., MADA and III Taiwan) and joint research programmes (e.g., German-Thai Funding Programme, UK-Thai Research and Innovation Fund).

Interaction

Creating strategic alliances between farmers, entrepreneurs, academia and government, as well as strengthening and encouraging effective collaboration on research, policy decisions, education programmes, etc. (e.g., National Roundtable Discussions, citizen participation, Joint Research Programmes). Leveraging on existing institutions (e.g., SEAFDEC and World Fish) as platforms to link and expedite partnerships and collaborations with fishery and aquaculture industry.

Institutions

A whole-of-government/ whole-of-society approach through high level coordination between government institutions, academia, industry, and society facilitated by a coordinating body (e.g., national level advisory council, commission). Holistic policy making approach that is cross-cuts sectors and incorporates ESG/SDGs for sustainable capture fisheries and aquaculture development (e.g., balancing growth and planetary health, diversified culture species, prevent fish stock exploitation). Strengthen the role of NGOs and farmers on the ground through bottom-up management, citizen participation approach, and as ESG role models.



Incentives

Fiscal and non-fiscal incentives to promote technology adoption, collaborative research/innovation, and stimulate market demand for locally sourced produce/technologies, such as funding and grants for joint research, uptake of emerging technologies such as blockchain traceability, recirculating aquaculture systems to improve yield, and electricity tariff subsidies. Collaboration with industry to improve remuneration and job opportunities to attract and retain local and foreign talent. Introduce profit sharing mechanisms and incentivise knowledge sharing/participation in aquaculture projects.

Infrastructure

Create supporting infrastructure such as local processing plants and aquaculture wastewater treatment systems. Utilisation of AI, automation and other emerging technologies to reduce labour intensive process and improve efficiency.

Infostructure

Strengthen data collection, harmonisation and sharing between government agencies, as well as promote open-access data for data-driven innovations. Uptake/Adoption of frontier or emerging technologies for fisheries and aquaculture (e.g., IoT farms, automated fishing vessels, predictive models for multispecies, weather, and natural disasters). Integrating ESG into the supply chain through utilisation of blockchain for seafood traceability, certification, etc.

Intellectual Capital

Intensifying research and commercialisation on emerging technologies, seed, nutrition, genetics/breeding for resiliant species (i.e., climate change, disease), efficient alternate cropping/heterogeneous farming, etc. Developing future-proof farmers by collaborating with industry to co-create attractive career pathways, hands-on/experiential contemporary education programmes, and dedicated training centres. Educational curriculum and training programs (University and TVET education) need to incorporate 10-10MYSTIE framework to modernise fisheries and aquacultures.

Integrity

Review existing legislation, enactments, and ordinances to ensure laws remain contemporary of current technologies and trends. Setting clear KPIs as well as economic and environmental targets for government institutions aligned to national sustainability goals. Institutions are to be held accountable for set targets and KPIs to improve stakeholder trust. Effective enforcement of environmental management and protection of local businesses from contraband and food safety risks (e.g., anti-dumping policy, food safety and illegal import checks for imported products).

Group 2: Coastal and Maritime Tourism Gaps – 8i Ecosystem Analysis

Internationalisation

Lack of global competitiveness in creating truly unique experiences (only in Malaysia) and high-value segments demanded by foreign visitors due to reliance on already created technologies and ideas[6].

Interaction

Poor communication between institutions and industry impacting policies that affect a broad range of stakeholders (e.g., grassroots level). Lack coordination between tourism and related sectors (e.g., transport, hospitality, etc.) creating disjoints in travel experience, environmental protection, moving up the global value chain.

Insitutions

Systemic issues associated with weak political stability, lack of long-term vision, poor policy implementation, and poor alignment of related national policies. Poor governance structure leading to overlaps in jurisdiction between agencies (in addition to poor clarity in defining state and federal lines) and weak systematic management with long-term monitoring (i.e., segmented management body and marine resources management). Public agencies working in silos lacking strategic and effective communication/collaboration. Ineffective management of marine protected areas to control over-extraction of resources and safeguard industry against climate change.

Incentives

Lack of support, incentives and financing mechanisms for tourism sector players looking to investing into emerging technologies and sustainability (e.g., circular economy). Lack of matching grants schemes to encourage private-academia collaboration for technology and science-driven solutions.

Infrastructure

Low adoption of emerging technologies by industry and tourism facilities, with a majority of marine tourism sector relying on legacy technologies. Weak supporting waste management infrastructure for communities living close to water sources leading to water pollution caused by littered waste floating towards ocean[1,2]. Weak supporting infrastructure to protect coastal tourism zones from weather effects (e.g., monsoon, climate change, coastal erosion), creating periods of inactivity caused by damage, infrastructure restoration, and halting of services due to weather[3,4,5].

Infostructure

Weak supporting digital infrastructure enablers (i.e., high-speed internet, 5G network coverage). Weak marine monitoring systems and low utilisation of digital technologies resulting in weak/lack of marine environmental monitoring systems. Weak data collection and sharing resulting in lack of data-driven digital solutions (creation and adoption) within the marine tourism sector.

Intellectual Capital

Weak quadruple helix attributed to academia research done in silo, low public-private collaboration, and low resource support for R&D. Insufficient labour force due to weak labour retention, high turnover rate, talent deficit (e.g., graduates leaving for different field), and poor career opportunities. Superficial market intelligence and weak designers of new experiences (sector lacking innovative capabilities).

Integrity

Weak monitoring of stakeholders (e.g., agencies, industry, grant rewardees) leading to weak outcomes and poor policy implementation. Insufficient monitoring and enforcement for protection of protected marine areas and species leading to loss of biodiversity and impacting tourism services (e.g., turtle watching). Threat of polluted tourist zones due to weak enforcement of environmental protection laws on other maritime/non-maritime industries. Weak legal framework for marine tourism sector due to lack of descriptive laws/regulations and non-exhaustive laws.

Group 2: Coastal and Maritime Tourism Way Forward – 8i Ecosystem Analysis

Internationalisation

Promoting Malaysia as a sustainable tourist destination that champions green tourism through international-level conservation (e.g., Ramsar site, Geopark) and champion Malaysia's oceans as 'blue lungs'. Trend scanning of international market demands (e.g., sustainability, environmental protection, climate change) to adapt local sectors to global trends. Improving international knowledge absorption of local industries and talents. Creating internationally recognised certification and accreditation programmes to improve local sector competitivity, as well as integration of Halal standards with ESG/SDGs to create market Malaysia as a sustainable Halal tourist destination.

Interaction

A whole-of-society approach by formalising public-private-society independent collaborative platforms (e.g., CREST) for policy design and decisions, research, innovation, awareness programmes, and sector investment. Public-driven public-private partnerships for environmental R&D, green tourism technologies, and strategies to improve attractiveness of local services and products. Increase participation of grassroot level in ecotourism activities.

Institutions

Ensuring long-term growth and sustainability of sector through long-term vision, comprehensive and cohesive national plans incorporating ESG/SDGs and green technologies, and climate change preparedness. Establish a coordinating body/agency for policy making, implementation, and review for maritime related industries inclusive of tourism sector to ensure goals across sectors/stakeholders are met. Empowering NGOs, industry organisations, citizen (e.g., Reef Guardian SIMCA – Sugud Islands Marine Conservation Area).

Incentives

Leverage on existing incentives (e.g., Special Tourism Investment Zone, hospitality projects, green initiatives, PIC MIDA, MyHIJAU scheme green incentives and tax exemption) and improve grant schemes incentivising public-academia-industry collaboration, international knowledge transfer (e.g., MOHE supporting fundamental maritime research). Start blue finance mechanism to enhance community engagement and formulate payment for ecosystem services. Extending the Industry4WRD policy to industries beyond manufacturing – inclusion of tourism industry for Tourism 4.0 and incentive schemes for research and adoption of emerging technologies.

Infrastructure

Improve supporting waste management infrastructure for communities living near water bodies and systems (e.g., lakes, rivers, coast) and increased deployment of automated river cleaning technologies (e.g., Ocean Cleanup) to intercept waste ending up in oceans. Adoption of emerging technologies to power green tourism industry. For instance, green cruise lines powered by renewable energy using solar sails, energy efficient systems (e.g., Ecoship)[1] or coastal renewable energy plants for green facilities and ships.

Infostructure

Nationwide deployment of 5G network and high-speed internet as well as improved data collection and sharing to enable emerging technologies such as digital twins to visualise tourist/citizen response to service changes, augmented reality for ocean/reef tours, and advanced climate models to predict monsoon impacts for early contingency[2,3,4]. Virtual reality services to supplement during downtimes caused by yearly weather or global events (e.g., monsoon, pandemic) and to protect conservation sites from damage caused by increased tourist traffic. Partnership with coastal tourist sites and ocean vessels (e.g., cruise ships) for collection of ocean and climate data in real time using sensors.

Intellectual Capital

Academia-industry collaboration to improve environmental knowledge of industry (e.g., tour guides, ground staff, SMEs, corporations) and for industry-relevant Smart Tourism/Tourism 4.0 technologies. Improving talent retention by providing attractive career pathways, opportunities and benefits for industry workforce; co-designing education (e.g., tertiary, TVET) for industry-relevant experience and vertical opportunities for career and further education; multidisciplinary education that incorporates resource management, coastal conservation, and sustainabiltiy; and micro-credentials and stackable units. Leverage on existing research institutions or ecotourist spots for eco-edu-tourism; training programmes focused on environmental awareness, protection, and sustainability; and citizen science programmes to improve youth involvement in awareness programmes. Improved environmental protection and research to enhance endangered species protection and spillover effect into tourism industry (e.g., taxonomy, DNA sequencing studies).

Integrity

Improve enforcement of rules, regulations, and guidelines to ensure sustainable industry with proper monitoring of marine protected areas and outcomes tied to grant schemes and incentives. Create business-friendly policies and regulations with clear guidelines to increase private participation and ease of transition into green practices. Ensure local certifications, accreditation, and training are internationally recognised through adoption of international best practices and collaboration with internationally recognised bodies/certification. Integration of ESG/SDG standards for maritime related activities (e.g., mining, transport) with clear and strict guidelines and enforcement to prevent pollution and environmental degradation of prime tourist zones and marine protected areas.

Group 3: Extractive Industries of Non-Living Ocean Resources Including Desalination for Freshwater Generation Gaps – 8i Ecosystem Analysis

Internationalisation

Oil and gas industry remains globally competitive but slow to shift towards sustainability trends and susceptible to changing market demands. Current local technology, knowledge capability and legal framework create barriers for offshore mineral extraction expansion, with, local industry unable to compete or enter the global supply chain.

Interaction

Weak collaboration between stakeholders such as conflict between State and Federal jurisdiction and weak knowledge sharing between industry big players with SMEs (i.e., territorial with market share and MNCs conducting research in home country).

Institutions

Lack of coordination between agencies and poor governance structure. Strong institutional support for select extractive industries (e.g., O&G and inland mining), with weak support for other subsectors including offshore mineral mining. Lack of national plans for transitioning of extractive industries to greener practices and alternatives to match changing consumer and market trends caused by rising climate change concerns.

Incentives

Insufficient fiscal and non-fiscal incentives to encourage industry adoption and maintenance of more advanced technologies. Weak financing mechanisms to support research and innovation into offshore mineral mining, carbon capture, and green mining technologies.

Infrastructure

Maturity in infrastructure limited to O&G subsectors, while it remains nascent for other subsectors such as deep-sea mining, desalination, etc. Legacy technology predominant for these sectors and creates barrier for deep-sea mining. Lack of desalination facilities, placing pressure on surface water resources to to provide for majority of water consumption.

Infostructure

Current data availability and collection for offshore mining (particularly deep-sea) is limited coupled by low level use of digital technologies and data analytics. Weak supporting digital infrastructure for high-speed offshore connectivity for adoption of IoT solutions.

Intellectual Capital

Talent deficit experienced by industry due to negative perception of industry creates difficulty attracting and retaining talent, aging workforce, and O&G tied to climate change. This is coupled by imbalance in expertise that is mostly concentrated at Federal level. There is weak public awareness regarding the industry which extends beyond O&G (e.g., offshore minerals, deep seabed mining, etc.) Although there is ongoing research into offshore sand and mineral resources (i.e., mapping of Kelantan, Terengganu and Sabah by 2030, and research, development and commercialisation initiative by Mineral Research Centre to commence 2021), current research efforts into resources apart from petroleum is limited, siloed, misaligned to industry needs, and is being poorly conveyed.

Integrity

Strong legislative support limited to O&G (primarily petroleum) and weak for other subsectors such as offshore mining (i.e., under state jurisdiction within 3 nautical miles only). There are differences between State and Federal regulations, making it difficult for stakeholders to collaborate and conduct interstate business. Weak enforcement (e.g., sand mining and exports) and lack of KPIs and national plans that encompasse extractive industries and its transition towards greener production.

Group 3: Extractive Industries of Non-Living Ocean Resources Including Desalination for Freshwater Generation Way Forward – 8i Ecosystem Analysis

Internationalisation

Ensure local industries meet sustainable mining best practices and standards (UNSDGs, Australian and Indonesian Offshore Mining Acts for benchmarks; comply with UNCLOS, ISA Mining Code, IMO Regulations for deep-sea mining). Instruments to support SME penetration into global supply chain. Create strategic linkages between local and international research institutions to develop contextualised technologies and processes for offshore extraction.

Interaction

Strengthen State-Federal cooperation and set up a national council with multistakeholder committee (public, private, academia, NGOs and society) to advise on policy decisions and national trajectory for marine-related industries. Programmes/platforms linking larger corporation with SMEs for knowledge sharing (win-win collaborations that leverage on large company resources and agile innovative SMEs). Leverage on existing institutions to create collaborative linkages between academia and industry (e.g., Mineral Research Centre, Malaysian Technology Development Corporation) for research through multidisciplinary working groups.

Institutions

Whole-of-government / Whole-of-society approach through establishing special committee for deep-sea mining consisting of government, industry experts, academia, environmental protection organisations and society to ensure policy decisions are comprehensive, science-driven and holistic. Improve structural governance and coordination between agencies (e.g., National Water Resources Council, National Physical Planning Council) for better marine spatial planning. Long-term national plans that ensure SDGs/ESGs targets and trends are included for marine-related industries and aligned with other sector sustainability plans/goals.

Incentives

Fiscal and non-fiscal incentives to improve development and adoption rate of local offshore mining technologies (e.g., financial assistance, matching grants, advisory assistance). Incentivise adoption of ESGs and transitioning of industry to green processes/technologies by providing competitive fiscal incentives (e.g., green tax exemption). Strong public funding into fundamental research that is industry relevant to promote local uptake and commercialisation rates.

Infrastructure

Create supporting infrastructure for offshore mining and desalination that utilise innovative technologies for recycling/repurposing mining by-products (e.g., desalination brine effluent recovery). Integration of carbon capture and sequestration facilities to offset emissions generated by non-RE subsectors. Repurposing decommissioned/abandoned offshore facilities for off-grid deep-sea research stations focused on deep-sea mining research (i.e., integrated with RE energy production, desalination and wastewater treatment plant). Utilisation of emerging technologies for deep-sea exploration and research (e.g., drones, sensors, artificial intelligence).

Infostructure

Data repository of oceanic data by strengthening data collection, harmonisation and sharing between stakeholders for data-driven solutions. Utilisation of IoT, sensors, and artificial intelligence for unmanned deep-sea explorations and mining operations. Improving digital infrastructure for offshore network connectivity (e.g., narrowband) to ease adoption of digital technologies that leverage on cloud-computing, remote monitoring, automation, etc.

Intellectual Capital

Awareness programmes to improve public awareness on extractive industries (e.g., CEPA). Knowledge sharing between more matured inland extraction players and offshore players, and greater linkages between academia and industry to improve industry-relevance of current research. Deep-sea mining still in its infancy in Malaysia. This will require additional research into impact assessments (potential marine harm) and sustainable technologies for deep-sea mining to prevent any negative knock-on effects (e.g., fisheries, tourism). Co-developing education programmes and career pathways that offer opportunities for further education, career development, leverage on advanced technologies, and are aligned to current sustainability values to attract talents and improve career/talent pool sustainability.

Integrity

Harmonising Federal and State laws and establish legal framework for other extractive industries (offshore, deep seabed mining, etc.) within and beyond local waters (i.e., Federal, UNCLOS). Comprehensive national initiative/plan for blue economy and inclusion of extractive industries in broader national plans that coordinate across sectors and meet sustainability targets. Adoption of digital technologies to improve enforcement and monitoring of public and private sustainability targets (e.g., blockchain certification, egovernment services, open-access public data and records).

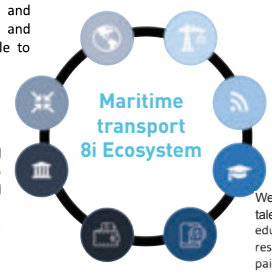
Group 4: Maritime transport, ports and related services Gaps – 8i Ecosystem Analysis

Internationalisation

Local shipbuilding and ship repairing (SBSR) overly dependent on O&G exports, making the industry susceptible to price fluctuations, market demand, and global transition to sustainable fuel sources. Additionally, local shipbuilders are outcompeted by more cost-competitive countries (e.g., China). **Compounding issues with legacy infrastructure and technologies, weak effective collaboration and supporting legal and institutional framework has led to Malaysia losing in market share against strong regional players (e.g., Singapore, South Korea, Hong Kong and China).**

Interaction

Poor public-private partnerships for maritime research and commercialisation leading to lack of locally produced ship parts and machinery. Current services are stakeholder specific and are unable to provide complete supply chain solutions (e.g., finance, insurance, etc.)



Institutions

Institutions working in silos further exacerbated by disjointed and overlapping jurisdictions. This poor coordination cascades down to stakeholders on the ground which affects port planning and management (i.e., ports working independently rather than collaboratively). There is also a lack of a coherent and comprehensive ocean policy that encompasses maritime transport as well as other maritime industries.

Incentives

Implementation of ESG laws and regulations are costly, thus disincentivising industry investment due to required high initial capital. Weak incentives and legal instruments to encourage use of locally repaired or built ships due to greater cost-competitivity of foreign products.

Infrastructure

Mature infrastructure and technology adoption at major ports, but limited at smaller ports. However, even at major ports, advanced technology adoption, machinery and facilities are limited in availability. Reliance on legacy infrastructure and technologies provide limited support for equipment breakdown, poor vessel/voyage performance, and insufficient port systems resulting in economic loss.

Infostructure

E-navigation is currently being explored in Tanjung Pelepas and Port Klang. However, these technologies are limited to major hubs. There is limited data availability and sharing in real time between stakeholders, thereby creating inefficiencies in planning, procedures and vessel space utilization[1]. Open data on maritime industry, cargo handling and so on are provided by DOSM, but level of granularity insufficient. Lack of collection and sharing of ocean and coastal data and environmental monitoring system. Lacking digital infrastructure enablers (high-speed internet, 5G network) and data availability create barriers for data-driven solutions (e.g., advanced climate models, IoT ports).

Intellectual Capital

Weak ability to attract and retain talent due to inssuficient job opportunities and talent seeking better prospects abroad. This is also compounded by limited further education opportunities focused on port management and operations. Good research being conducted on the ground by local universities (e.g., UTM-Jotun for paint with anti-biofouling tech; MIMA policy papers, studying Straits; UMT-UTM ballast water treatment system; UTM-Johor Port Authority air emission management system). However, there is difficulty getting industry buy-in and commercialising.

Integrity

Plans lack have clear and measurable hard targets (e.g., MSMP 2017-2020). Additionally, these targets are seldom reviewed or communicated clearly to stakeholders. Lack clear policy targets for ESG and the transition of maritime transport related industries towards green maritime logistics. Weak enforcement of environmental protection (e.g., pollution by other maritime industries) and against international encroachment of national waters. Weak use of digital systems for governance to plan and implement policies and strategies across jurisdiction.

Group 4: Maritime transport, ports and related services Way Forward – 8i Ecosystem Analysis

Internationalisation

Regional hub for green maritime logistics – leverage on alternative/substitute products and services to meet sustainability goals or market trends (e.g., e-commerce, biofuel, hydrogen); as well as regional ship recycling hub. Greater collaboration between regional countries with sharing of ASEAN international waters. Improve legal framework and incentivises to entice materials manufacturers to relocate to /establish within Malaysia to reduce cost of and improve price competitiveness of local shipbuilding services .

Interaction

Public-driven public-private collaboration for maritime/green maritime research and commercialisation (e.g., Singapore MPA and industry collaboration to fund decarbonisation centre and R&D). Encourage collaboration between stakeholder in sharing of resources (e.g., multiple shipyards for single ship). Improve local service competitiveness by offering comprehensive end-to-end services through cross-sectoral partnerships (e.g., finance, insurance, other professional services).

Institutions

Establish a coordinating body for the maritime industry for the implementation, coordination of stakeholders, and follow throw of policy implementation (i.e., achieve set targets and KPIs, hold stakeholders accountable). Comprehensive maritime policy for sustainable development by including/considering the intertwined relationship of all maritime industries (including transport) and in the design of related sector/national plans for sustainable development.

Incentives

Improve incentives for technology adoption, investment, and research through fiscal/non-fiscal incentives, business friendly policies, supporting infrastructure, grants, etc. Profit sharing mechanisms between charterer and vessel owners for cost-savings derived from retrofitting ships with advanced technologies[1]. Business friendly legislation and regulations to improve local business competitivity by encouraging locally sourced vessels and services (e.g., UK and Australia procurement reformation, Indonesia cabotage policy promoting local fleet services).

Infrastructure

Creating/Optimising infrastructure that considers multiple sector requirements, future trends and growth, and hinterland services. Physical and digital infrastructure to support adoption of emerging technologies leveraging on sensors, digitalisation, automation, data collection, etc. Provide supporting infrastructure for transition towards green shipping/transport such as biofuel supply stations, offshore renewable energy plants (e.g., wind, wave, desalination for hydrogen fuel generation).

Infostructure

Highspeed/5G connectivity to enable the use of emerging technologies (e-navigation, IoT, cloud-based services, big data) for seamless data exchange, integration of ocean, weather and ship data for route planning, and smart ships. Central database or nodes to facilitate data exchange for more efficient route and cargo planning.

Intellectual Capital

Academia-private co-designing of education and matching to industry needs. High tech industry requires more qualified talents, demanding better remuneration, thus leading to overall improvement in job prospects and attractiveness. Greater collaborative research between industry players, ports, shipbuilders with academia to find cost-effective innovative solutions.

Integrity

Leverage on digital technologies and satellite data/monitoring for real time monitoring of national waters for security, defence, pollution, and to combat encroachment (e.g., Royal Malaysian Navy, Malaysia Maritime Enforcement Agency, Royal Malaysian Customs Department, Marine Policy, Marine Department, etc). Clear and measurable targets for national plans and policies, as well as monitoring and review mechanisms in place to ensure responsible parties are held accountable for set targets and KPIs of said policies, national plans, etc. Additionally, information on their progress should be made transparent to all to improve stakeholder trust. Applying an overarching portfolio for the shared jurisdiction and KPIs of maritime industries that stretches ministries and agencies (e.g., Ministry of Finance, Ministry of Science, Technology and Innovation, Ministry of Defence).

Group 5: Renewable Energy Gaps – 8i Ecosystem Analysis

Internationalisation
Biomass volume and production efficiency of local sectors are low making local firms unable to compete with more cost-competitive nations (e.g., local seaweed cultivation labour cost higher). Low knowledge sharing and absorption of foreign technologies, as well as lack of easily upscaled product to compete with international markets.

Interaction
As there is a considerable amount of on-going research on marine biotech, the lack of interactions, communication and sharing of information between the relevant stakeholders may possibly result in duplication of efforts, which is not time and cost effective. Industries and research institutions have different focus areas (mismatch in supply and demand), made possible as a result of the lack of communication and coordination.

Institutions
Absence of an overarching institution that oversees and governs the marine biotechnology sector in the country (I.e., to lead the different agencies under the common umbrella of marine biotech and bio-products). Lack of a central funding agency that focuses on providing incentives to translate research into commercialization of products and services. The governing bodies for the different types of marine resources are unclear – e.g., challenging for industries to identify the institution responsible for seaweeds.

Incentives
Insufficient funding for R&D of marine biotechnology and bio-prospecting. Inadequate resources to translate project findings into product or service prototypes, and consequently into commercialized products or services. Presence of differing expectations between industry players (prefer low hanging fruits with less advanced or complicated projects) and funders (prefer more advanced technologies), which may create complications in the process of obtaining funding. Lack of funding to bridge gap between research and commercialisation (industry players) in order to develop product/service that has sufficient volume/ROI to attract venture capitalists/angel investors.

Infrastructure
Use of low-level technologies and lack of the sufficient basic infrastructure leading to low biomass production.

Infostructure
Difficulty in obtaining critical info vis a vis the marine biotech field – e.g., the current stakeholders in the field, research conducted by the different agencies, and well as the current available funding. Lack of information and data on the threatened marine resources.

Intellectual Capital
Mismatch of the current research focus areas and markets needs (i.e., mismatch of supply and demand) – e.g., lack of studies on upstream activities, such as culturing or sustaining live cultures of microbes. Lack of capable personnel to advance the field – e.g., to advance R&D and increase industry competitiveness. Lack of awareness on the employability of marine graduates/experts, thus resulting in low interest from the public. Absence of marine biotech course in public universities. Absence of a one stop institution to obtain research permits for projects related to marine biotechnology (i.e., issues of getting research permits from various agencies), increasing the complexity and time needed to plan and conduct research.

Integrity
Absence of regulating body to monitor the harvest of natural resources outside of the Marine Park. There is also a lack of mutual understanding on the legal interpretation of "wildlife" – i.e., if it includes marine wildlife, or just terrestrial ones. Absence of a national registry to ensure transparency and to prevent exploitation of resources. Over reliance on wild harvesting resulting in an insufficient and unsustainable production of marine resources, which may affect the equilibrium of the whole ecosystem.

Group 5: Renewable Energy Way Forward – 8i Ecosystem Analysis

Internationalisation
Derive knowledge from expertise and experience of other developed nations when devising future RE strategies. Establish better communication with the WTO to achieve mutual understanding (e.g., on the issue of palm oil production).

Interaction
Involvement of relevant industry experts in the R&D process since the preliminary stages. Improve communication between all stakeholders, especially with policymakers on the prevailing issues within the ecosystem – e.g., by establishing regular engagement sessions involving all relevant stakeholders. Establish strong network between academia, research institutes, and industries to facilitate knowledge transfer and expedite commercialization of R&D creations. Early interactions with financial institution to expedite funding process for technology commercialisation.

Institutions
Establish an empowered consortium (i.e., with top down approach) to drive and lead a national RE agenda with goals and targets that are collectively agreed by all stakeholders. SEDA to drive the identification of Malaysia's optimum energy mixture spectrum based on its geolocation. Establish a one-stop centre for technology demonstration to (i) facilitate industry buy-ins and (ii) stimulate interests among Malaysian companies to take part in technology R&D. Formulate a comprehensive national sustainability plan/policies and/or coordinating body that coordinates between the different portfolios (e.g., ensure the sufficient provision of EV charging stations to encourage EV adoption).

Incentives
Develop incentives to encourage uptake and execution of RE technologies and projects. This is to derive better ROV in the long-term, as it helps ensure energy security and conservation of natural ecosystem, both of which are heavily tied to the continuous supply of many integral resources and functions that have important economic and social values. Investment opportunities, especially on RE from the ocean/sea (e.g., wind, wave and tidal energy) can be enhanced. Formulate market stimulating policies to encourage greater demand/production of RE – e.g., tax exemption, rebates, certificates/awards, R&D grant schemes; applicable fields include transportation, buildings, industries/business usage, and manufacturing.

Infrastructure
Develop adaptive facilities to facilitate integration of RE energy into current convention energy system. Increase the available infrastructure to support RE adoption – e.g., RE infrastructure for transport (new EV budget) and shoreline RE plants (e.g., produce hydrogen fuel for green shipping/decarbonise maritime transport).

Infostructure
Develop local/in-house technologies for better adaptation to local conditions and needs (e.g., distinct energy mix in different countries). Explore the application of AI in harvesting RE, not only to enable easier and more seamless integration of RE into the current RE system, but also to maximise productivity. Explore the potential of ocean-based RE technologies, which are currently still lacking in the country. Adopt and integrate emerging technologies to increase data availability and enable data-driven solutions.

Intellectual Capital
Critical need to improve awareness and knowledge of citizens on the importance of RE. Train and cultivate next generation talents to advance the RE field (e.g., engineers and local entrepreneurs) by introducing new courses or improving the ones that are already in place. Embed and integrate IR4.0 into school curriculums to better prepare students for the digital workforce. Increase private sector involvement in the training of RE talents. Carry out periodic foresighting measures equipped with proper implementation strategies to address gaps in the supply and demand of talents.

Integrity
Review and assessment of the Renewable Energy Act/Policy to track progress of the set targets. Conduct a comprehensive study on the effects of ESG implementation on the country's economy. Adopt a national carbon calculator as a strategy to measure and record the carbon emissions in an accurate and standardized manner.

Group 6: Waste Disposal Management Gaps – 8i Ecosystem Analysis

Internationalisation
Recycling rate heavily lags behind developed countries such as Germany[3]. High generation of household waste compared to other developing countries such as Philippines and Indonesia[7].

Interaction
Inadequate communication and engagement between the government and local communities. Lack of partnerships and collaborations between industry and academia to enhance research and innovation, as well as to deliver commercial products.

Institutions
Absence of a centralized platform to plan and lead sustainable waste management in the country. The implementation of waste policies is not standardized across all states, resulting in ineffective waste management – e.g., in the present moment, only seven states in the country adopt Act 762 (Solid Waste and Public Cleansing). Lack of a coordinating agency to overlook marine health and waste issues. Linear municipal waste systems that focuses on waste collection instead of recycling[1].

Incentives
Lack of proper regulations or a centre platform to manage incentives for sustainable waste management for SMEs (e.g., through waste minimisation, recycling, and upcycling), thus reducing the effectiveness of incentives implementation/provision. Lack of incentives for source separation and diversion[1]. High equipment and operation costs involved in the construction of environmental efficient WTE systems, resulting in low profit margins and potentially deterring investors from investing into this system[6]. Insufficient funds and financial support from government and financial institutions to construct sanitary landfills[6].

Infrastructure
Insufficient treatment and recycle facilities to keep up with the demand of waste management – e.g., as the recycling facilities in Sarawak are unable to keep up amount of waste, some of these waste have to be shipped to the Peninsular to undergo recycling. Some infrastructure are not properly designed before establishment, resulting in the subsequently inability to operate - e.g., incineration plants in Langkawi and Cameron Highlands[5]. Absence of proper infrastructure to collect landfill gas (LFG) and leachate[6].

Infostructure
Lack of a centralised real-time database on waste-related information (e.g., volume of biomass), leading to data fragmentation and hindering effective strategy and decision-making.

Intellectual Capital
Waste officers lack the necessary knowledge and skills to accurately distinguish waste types, affecting subsequent management procedures[4]. [inferred] Inadequate awareness and knowledge among companies regarding the importance and method to execute separation at source (SAS). Lack of awareness among citizens on the importance of domestic segregation and recycling. Inadequate trainers available to train local communities on waste management. The progress of R&D in sustainable waste disposal management still lags behind many countries, especially on technologies or processes that are cheaper to construct, and can be upscaled and applied to a broader range of waste. Inadequate knowledge among policy makers and businesses led to extraneous investment on infrastructure which are not properly operated and maintained - e.g., small incineration plants in Langkawi and Pangkor Island[4]. R&D outputs are not sufficiently translated to commercialization.

Integrity
Enforcement of legislations is lacking, especially in certain locations in the country (e.g., marine tourist areas), resulting in the continued pollution and degradation of the natural ecosystem. Continued importing of garbage from developed countries to generate revenue, especially trash that cannot be treated/recycled/do not have a proper established management process. Presence of corruptive and illegal practices within the waste disposal management field – e.g., dozen of illegal recycling plants at the Pulau Indah industrial zone that carry out prohibited waste management method, i.e., open burning of plastics[2]. Absence of standards to stipulate the distance of incineration/WTE plants from city centres or housing areas, potentially creating long-term negative health impacts[6].

Group 6: Waste Disposal Management Way Forward – 8i Ecosystem Analysis

Internationalisation
Collaborate with international institutions (e.g., NGOs such as Ocean Cleanup) to leverage on international expertise and technologies. Regional recycling hub through multi-country alliance towards research, technology/solutions development, and recycling of waste for circular economy.

Interaction
Encourage collaborative projects between governmental agencies, academia and the industry to utilise or convert waste into create products and processes with economic or commercial value. Improve communication and cooperation between local and federal authorities on the planning and establishment of sustainable waste management policies[6]. Promote greater involvement of local communities in waste management (e g., beach clean-ups and SAS at home).

Institutions
Create a central agency or institution that coordinates and leads sustainable waste management efforts in the country. Establish a centralized body to overlook the health of ocean and marine ecosystem. Create a uniform policy which is incorporated in the waste management system across all states. Establish rules/standards with clear guidelines on the safe distance/buffer zone between waste facilities and housing or/and city centres[2].

Incentives
Impose regulations on single use plastics to deter reduce usage. Provide more incentives to promote R&D and commercialisations – e.g., enhance the development of the Green Technology Financing Scheme to encourage the development and commercialization of green technologies. Create a more seamless process to expedite the sharing of R&D projects to the higher authorities (e.g., to obtain grants for commercialization). Creation of cess fund and compulsory contribution from all industries to drive R&D. Enact market stimulating policies to encourage greater demand and production related to circular economy – e.g., tax exemption, rebates, certificates/awards, R&D grant schemes, especially among big/multinational corporations such as Ikea and Uniqlo. Provide more financial aids/incentives/subsidies for construction of WTE systems.

Infrastructure
Increase the amount of material recovery facilities in the country. Build or provide sufficient waste disposal infrastructure in local community areas. Develop infrastructure to capture LFG and leachate – e.g., perforated pipes. Apply nature-based solution in the coastal waste management process. Establish regular maintenance in all waste management facilities to ensure optimum functioning[1].

Infostructure
Gather and centralise the real-time database on waste-related information under one ministry or agency. Enhance citizen science program to foster more comprehensive data collection.

Intellectual Capital
Better educate relevant personnel on waste disposal and sustainable waste management knowledge – e.g., regarding the different types of waste and methods of identifying and segregating them. Introduce and induce community-based 3R programs among citizens – e.g., teach them the importance of the 3R and ways to execute them, such as segregating waste at home. This can also help induce the habit of SAS among businesses and industries in the long run. Induce awareness and provide knowledge to citizens on the importance of sustainable waste disposal management (e.g., for the health of the environment) through local community projects. More research needs to be done on recycling innovations – e.g., innovate cost-effective and scalable solutions to process the different types of waste.

Integrity
Impose ban/restrictions on the import and/or acceptance of waste from other countries. Stricter implementation of the polluter pay principle. Be more stringent with the issuance of permits to import and recycle plastic waste (i.e., careful review of the company profile and their recycling capacities)[3]. To ensure enforcement at the coastal areas – e.g., local authorities need to extend their area of waste management coverage to the costal areas. Establish KPI to assess the progress of waste disposal management (e.g., awareness programs for local communities) for all relevant agencies. Enforce SAS for businesses and industries. Implement the pay-as-you-throw scheme to raise awareness on the true costs of waste management among citizens.

Group 7: Marine biotechnology and bio-prospecting Gaps – 8i Ecosystem Analysis

Internationalisation

Biomass volume and production efficiency of local sectors are low making local firms unable to compete with more cost-competitive nations (e.g., local seaweed cultivation labour cost higher). Low knowledge sharing and absorption of foreign technologies, as well as lack of easily upscaled product to compete with international markets.

Interaction

As there is a considerable amount of on-going research on marine biotech, the lack of interactions, communication and sharing of information between the relevant stakeholders may possibly result in duplication of efforts, which is not time and cost effective. Industries and research institutions have different focus areas (mismatch in supply and demand), made possible as a result of the lack of communication and coordination.

Institutions

Absence of an overarching institution that oversees and governs the marine biotechnology sector in the country (I.e., to lead the different agencies under the common umbrella of marine biotech and bio-products). Lack of a central funding agency that focuses on providing incentives to translate research into commercialization of products and services. The governing bodies for the different types of marine resources are unclear – e.g., challenging for industries to identify the institution responsible for seaweeds.

Incentives

Insufficient funding for R&D of marine biotechnology and bio-prospecting. Inadequate resources to translate project findings into product or service prototypes, and consequently into commercialized products or services. Presence of differing expectations between industry players (prefer low hanging fruits with less advanced or complicated projects) and funders (prefer more advanced technologies), which may create complications in the process of obtaining funding. Lack of funding to bridge gap between research and commercialisation (industry players) in order to develop product/service that has sufficient volume/ROI to attract venture capitalists/angel investors.

Infrastructure

Use of low level technologies and lack of the sufficient basic infrastructure leading to low biomass production.

Infostructure

Difficulty in obtaining critical info vis a vis the marine biotech field – e.g., the current stakeholders in the field, research conducted by the different agencies, and well as the current available funding. Lack of information and data on the threatened marine resources.

Intellectual Capital

Mismatch of the current research focus areas and markets needs (i.e., mismatch of supply and demand) – e.g., lack of studies on upstream activities, such as culturing or sustaining live cultures of microbes. Lack of capable personnel to advance the field – e.g., to advance R&D and increase industry competitiveness. Lack of awareness on the employability of marine graduates/experts, thus resulting in low interest from the public. Absence of marine biotech course in public universities. Absence of a one stop institution to obtain research permits for projects related to marine biotechnology (i.e., issues of getting research permits from various agencies), increasing the complexity and time needed to plan and conduct research.

Integrity

Absence of regulating body to monitor the harvest of natural resources outside of the Marine Park. There is also a lack of mutual understanding on the legal interpretation of "wildlife" – i.e., if it includes marine wildlife, or just terrestrial ones. Absence of a national registry to ensure transparency and to prevent exploitation of resources. Over reliance on wild harvesting resulting in an insufficient and unsustainable production of marine resources, which may affect the equilibrium of the whole ecosystem.

Group 7: Marine biotechnology and bio-prospecting Way Forward – 8i Ecosystem Analysis

Internationalisation

Facilitate knowledge and technology exchange with international counterparts. Establish clear guidelines that stipulates clear rules/conditions for accessing and sharing of marine resources with other countries, such as the ABS regulation and Nagoya Protocol.

Interaction

Increase involvement of experts in the field (e.g., industry experts, researchers, and academics) to serve as advisory council for marine biotech. Create programs and network platforms to connect researchers and industry players (e.g., through public-private research network program).

Institutions

Formulate an overarching maritime policy to govern and guide ocean governance in the country – "explore, exploit, conserve, and manage". [inferred] Expedite the process of formulating and finalizing the National Ocean Policy to provide a national framework for protecting, maintaining and restoring the health of ocean. Establish an overarching governing body that leads the various marine biotech agencies with different disciplines – e.g., the National Organization for Marine Biotechnology. Establish an advisory panel that consists of experts to provide free consultations and advice regarding marine biotech and bio-prospecting.

Incentives

MOSTI to give more attention to the commercialization of marine biotechnology related-products and services (especially based on the 10-10 STIE framework) to generate ROI. Establish innovative financial solutions such as ocean-risk insurance and KPI-based loans to assure investors on the ROI. To consider providing incentives to local companies to help increase their industry competitiveness – e.g., reduce labour cost for seaweed cultivation (labour cost is higher in Malaysia than in neighbouring countries). Provide sustainable funding for niche areas. Financing schemes and research grants to assist industry players in research to commercialisation that involve partnerships with academia to ensure industry relevant research.

Infrastructure

Where possible, carry out the sharing facilities and instruments to reduce costs needed to purchase and/or establish new infrastructure for marine biotech (e.g., the National Science Facilities and Equipment Sharing).

Infostructure

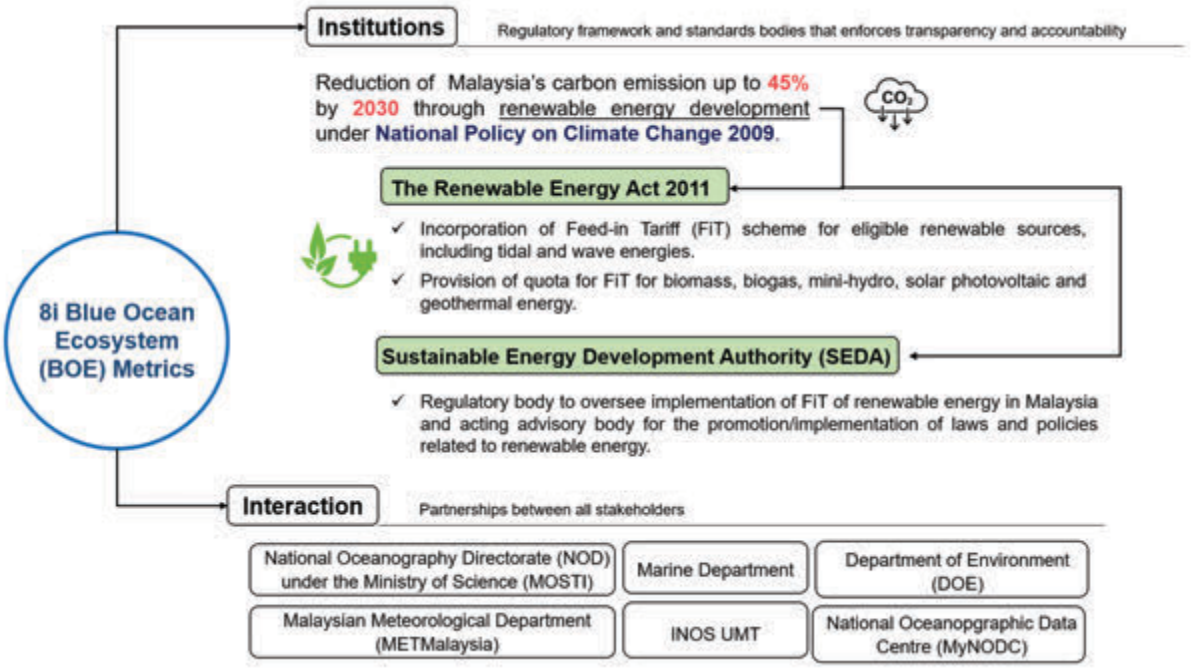
Establish the needed measures (e.g., advanced monitoring technologies and data repository system) to provide assessment baseline data on the threatened marine species in the country.

Intellectual Capital

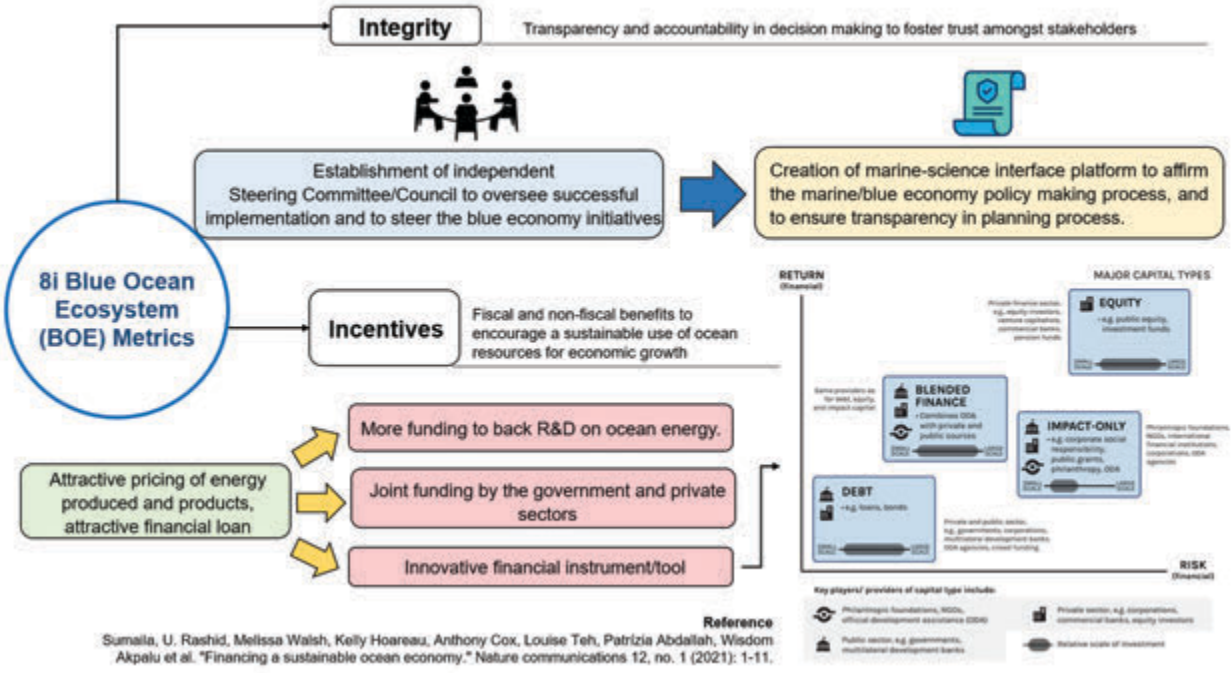
Establish a Marine Network Platform that functions as a one-stop education centre that provides information on all marine biotech and bio-prospecting-related topics (similar to National Science Center). Cultivate talents to progress and advance the field. Identify niche areas within the marine biotech field for talent development.

Integrity

Create a national register for marine biotech to ensure transparency, as well as to prevent resources from being exploited. Additionally, clear guideline on the access and sharing of marine resources (e.g., ABS regulation and Nagoya Protocol) when collaborating with international parties.



8i Blue Ocean Ecosystem (BOE) Metrics for Renewable Energy Sector



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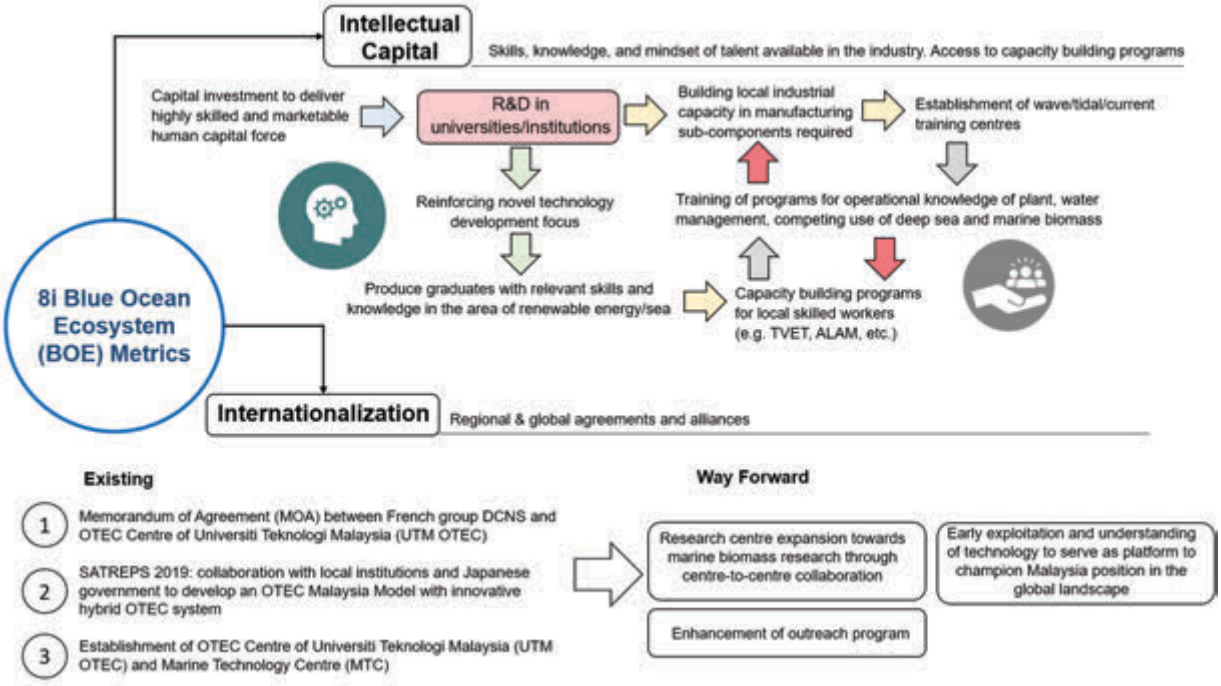

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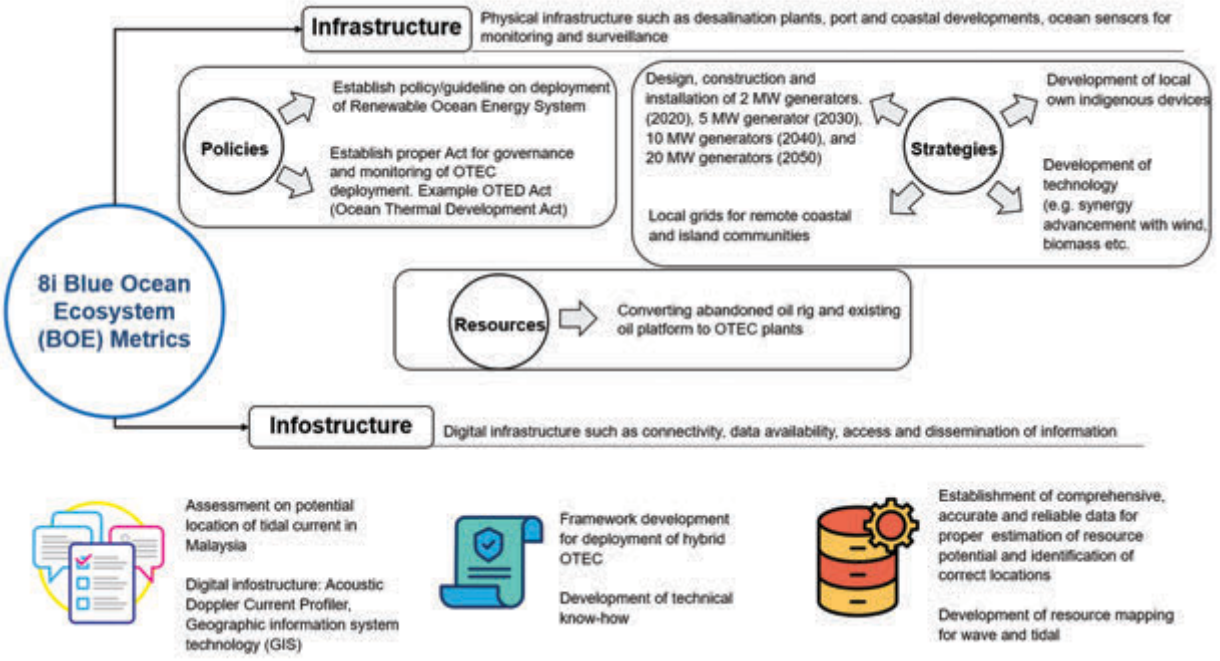

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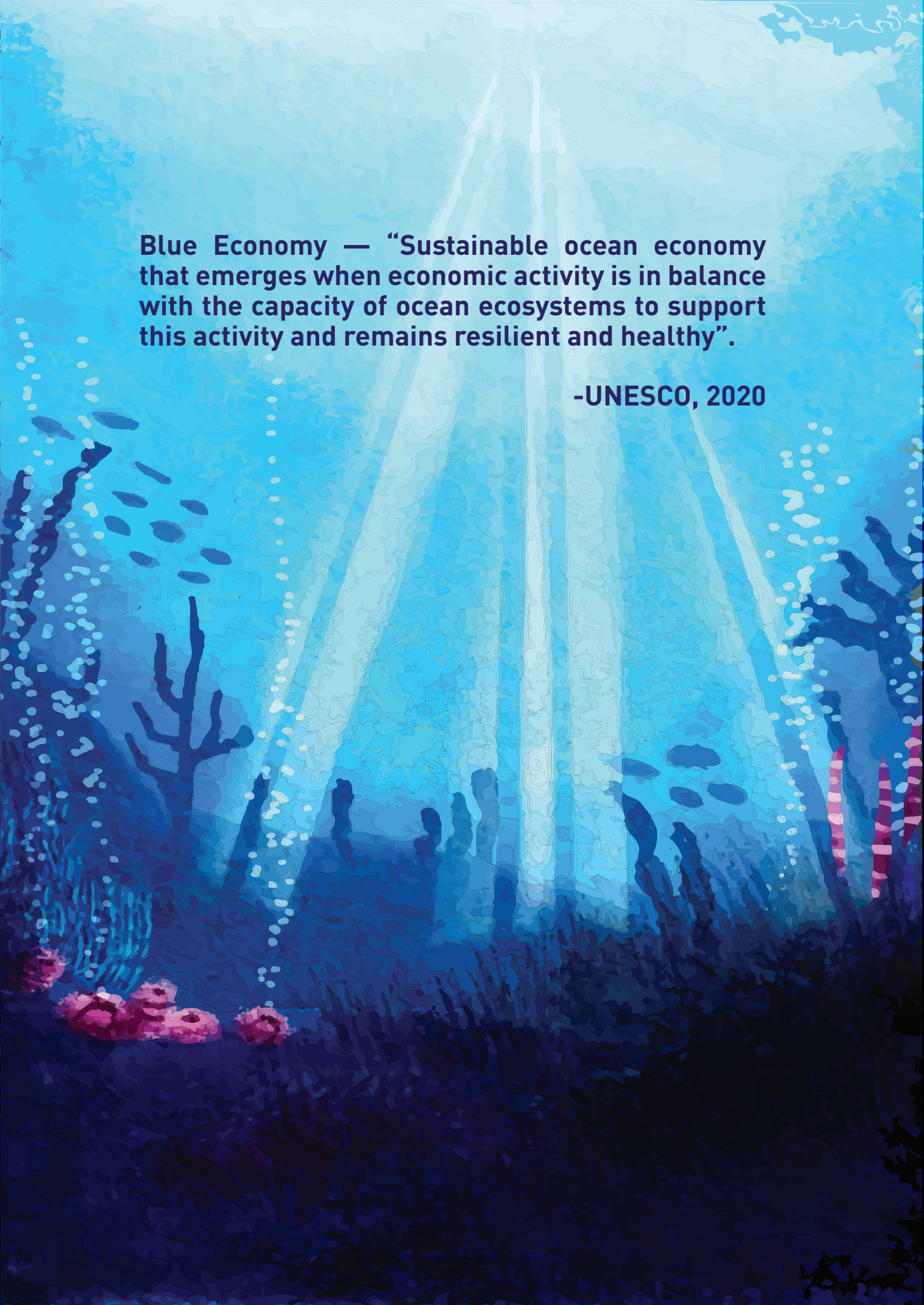

Blue Economy — "Sustainable ocean economy that emerges when economic activity is in balance with the capacity of ocean ecosystems to support this activity and remains resilient and healthy".

-UNESCO, 2020