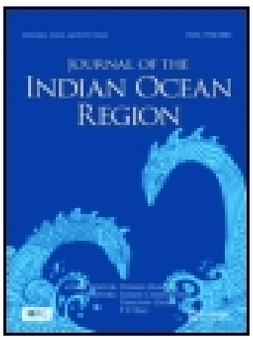

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# Harnessing Kenya's Blue Economy: prospects and challenges

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**ABSTRACT**

Kenya enjoys a marine coastline of about 640 km giving a total area of territorial waters of 9700 $km^2$ while the EEZ is 142,400 $km^2$. She further lays claim to an extended EEZ of approximately 103,320 $km^2$ and has 13,600 $km^2$ of inland waters. The government recognizes the potential of this maritime resource to boost the country's economic outlook and has made Blue Economy (BE) part of the economic pillar in its development blueprint. For effective development of the BE, Kenya needs, among other things, to: build human resource capacity through investing in marine education and training; boost marine scientific research; support the traditional industries of fisheries, aquaculture, tourism, blue biotechnology, ports and shipping; develop BE database; resolve outstanding boundary disputes; and reduce illegal unreported and unregulated fishing. The study posits that Kenya already has sector-wise experiences and assets as demonstrated by the numerous government institutions participating in the BE and is only lacking policy integration, coordination and coherence.

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Blue Economy; sustainable development; governance; COVID-19

## Introduction

The sum of economic activities of ocean-based industries together with the assets, goods, and services provided by the marine ecosystems is normally referred to as the oceans economy (OECD, 2019). Blue Economy (BE) is a relatively new concept that focuses on the sustainability of the ocean's economy. BE, therefore, seeks to promote growth, social inclusion, job creation, improvement of livelihoods, and increase food production from the sea, while at the same time ensuring the environmental health of the oceans and other water bodies (Childs & Hicks, 2019; UNDP, 2018; UN-Habitat, 2018; World Bank and United Nations, 2017).

The concept of BE emerged at the United Nations (UN) Conference on Sustainable Development in 2012, also known as Rio+20 conference. Prior to the conference, Small Island Developing States (SIDS) and coastal Least Developed Countries (LDCs) had questioned the focus of the 'Green Economy' and its applicability to them given their

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dependence on the ocean and marine economy. The concept of BE was subsequently espoused and since that time there has been increasing global acceptance of the concept (Choi, 2017; Eikeset et al., 2018; Silver et al., 2015; Whisnant & Reyes, 2015; Garland et al., 2019).

The UN 2030 Agenda for Sustainable Development Goals (SDG), Goal 14, 'Life below Water' aims to conserve and sustainably use the oceans, seas, and marine resources for sustainable development (United Nations, 2015; UN, 2018). Within the goal, Targets 14.4 and 14.6 emphasize the importance of action on overfishing, illegal unreported and unregulated (IUU), and fisheries subsidies, while Target 14.7 focuses on enhancing the economic benefits to SIDS and coastal LDCs from the sustainable use of marine resources, through sustainable management of fisheries, aquaculture, and tourism (UN, 2014; UN, 2015; UNDP, 2018). As pointed out by Roberts and Ali (2016), BE plays additional roles in addressing other SDGs of poverty alleviation, food security, affordable and clean energy and climate action. The African Union's (AU) Agenda 2063 also recognizes the BE as a potential major contributor to the continent's transformation and growth. This is outlined in the 2050 Africa Integrated Maritime Strategy (AIMS), a plan that aims to create wealth from Africa's oceans, seas, and inland waterways to foster a thriving maritime economy (African Union Commission, 2014; African Union, 2014; UNECA, 2016).

The World Bank (2017) has highlighted the diverse components of the BE including traditional ocean industries such as fisheries, aquaculture, tourism, ports, and maritime transport and also the new and emerging industries, such as offshore renewable energy, seabed extractive activities, and marine biotechnology and bio prospecting (Table 1). Globally, it is estimated that ocean-based industries and activities contributes about USD 2.5 trillion per annum (3% of global GDP) and creates millions of jobs (World Bank, 2017; UNCTAD, 2014). Indeed, ocean industries are forecasted to be the key drivers of global economic growth over the next decade with the global ocean economy projected to double in size by 2030 (OECD, 2016).

Taking cognizance of the created awareness of economic and social worth of the BE, Coastal and Island States have staked claims of sovereignty over their ocean spaces and resources by delimiting their overlapping maritime zones through establishing a boundary (Colgan, 2018; Kildow & McIlgorm, 2010) using the mechanisms in the 1982 United Nations Convention on the Law of the Sea (UNCLOS). UNCLOS sets out the legal framework for all ocean-related activities including provisions on a state's national jurisdiction over the ocean space, access to seas, navigation, exploitation of maritime resources, scientific research, seabed mining, and the settlement of disputes concerning application and interpretation of the convention (UN, 1982).

Kenya's BE concept is aligned to that of AU and covers all waters in oceans, seas, coasts, lakes rivers, dams, and underground water. The nation's marine coastline stretches from Somalia in the North to Tanzania in the South on the Western Indian Ocean covering a distance of about 640 km with a total territorial water area of 9700 $km^2$ and an EEZ of 142,400 $km^2$. Kenya also lays claim to an extended EEZ reaching 350 km with an extra area of approximately 103,320 $km^2$ (Figure 1). In addition, Kenya has 13,600 km of inland water resources comprising of lakes, dams, and rivers of varying sizes (Table 2). Consequently, the total maritime domain of the country is approximately 255,420 $km^2$ which is approximately half of the country's landmass area of 580,000 $km^2$ (SDF, 2016). The role of BE in poverty alleviation, food and nutrition security, employment creation,

**Table 1.** Components of Blue Economy.

| Type of activity | Ocean service | Industry | Drivers of growth |
|---|---|---|---|
| Harvesting of living resources | Sea food | Fisheries | Food security |
| | | Aquaculture | Demand for protein |
| | Marine biotechnology | Pharmaceuticals, Chemicals, marine derived bio-products | Research and development for healthcare and industry |
| Extraction of non-living resources, generation of new resources | Minerals | Seabed mining | Demand for minerals |
| | Energy | Oil and gas | Demand for alternative energy sources |
| | | Renewables (offshore wind, wave energy, tidal energy) | |
| | Fresh water | Desalination | Demand for freshwater |
| Commerce and trade in and around the oceans | Transport and trade | Shipping (ship owners and operations, boat and ship repairs, safety and training, marine engineering) | Growth in seaborne trade; International regulations |
| | | Port infrastructure and services (agents and brokers, ship suppliers, stevedores, roll-on roll-off operations, custom clearance, freight forwarders, insurance, charterers, legal, and financial services) | |
| | Tourism and recreation | Coastal and maritime tourism (angling, skiing, surfing, sail boating, kayaking, scuba diving, bird watching, and ecotourism) | Growth of global tourism |
| | | Coastal development | Coastal urbanization<br>Domestic regulations |
| Response to ocean health challenges | Ocean monitoring and surveillance | Technology, R & D, and Education | R & D in ocean technologies |
| | Carbon sequestration | Blue Carbon | Growth in Coastal and Ocean protection and conservation activities |
| | Coastal protection | Habitat protection and restoration | |
| | Waste Disposal | Assimilation of nutrients and wastes | |

Adapted from: World Bank (2017).

and environmental sustainability has been recognized by the Government of Kenya (GoK) with BE development made a key subsector of the country's growth strategy (Wairimu & Khainga, 2017).

This paper discusses the potential contribution the BE can make toward the country's fiscal growth and development, explores the envisaged challenges to realizing the BE potentials, and proposes the possible management framework to be employed.

## Methodology

The study adopted a desktop research review of secondary information data available online including research publications, conference papers, UN reports, concept papers published by various independent organizations as well as non-governmental organizations, policy documents, and white papers of governments, plus gray literature on the same. Desktop research is an appropriate method because it is used to gather facts and research data available that aid to respond to numerous aspects of a research question and objectives of the study. Content analysis technique was used for the data analysis. This is a research tool for interpreting textual material to elicit meaningful information over different themes. The rationale for using the content analysis technique is because it

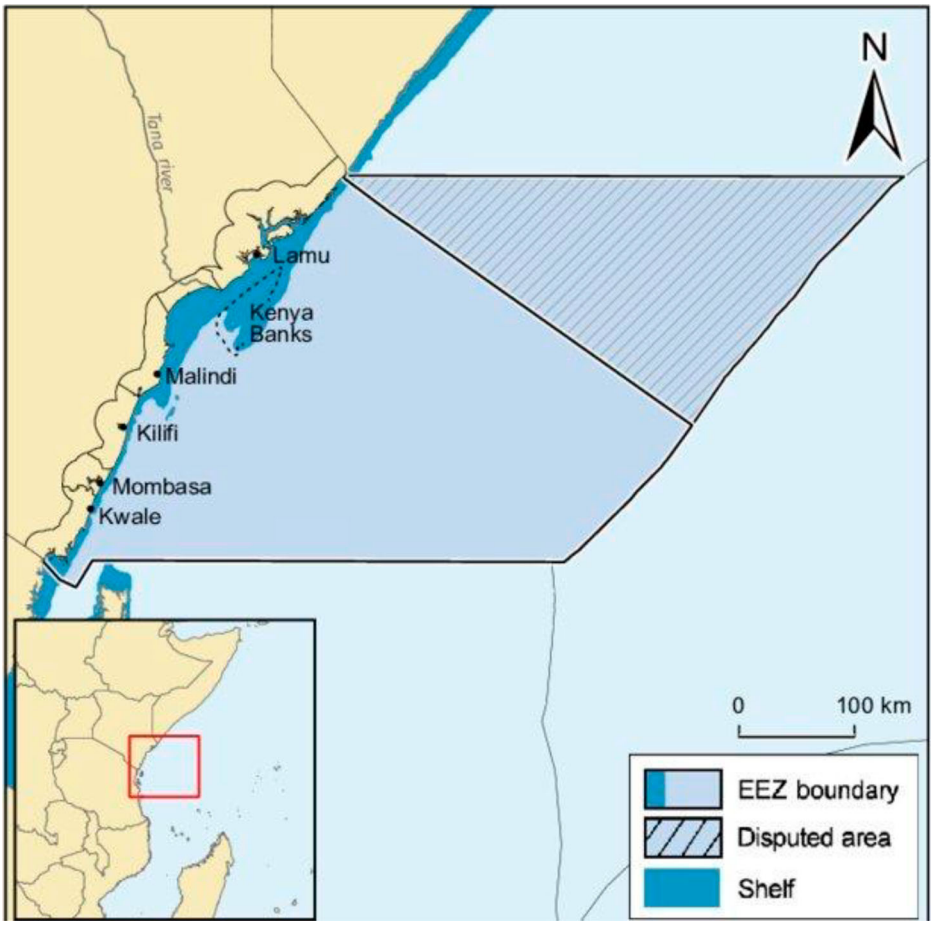


**Figure 1.** Kenyan Exclusive Economic Zone, Shelf Water, and Major Coastal Towns (Source: Le Manarch et al., 2015).

**Table 2.** Lakes, Rivers, Mangrove spp, Sea grass spp and Aquaculture spp in Kenya.

| Major lakes and rivers | Mangrove species | Sea grasses | Cultured aquaculture species |
|---|---|---|---|
| Lake Victoria (Kenya's portion: 4128 km$^2$) | *Avicennia marina* | *Cymodocea rotundata* | Tilapia (*Oreochromis niloticus, Oreochromis esculentus*) |
| Lake Turkana (6405 km$^2$) | *Bruguiera gymnorrhiza* | *Cymodocea serrulata* | Catfish (*Clarias gariepinus*) |
| Lake Naivasha (210 km$^2$) | *Ceriops tagal* | *Enhalus acoroides* | Common Carp (*Cyprinus carpio*) |
| Lake Baringo (129 km$^2$) | *Heritiera littoralis* | *Halophila minor* | Milk fish (*Chanos chanos*) |
| Lake Bogoria | *Lumnitzera racemosa* | *Halophila ovalis* | Rainbow trout (*Oncorhynchus mykiss*) |
| Lake Magadi | *Rhizophora mucronata* | *Halophila stipulacea* | Mullets (*Mugil cephalus*) |
| Lake Elementaita | *Sonneratia alba* | *Halodule uninervis* | Oysters (*Crassostrea cucullata*) |
| Lake Nakuru | *Xylocarpus granatum* | *Halodule wrightii* | Shrimp (*Penaeus monodon*) |
| River Tana (700 km long) | *Xylocarpus moluccensis* | *Syringodium isoetifolium* | Mud crab (*Scylla serrata*) |
| River Athi/Sabaki (530 km) | | *Thalasodendron cilitatum* | Seaweeds (*Eucheuma denticulatum, Kappaphycus alvarezii*) |
| River Ewaso Nyiro (520 km) | | *Thalasodendron hemprichii* | |
| River Mara (280 km Long) | | *Zostera capensis* | |
| River Nzoia (240 km long) | | | |
| River Yala (170 km long) | | | |
| River Sondu (105 km long) | | | |

allows the qualitative and quantitative data collected in previous studies to be analyzed systematically and generalizations drawn.

## Kenya's BE

Kenya's BE comprises an array of maritime resources including the living resources (capture fisheries, aquaculture, mangroves, corals, seagrasses, seaweeds, and Artemia), the non-living resources (marine minerals including salt, offshore oil, and gas), the renewable resources (wind energy, tidal energy, solar energy, and blue biotechnology), and trade and commerce (tourism, shipping, maritime transport, and ports).

### *Living resources*

Kenya is endowed with vast fish resources in its marine and inland waters. Fish is highly nutritious containing high-quality animal protein and provides a range of micronutrients, essential vitamins, minerals, and essential fatty acids particularly long-chain omega-3 fatty acids which cannot be easily substituted by other food commodities (Bene et al., 2015; Chan et al., 2019; Kawarazuka & Bene, 2011; Rasowo, 2015; Rasowo et al., 1995). Fisheries (capture fisheries and aquaculture), therefore, have significant potential to contribute to the goals of reducing food and nutrition insecurity, generating income, reducing poverty, and creating employment (Chan et al., 2019).

In Kenya, capture fisheries comprise both inland freshwater and marine fisheries with the freshwater fisheries being dominant and accounting for about 95% of the total national production. The bulk of the Nation's freshwater fish catch comes from the Kenyan part of Lake Victoria (90%) and L. Turkana (4%), with the rest emanating from lakes Baringo, Naivasha, Jipe, the rivers and dams (SDF, 2016).

The inland freshwater capture fishery of L. Victoria supports both commercial and artisanal fishery consisting predominantly of Nile perch (Lates niloticus), Nile tilapia (*Oreochromis niloticus*) and cyprinids (*Rastrineobola argentea*) (Njiru et al., 2018). The Nile perch is primarily for the export market while the small indigenous fish, *R.argentea*, locally known as 'omena' or 'dagaa' are largely sold in the local market thus forms an important source of micronutrients in traditional diets. The marine fishery comprises coastal and oceanic resources and are exploited by both small-scale, semi-industrial, industrial and recreational fisheries. The coastal fisheries is mainly artisanal and small-scale with the fishing concentrated in nearshore waters and targeting mangrove-, seagrass-, and coral reef-associated species such as rabbitfish, parrotfish, emperors, groupers, grunters, and crustaceans including prawns and lobsters, octopus, squids, sea cucumbers, and mollusks (SDF, 2016). Kenya's oceanic fisheries primarily focus on tuna and tuna-like fish, sharks, and other large pelagic species (SDF, 2016).

Aquaculture includes unfed and fed types cultivated in both freshwater and saltwater (marine) systems with freshwater aquaculture production showing faster growth compared to the marine (mariculture) (Njiru et al., 2018; Opiyo et al., 2018; Munguti et al., 2014). Freshwater aquaculture involves both cold and warm water fish species with the main cold-water species under culture being the rainbow trout (*Oncorhynchus mykiss*), while the major warm water species comprises of Nile tilapia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*), and common carp (*Cyprinus carpio*). Mariculture

species cultured are Milkfish (*Chanos chanos*), Grey mullets (*Mugil cephalus*) Mud crabs (*Scylla serrata*), Oysters (*Crassostrea cucullata*), Shrimp (*Penaeus monodon*), and Seaweeds (mainly *Kappaphycus alvarezii*) (Opiyo et al., 2018; KMFRI, 2017; Munguti et al., 2014; Mirera, 2011).

Mangrove forests occur along the coast between Kiunga at the Kenya-Somalia border to the north and Vanga at the Kenya-Tanzania boundary to the south. Doute et al. (1981) estimated the mangrove cover to be 61,271 ha but this has been declining in quality and land cover with recent estimates putting the cover to be between 50,000 and 60,000 ha (Food and Agriculture Organization of the United Nations [FAO], 2016a). All the nine mangrove tree species recorded in the Western Indian Ocean (WIO) region occur in Kenya (Table 2) with the most dominant species being *Rhizophora mucronata* (Mkoko) and *Ceriops tagal* (Mkandaa) that occupy more than 70% of the formation. The forests provide a range of goods and ecosystem services including: carbon sequestration and storage; prevention of coastal erosion; encouraging soil deposition; provision of food, shelter, and sanctuary for birds, mammals, and other wildlife; and providing breeding, nursery and feeding grounds for a wide variety of marine organisms (MacNae, 1974). In addition, the mangroves support a rich and diverse fish fauna thus are important for coastal and nearshore fisheries (Rasowo, 1992; MacNae, 1974). The forests offer diverse livelihood options to the local people and contribute immensely to the national economy with major economic returns coming from timber, fisheries, honey, wax, and tourism.

The coral reef coverage in Kenya is expansive with over 250 species of hard and soft corals identified to date (Tuda & Omar, 2012). This rich and diverse reef ecosystem is of great importance to the country, both ecologically and socioeconomically as they provide important fish habitat and support coastal fisheries (Obura et al., 2017; Ateweberhan et al., 2011). Furthermore, coral reefs are important to the coastal environment as they provide protection from damaging effects of powerful waves and tropical storms thus preventing coastal erosion (Ferrario et al., 2014). Indeed, coral reefs support Kenya's coastal tourism as they contribute to the formation of Kenya's sandy beaches and sheltered harbors.

Twelve sea grass species have been encountered widely distributed along the entire Kenyan coastline (Table 2) with the most abundant and dominant species being *Thalassodendron ciliatum* (Aleem, 1984). Sea grasses are one of the most efficient carbon sinks, fixing organic carbon and sequestering atmospheric carbon dioxide hence mitigating the impact of climate change (Duarte et al., 2010; Githaiga et al., 2017). Sea grass meadows support fisheries and biodiversity conservation as they are the nursery, breeding, and feeding grounds for many marine fish and crustacean species of economic importance in Kenya (Musembi et al., 2019; Farina et al., 2009; Dewsbury et al., 2016; Cullen-Unsworth & Unsworth, 2013; Unsworth et al., 2018). In addition, these sea grass beds sustain sizable populations of two endangered species, the green turtle (*Chelonia mydas*) and the dugong (*Dugong dugong*) both of which feed on sea grasses (Coppejans et al., 1992).

Studies carried out by Bolton et al. (2007) show that Kenya has a rich seaweed flora with 386 species so far recorded. Two of these, the eucheumoids (brown *Eucheuma denticulatum* and brown *Kappaphycus alvarezii*) are globally farmed commercially for their phycocolloid, carrageenan, which is used in food, pharmaceutical and cosmetic industries

(McHugh, 2003). Like in other developing countries, the increasing world demand for carrageenans has stimulated the commercial cultivation of the red seaweeds, *Eucheuma* and *Kappaphycus* in Kenya, thus transforming the mariculture into a source of foreign exchange earnings and livelihood to communities in the coast (Wakibia et al., 2011; Luxton & Luxton, 1999; Mshigeni, 1994). The culture of *E. denticulatum* and *K. alvarezii* was started in 2004 and 2009, respectively (Wakibia et al., 2011).

Artemia biomass and cyst production is a byproduct in the sea salt production system. As the sea water gets progressively saline during passage through the evaporation ponds, mortality of most living organisms in the sea water occurs due to their low tolerance to the increasing water salinity. Those organisms that survive tend to proliferate due to lack of competition. One of the organisms which survives due to its high tolerance of salinity is the brine shrimp *Artemia* which normally produces adults (biomass) or cysts depending on the degree of salt concentration (Rasowo, 1992; De Vos et al., 2018). *Artemia* biomass and cysts are harvested, processed, packed, and sold to shrimp and fish hatcheries as larval food. The global demand is quite high with the cysts fetching a handsome price as an export commodity with Artemia cysts prices ranging between 50 and 100 USD/kg (De Vos et al., 2018). The solar salt farms operating in the Kenyan north coast produce *Artemia*.

### *Non-living resources*

Large offshore gas deposits discovered in Tanzania and Mozambique along with terrestrial oil finds in Uganda and recently in Kenya's Turkana region have stimulated interest in exploration for oil and gas resources in Kenya's offshore waters of the WIO. Despite limited results to date, it is still widely believed that the waters around Kenya and Somalia's maritime boundary contain significant deposits of oil and gas.

Marine mining involves the extraction and processing of chemical elements dissolved in sea water (e.g. sea salt and potassium), marine aggregates (sand and gravel), and marine minerals and metals in and on the seabed (European Commission, 2019). Kenya has a vibrant sea salt manufacturing sector using the solar salt evaporation technique. The process involves sea water being pumped from the ocean and gradually transferred through a series of evaporation ponds. As the water is moved through the evaporation ponds, it gets more saline with the resultant brine finally ending in the crystallization ponds where it is harvested as raw salt. Most of the salt manufacturing companies are situated in the Kenyan north coast namely: Kensalt Ltd, Kurawa Industries Ltd, Malindi Salt Works, Krystalline Salt Ltd, Kemu Salt Packers Production Ltd, and Mombasa Saltworks Ltd. The country's production meets domestic demand with the excess being exported to neighboring countries.

Globally, seabed minerals eliciting great interest include cobalt-rich ferromanganese crusts, polymetallic manganese nodules, and polymetallic sulphides, with the last being sources of rare earth minerals important to new information and communication technology hardware and renewable energy technologies like solar panels (Jacobson & Delucci, 2011; Kraska, 2012). Deep-seabed mining is capital intensive requiring complex infrastructure, appropriate technology and skills. Kenya needs to partner with private sector investors and developed countries having the skills and financial muscle to be able to exploit this resource. Deep-sea mining must however be treated with caution considering the

concerns raised about the environmental costs of extraction of the minerals not being consistent with the BE vision (World Bank & UN DESA, 2017).

### *Trade and commerce*

Blue tourism is a key ocean-based industry and the second largest source of foreign currency earnings for Kenya and an important revenue stream contributing about 10% of the country's GDP (KNBS, 2017). Kenya has been a preferred destination for many regional and international holiday makers mainly because of its good climate, splendid sites, diverse wildlife, beautiful beaches, and hospitality. The main drivers for the country's tourism growth in 2019 were mainly political stability and improved security situation especially in the coastal region. Nonetheless, tourism is highly dependent on the quality of natural ecosystems and in order to remain a tourism destination of choice, the country needs to do more: the coral reefs need to be kept healthy and visually appealing; the tourist supply chain needs to be improved including the supporting infrastructure to get the tourists to the sites, and sufficient number of quality experiences need to be provided to tourists so as to increase their visitation and duration of stay in the country.

About one half of the global population, most of its largest cities and industries tend to be concentrated in coastal areas to ensure access to transport routes and continuous flow of trade. Indeed, the main transport mode of global trade is ocean shipping with around 90% of traded goods being transported by ship (International Transport Forum [ITF], 2018). The Indian Ocean contains several of the world's largest shipping lanes, catering for about 30% of global shipping movement (ITF, 2018). Kenya has seaports facing the Indian Ocean and inland ports facing L. Victoria with more than 90% of its external trade being seaborne.

### *Renewable energy, marine biotechnology, and desalination*

In solidarity with global efforts to mitigate climate change by reducing fossil fuel usage, Kenya continues to invest heavily on producing energy from renewable energy resources particularly geothermal, hydroelectricity, onshore wind, and solar energy sources. Noticeable investments include the 310 MW Lake Turkana Wind Power project and the 54.6 MW Garisa Solar Power Plant (Obura, 2019; African Development Bank, 2015). The country is yet to exploit its marine renewable energy resources such as tides and waves, offshore wind, thermal gradients, ocean currents, salinity gradients, and marine biomass (Borthwick, 2016).

With its ocean waters and several inland saline and soda lakes, investment in marine biotechnology holds huge potential of bringing economic growth and development in Kenya if properly harnessed. Marine biotechnology is concerned with the exploration and exploitation of diverse marine organisms containing various chemical products, enzymes, and other ingredients for use in pharmaceutical, biomaterials health care, and make up industries (Day et al., 2016). Marine biotechnology has the potential to deal with many global challenges by contributing to human health, sustainable food supplies, energy security, and environmental remediation (Hunt & Vincent, 2006). Research shows that marine bacteria are a potential source of drugs and can make critical contribution to the development of antibiotics (Hunt & Vincent, 2006).

Desalination is an energy-intensive technology that is often used to overcome freshwater shortages in areas where scarcity is experienced. The county of Mombasa which suffers perennial shortage of freshwater has in collaboration with the National government, rolled out plans to desalinate the abundant waters of the Indian Ocean to produce freshwater for its residents. Land has been set aside to construct a large-scale desalination plant with a capacity to purify 100,000 $m^3$ of water daily and a smaller one of 30,000 m3/day (Atieno, 2019).

## Challenges to development of the BE

As a signatory to the Convention on Biological Diversity (CBD), Kenya has a commitment to the CBD Aichi Target 11 and the SDG 14 (Target 14.5) which calls for conservation of 10% of the coastal and marine areas through effectively and equitably managed, ecologically representative and well-connected system of protected areas and other area-based conservation measures by 2020 (CBD, 2012). Kenya uses two area-based management tools, namely, the Marine-Protected Areas (MPAs) and locally Managed Marine Areas (LMMAs) (Table 3) as strategies to meet its conservation obligation to the CBD (Tuda & Omar, 2012). Data show that the current total national marine conserved area achieved by the 6 MPAs and the 24 LMMAs is only about 1% consequently leaving a gap of about 9% in order for Kenya to attain the Aichi Target 11(Obura et al., 2017). The challenge is how to make the already conserved areas deliver tangible benefits to the local communities hence create incentives for them to identify with, protect the resource and champion expansion of the areas.

Limited accurate and persuasive information on potential of offshore fishing in Kenya's EEZ continues to hinder private enterprise from investing on offshore capture fisheries and this is further exacerbated by shortage of offshore domestic industrial fishing vessels plus the challenge of foreign vessels fishing in Kenya's EEZ not bothering to land 30% of their catch in the country as mandated by law. In L. Victoria, inadequate protection of fish breeding grounds from fishermen and the water hyacinth (*Eichhornia crassipes*) infestation, which blocks access of fishing boats to beaches and fishing grounds, are problems that need to be resolved. The limited capacity of beach management units (BMUs) of both inland and coastal fisheries to manage and implement activities required by KFS and County fisheries officers and ineffective enforcement of fisheries laws and regulations are challenges to be surmounted. For inland and marine aquaculture, the

**Table 3.** Some of Kenya's MPAs.

| MPA | Designation | Size ($km^2$) | Year established |
|---|---|---|---|
| Kiunga | MR & MaBR | 600 | 1980 |
| Malindi Marine Park | MP & MaBr | 6.3 | 1968 |
| Watamu Marine Park | MP & MaBR | 32 | 1968 |
| Malindi & Watamu | MR & MaBR | 177 | 1968 |
| Mombasa | MP | 10 | 1986 |
| Mombasa marine Reserve | NR | 200 | 1986 |
| Diani | NR | 75 | 1993 |
| Kisite | NP | 28 | 1978 |
| Mpunguti | NR | 11 | 1978 |

Note: MR, marine reserve; MP, marine park; MaBR, man and biosphere reserve; NR, national reserve (Source: Tuda & Omar, 2012).

inadequate supply of quality and affordable feed and fingerlings, insufficient capacity for extension service, shortage of hands-on experienced fish farm instructors, and poor monitoring and control of the proliferation of intensive floating net cage culture in the lake are issues that need quick solutions.

Much of Kenya's maritime territory, including the seabed, remains unmapped and poorly described resulting in limited knowledge on what resources are contained in the water column and the ocean bottom. A comprehensive bathymetry of Kenya's EEZ must be carried out in order to make it possible to identify unique and important geological features such as sea mounts, deep canyons, and other critical features that may influence fishery productivity and deep-sea mining investment decisions (KMFRI, 2017). A BE database needs to be developed and managed as a marketing tool to attract private sector investment. Connected to this is the lack of a functional BE development master plan and a national marine spatial plan both of which are necessary for planning and coordination.

Maritime security including security of the ports and infrastructure are very important to Kenya because the country relies heavily on the ocean for transport, trade, food, and international communication. Threats to maritime transport have far-reaching knock-on effects on trade, food security, tourism, and other ocean industries as was evidenced by the severe negative impacts it had in Kenya during the peak of piracy activities off the coast of Somalia, Kenya, and the Gulf of Aden region from 2008–2012 (Otto, 2012). Piracy and armed robbery at sea, illicit trade in crude oil, arms and drugs trafficking, human trafficking and smuggling of contraband goods, marine pollution, and illegal activity in protected areas require enhanced regional and international collaboration to overcome (African Union, 2014; Bueger, 2015).

Transnational crime in the form of IUU fishing is another threat to sustainable management of Kenya's fish resources. It is believed that the country may be losing up to USD100 million annually to IUU fishing through the activities of larger vessels operating off shore in the Indian Ocean (Marete, 2018). Others are through fishing practices within the small-scale sector using illegal fishing gears such as nets with mesh sizes below the legal minimum requirement, dynamite fishing, and the criminal operations of small-scale fishers entering Kenya's waters from neighboring countries. It is hoped that the recently launched Kenya Coast Guard Service will work closely with the State Department of Fisheries and Blue Economy to curb this menace (Anon, 2018). Kenyan fishermen are frequently caught up in cross-boundary fishing conflicts in L. Victoria, L. Turkana and the Indian Ocean. So far, the conflicts have been resolved through machineries of the regional fisheries management bodies.

A challenge which is geo-political in nature is the maritime boundary dispute with Somalia. Kenya's maritime sovereignty is being challenged by Somalia which instituted proceedings against her at the International Court of Justice (ICJ) in 2014 (Hasan et al., 2019). Kenya's claim is a straight line starting from the Nation's land boundary terminus and extending due east along the parallel of latitude on which the land boundary terminus sits, through the full extent of the territorial sea, EEZ and continental shelf, including the continental shelf beyond (Figure 2). Somalia maintains that the boundary line should be the median line as provided for in Article 15 of the UNCLOS. Further, Somalia insists that the EEZ and continental shelf boundary should be established in terms of the 'three-step process' applied by the ICJ in its interpretation of Articles 74 and 83 of


**Figure 2.** Kenya-Somali maritime border dispute.

UNCLOS. This process first requires that the Court draws a provisional equidistance line and secondly, the Court is to 'determine whether there are 'relevant circumstances' that render the provisionally drawn equidistance line inequitable'. Thirdly, the Court is to 'test the proposed delimitation line to determine whether it results in any gross disproportion'. The dispute is because of a triangular stretch of 100,000 $km^2$ offshore territory that is about 370 km from the coastline, purported to have huge oil deposits (Hasan et al., 2019). Kenya fears that an unfavorable ruling will lead to the loss of about 26% of its EEZ and her offshore exploration limited by lack of direct access to the high seas. It is paramount in the interest of security, economic development, and better maritime governance that this issue is resolved.

Roxy et al. (2014) has provided evidence showing that the WIO is warming at a rate faster than any region of tropical oceans. A warmer WIO, with declining productivity, will impact the fisheries with species-specific shifts in range and migratory patterns particularly for the hypoxia-sensitive pelagic species such as the tuna, marlin, swordfish, and sharks (Leung et al., 2019; FAO, 2018; Gregoire et al., 2019; Stramma & Schmidtko, 2019; Roxy et al., 2016; Gruber, 2011). This is envisaged to have negative consequences to Kenya's tuna fishery. Coral reefs, mangroves, and seagrass beds that provide important fish habitat and support coastal fisheries in the WIO region are already facing unprecedented stress from warming and rising seas, acidification, coral reef bleaching, and storms resulting in a decrease in their ecosystem services and knock-on effects on the reef fisheries, demersal fish stocks, and invertebrates (Altieri et al., 2019; Hoegh-Guldberg et al., 2017; Obura et al., 2017; Diop et al., 2016; Ateweberhan et al., 2011).

## Framework for leveraging the BE in Kenya

The development of Kenya's BE will require strategic planning and management frameworks which entrench good governance, relevant policies, and robust investment and financing regimes. This entails quantifying output from Kenya's ocean economy, putting in place enabling maritime policies, legal, regulatory and institutional frameworks, identifying and investing on priority blue growth sectors, investing in management and protection of marine natural assets, knowledge sharing and collaboration, and developing a strong human resource base and marine science capability.

(i) Measure the size of Kenya's ocean economy

What gets measured gets managed (Colgan, 2016; Golden et al., 2017; Patil et al., 2018) hence in order to inform the planning, investment, and monitoring process of Kenya's BE, basic measures of the ocean economy are required. Currently, there is lack of disaggregated data quantifying the economic and social value of Kenya's ocean-based industries except for the traditional industries of fisheries and tourism, and even here, the data is merged with other sectors. Lack of data restricts predictions of performance of envisaged industries which in turn complicates their management, monitoring, and investment levels (Colgan, 2016). It is recommended that the country should, as a first step, identify and quantify the output from each of its ocean industries using common indicators such as employment, turnover, and gross value added preferably using the United Nations International Standard Industrial Classification system (ISIC) (Colgan, 2016; ISIC, 2008). An ocean account should then be created at the Kenya National Bureau of Statistics (KNBS) which would provide a snapshot in time of the performance and contribution of each of the ocean industries to the overall national economy. Indeed, most of the countries who are leaders in BE development like China, USA, Australia, Canada, South Africa, Seychelles, etc. have evaluated their ocean industries and created national income accounts which they are using to inform development of the BE.

(ii) Identify and invest on priority growth sectors

In order to foster faster development, it is prudent to focus investment efforts on selected key BE sectors with potential high economic returns. The identified areas then become the main recipients of investment resources, research and development funds, and general sectorial support. In our view, the candidate sectors include marine and inland capture fisheries, aquaculture, blue tourism, maritime transport, shipping and ports, and marine biotechnology.

*Marine and inland capture fisheries:* Although Kenya's capture fisheries currently contribute less than 1% to the GDP, the sector is of great strategic value given the role it plays in employment creation, income generation, and contribution to food security. The sector directly employed over 100,000 Kenyans and supported livelihoods of over 2 million through fishing, boat building, equipment repair, fish processing, and other ancillary activities in 2016 (SDF, 2016). The sustainability of the two major inland freshwater capture fisheries of L. Victoria and L. Turkana is uncertain since their fish stocks

are declining due in part to overfishing, overcapacity, and eutrophication in the lakes. The fishery requires investment in the strict enforcement of climate resilient fisheries management regimes including appropriate and healthy fishing practices, controls on fishing effort, fleet size and mesh size, and protection of breeding grounds. These measures will give the dwindling fish stocks a chance to recover (Njiru et al., 2018; Rasowo, 2015; FAO, 2015, 1995).

The Indian Ocean is the world's second largest tuna fishery worth USD 2.3 billion per year out of which an estimated USD1.3 billion is caught in the WIO (Obura et al., 2017). Kenya's maritime territory is located within this tuna belt in the South West Indian Ocean and should put in place strategies to exploit this resource estimated to be between 150,000 and 350,000 MT per year if fully exploited (SDF, 2014). Presently, a few commercial fishing vessels owned by Distant Water Fishing Nations are given annual licenses through the Kenya Fisheries Service to harvest catches in the EEZ. Majority of these foreign vessels do not land fish in Kenya as per the mandatory legislation thus denies the country jobs and food security.

In order to increase production in the marine capture fisheries, GoK must invest on strategies that empower the artisanal fishers to transfer effort from coastal to offshore oceanic fisheries resources. This requires the purchase of bigger and more powerful fishing vessels and gear, re-training fishers on offshore fishing techniques and gear use. The use of technological innovations that attract the fish need to be embraced by installing networks of low-cost fish aggregating device to improve the offshore catches. Support to fishers in the form of capacity building on entrepreneurial and organizational skills as well as enhancing access to financing should be prioritized. Since private sector involvement is critical for the improvement of fishery catches, the GoK needs to share scientific and persuasive data regarding the potentials of offshore fishing with the private sector to encourage them to invest in offshore fishing as a profitable venture. KMFRI has the capacity and resources to undertake the task of providing the scientific data and ought to be the lead agency.

Adopting a value chain approach aimed at pinpointing the challenges along the chain will further boost overall inland and marine capture fisheries production. A value chain strategy helps decrease wastes and losses, explore new markets, and improves working conditions and management of fish stocks (Affognon et al., 2015). Fish post-harvest losses and waste along the value chain can be reduced through the development of cold chains as well as value addition by sun-drying, smoking, salting, and frying the fish. The GoK has rolled out plans to develop fishing ports with enhanced fish storage facilities at Shimoni, Kilifi, Liwatoni, and Lamu to compliment the main fish landing port of Mombasa. For best results and sustainability, capacity building of BMUs should best be carried out by first enhancing the management capacity of both national and county officers of fisheries. Lastly, the extension services need to be boosted and the roles of each player clarified in order to avoid the current confusing extension service structure undertaken by both KMFRI and KFS.

IUU fishing undermines legal fisheries and security of incomes and jobs in all Africa fishery states and must be combatted jointly by all port states through ratifying and enforcing the full implementation of the FAO Port State Measures Agreement (FAO, 2016c). The FISH-i Africa platform, which Kenya is a member, is an information sharing portal which supports due diligence on vessels in the deep-sea waters of the WIO to make sure that

vessels that have committed fishing crimes elsewhere are not licensed to fish in the waters of member States. All coastal and island states of Africa must be encouraged to be active members of this platform.

*Aquaculture*: Reports show that aquaculture production (almost exclusively freshwater) increased dramatically from 4452 MT in 2008 to 24,096 MT in 2014 due to the Economic Stimulus Program (ESP-FFEPP) wherein the government subsidized fish farming (KMFRI, 2017). The production dropped sharply to 18,656 MT in 2015 and further to 14,952 MT in 2016 following the end of the program (Kenya National Bureau of Statistics, 2017; KMFRI, 2017). Marine aquaculture production remains at only 1000 MT per year and is maintaining that level.

To revamp aquaculture production, fish farmers need to embrace the use of improved brood stock, quality, and certified seed, and up scaling the use of quality affordable domestic feeds for the fed aquaculture operations (finfish, crustaceans, and gastropods). The GoK should develop aquaculture business environment by promoting access to credit and insurance to the farmers, facilitate capacity building to produce skilled aquaculture labor force, develop a strong aquaculture research base, and promote access to both domestic and export markets (Chan et al., 2019). A comprehensive value chain approach to the aquaculture production together with strategies of attracting private sector investments must be put in place in order for the subsector to flourish faster (Costello et al., 2019).

*Blue tourism*: The tourism industry has been a major source of foreign exchange earnings and a significant contributor to Kenya's GDP. The actions needed to unlock the full potential of this sector is to diversify coastal and maritime tourism products and in particular promote eco- or nature-based tourism such as sport fishing, diving, boating, yachting in both the Indian Ocean, L. Victoria and the other lakes, rivers, and dams. The model followed ought to be community-based tourism whereby local communities control tourism activities and network by providing the basic services such as accommodation, tourism operator, and guiding (Tonazzini et al., 2019). Beach tourism continues to face competition from similar destinations in the world so in order to survive, Kenya needs to diversify the product to include culture and heritage. Together with this is the need to increase beach security, improve the cleanliness, and have functional lifesaving systems in the beaches.

*Maritime transport, Blue Shipping, and Ports*: Kenya is a key transport node linking the Indian Ocean with the land-locked countries of Uganda, Burundi, Rwanda, the eastern Democratic Republic of Congo, South Sudan and Ethiopia. It is, therefore, not surprising that its coastal port, Mombasa port, is ranked Africa's fifth busiest after Morocco's Tangier, Egypt's Port Said, South Africa's Durban, and Nigeria's Lagos (Anon, 2019). Quality seaport infrastructure improves cargo throughput, boosts trade, and enhances the ports international competitiveness (European Commission, 2019). GoK is investing on the provision of world class maritime infrastructure by upgrading and expanding its existing port facilities in Mombasa and Kisumu as well as renovating small fishing ports of Shimoni, Kilifi, and Lamu along the coast. Additionally, she is building a new deep-water seaport in Lamu which is part of a larger USD 25.5 billion infrastructure investment program known as the 'Lamu Port-South Sudan-Ethiopia Transport (LAPSSET)

corridor' and entails the building of the Lamu port, new roads, railways, pipelines, refineries, and airports in Kenya, South Sudan, and Ethiopia (Anon, 2019).

Simultaneously with improvement on facilities for loading/offloading ships, GoK has invested on roads and rail networks to ensure efficient movement of goods from the Mombasa port to the hinterland markets. An Integrated National Maritime Transport Policy has been developed aimed at strengthening the maritime transport sector through a range of interventions including enhancement of inland water maritime transport, localization of marine cargo insurance and the revival of the Kenya National Shipping Line (KNSL) (Marete, 2018). By owning a shipping line, the government's strategy is to benefit from the regional and global maritime value chain and make the cost of Kenya's goods more competitive.

An efficient port promotes economic competitiveness and growth by lowering logistical costs of moving goods while contributing to overall convenience of passengers. Statistics show that most African ports are far below the global average in shipping capacity and efficiency and have longer average turnaround times than any other region in the world (Benson, 2018; UNCTAD, 2018). The Kenya Ports Authority (KPA), the government body mandated to manage and operate ports in Kenya, is currently leveraging on a partnership with the Port of Singapore Authority (PSA) to help improve its efficiency and operational capacity. PSA manages the Port of Singapore which is one of the most efficient and busiest seaports in the world.

*Blue Biotechnology*: Kenya has five 'soda' lakes namely Bogoria, Elementaita, Magadi, Nakuru, and Turkana with the most alkaline being L. Bogoria and L. Magadi. Some of these soda lakes contain an array of unique micro-organisms which contain a range of chemical products that can be used in the pharmaceutical and biomaterials health care industries. A case in point is the giant International Biotechnology conglomerate that in the 1990s harvested a microorganism from L. Bogoria which was used to develop antibiotics and cleaning products from which they earned millions of US dollars at the expense of Kenyan researchers and the local community living around the lake (Wakali, 2017). Our view is that focused research on the resources of these soda lakes particularly the micro-organisms could fuel the development of a robust blue biotechnology sector in Kenya.

A robust biotechnology sector has the potential to contribute to Kenya's economic growth and employment creation while supporting environmental protection. It is noteworthy that the GoK has developed a comprehensive national policy to guide research and the commercialization of biotechnology products. The policy provides those developing and applying the technology with a clear framework under which to operate and commits the government to give priority to the provision of relevant institutional, infrastructural, and legislative framework.

(iii) Establish enabling Governance and Legal Frameworks

Most countries at the forefront of BE exploitation have marine specific legal frameworks, policies, plans, and strategies in place and Kenya can emulate and implement this as a best practice (National Marine Science Committee, 2015). Some of these structures and plans are already in place and only needs policy integration and proper synchronization. The constitution of Kenya (Republic of Kenya, 2010) specifies the right to sustainable environment as a fundamental right and freedom with Article 42 providing

for 'the right to a clean and healthy environment' which includes the right to have the environment protected for the benefit of present and future generations. Furthermore, Article 69(a) discusses the role of the state in ensuring sustainable development as well as the importance of equitably sharing of benefits derived from the environment.

The GoK has enacted several policies, laws, and plans which address diverse aspects of the BE such as the National Environmental Management and Coordination Act, Wildlife (Conservation and Management) Act, Fisheries Management and Development Act, Kenya Tourist Development Corporation Act, Maritime Zones Act, Forest Act, National Environmental Policy for infrastructure projects in the BE, National Ocean and Fisheries Policy, Forestry Policy and Wildlife Policy. Others include the Integrated Coastal Zone Management (ICZM) Plan formulated for the Kenyan coast, the Marine Management Plan, the Forest Management Plan specifically targeting mangrove forests and the Kenya National Tourism Blueprint 2030. The Nation's Third Medium-Term Plan (MTP III) contains the BE Sector Plan 2018–2022 encompassing fisheries, aquaculture, tourism, logistics, shipping, ports transport, and environment.

The State Department of Fisheries, Aquaculture and the Blue Economy guides policy and steers the research, innovation, and knowledge management for the fisheries sector (capture fisheries and aquaculture). To strengthen governance of the fisheries sector, the Fisheries Management and Development Act 2016 established institutions, namely, Kenya Fisheries Advisory Council, Kenya Fisheries Service, the Kenya Fish Marketing Authority, the Fisheries Research and Development Fund, the Kenya Fish Levy Trust Fund, and a Tuna Fisheries Development and Management Strategy. The mandate of these institutions is to strengthen the fishing industry and aquaculture and to enable investment along their value chains.

The State Department of Shipping and Maritime Affairs is responsible for the maritime and fishing industry, registration for ships and seafarers and human resource development. Kenya Maritime Authority (KMA) is the regulator of maritime affairs including safety, security, and certification of ships and seafarers. The Ministry of Environment and Forestry monitors land-based sources of pollution to the water bodies, while the Kenya Forest Service is mandated to manage the country's forest resources including mangrove forests. In addition, the Kenya Wildlife Service was created to conserve and manage terrestrial and marine national parks and reserves including the MPAs and LMMAs. The other players engaged in Kenya's BE include: Blue Economy Secretariat and BE steering Committee, Kenya Ports Authority, Agricultural Fisheries and Food Authority, Kenya Marine and Fisheries Research Institute, Kenya Coast Guard Service, Kenya National Shipping Line, Kenya Ferry Services Limited, Water Resource Management Authority, LAPSSET Corridor Development Authority, Mining and Oil Exploration Regulatory Authority, and Kenya Railways Corporation. Regionally and internationally, Kenya is a host/player in UNEP, Indian Ocean Commision (IOC), the Nairobi Convention, IOTC, UNCLOS, CBD, West Indian Ocean Marine Sciences Association (WIOMSA), FAO among a host of others and should, therefore, leverage on these linkages to develop its BE.

(iv) Invest in Effective Management and Protection of Marine Natural Assets

According to OECD (OECD, 2016, 2019), an integrated approach to ocean management is mandatory if sustainable exploitation of the oceans economy is to be realized. Several

science and area-based management tools have been recommended including ICZM, Ecosystem-Based Management (EBM), Marine Spatial Planning (MSP), and MPA. Area-based management means that different ecosystems are managed according to their particular needs (OECD, 2017a, 2017b).

MSP delivers integrated sector planning so as to reduce conflict and pressure on the natural resources as it defines spaces for industrial development, shipping lanes, fishers, marine aquaculture, tourism, energy, and marine reserves that separate conservation from other uses (Agardy et al., 2011; Ehler, 2008; Douvere, 2008; IOC-UNESCO, 2018). An MSP exercise is underway in Kenya which will describe the different uses and existing sectors operating in the country's marine area (MPAs, fisheries, navigation, tourism areas need, local communities engagement, and resource utilization), sites of potential conflict, choke points between the sectors, areas of blue growth, and eventually will provide a more integrated basis for management decision-making (Ong'anda, 2019).

The UN Environment Program (UNEP's) Blue Carbon Initiative promotes EBM and innovative financing instruments to help restore, protect, and manage degraded Blue Carbon marine ecosystems such as mangroves, seagrasses, salt marshes, and coral reefs in order to ensure that their carbon sequestration and storage functions are maintained (UN Environment, 2018). These coastal Blue Carbon ecosystems have the potential to mitigate climate change and help countries meet their international climate, restoration, and biodiversity commitments. Under the Paris Agreement on Climate Change in 2015, countries including Kenya, committed to develop a set of 'Nationally Determined Contributions' that will collectively limit global warming to 1.5°C through reduction of emissions of climate-changing gases by 30% by 2030. UNEP, KFS, KMFRI, and other partners recently launched the Vanga Blue Forests Project on the Kenyan coast to trade carbon credits from mangrove conservation and restoration. This builds on the success of a similar project, the Mikoko Pamoja, which has been trading mangrove carbon credits on the Voluntary Carbon Market since 2012. Mikoko Pamoja has been verified by the Plan Vivo carbon trading standard to sell 3000 tons of $CO_2$ per year over 20 years for about $5 to $6 a ton. The carbon credit proceeds go into financing more forest protection and restoration and to community-chosen projects.

(v) Embrace collaboration and knowledge sharing

The sustainable development of Kenya's BE requires partnerships and collaborations among countries, the national and county governments, local communities, private investors, industry, environmental organizations, academia, researchers, and global partners. Collaboration leads to coordinated efforts and the sharing of risks, costs and benefits of the various activities. Collaboration also improves sharing of information on which the country may base its decision-making while reducing the cost of obtaining the information. Likewise, collaborations and partnerships reduce the number of both the user-user and user-environment conflicts. Normally, governments are cautious about sharing data for fear of compromising commercial opportunities, however, this should not stop them from sharing metadata, so that more can be known about the data that exist and their quality hence prevent expenditure on collecting data that already exists. As a key founder member of the 21 member regional organization, the Indian Ocean Rim Association (IORA), Kenya should leverage on this membership to enhance collaboration within

the IORA member states as well as the dialog partners consisting of China, Egypt, France, Germany, Japan, the UK, and the US to boost the development of its ocean economy (IORA, 2014).

(vi) Invest in developing a strong human resource base and marine science capability

Sustainable exploitation of Kenya's oceans economy will require a pool of manpower with skills sets appropriate for the various technical and managerial fields in the maritime area (Siringi et al., 2019). In addition, the nation needs to generate and disseminate current scientific knowledge on its marine environment. Notably, the GoK has established KMFRI to undertake marine science research while Schedule 4 of the Constitution of Kenya 2010 on 'Maritime Navigation' has mandated KMA to develop the maritime sector through enforcing globally recognized MET. The education and training must ensure that the graduates are competent and meet the expectations of domestic and international employers as well as the regulators. This is to be achieved by providing practical exposure or apprenticeships and delivering the training in conformity to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) 1978 as amended (Ghosh, 2018; Ghosh et al., 2014; International Convention on Standards of Training Certification and Watchkeeping for Seafarers, 2017; Wei, 2013). Focused investment in these institutions is needed to guarantee they fulfill their mandate.

MET in Kenya is provided through programs at both universities and technical vocational education and training (TVET) institutions. Universities develop own curricula for degree-level courses as empowered by their respective charters. TVET curricula for maritime courses offered at craft, artisan, and diploma levels are, however, developed through a partnership between KMA and the Kenya Institute of Curriculum Development. Technical University of Mombasa (TUM), Jomo Kenyatta University of Agriculture and Technology, Mount Kenya University, Bandari Maritime Academy, Coast National Polytechnic and Railway Training Institute (TRI) Marine School Kisumu are among the major institutions involved in MET. Challenges these institutions face include shortage of opportunities for onboard training for students who complete shore-side training, shortage of lecturers and instructors with professional competency in maritime disciplines, and insufficient training facilities and equipment to enable students acquire the practical training to attain the competencies for STCW 1978 qualification and certification. Notably, TUM has the only Engine Room Simulator in the country while the Kenya Navy Training School has a simulation complex for navigation including a Full Mission Bridge Simulator. There is no training ship in the country. Teaching quality can be improved by sending lecturers and instructors for training courses abroad and initiating staff exchange programs to source teachers from abroad. In addition, the government should use its partnership with the Mediterranean Shipping Company, which owns both cargo and cruise ships, to provide practical shipboard training to the Kenyan rating, cadet, and officer trainees.

## Conclusion

With its geostrategic location in the Indian Ocean, a delimited maritime territory which is half the size of its land area, and a youthful population, Kenya has what is needed to transform into a maritime economy. The political goodwill from the current government is an

added advantage. It is noteworthy that the GoK has anchored the BE in the country's economic pillar of the Vision 2030 development blueprint specifically to achieve the food security and manufacturing targets. From the information collected in this study, Kenya already has sector-wise experiences and assets in place to implement the development of the BE.

The recent emergence of COVID-19 pandemic has heavily impacted all BE sectors and changed the landscape in ways that were unimaginable just a few months earlier. The restrictions on people's movements including curfews, lockdowns, suspensions of international, and domestic flights, and shipping has disrupted the supply and demand chain, shut down the entire BE and wiped out years of economic gains. Although we remain optimistic that the sector will soon recover and revert to the pre-pandemic level, close monitoring is needed to cushion the aspirations of the upcoming United Nations Decade of Ocean Science Development (2021–2030) from the effects of the COVID-19 pandemic.

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