Future Exploitation in the Western Indian Ocean

Possibilities for the region’s coastal states and island nations

2020:10

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Anthesis

2020-04-30

Report 2020:10

www.anthesis.se

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Background

Future ocean exploitation of Areas Beyond National Jurisdiction

A previous study made by Anthesis on behalf of the Swedish Agency for Marine and Water Management investigated future possible exploitation in international waters (Areas Beyond National Jurisdiction) where the following future activities were identified for the next 30-50 years:

- Marine research
- Offshore energy (solar, wind, wave power and ocean thermal energy (OTEC))
- Carbon capture and storage (CCS)
- Marine biotechnology
- Marine genetic resources (MGR)
- Human habitat (floating cities)
- Ocean plastic harvesting
- Mariculture: food production and biomass

This report is connected to the study. Its purpose is to make a case study of the Western Indian Ocean (WIO) area, exploring which of these activities are feasible in the area and what the conditions are for the region's coastal states and island nations to take economic advantage of the activities.

Preconditions in the Western Indian Ocean

The Indian Ocean is one-fifth of the total area of the world's oceans and is the smallest, geographically youngest, and the physically most complex of the world's three major oceans. It stretches for more than 10 000km between the southern tips of Africa and Australia and has an area of about 73 440 thousand square km. The WIO region refers to the waters adjacent to the mainland African countries of Somalia, Kenya, United Republic of Tanzania, Mozambique and South Africa, as well as the oceanic areas surrounding the island states of Madagascar, Seychelles, Comoros, Mauritius and the French Territories (Réunion, Mayotte, and the Scattered Islands). The WIO features warm tropical waters, coral reefs, seagrasses, mangroves and wide sandy beaches (Obura, et al., 2017)

The total population of the WIO region is estimated at 220 million, of which over a quarter (60 million) live within 100km of the shoreline. Cultures based on fishing, maritime trade and marine resource use go back several hundred years in many parts of the region but rapid population growth and geopolitical and cultural changes in the last 50 years have undermined traditional practices associated with the ocean.

The coastal resources and near-shore fisheries are under pressure as communities rely on those same resources for economic and food security as well as for their social and cultural identity. The population that directly impacts the coastal zone is estimated at over 130 million, as the drainage basins of the region's large rivers extend thousands of kilometres into the continent. Global trade also adds to the pressure on coastal resources such as fishing to supply markets on other continents. Moreover, more than 30 million people live on the islands of the WIO and the East African coastal communities who are dependent on the marine resources, goods and services. These resources are their primary source of livelihood and income and are under pressure from overfishing, overdevelopment, pollution, environmental degradation, and climate change (Obura, et al., 2017).

Topography of the Indian Ocean, especially the WIO plays a large role in determining what type of activities are possible in the area. At the same time, it is important to consider that the WIO is an area with strong tropical cyclones that can span over 1000 km in diameter (see Figure 1). The paths and location of the storms may change due to climate variables such as wind fields and sea surface temperature. Strong cyclones are the reason why building in shallow areas around Madagascar is complicated even if the long continental shelf would allow it.

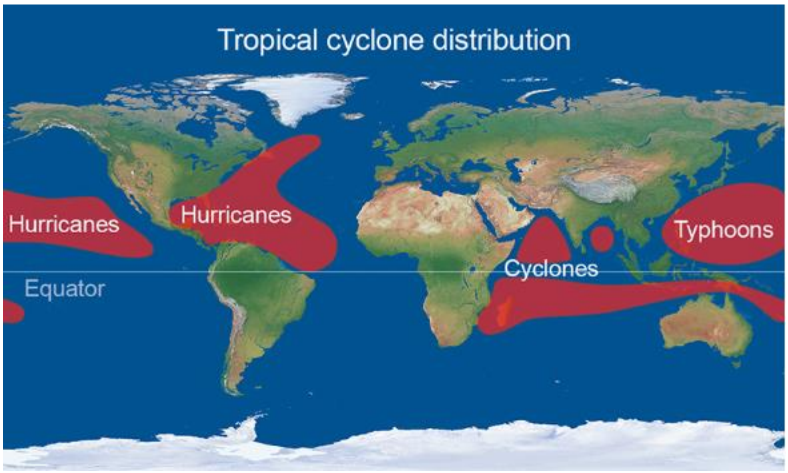

Figure 1. Tropical cyclone distribution (WMO, 2020).

Needs and future development in the area

The WWF have noted in their report 'Reviving the Western Indian Ocean Economy', a rapid increase in human populations, a high reliance on coastal and marine resources for living and livelihoods, and demand from distant markets as key pressures causing the overexploitation and degradation of coastal ecosystems. In 2015, the population in the WIO region was approximately 220 million, which is an increase of 280% since 1975. Future projections on population growth say that this growth will continue and in 2030 the population will have grown to 306 million, and quadruple by 2100 to 818 million. This growth is predicted to continue into the next century.

All nine countries in the WIO region rely on imports of oil to fuel power stations to generate electricity. For some countries, fossil fuels are the main source of energy. This dependence is notably for the smaller island states like Mauritius, Comoros, Seychelles and France (Mayotte and Reunion), but also Madagascar and even some of the larger mainland Africa states like Kenya. In Mozambique and South Africa, coal is the predominant source of energy for power stations, with hydropower also contributing significantly. The latter source is also important in Tanzania, contributing 49% of energy needs (Bosire, et al., 2015).

The development of the oil and gas extractive industry is occurring in a region (the WIO region) which is (i) world renowned for its biological diversity, (ii) supporting very important national, regional and international fisheries (mainly shrimp and tuna), and (iii) a growing and internationally renowned tourism spot in which the attractions of iconic natural features are enriched by cultural diversity and history. This area also supports (iv) important artisanal fisheries; (v) ports, which are not only important for the coastal countries, but also for the hinterland; (vi) important coastal agriculture; (vii) major industrial areas; (viii) coastal mining; (ix) coastal transport; and (x) important human settlements, which are directly dependent upon natural resources for their livelihoods. (WIOMSA, et al., 2012)

According to the WWF report 'Reviving the Western Indian Ocean Economy', the health of coral reefs are increasingly worsening due to warmer, acidified seas and increasingly frequent major climate-related events, in combination with the relentless increase in pressures from local human populations. The greatest impact of the decline of coral reefs, mangroves and seagrass beds is the loss of their ecosystem services, such as their function as a nursery for fish species. This loss of function translates into shrinking adult fish populations and declining fish catches. Other negative effects include decreasing biodiversity, shoreline protection and tourism value. Impacts on human well-being associated with the loss of these ecosystem goods and services include food insecurity and the loss of livelihoods, emphasizing the need for good management to maintain the health of ecosystems.

Sustainable development in combination with economic growth has been set out as strategic target for Africa in the Agenda 2063. The Agenda 2063 is a strategic framework for delivering on Africa's goal for inclusive and sustainable development and is developed by the African Union. The Agenda goals were set up and accepted on blue/ocean economy to accelerate economic growth – where marine resources, energy, port operations, marine transport, sustainable natural resource management and biodiversity conservation are priority areas. The goal and the priority areas will contribute to the 'Aspiration of A prosperous Africa' as is the name in the Agenda 2063, based on inclusive growth and sustainable development. The blue economy, and the sustainable use and management of water resources are included in the aspiration and shall contribute to growth, socio-economic development, capacity building, the inclusion of vulnerable populations (including island states) as well as unity and regional cooperation. The Agenda 2063 gives a framework and direction for the local governments in the Western Indian Ocean where some of the governments has gone further in developing strategies for a Blue Economy such as Mauritius and the Seychelles. The Seychelles has approved a National Blue Economy Strategic Framework and Roadmap where the goals are related to economic diversification and resilience. In this framework, an increase in GDP is derived from marine sectors with the creation of jobs, food security, climate resilience and the maintenance of the integrity of habitats and ecosystem services.

Economic aspects related to the Western Indian Ocean

According to the WWF report 'Reviving the Western Indian Ocean Economy', the annual "gross marine product" of the WIO region – equivalent to a country's annual gross domestic product (GDP) – is at least US$20.8 billion. The total "ocean asset base" of the WIO region is at least US$333.8 billion. These figures are derived from direct outputs from the ocean such as fisheries and services supported by the ocean like tourism and carbon sequestration. Tourism – coastal and marine – stands for the largest contribution to the economics with around 69% of the ocean output which in turn is around US$14.3 billion annually. The second largest contribution to the gross marine product comes from carbon sequestration (14% of the ocean output equalling US$2.9 billion annually) and after that fisheries (9.5% of the ocean output equalling US$1.9 billion annually). These values do not include any validation of other indirect values such as the ocean's role in climate regulation and temperature stabilisation, the production of oxygen, the social values in spiritual and cultural enrichment provided by the ocean or the value of biodiversity.

In absolute terms, the annual economic value may appear small compared with the global ocean economy estimated at US$2.5 trillion. However, it is important to view the region's economic context in three ways. First, several of the countries of the WIO are among the poorest in the world. Any economic contribution is important in alleviating poverty, so the ocean's annual contribution of US$20.8 billion is very significant. Second, this value is important in the context of the food and livelihood benefits that the ocean provides which are not captured in conventional economic analysis. Third, like its national economies, the region's ocean economy has growth potential if ocean and coastal assets are managed sustainably, starting from relatively low levels of development.

The WWF report also states that the loss of coral reef biodiversity and ecological function has severe consequences for countries bordering the WIO. Coral reef-associated fisheries sustain the livelihoods, food security and protein intake of many small-scale fishermen in the region. Furthermore, coral reefs are the primary asset for the coastal tourism sector, providing coastal protection, recreation areas and seafood worth US$18.1 billion annually. Tackling climate change is a global challenge and is key to protecting coral reefs. In addition to this, countries in the WIO region must take further urgent action to protect reef health. This includes decreasing threats to reefs under their control, such as destructive fishing and pollution, taking a proactive approach to improve reef conditions and identifying reef-specific management actions and options.

There have been relatively few studies on the economic and social impacts of climate change in the WIO with little consistency among methods and objectives. Nevertheless, those studies that do exist begin to give some idea of the scale of the impact of climate change. The economic costs to diving tourism in Zanzibar and Mombasa from the 1998 coral bleaching event, the worst bleaching event recorded in the WIO region, were respectively estimated at approximately US$2–3 million and US$10–15 million. The value of coastal assets in Dar es Salaam, Tanzania, exposed to a one-meter sea-level rise and more intense storms was estimated at US$5.3 billion. Sea-level rise of 43cm by 2100 could affect a projected 913,500 people in Tanzania, and 2,271,000 in Mozambique. The social impacts of climate change include the migration of people, often due to habitat loss and environmental degradation, and the loss of livelihoods. Climate refugees are likely to increase along the coastlines of the region, with significant repercussions on fisheries as they turn to fishing as a source of food (Obura, et al., 2017).

In the report 'The Oceans Economy – Opportunities and Challenges for Small Island Developing States' from the UN (Eugui, et al., 2014), a shift in the centre of global economic activity towards emerging and developing countries is projected to considerably increase the share of South-South trade in global trade within in the next two decades, resulting in significant increases in shipping in those parts of the world. Similarly, climate change and other environmental pressures are expected to influence the ocean environment in important ways as previously discussed. Lastly, the legacy of largely sectoral approaches to ocean governance, at the expense of more holistic solutions, promises to remain a serious impediment to efforts aiming at more integrated ocean management.

Trade in marine products can create opportunities for economic growth, export diversification and new investments. Moreover, as technology evolves and marine resources become more accessible and their use more feasible, new economic and trade sectors are also likely to emerge, potentially generating new job opportunities. Major trade sectors where opportunities already exist or could be found in the near future include sustainable fishing and aquaculture, certain marine transport services, port management, marine renewable energy, marine bio-prospecting and biotechnology, regulated sea-bed mineral resource extraction and maritime and coastal tourism (Eugui, et al., 2014).

Possible economic advantages of future exploitation

It is impossible to say with any degree of confidence how the drivers mentioned above will eventually interact to create the future of the WIO in 2030/50. However, with indications and trends such as climate change, a significant increase in population growth and urbanisation, food security issues and sustainable energy provision, some of the described activities below could offer important opportunities for the region's coastal states and island nations.

The activities in the previous study on possible future exploitation in the Areas Beyond National Jurisdiction in 30-50 years has been discussed in interviews with Jesper Vasell, KTH (Vasell, 2020) and Lena Gipperth, GU (Gipperth, 2020). The activities have been assessed in order to see which type of activities are possible in the WIO area and what the conditions are for the region's coastal states and island nations to benefit from economic exploitation.

Research

The marine research in the WIO is strengthened and intensified by the organization WIOMSA – Western Indian Ocean Marine Science Association. The organization is a regional non-governmental, non-profit membership organization promoting the educational, scientific, and technological development of all aspects of marine science throughout the region. This is with a view towards sustaining the use and conservation of its marine resources. WIOMSA especially focuses on linking the knowledge from research to the management and governance issues that affect marine and coastal ecosystems in the region.

WIOMSA work in the following five broad programmatic areas:

- Capacity building
- Scientific research
- Information dissemination and communication
- Partnership/networking
- Resource mobilization

WIOMSA play a very important role in developing and spreading the knowledge about the ecosystems in the ocean and stimulate the sustainable development in the area. As the interviewed experts clearly points out – the organisation helps the region in intensifying the research and competence around the issues of marine science, but also in adjacent areas such as ecology, biology and socio-economic issues.

The future marine research in the area will most surely have a starting point in the WIOMSA-organisation according to our interviewed experts. According to (Kelleher, 2019) WIOMSA cover activities within ocean literacy, knowledge exchange, targeted research, and a science to policy interface which is an important part of developing and driving the research in the region. Through WIOMSA and its partnerships and network a large number of stakeholders are included which brings credibility to the activities.

Innovations in advanced materials, underwater technology, sensors, image processing, satellite technology, computerization, big data analysis, autonomous systems, biotechnology and nanotechnology - all sectors of the marine economy - are expected to be affected by these technological advances. (OECD, 2016)

Offshore energy and storage

The world's demand for renewable energy is expected to increase by 250% by 2035 as written in the report Oceans Economy – Opportunities and Challenges for Small Island Developing States (Eugui, et al., 2014). The generation of renewable energy from tides, waves, wind turbines located in offshore areas, submarine geothermal resources and marine biomass could be viable alternatives for contributing to energy needs and climate change mitigation objectives. For island states, such renewable energy sources could help diversify their energy portfolios and secure higher levels of energy security.

Marine renewable energies have a huge potential in the WIO region to increase the general availability of energy and to support energy security, especially in countries that have a heavy dependency on oil imports and other non-renewable sources. The biggest constraints on these alternatives currently are the levels of technology development, the cost, and garnering political support for investments (Attri & Bohler-Muller, 2018).

The WIO region is working actively to stimulate the development of Offshore energy. Measures to promote offshore renewable energy include investment incentives, public private partnerships, opening access to the electric grid and technology transfer. Many of the countries also consider Marine Spatial Planning (MSP) which can be an important governance measure to include stakeholders through participatory planning and avoid conflict of interests as well as minimise negative ecosystem impact to stimulate investment leading to sustainable growth. With MSP environmental impacts can be considered in decisions and permits so that negative impacts can be minimized regarding changes in coastal currents and topography, mortality of fish and seabirds, underwater noise and habitat change as result of for example OTEC wastewater. (Kelleher, 2019)

In their book, Attri and Bohler-Muller have identified different types of marine energy sources that would be suitable in the WIO area (wave power, OTEC, tidal barrage, tidal current, ocean current). According to them, wave power and OTEC would have the most potential in areas such as the Seychelles, Mozambique, Madagascar, Mauritius, southern Tanzania, Comoros and Mayotte. In addition, they add that there are already several ongoing projects on renewable offshore energy but these are mostly in experimental and pilot stages (Attri & Bohler-Muller, 2018). Hammar, et al. (2012) add in their report that the potential for tidal power and ocean current power are more restricted in the WIO area but may have potential at some locations.

Wind power has been considered to have limited opportunity for development in the WIO area due to the weather conditions including the cyclones described earlier which removes many of the areas for possible exploitation

Wave power

Wave energy converters capture the energy contained in ocean waves and use it to generate electricity. There are three main categories of converters; oscillating water columns that use trapped air pockets in a water column to drive a turbine; oscillating body converters that are floating or submerged devices using the wave motion (up/down, forwards/ backwards, side to side) to generate electricity; and overtopping converters that use reservoirs to create a head and subsequently drive turbines.

Due to the limited commercial experience, the estimates for the levelized cost of electricity (LCOE) of wave energy technologies in 10 MW demonstration projects is in the range of EUR 330-630 per megawatt-hour (/MWh). However, there is considerable scope for economies of scale and learning, with the projected LCOE for wave energy in 2030 estimated to be between EUR 113-226/MWh if deployment levels of more than 2 gigawatt (GW) are achieved (Kempener & Neumann, 2014).

Opportunities and barriers regarding wave power in the WIO include (Hammar, et al., 2012):

- Allows for considerable energy extraction
- The resource may be of interest for both large-scale generation and micro-scale applications for remote area electrification and desalination purposes
- Occurrence of tropical cyclones in southern WIO would restrict the number of suitable sites.

La RéUnion is one of the pioneers in wave power and had a prototype in use as well as plans for expansion in two further steps with a 2 MW facility and a 15 MW facility in the third stage (Royer, 2015). The installation however was swept away by a cyclone in 2014 and caused damages on the island (Parkinson, 2014).

Floating solar energy

Solar energy has a huge potential in this area but so far it has mainly been exploited on land. Considering solar power based in the sea, floating applications are seen as a promising technology. The Seychelles are already exploring the technology where a floating solar panel facility will be installed in Mahé Island's Providence Lagoon. The facility is expected to have a capacity of 3.5-4 MW, reducing carbon emissions by over 3 500 tonnes/year.

Floating solar power technology can be a future possibility, but solar power will most certainly be exploited on land first. However, this technology could be combined with other renewable energy technology like Ocean Thermal Energy Conversion (see description in the next section) when constructing multi-tech- energy farms to utilise the infrastructure investments in a more efficient way.

Total capital expenditures for turnkey floating PV installations in 2018 generally ranged between USD 0.8–1.2 per Wp (figure 4), depending on the location of the project, the depth of the water body, variations in that depth, and the size of the system (World Bank Group, ESMAP and SERIS, 2018).

Figure 2. Near-shore floating installations in the Baa Atoll of the Maldives (World Bank Group, ESMAP and SERIS, 2018).

Ocean Thermal Energy Conversion (OTEC) and Deep Ocean Water Applications (DOWA)

Ocean thermal energy conversion (OTEC) uses the temperature difference between warm surface water and cold deep seawater to generate electricity. Warm surface water is pumped through an evaporator containing a fluid that vaporizes and drives a turbine/generator. The vaporized fluid is turned back into a liquid in a condenser cooled with cold ocean water pumped from a greater depth. Depending on conversion principles, desalinated water may be collected as a by-product.

A handful of initiatives are being designed and implemented in the field of Deep Ocean Water Applications. One example is Mauritius, which is implementing activities within its oceans economy's national strategy. The private sector-driven initiative has two different categories of activities: upstream and downstream. Upstream activities are of interest in the area of renewables, since they focus on the extraction of deep-sea water for commercial applications and green cooling of buildings. Downstream activities would include other related services such as eco-tourism where certain hotels are already incorporating photovoltaic panels for energy generation (The Oceans Economy).

Opportunities and barriers with OTEC in the WIO include ((Hammar, et al., 2012):

- Low variation
- Predictability of power generation from the energy source
- Environmental impacts of OTEC are not fully known
- Technology needs to be developed more to be interesting for small island countries

Energy storage

Energy storage offshore is a possibility to solve the problem of intermittent renewable energy production meaning that the full potential in the renewable source can be utilised. Different solutions for energy storage have different energy carriers but often hydrogen is mentioned. Mechanical resistance can also be used as an intermediate carrier. Energy storage would probably be needed to enable the full potential of solar, wave, tidal and current power technology.

Carbon Capture and Storage

Carbon Capture and Storage is closely connected to oil and gas industry. In the WIO region all the countries have negotiated or are negotiating offshore oil or gas exploration contracts, and several have negotiated production contracts/ concessions where South Africa, Mozambique and Tanzania are active producers. The sector is seen as a growing opportunity for economic growth in the region but with climate change and carbon dioxide emission connected to the utilisation of the fossil fuels it is a controversial issue regarding sustainable development. While regional cooperation on oil and gas can be useful, countries are also in competition for investment. Nevertheless, cooperation and sharing of experiences in negotiating and managing offshore hydrocarbon contracts is an area which could yield substantial mutual benefits and could include sharing of information on the performance and corporate social responsibility of offshore contractors or investors active in the region. (Kelleher, 2019)

The countries with a coastline bordering the WIO are just starting to consider CCS-technologies, as *Figure 3* shows. It can be seen in this figure that South Africa has made the greatest progress in this field and was reported in 2014 as 'Making progress' with strong storage prospects. Earlier reports from the Global CCS institute imply that Kenya also have considered CCS but are just starting development in this field. To be considered 'storage ready' a country has to meet a series of criteria including a strong knowledge of storage resource, applied research and development programs and achieved deployment of actual injection projects.

The results from an assessment of CCS potential in South Africa published in 2010, concluded that the majority of storage potential occur in the Mesozoic basins of South Africa with app 150 Gt of theoretical storage capacity identified, of which 98% occurs offshore. (Chabangu, et al., 2014)

Offshore storage started in early 70s but is still an unexplored technology where one of the first offshore carbon capture networks is being developed in Norway. Just recently, the project called the Northern light, have completed the first well and are evaluating the data to see how the injection of CO_2 can be secured. (Snieckus, 2020)

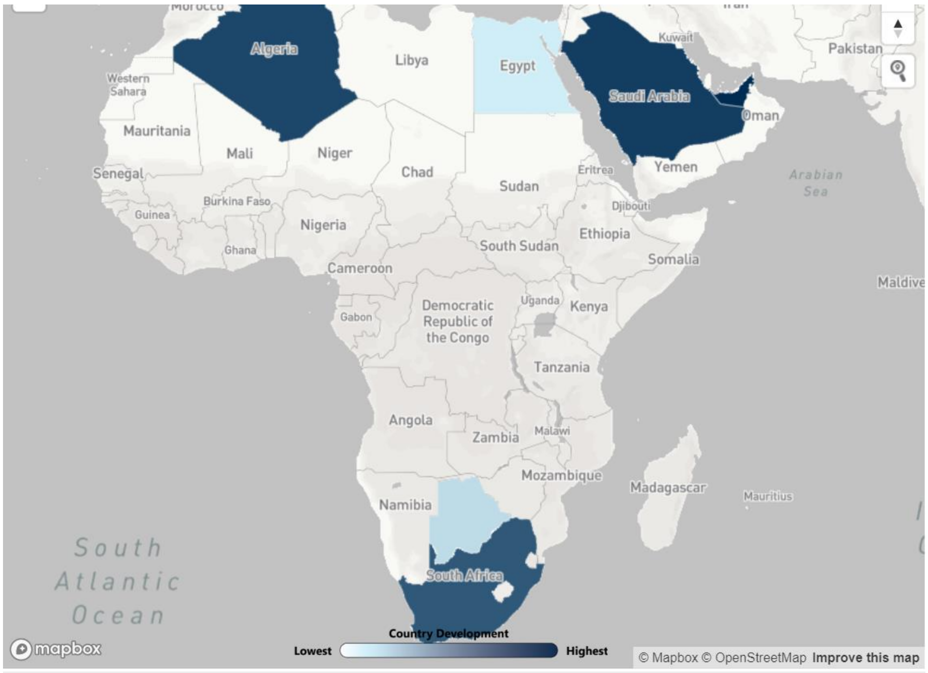

Figure 3. CCS Readiness index (Global CCS Institute, 2019). The CCS readiness Index actively monitors the progress of CCS deployment. The index tracks a country's requirement for CCS, its policy, law and regulation and storage resource development.

CCS will be an increasingly important and necessary option for many industrial sectors, such as steel, cement, and chemicals. Many of these sectors do not have any alternatives for reducing their emissions aside from CCS as carbon dioxide is generated in the process (as well as the fuel they use). The ability of CCS to be developed in these sectors will therefore help maintain many of these vital industries in the UK and elsewhere, making a significant contribution the local economy, and helping to retain a large number of jobs. The CCS association has shown in studies that CCS could create 100,000 jobs across the UK by 2030, contributing £6.5 billion to the UK's economy. (Association, 2020).

There is a large amount of data and case studies available on potential job creation from CCS in the power sector. Taken together, these paint an impressive picture with a range of 1000-2,500 jobs created during plant construction (typically four to six years) per power plant CCS installation. Most of the jobs are created in the construction phase but some jobs will remain, in operating and maintenance of the plant (TUC, 2014).

Many studies are connected to the construction and implementation on CCS technology for power plants and not separately for the storage of the carbon dioxide. However, if the potential areas for storage in the region stated by (Global CCS Institute, 2019) are utilised, the countries with a high percentage of coal fired plants as well as steel, cement and chemicals industries, could benefit from increased job opportunities with deployment of the CCS technology as a whole system.

Marine biotechnology and marine genetic resources

By 2025, the global market for marine biotechnology is projected to reach $6.4 billion, spanning a broad range of commercial purposes for the pharmaceutical, biofuel, and chemical industries (Blasiak, et al., 2018). Marine genetic resources are found throughout the oceans, although species richness and diversity tend to be higher closer to land.

Patents making direct use of marine genetic resources have grown significantly over the past 10 years, with about 10,000 patents published in peak years (see Figure 4). It is highly probable that most cases of access and use to these resources may have not been granted by national authorities when falling within the EEZ, thus probably leaving the patent applicant as the sole collector of benefits. This is confirmed by the fact that there are very few cases of ABS (Access and Benefit Sharing) contracts on marine resources and even fewer ABS laws specifically dealing with marine genetic resources (Eugui, et al., 2014).

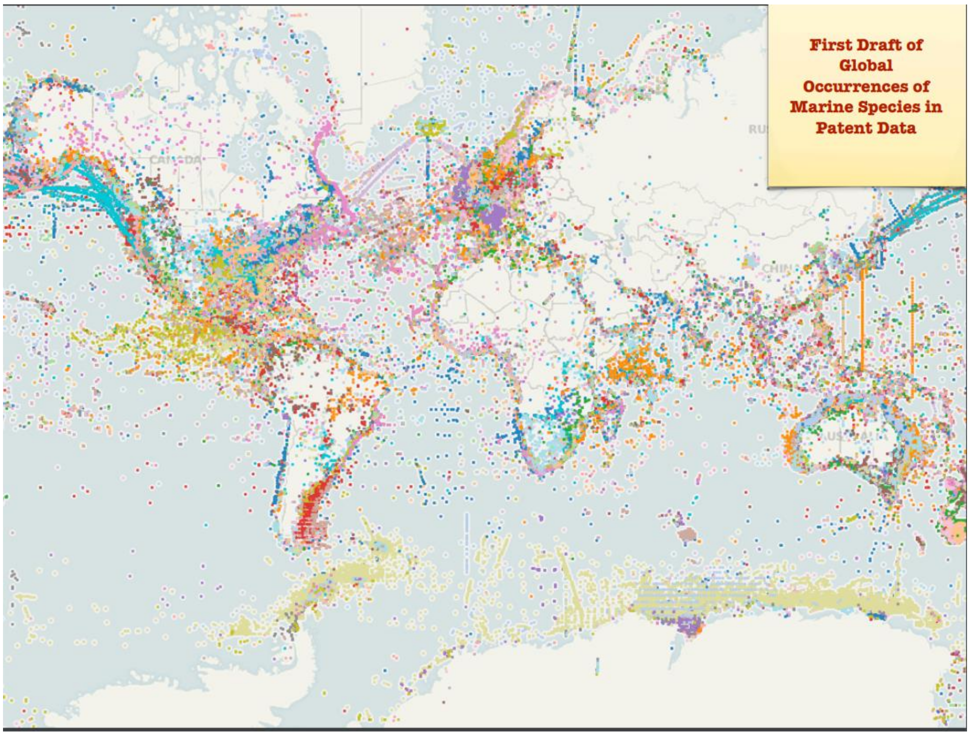

Figure 4. Patent data applied for based on marine species (Oldham, et al., 2013).

In their research article, Blasiak, et al., (2018) reveals how a single company has registered half of all existing patents associated with genes from marine species and that only 10 countries accounted for 98 percent of the patents.

The WIO region is characterized by high diversity in both species and ecosystems, which ranks it as one of the world's richest ocean areas encompassing the world's second richest marine biodiversity hotspot. Coral reefs, mangroves, salt marshes, seagrass beds, as well as pelagic and deep-sea habitats generate high biodiversity and productive waters which in turn support economies and livelihoods (Obura, et al., 2017).

Floating cities

Floating cities are considered as a possibility in the main study for ABNJ to increase the area of habitable space. This space is needed due to population growth, sea level rise, and migration. In some cases, floating cities are wanted to escape national regulation. Considering the WIO, floating cities are not seen as an opportunity. In conversations with interviewed experts, the exploitation in the area regarding this development could be in connection to urban development, however it would make no sense since there is enough space to grow the coastal cities on land. One potential use however was in connection to port development, where floating infrastructure could be of interest to address environmental issues such as direct loss of coastal habitats. Floating infrastructure could be of interest to mitigate the negative environmental impacts which can be caused by exploitation, yet still give the opportunity to develop the important infrastructure.

Politically, the Indian Ocean is becoming a pivotal zone of strategic competition. China is investing hundreds of billions of dollars in infrastructure projects across the region as part of its 'One Belt One Road' initiative.

For instance, China gave Kenya a US$3.2 billion loan to construct a 470 kilometre railway (Kenya's largest infrastructure project in over 50 years) linking the capital Nairobi to the Indian Ocean port city of Mombasa (Jeffrey, 2019).

Ocean plastic harvest

Africa has a low plastic footprint with an average plastic consumption per capita of 16 kilograms per year, compared to more than 100 kilograms per year in the US and Europe. However, the region, is still highly affected by the plastic pollution. Figure 5 shows how the mismanagement of end of life plastics in specific countries, results in just 10 rivers transporting 90% of the river-borne waste into the ocean, where it accounts for almost a quarter of marine plastic litter. It also shows how the ocean's currents form 'trash-mountains' of plastic by moving the materials into specific geographic regions and bays in which they accumulate. Research suggests that only 1-2% of the plastic entering the oceans remains at the surface where it could, in theory be recovered.

The Indian plastic trash mountain:

- Location: the Indian Ocean eddy.
- Size: between 2.1 and 5 km2.
- Characteristics: this waste has been associated with the deaths of a range of species such as sea turtles and birds.

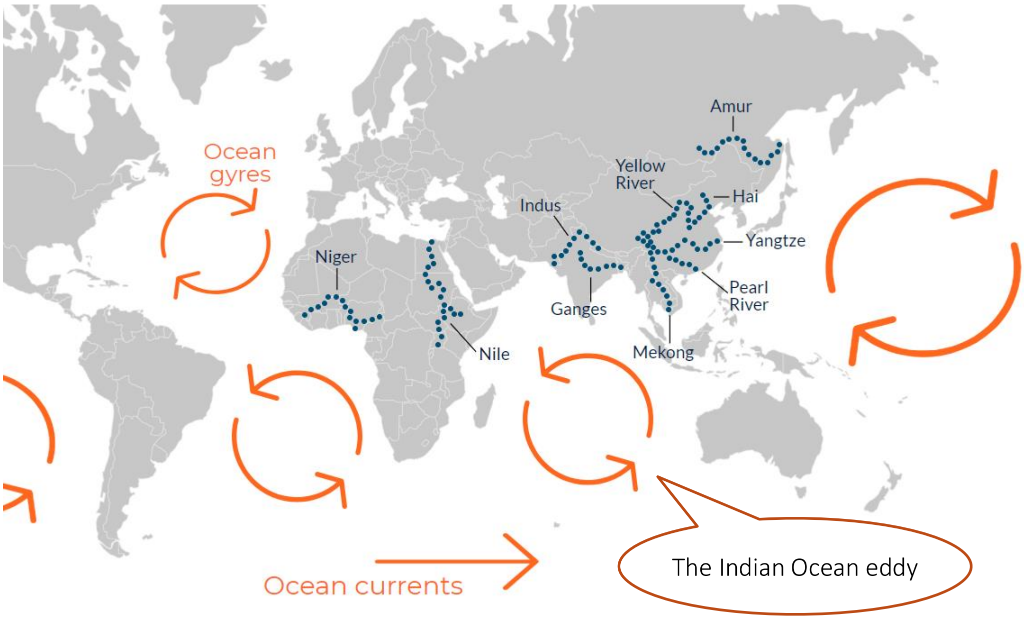

Figure 5. Movement of river-borne plastic waste into the oceans (Simpson & Hitchen, 2019).

The countries in the WIO area derive more than 22 billion US dollars of marine goods and services from the Indian Ocean annually through fisheries, trade, and tourism, which are sectors threatened by plastic pollution. That makes marine litter a serious problem in most coastal urban centres within the WIO. Suspended solids from municipal wastewater in coastal areas of the WIO region is estimated to be more than 97,000 tons per year, with major land-based sources being, solid waste dumpsites, surface water runoff, and public litter on beaches and other coastal areas. For the WIO, there are business opportunities within the plastic value chain seeing that less than five per cent of plastic material is recycled in the WIO with only South Africa, the Seychelles and Mauritius having formal programmes for recycling plastic waste.

Kenya has the most severe penalties in the world for the sale and use of plastic bags, with fines of up to $40,000 and a jail term of four years. Several other African countries like Rwanda, Mauritania and Morocco have also banned the use of plastic bags in their countries. The case of Kenya's plastic bag ban is in this regard enlightening on the critical socio-economic dimension of the plastic issue. In light of the Continental Free Trade Area (CFTA) which brings with it, opportunities for economic transformation across the continent, the CFTA creates new opportunities beyond national borders. The regional economic dimension is also highly important in terms of the coordination of efforts. The CFTA will enable companies and manufacturers to expand their operations into neighbouring countries to gain from favourable opportunities and link to new distribution networks. Without a regional approach, manufacturers facing stringent plastic bans may be tempted to explore options to shift their operations to countries where such regulatory restrictions are not yet developed. This will undermine progress in countries trying to tackle the plastics pollution problem as they may face illegal entry of banned plastic commodities.

The IUCN[1] is working with businesses to help them improve their understanding of their plastics footprint. This requires metrics and indicators which currently do not exist. To address this gap, the IUCN is working with footprint and life cycle analysis experts and businesses to develop a plastics footprint calculator to help businesses close the plastic loop by consolidating data, quantifying scales of plastic flows, and developing solutions to guide decision-making.

To this end, the IUCN has initiated multi-stakeholder dialogue processes to explore how to shift towards national circular economic models considering the entire lifecycle of plastics in order to 'close the plastic tap'. With the IUCN initiative MARPLASTICCs, cooperation with the private sector is manifold, supporting platforms for fostering leadership and innovative solutions and actions, as well a better understanding and assessment of the plastic footprint and stimulation of corporate stewardship.

The countries in the WIO area can address their problems with plastic pollution by creating business opportunities through circular economy models. The area can increase recycling rates and use plastic material in a better way whilst still maintaining a low plastic consumption.

To support that opportunity, the WIO countries can selectively apply some of the EU initiatives, which are considered has the most advanced suite of measures stipulated in the Circular Strategy. The most important according to the summary made by Kelleher, 2019 would be to build a single regional market for recycled plastics. A way forward in doing so could be to establish a common tariff scheme for single use plastics and plastic products with low or no recycled content. This could support the economies and stimulate recycling and waste source separation as well as promote regional manufacture of substitutes for single-use-plastics and products using recycled plastic. Possible future trade measures may be required that specify recycled content in plastic products and extend to controls over international trade in plastic feedstock. These latter measures would require development of standards, criteria and compliance mechanisms, such as the on traceability and certification of recycled raw material. (Kelleher, 2019)

Mariculture: food production and biomass

Fish and fish products are an important sector of global trade. In 2013, total world exports of fish and fishery products were estimated to reach US$136 billion, showing an average of a 12 per cent annual increase over the previous 10 years. Most of these exports are driven by the demand in developed countries, which account for more than 75 per cent of global fish imports. It is anticipated that demand from Asia will grow at a rate comparable to that of demand from developed country markets. This is

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[1] The International Union for Conservation of Nature

partly the consequence of shrinking fisheries stocks available in the neighbouring seas of industrialised countries due to excessive exploitation over the last 200 years.

According to the WWF (Obura, et al., 2017), fisheries represent the largest asset of the WIO, with their value estimated at US$135 billion, or 40% of the total natural assets of the WIO. This matches the conventional wisdom in the region of fisheries being the largest contributor to ocean wealth and emphasizes the need to see fish stocks as capital from which to draw from sustainably for the long term, rather than to be exploited to the maximum in the short term. Beyond these numbers, there are also more intangible benefits of the WIO such as security (of livelihoods, food, etc.), spiritual and cultural enrichment, climate regulation and recreational value. These benefits should also be acknowledged and taken into policy consideration, even if these benefits cannot yet be effectively captured in classical economic analysis.

Small-scale fisheries are difficult to value but nonetheless important to human well-being. Much of the catch from small-scale fisheries in the WIO is not sold in markets, and the high dependence on fish protein of some vulnerable demographic groups goes beyond current valuation methods. Local fishing is also important in maintaining social cohesion in coastal communities. The small-scale fisheries are critical in supporting livelihoods, food availability and to secure income, particularly for the poor living by the coast. Fishery resources are traditionally viewed as public goods and characterized by open access, and so have often been poorly managed and sustained (Obura, et al., 2017).

Mariculture is a specialized area of aquaculture, focused on the production of marine species in seawater, and is less developed than freshwater aquaculture. Three of the WIO countries produce mariculture products – Tanzania, Madagascar and Mozambique. Tanzania primarily produces seaweed for commercial uses which is over 90 % (by weight) of the region's mariculture products. The value of the produced seaweed is very low being valued at 10 % of other seafood products. These three countries have prawn farming at an industrial scale, but this is still a low level compared to international norms. Other farmed marine species include finfish, shellfish and sea cucumbers.

Labour-intensive methods and sales to local markets can build livelihoods for tens of thousands people and enhance food security in local households. Efforts to develop livelihood-oriented mariculture are spread throughout the region, as in Madagascar with sea cucumbers, Kenya with mangrove crabs and Tanzania with seaweed. Governments, non-government organizations (NGOs) and donors are investing significantly in research on species and methods for mariculture, developing hatcheries to overcome insufficient seed stock for most marine species, and promoting reliable market links.

There are significant barriers to mariculture development with the lack of technical expertise, environmental and disease problems as well as a market with few buyers lowering the economic viability of production. Nevertheless, mariculture represents a significant opportunity for future food security, livelihood development, and relieving the pressure on overexploited coastal and marine resources. Systems need to be developed to ensure that ecosystems are not undermined and adopted to local governance and security to be sustainable. (Obura, et al., 2017)

The use of algae as biomass for energy production also offers promising opportunities for the future development of the second and third generations of non-food-based biofuels. Production of algae biomass could be done through sustainable aquaculture, generating jobs and new value chains that could also cover algae for food consumption. Algae use for biofuel is expected to increase during the coming decade. Marine biofuel production could also be complemented with the use of bagasse or coconut wood (by-products of sugar cane and copra not used for food) for the production of electricity. The local production of algae biofuels could be particularly useful in reducing import dependency on fossil fuels for local transportation and electricity generation. This can have positive effects on the trade balance for countries that are dependent on fuels for the generation of electricity (Eugui, et al., 2014).

Conclusions

There can be no healthy economic future for the countries of the WIO without protecting and restoring the ecosystems and habitats that underpin industries like sustainable fishing and tourism. Building climate resilience is also a key concern for WIO countries. The Intended Nationally Determined Contributions (INDCs) submitted by the regional countries to the United Nations Framework Convention on Climate Change (UNFCCC) contain references to building resilience in many sectors as well as commitments to reduce carbon emissions and build up carbon sinks through natural (including coastal) assets. The region's relatively intact coastal ecosystems provide an important advantage in this area (Obura, et al., 2017).

Mauritius launched its first oceans economy roadmap in 2013, which seeks to take advantage of the immense economic potential of the oceans. The roadmap places an emphasis on the need to make use of the untapped value locked up in the EEZ by ensuring the sustainable and coordinated utilisation of living and non-living resources. Sectors of interest include tourism, seaports, and seafood-related activities. In order to advance the roadmap's priorities, a national public-private task force as well as an oceans business park and an oceans research centre will be created. This new institutional set up will be complemented and supported by a comprehensive regulatory review of the ocean's economy.

Another aspect that is important to consider in the WIO region, is who owns future exploitation projects and who has a right to the resource. One of the interviewed experts stressed in the interview with Anthesis that it is important to protect local communities from big international companies who would extract the local resources and take the profit.

Combining the future trends, coming needs and the potential of the described activities in previous sections, the following possibilities are considered to be the most promising for the nations and states in the WIO to take economic advantage of:

- Research
- Offshore energy
- Marine genetic resources
- Mariculture
- CCS

Research

One of the recommendations in 'The Oceans Economy in 2030' (OECD, 2016) report to boost the long-term development of emerging ocean industries and their contribution to growth and employment, was to promote increased international cooperation in marine science and marine technology and strengthen integrated maritime management. This could create possibilities for increased innovation and develop the organisational related issues concerning marine management. In the context of the WIO, this is enabled through the WIOMSA organisation, which emphasizes cross-border cooperation. WIOMSA utilises its platform that has been built up for a long time in networking and exchange of views and experiences which is recommended in the report.

Offshore Energy

Many of the countries in the WIO have low energy security with an increasing energy demand. Here, renewable offshore energy could have a large impact on the possibility for economic growth. By becoming more self-sufficient in producing local sustainable energy, local businesses have better opportunities for development. A joint investment framework, targeted consumption subsidies and the creation of regional renewable energy authorities and companies could prepare the region for attracting investment and the deployment of pilot facilities. Additionally, it could promote environmental goods and services related to energy generation and efficiency, as well as ensuring their availability, making the acquisition of inputs more affordable (Eugui, et al., 2014).

Marine genetic resources

With the high levels of biodiversity within the WIO and as patent registration has shown the potential for marine genetic resources are large, the challenge remains on how to exploit this potential. Only a few companies are active in patenting, as are a few countries. huge potential of MGR in WIO lies in its coral reefs, mangroves, salt marshes, seagrass beds, as well as pelagic and deep-sea habitats. However, research is crucial as developing innovations that can be beneficiary to local business development to support economies and livelihoods.

Mariculture

According to the WWF (Obura, et al., 2017), fisheries represent the largest asset of the WIO, with their value estimated at US$135 billion, or 40% of the total natural assets of the WIO. As the demand for fish continues to grow and the availability of wild-capture fish decreases, there will be a greater role for aquaculture to enhance the wild capture supply and ensure that wild stocks within EEZs of small island developing states are conserved and well managed (Eugui, et al., 2014). The key is to develop small-scale fishing into a more sustainable sector using mariculture as an opportunity. However, today there are significant barriers to mariculture development with the lack of technical expertise, environmental and disease problems as well as a market with few buyers lowering the economic viability of production that needs to be overcome.

CCS

The carbon capture and storage sector is growing due to climate change and the need to reduce carbon dioxide levels. There are some geological formations suitable for storage for example off the coast of South Africa and Kenya. South Africa is one of the pioneers in the technology having a few pilot and demonstration projects. In combination with explorations in oil and gas, this is a promising possibility for developing both businesses and job creation, as well as contributing to reductions of greenhouse gases in the atmosphere.

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