CLIMATE CHANGE IMPACT ON THE OCEAN ECONOMY AND POLICY IMPLICATIONS FOR SOUTH AFRICA

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ABSTRACT

In South Africa, the ocean economy is generally defined as all economic activities that are linked to the oceans natural resources and environment. These activities include marine aquaculture, fisheries, marine transport and manufacturing, offshore oil and gas exploration, coastal and marine tourism, and small harbours. Studies have shown that climate change has remarkable impacts on the ocean economy in general, and particularly economic activities discussed in this paper to varying degrees. Climate change presents a tangible threat to sustainable trade and development, and will impact on the potential of the ocean economy. The ocean economy could contribute to the economic growth of South Africa and have reciprocal impact across businesses, government and society. Ocean economy and climate change are constructs that are multi-dimensional in essence, and span a range of public policy domains. Achieving the full potential of the ocean economy whilst simultaneously mitigating the knock-on impact of climate change requires a horizontally integrated public policy framework. Policy development should be cognizant of the need for adaption and mitigation and needs to be inclusive of a broad spectrum of stakeholders, notably government, business, and communities.

INTRODUCTION

Climate Change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (as defined in the United Nations Framework Convention on Climate Change - UNFCCC). In IPCC (Intergovernmental Panel on Climate Change) usage, Climate Change refers to any change in climate over time; whether due to natural variability or as a result of human activity that alters the composition of the global atmosphere, and that is in

addition to natural climate variability observed over comparable time periods. The Ocean Economy is generally defined as all economic activities that are linked to the oceans natural resources and environment and/or are dependent to a degree on the ocean. Its projected value by 2030 amounts to USD 3Trillion, and an estimated 23% of humankind's carbon emissions are absorbed by the oceans (UNESCO Ocean Action, 2021), making climate change and ocean economy globally significant. Fisheries and aquaculture, marine and coastal tourism, offshore extractive industries and other ocean-based industries have been estimated to generate a value of US$296 billion and support 49 million jobs (African Union Strategy and Action Plan report, 2022).

Both climate change and ocean economy impact on the lives of many people in many countries and across geo-political boundaries, and both are multi-facetted with intersecting dimensions. How these are managed is critical to ensure sustainability. This requires unique and break-through policy frameworks. This would ensure that risks that are posed by climate change will be monitored and managed as a measure to attain the development goals.

In South Africa, the Ocean Economy is generally defined as all economic activities that are linked to the oceans natural resources and environment and/or are dependent to a degree on the ocean. The country's coastline stretches over 3000km^2 (Verheye et al., 2016) from its border with Namibia on the Atlantic coast southwards around the tip of Africa and then north to the border of Mozambique on the Indian Ocean (Figure 1). To unlock the potential of the oceans economy, the South African government focused on six priority growth areas. These areas are marine transport and manufacturing, offshore oil and gas exploration, aquaculture, coastal and marine tourism, small harbours, and marine protection services and ocean governance. The fisheries subsector has been recently included through the Oceans Master Plan underway in South Africa. The focus areas are/can be affected by climate change to varying degrees. In general, however, studies have shown that climate change has remarkable impacts on the ocean economy. In this paper, we consider the ocean economy sectors of industrial potential (value) and mostly at risk in relation to climate change, and these exclude marine protection services and ocean governance.

These potential growth areas of the economy fall under multiple government departments including DFFE (Forestry, Fisheries & the Environment), DMRE (Mineral Resources & Energy), DPE (Public Enterprises), DT (Transport), and DTIC (Trade, Industry & Competition). It should be noted that while the DFFE is responsible for South Africa's climate change policy and its implementation, there is little evidence of the effectiveness of the efforts emerging from a single central point to coordinate policies pertaining to the ocean economy. We explore the policy implications of the impact of climate change on the ocean economy.

CLIMATE CHANGE AND THE OCEAN

An estimated 60%–90% of global ocean heat content change associated with global warming is based in the Southern Ocean (Sallée, 2018). This fact is interesting because Africa contributes the least to atmospheric concentration of greenhouse gases and climate change but will be impacted more than most from the other parts of the world (African Development Bank Group, 2021) Beyond the steady overall warming of the global climate, there are short-term periods of exceptional warmth known as heatwaves which happen underwater, and the impacts can be felt beyond the sea. These marine heatwaves are periods of extreme warm sea surface temperatures (mostly attributable to human-induced warming) that persist for days to months and can extend up to thousands of kilometres. The seawater temperatures during marine heatwaves exceed a seasonally-varying threshold (Hobday et al., 2016). Modelling results suggest that marine heatwaves will become very frequent and extreme under global warming. The extremes include periods of intense upwelling, deoxygenation events, and ocean temperatures that are unusually warm and cold (Hobday et al., 2018). Some of the recently observed marine heatwaves revealed the high vulnerability of marine ecosystems and fisheries to such extreme climate events (Frölicher et al., 2018).

IMPACT ON THE OCEAN ECONOMY

Climate change disrupts ocean patterns and thus fish distribution and migration patterns, with a direct risk to food security of fish-dependent coastal communities. These communities, and ecosystems are threatened by pressures such

as the overharvesting and illegal harvesting of fisheries and other marine resources, pollution, unsustainable coastal development, habitat destruction and governance challenges (African Union Strategy and Action Plan report, 2022). Climate change can impact marine ecosystems through ocean warming by increasing thermal stratification and reducing upwelling, sea level rise, and through increases in wave height and frequency, increased risk of diseases in marine biota and decreases in the pH and carbonate ion concentration of the oceans and reduce productivity (Wang et al., 2004b; Sarmiento et al., 2004a; Harvell et al., 2002; IPCC, 2001; Cox et al., 2000). In coastal areas and margins, increased thermal stratification may lead to oxygen deficiency, loss of habitats, biodiversity and distribution of species, and impact whole ecosystems; changes to rainfall and nutrient flux from land may exacerbate these hypoxic events (Rabalais et al., 2002).

Marine heatwaves exert a strong influence on biological systems. A variety of impacts have been associated with these anomalous events, including shifts in species ranges and local extinctions (Wernberg et al., 2016), and economic impacts on aquaculture and seafood industries through declines in important fishery species (Hobday et al., 2018). Projections of ocean biological response to climate warming by 2050 show contraction of the highly productive marginal biome by 17% in Southern hemispheres (Sarmiento et al., 2004b).

The factors that impact significantly on the sectors of the ocean economy are temperature, sea-level rise, extreme weather conditions, and ocean acidification (Reid et al., 2019; Maulu et al., 2021). The sectors of the ocean economy of industrial potential/value are affected collectively and/or separately by these factors as described below.

Marine Aquaculture and Fisheries

The heavy reliance of most aquaculture on the ambient environment suggests inherent vulnerability to climate change effects on the resources and related biology. A number of biological impacts in South African marine systems including eastward shifts in the distribution of several fish species has been observed (Ortega-Cisneros et al., 2021). Climate change-mediated physiochemical outcomes important to aquaculture include extreme weather, precipitation and surge-based flooding, water stress, ocean acidification, sea-level rise, saltwater intrusion, and changes to

temperature, salinity, and dissolved oxygen (Reid et al., 2019). Response to a climate change stressor will be a function of where changes occur as cultural practices, environment, and region both affect stressor exposure and biological response between species or populations. Disease (and harmful algal blooms) is a major aquaculture limiter, and climate change is expected to further affect plant and animal health through the host and/or infectious agents (Reid et al. 2019). The relationship between such (potential) effects of climate change and aquaculture production was reviewed by Maulu et al. (2021). The implications on the sector's sustainability include alteration of productivity and pricing as well as other goods and services needed by fishers and aquaculture producers. The spatial extent of South Africa's marine aquaculture and fisheries provinces is shown in Figure 1.

Figure 1: Coastal Provinces of South Africa (shown in aqua/cyan) with dominant fisheries sector of the ocean economy indicating the industrial potential of the sector, overlain on Google Earth.

Coastal and Marine Tourism

Attractive and safe tourism environments are highly sensitive to weather conditions. Flood risks and water-pollution-related diseases in coastal areas, as well as coral reef bleaching as a result of climate change, could impact negatively on tourism (IPPC 2007). This is particularly so owing to the exceedingly complex modelling of climate

change and human behavior including personal preferences and choices. Coastal and marine recreation requires suitable weather conditions and attractive (and safe) environments and as such, it can be directly impacted by climate change (Moreno and Amelung, 2014). The diversity of coastal and marine recreation goes well beyond the typical beach (sun, sand & sea) tourism. It embraces the full range of tourism, leisure, and recreationally oriented activities that take place in the coastal zone and the offshore coastal waters (Hall, 2001). These include coastal tourism development (accommodation, restaurants, food industry, and second homes) and the infrastructure supporting coastal development (e.g. retail businesses, marinas, and activity suppliers). Marine tourism includes ocean-based tourism such as deep-sea fishing and yacht cruising.

Marine Transport and Manufacturing

The marine transport or shipping industry's biggest challenge due to climate change is the International Maritime Organization (IMO) de-carbonization targets associated with greenhouse gas emissions. The IMO significantly reduced allowable sulphur levels in marine fuel oil under the International Convention for the Prevention of Pollution from Ships (MARPOL), known as IMO 2020 (Allianz Global insights, 2020). Shipping plays a central role in global supply chains, meaning many industries will use the shipping sector to facilitate their net zero goals (S&P Global insights, 2022). This is supported by marine manufacturing in the form of ship and rig repair, refurbishment and boatbuilding. Climate change will impact on marine transport and manufacturing mainly through sea-level rise and extreme storms, affecting navigability of seawater channels, the stability and safety of manufacturing infrastructure and higher insurance premiums. It is known that a rough sea makes for a very uncomfortable voyage aboard a ship. Weather systems therefore strongly influence shipping operations and are exacerbated by sea-level rise.

Small Harbours

Small harbours such as shown in Figure 2 run along the coastal water-land interface in support primarily of the near–shore and offshore industries of fishing, aquaculture and other maritime economic activities in South Africa. Due to their locations along open coasts, the small harbours are highly susceptible to the impacts of climatic hazards such as rising sea levels, storm surges, waves and winds. The harbours in

general provide access to markets and supply-chains and are integral to maritime transport, as well as fisheries, offshore energy development, and many economic activities in coastal zones (Asariotis, 2021). As such, they are essential for the economy of their cities. South Africa has 12 proclaimed fishing harbours in its Western Cape province and ~55 unproclaimed harbours along its Northern Cape, Eastern Cape and KwaZulu Natal provinces (Public Works and Infrastructure Report, 2019).

Figure 2: Port St-Francis Harbour where fishing activity takes place in the Indian Ocean is an example of unproclaimed small harbour in the Eastern Cape Province.

Offshore Oil and Gas

Climate-related threats to the oil and gas industry have already begun to manifest, and significant of oil and gas reserves could be threatened by climate change (Dong et al., 2022). Oil spill risk is a key environmental challenge that can be exacerbated by climate change, as can be seen in the case of Hurricane Ida which caused a record 55 spills in the Gulf of Mexico and created historic disruptions to the supply of both crude oil and refined products (Dong et al., 2022). Changing climate is likely to affect oil and gas operations in low-lying coastal areas and the outer continental shelf. Oil and gas production in these regions comprises a large sector of the economies of many energy producing nations. Six key climate change drivers in coastal and marine regions are identified by Burkett (2011) with respect to oil and gas development: changes in carbon dioxide levels and ocean acidity, air and water temperature,

precipitation patterns, the rate of sea level rise, storm intensity, and wave regime. These key drivers have the potential to independently and cumulatively affect coastal and offshore oil and gas exploration.

Having analysed the various factors, we summarize in Table 1 the impact of climate change factors, also referred to as stressors, on various sectors of the ocean economy.

POLICY IMPLICATIONS

While an implementation framework was developed to grow the ocean economy in South Africa, a comprehensive national policy that cuts across various line-functions departments of government is required for effective delivery. Facilitative institutional arrangements and coordination is critical for policy development pertaining to cross-sectoral departments, as shown by Ortega-Cisneros et al. (2021) for the Fisheries sector. While various committees exist in South Africa around climate change, such as the Inter-Ministerial Committee on Climate Change (IMCCC), the Intergovernmental Committee on Climate Change (ICCCG), and the recently formed Presidential Climate Change Coordinating Commission (PCCCC), a single point of coordination to serve as the link between climate change and ocean economy is critical to the growth of the ocean economy and its sustainability.

Currently, the Department of Forestry, Fisheries and the Environment (DFFE) is responsible for South Africa's climate change policy and its implementation. The relevant document, which represents South Africa's vision for an effective climate change response, and the long-term just transition to a climate resilient and lower carbon economy and society, is the National Climate Change Response Policy (NCCRP 2011). The Department of Mineral Resources and Energy (DMRE) policy pertaining to climate change may be found in its integrated resource plan document (IRP 2019) which states that 'South Africa is a signatory to the Paris Agreement on Climate Change and has ratified the agreement'. There is however no mention of the ocean. In its Comprehensive Maritime Transport Policy (CMTP) statement 23, the Department of Transport (DT) states: 'The Department shall in collaboration with other relevant Government departments and agencies put into place strategies to alleviate the current and future impacts to the maritime industry and the port system brought

about by climate change'. The implication of uncoordinated policies is that the unlocking of the full potential of the ocean economy yielded sub-optimal results. It may thus be recommended that consideration is given to a single point of coordination to enable integrated 'wall-to-wall' policy development for the ocean economy and its relation to climate change. This can only be achieved through a horizontally integrated public policy framework. In its climate change and resilient development strategy and action plan 2022-2032, the African Union recommends strong, integrated and cohesive policy environment toward building a climate-resilient African blue economy.

Policy development must take into cognizance the need for continuous adaption and mitigation as climate change related risks to health, food security, livelihood, water supply, human security, and economic development will increase due to the projected 1.5°C global warming (IPCC, 2018). In the face of such risks, both the industry and communities will need to mitigate impact and adapt accordingly (Maulu et al., 2021). Marine aquaculture, fisheries, and marine coastal tourism are the sectors of the ocean economy most in need of adaptation to ensure they can continue to provide valued functions as the climate changes (Gaines et al.,.2019). Climate-driven impacts in South Africa have resulted in distribution shifts and declines in abundance of important fisheries targets, with negative consequences for the people and businesses dependent on these resources. Similarly, the sustainability of the sector depends on its readiness to adapt to climate change (Ortega-Cisneros et al., 2021). An integrated ocean planning approach will help design efficient and effective climate responses and achieve *SDG 14, Life Below Water*: to conserve and sustainably use the oceans, seas, and marine resources for sustainable development (Castaño-Isaza and Diez, 2021).

Table 1: Impact of Climate Change Factors on Ocean Economy Sectors

Climate Change Factors	**Economy Focus Area Affected**	**Impacts**
Temperature [high temperatures, melting ice, large variations (spatial and temporal), frequent freeze and thaw cycles]	Aquaculture	Seafood industries adversely affected through vulnerability of fisheries and marine ecosystems, including shifts in species ranges and local extinctions.
	Coastal & Marine Tourism	Variable extent and dependence but high temperatures tend to attract more tourism.
	Marine Transport & Manufacturing	Longer shipping season and new sea routes; additional support services and navigation aids such as ice-breaking search and rescue; damage to infrastructure, equipment and cargo; increased construction and maintenance costs; new ship design and strengthened hulls; environmental, social, ecosystem related and political considerations; higher energy consumption in ports; challenge to service reliability.
	Offshore Oil & Gas	Maintenance problems; degradation of structures
	Small Harbours	Deterioration of paved areas; damage to equipment (e.g. cranes); higher energy consumption and CO2 emissions due to refrigeration needs for perishable goods and air conditioning.
Sea-Level Rise [flooding and inundation, erosion of coastal areas]	Aquaculture	Breeding programs and the economic sustainability of the sector affected through destruction of seed supply for aquaculture production.
	Coastal & Marine Tourism	Coastal erosion (of beaches) reducing the value of these destinations for tourism; damage to infrastructure, settlements and facilities that support livelihoods in small communities.
	Marine Transport & Manufacturing	Damage to infrastructure, equipment and cargo; increased construction and maintenance costs; variation in demand for and supply of shipping and port services; challenge to service reliability and reduced dredging; reduced safety and sailing conditions; higher insurance premiums.
	Small Harbours	Damage to infrastructure; high cost of port performance; reduced shipping activity.

Extreme Weather Conditions [hurricanes, storms, floods, increased precipitation, wind]	Aquaculture	Increased production cost; damage to production facility; water quality deterioration/pollution.
	Coastal & Marine Tourism	Beach tourism very sensitive to weather conditions.
	Marine Transport & Manufacturing	Damage to infrastructure, equipment and cargo; reduced safety and sailing conditions, challenge to service reliability; variation in demand for and supply of shipping and port services; change in trade structure & direction.
	Offshore Oil & Gas	Affect exploration, transportation and other production activities including platforms, drilling rigs, offshore pipelines, and mobile offshore drilling units; storm surge flooding can affect storage tanks.
	Small Harbours	Damage to infrastructure, equipment and cargo; disruption of services; reduced safety conditions.
Ocean Acidification	Aquaculture	Water quality deterioration radically alters aquatic ecosystems, leading to poor productivity.
	Coastal & Marine Tourism	Coral reefs tourism including diving/undersea activities are adversely affected.

CONCLUSION

The ocean is an important carbon sink that helps mitigate climate change, whilst the impact of climate change related events in turn would significantly impact on the capability and functionality of the ocean economy. The ocean economy and climate change are multi-dimensional constructs that span a range of public and international policy domains. Joined-up, horizontally integrated policy is essential to realize the full socio-economic potential of the ocean economy whilst simultaneously mitigating climate change impacts. Key to effective policy development, is the design of institutional arrangements that span across and between those government departments that play a role in the functionality of the ocean economy and those with environmental and climate-related responsibilities. These are crucial for the coordinated implementation of such policy and the achievement of sustainable development and growth. Through-out the policy development and implementation cycle, the involvement of impacted stakeholders, notably communities and business, is critical to the successful achievement of policy intentions.

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