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Climatic drivers of change and the future of African ocean assets

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Introduction

Earth is distinguished from all other known planets by the presence of a warm, salty ocean that covers over 70% of its surface. The ocean regulates our climate and drives weather patterns that determine rainfall, drought, and floods; it produces half the oxygen we breathe, and absorbs 30% of the anthropogenic emissions of carbon dioxide (CO_2), and around 93% of the added heat arising from human-driven changes to the atmosphere (IPCC 2013). Worldwide, 850 million people live within 100 km of tropical coastal ecosystems such as coral reefs and mangroves, whereby they derive multiple benefits such as food, transport, coastal protection, cultural services, and income from industries such as fishing and tourism (Burke et al. 2011). A healthy ocean is therefore an indispensable part of the Earth's life-support system and fundamental to human well-being.

That said, for much of human history, the ocean has been viewed and treated as an inexhaustible supply of food, a useful transport route, and a convenient dumping ground. As a result, the world's oceans are degrading under human pressure due to population growth, industrialisation, coastal development, intensive agriculture, over exploitation, and resource extraction. In addition, increasing atmospheric greenhouse gas concentrations pose a major threat to the oceans. According to the Intergovernmental Panel on Climate Change (IPCC), the impacts of climate change that will influence the ocean with a very high or high level of confidence include increased sea temperatures, acidification of ocean waters, and an increase in sea level (Hoegh-Guldberg et al. 2014). These changes are accelerating and if not halted or reversed within the next few decades, will have serious ramifications for marine ecosystems and human-well-being.

This background paper is not intended to be a definitive thesis on the impacts on climate change on the ocean, nor does it intend to provide an exhaustive list of non-climate impacts on ocean ecosystems. Rather this paper is intended to provide a high-level snapshot of the three key climate related trends facing the ocean, and to provide examples of how these may impact the African region. Finally, in light of the recent Sustainable Development Goal 14, a case is made for the benefits of preserving Africa's ocean assets and charting a course towards a sustainable ocean economy.

Climate drivers of change

Expert scientific consensus tells us that we are entering a worrying period of change and uncertainty for the ocean. Not only are we drawing down too much on our primary marine assets, which directly threatens the value of the annual dividend from the ocean, but also the impacts of climate change are already manifesting themselves. Human activities such as burning fossil fuels and deforestation have increased the Earth's average surface temperature by over 0.85°C during the period 1880 to 2012 (IPCC 2014), and there is a high level of confidence that global warming will place additional pressure on the ocean through increased sea temperatures, acidification of ocean waters, and an increase in sea level (Hoegh-Guldberg et al. 2014).

Sea temperature

Average sea surface temperature has increased by 0.65°C in the Indian Ocean, 0.41°C in the Atlantic Ocean, and 0.31°C in the Pacific Ocean (Hoegh-Guldberg et al. 2014). All three ocean basins will continue to warm, with sea surface temperatures predicted to be 1.8°C to 3.3°C higher under business as usual greenhouse gas concentration scenario (IPCC Representative Concentration Pathway (RCP) 8.5) than under strong mitigation scenario (IPCC scenario RCP2.6) scenarios (Hoegh-Guldberg et al. 2014).

Rising ocean temperatures are driving the expansion of marine dead zones, changing the flow of ocean currents, increasing diseases, changing productivity, and causing a decline in kelp forests and coral reefs worldwide (IPCC 2013; Bakun et al. 2010; Hoegh-Guldberg et al. 2014). As a result, these changes are altering the timing and location of key life history events such as plankton blooms, and the spawning and migratory behaviour of turtles, fish and invertebrates (Poloczanska et al. 2013, 2014) – including shifts in the distribution of tuna stocks eastward in the Pacific (Bell et al. 2013).

Coral reefs – the most diverse and productive of marine ecosystems – are showing some of the most visual signs of increased sea temperatures as a result of climate change. The first sign that a coral reef is in trouble from elevated temperature stress is a sudden change in colour, from brown to white (bleached). Mass coral bleaching events first appeared in the early 1980s and have steadily grown in size and intensity. The first global bleaching event was recorded in 1998, during which the world lost 16% of its coral reefs (Hoegh-Guldberg 1999). A second global event was recorded 12 years later in 2010, with a third global event in 2016. The frequency of global bleaching events appears to be on the increase, and at current rates of temperature rise, the world's oceans may become too warm for coral reefs by 2050 (Hoegh-Guldberg 1999).

Ocean acidification

In addition to increasing ocean temperature, CO_2 has flooded into the upper layers of the ocean where it has reacted with water to form a dilute acid, carbonic acid. As this dilute acid has formed, the average pH of the surface ocean has decreased by 0.1 units since the beginning of the pre-industrial period, which is equivalent to an increase in total acidity (protons) of 26% (IPCC 2013; Hoegh-Guldberg et al. 2014). Additional increases in atmospheric CO_2 are virtually certain to further acidify the ocean (Hoegh-Guldberg et al. 2014), with projected changes for the open ocean ranging from a pH change of –0.14 unit under strong mitigation (IPCC RCP2.6) to a pH change of –0.43 unit under business as usual (IPCC RCP8.5) (Hoegh-Guldberg et al. 2014).

A large number of responses to ocean acidification have been reported, with fundamental processes such as growth, reproduction, settlement of fish larvae, neurophysiology, foraging behaviour, bioerosion and calcification being affected (Munday et al. 2009a, 2009b; Kroecker et al. 2013; Poloczanska et al. 2013; Hoegh-Guldberg et al. 2007). In addition to increasing the acidity of the ocean, the influx of CO_2 has driven a decrease in the concentration of important dissolved compounds such as carbonate, which is a substrate for building the calcium carbonate skeletons and shells of many marine organisms. Corals, for example, are especially sensitive to decreases in the saturation states of aragonite and calcite (Hoegh-Guldberg et al. 2014), and these changes are very likely to have broad consequences such as the loss of three-dimensional coral reef frameworks (Hoegh-Guldberg et al. 2007; Anthony et al. 2008; Manzello et al. 2008; Fabricius et al. 2011; Dove et al. 2013) at relatively small (~50 ppm) additional increases in atmospheric CO_2.

According to scientific consensus, the speed at which these changes are occurring in the ocean has no parallel in the last 65 million years, if not the last 300 million years (Hönisch et al. 2012; IPCC 2013). It is also important to note that the time it takes for the weathering of continental rocks to bring ocean chemistry back to pre-industrial conditions is at least 10,000 years, and we are therefore essentially committed to acidification.

Sea level

As the temperature of the surface layers of the ocean has risen, the volume of the ocean has also increased due to thermal expansion and the contribution of water from the increased melting of glaciers and landlocked ice sheets. As a result, the sea level has risen by ~20 cm since the late 1800s (IPCC 2013). Sea level rise is very likely to increase during the 21st century (relative to 1971–2010) due to increased ocean warming and the continued contribution of water from loss of mass from glaciers and ice sheets, which will result in greater levels of coastal flooding and more frequent extremes by 2050 (Hoegh-Guldberg et al. 2014).

While the average global rate is 3.2 mm per year, there are big differences in the rate of sea level rise between regions based on local oceanography and long-term climate trends. For example, coastal areas in Northern Australia, South East Asia and Melanesia are experiencing rates of sea level rise which are 3-4 times the global average (IPCC 2013). Besides the obvious effects of coastal inundation and flooding of low lying areas, increases in sea level can also salinify coastal water supplies and challenge seagrass beds and mangroves, as these ecosystems will increasingly be pushed shoreward by rising seas – in many cases being squeezed up against coastal infrastructure and human communities (Saunders et al. 2013; van Bochove et al. 2014). Such changes not only decrease the ability of these ecosystems to provide ecosystem goods and services, but they also threaten to eliminate many low-lying island countries and territories (IPCC 2013). Furthermore, sea turtles are facing inundation of nesting sites by a rising ocean, as well as skewed sex ratios arising from increasing nest temperatures (Hamman et al. 2007; Fuentas et al. 2009).

What do these changes mean for Africa?

People's demands on nature are a function of population size, economic activity and consumption levels. Africa has a rapidly growing population that exceeded 1 billion in 2010 and is expected to reach 3 billion by 2050 if fertility rates remain constant (UN DESA Population Division 2011). African countries are also experiencing some of the world's highest rates of urbanisation, with many of the evolving cities unplanned and associated with growth of informal settlements, inadequate housing and basic services, and urban poverty (Yuen and Kumssa 2011).

Africa's food production systems are among the world's most vulnerable because of extensive reliance on rain-fed crop production, high intra- and inter-seasonal climate variability, and recurrent droughts and floods that affect both crops and livestock. The predicted reduction in precipitation by the end of the 21st century (Niang et al. 2014) will likely further contribute to increased urbanisation in the coastal zone through migration. As a result, increasing numbers of people will be vulnerable to coastal climate change impacts, such as flooding from sea level rise (Seto 2011). Sea level rise along coastal zones has the potential to disrupt economic activities such as fisheries and tourism, as well as exacerbate public health pressures. For example, an assessment of the impact of coastal flooding due to sea level rise in Kenya found that up to 86,000 people would be affected by 2030, with associated economic costs ranging from US$47 million to US$50 million (SEI 2009). In Senegal, a 1 m increase in sea level has the potential to inundate and erode more than 6,000 km^2 of coastal land and threaten infrastructure in excess of US$7 million (Dennis et al. 1995)

More than 25% of Africa's population live within 100 km of the coastal zone (Niang et al. 2014), and sea level rise therefore has the potential to increase the number of climate refugees along the African coastline. A rise in sea level of 43 cm by 2100 could affect a projected 913,500 people in Tanzania, and 2,271,000 million people in Mozambique (Brown et al. 2011). Africa's west coast is particularly vulnerable and at risk from erosion, inundation, and extreme storm events (IPCC 1997) – with inundation considered to be a significant concern, leading to the development of a coastal management scheme for West Africa (UEMOA 2010).

Sea temperatures in the coastal boundary systems (of which the African region forms a part) will continue to increase over the next few decades and centuries (Hoegh-Guldberg et al. 2014). Under business as usual (IPCC RCP8.5), sea temperatures are projected to increase by 0.62°C to 0.85°C over the near term and 2.44°C to 3.32°C over the long term (Hoegh-Guldberg et al. 2014). It only takes a temperature increase of 1-2°C to cause corals to bleach, and it is likely that coral bleaching and mortality will occur every 1 to 2 years by the mid- to late part of this century under low to high climate change scenarios (Hoegh-Guldberg 1999; Donner et al. 2005). Mass mortality events that affect coral reefs will result in changes to community composition in the near term and a continuing downward trend in coral cover in the longer term (Gardner et al. 2003; Bruno and Selig 2007). While there may be a lag between the loss of coral communities and the subsequent changes in the abundance and community structure of fish populations, it is virtually certain that composition of coral reef fish populations will change in the wake of an increased frequency of coral bleaching (Graham et al. 2007; Pratchett et al. 2008), and that the ecological recovery time will be less than the bleaching return time.

In the Western Indian Ocean, fisheries mainly depend on coral reefs, and increased bleaching and mortality will therefore have negative impacts on fisheries, fishery-related employment and nutrition. The climate signal of coral bleaching has already manifested itself in the Western Indian Ocean, where sea temperatures have increased by 0.60°C over 1950–2009, increasing the frequency of positive thermal anomalies that have triggered mass coral bleaching and mortality events across the region over the past 20 years (Ateweberhan and McClanahan 2010; Ateweberhan et al. 2011). Coral cover across the Western Indian Ocean declined by an average of 37.7% after the 1998 bleaching event (Ateweberhan et al. 2011), with additional bleaching in 2010 and 2016. These changes to the population size of key reef-building species will drive major changes in the abundance and composition of fish populations in coastal areas, and affect other ecosystem services that are important for underpinning tourism and coastal protection. For example, the economic costs of the 1998 coral bleaching event to dive tourism were estimated at up to US$2.2 million in Zanzibar and up to US$15.09 million in Mombasa (Brown et al. 2011).

Fish are important to nutritional security (Golden et al. 2016) and the ocean provided 64% of the production supplied by world fisheries in 2010 (FAO 2012). In the African region, capture fisheries and aquaculture contribute more than one-third of Africa's animal protein intake (Welcomme 2011), and demand for fish is projected to increase substantially in Africa over the next few decades (De Silva and Soto 2009). Declining ecosystems services as a result of human disturbance and climate change will place pressure on food security and livelihoods in the African region. In an analysis of fisheries in 132 countries, Allison et al. (2009) estimated that two thirds of the most vulnerable countries were in Africa. Among these countries, the most vulnerable were Angola, Democratic Republic of Congo, Mauritania, and Senegal, due to the importance of fisheries to the poor and the close link between climate variability and fisheries production.

Marine small-scale fisheries in developing countries account for around half of the fish harvested from the ocean, and provide jobs for more than 47 million people – about 12.5 million fishers and another 34.5 million people engaged in post-harvest activities (Mills et al. 2011). Small-scale fisheries therefore account for 56% of catch and 91% of people working in fisheries in developing countries (Mills et al. 2011), and form a significant component of the African fisheries. These small-scale fisheries tend to operate at family or community level, have low levels of capitalisation, and make an important contribution to food security and livelihoods. Being dependent on coastal ecosystems, such as coral reefs and mangroves, these small-scale fisheries will be challenged by the fact that these ecosystems are under serious pressure from human activities including deteriorating coastal water quality, sedimentation, and overfishing; and climate change including ocean warming and acidification.

Besides the small-scale fisheries, fisheries that exploit tuna and other large pelagic species are very valuable to many small island states within the Indian Ocean. Increasing sea temperatures and changing patterns of upwelling are projected to cause shifts in the distribution and abundance of pelagic top predator fish stocks, with potential to create “winners” and “losers” among island economies as catches of the transboundary tuna stocks change among and within their exclusive economic zones (Bell et al. 2013). Such patterns have already been recorded in the Indian Ocean whereby anomalously high sea temperatures of 1997–1998 coincided with anomalously low primary production in the Western Indian Ocean and a major shift in tuna stocks (Menard et al. 2007; Robinson et al. 2010). Fishing grounds in the Western Indian Ocean were deserted and fishing fleets underwent a massive shift toward the eastern basin – resulting in significant losses in tuna-related revenue in many countries throughout the Indian Ocean (Robinson et al. 2010). These trends highlight the overall vulnerability of tuna fishing countries in the Indian Ocean to climate variability (Hoegh-Guldberg et al. 2014).

Coastal and ocean systems are important for the economies and livelihoods of African countries, and climate change will only increase challenges from existing stressors, such as overexploitation of resources, habitat degradation, loss of biodiversity, salinization, pollution, and coastal erosion (Arthurton et al. 2006; UNEP and IOC-UNESCO 2009).

Towards a sustainable ocean economy

The new 17 Sustainable Development Goals (SDGs) provide a call for action by all countries, poor, rich and middle-income to promote prosperity while protecting the planet. Building on the success of the Millennium Development Goals, the SDGs recognise that ending poverty must go hand-in-hand with strategies that build economic growth, addressing a range of social needs including education, health, social protection, and job opportunities, while tackling climate change and environmental protection. The critical role of the oceans in sustainable development has been recognised through a dedicated goal – Goal 14: Conserve and sustainably use the oceans, seas and marine resources. This places the ocean in a central position in terms of sustainable development, noting that the ocean is also important in many of the other SDGs.

The principles of a sustainable ocean (‘blue’) economy represent an enormous opportunity for the African region. A sustainable ocean economy essentially conceptualises oceans as systems where spatial planning integrates conservation, sustainable use, resource extraction, bioprospecting, sustainable energy production and maritime transport (UN 2016). A sustainable ocean economy therefore incorporates ocean values and services into economic modelling and decision-making processes, and constitutes a sustainable development framework for developing countries addressing equity in access to, development of, and the sharing of benefits from marine resources; offering scope for re-investment in human development and the alleviation of national debt burdens (UN 2016).

By adopting the concept of a sustainable ocean economy and developing more coherent, integrated, fair, and evidence-based approaches to managing the economic development of the ocean, leaders stand to alleviate one of their defining obstacles to sustainable development – a narrow resource base. A sustainable ocean economy approach offers the prospect of sustained, environmentally sound, socially inclusive economic growth, as well as fostering innovation. Moreover, a path towards a sustainable ocean economy also incorporates and builds strategies that are important to not only address SDG14, but to contribute to meeting targets on at least nine other SDGs.

Applying the principles of a sustainable ocean economy would therefore provide social and economic benefits for current and future generations in the African region by contributing to food security, poverty eradication, livelihoods, income, employment, health, safety, equity and political stability. Travelling down this pathway would restore, protect and maintain the diversity, productivity, resilience, core functions and intrinsic value of marine ecosystems – the natural capital upon which its prosperity depends. This strategy also has opportunities in terms of preventing broader scale changes through carbon sequestration in marine ecosystems such as saltmarsh, mangroves and seagrass – 'blue carbon'. 'Blue carbon' operates in much the same way as strategies used on land to reduce emissions of greenhouse gas by reducing deforestation and encouraging afforestation.

Through wise management, ocean assets can help lift many African countries out of poverty and achieve the SDGs. That said, the risk is also high that unsustainable practices may destroy these very same assets. Striking a balance between short term gain and long term losses, whereby ocean assets are maintained over time, is therefore paramount. Getting this right is a core challenge that leaders will face and they will need to have accurate information and understanding available to make the right decisions for the long term prosperity of their people. Moreover, strong partnerships involving governments, institutions and private actors investing in natural assets and prudent economic management will be needed to generate shared value for the broader population.

Conclusion: Call to action

The African region is amidst transformational change, and is positioned to enter into a period of rapid economic growth, enabled by their current low baseline, rapid demographic growth, and access to new energy sources. However, in order for the ocean to play an increasing role in supplying resources, a paradigm shift is needed on how valuable ocean assets are used and conserved. The leaders of the Africa region are therefore faced with two pathways. The first is the current trajectory of increasing pressure on ocean assets, which will lead to environmental degradation with reduced opportunities. The second trajectory is to recognise the changes and uncertainties ahead and chart a course towards a sustainable ocean economy, which will ensure that the economic development of the ocean contributes to the prosperity and resilience of the African region long into the future.

Despite clear evidence that that the ocean assets of the African region are already under pressure, the potential for the African region to prosper from a healthy ocean is high. Business as usual practice can no longer be considered an option, and in order for the ocean to play an increasing role in supplying resources, a paradigm shift is needed on how valuable ocean assets are used and conserved. Through strong leadership and wise management, the leaders of the African region can deliver policy actions and economic stimulus to create a sustainable ocean economy.

That said, achieving sustainability will require visionary leadership, and bold and decisive action. It will take action and challenges that lie across a broad spectrum of change. African countries must also urge the international community to undergo deep and urgent action on climate change, especially given the fact that the ability of African nations to prosper will very much depend on reducing emissions of carbon dioxide and other greenhouse gases to zero within the next few decades or face potentially disastrous conditions.

The good news is that it is not too late, and such action will provide social and economic benefits for current and future generations. After all, the future is not a place we are going to go; it is a place that we are going to create.

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