OCEAN ACIDIFICATION (OA) WHITE PAPER

DRAFT OCEAN ACIDIFICATION PAPER FOR WESTERN INDIAN OCEAN REGION

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Background

Marine ecosystem management and conservation is facing growing challenges from multiple and cumulative stressors (Chapin et al., 2000). Marine ecosystems are threatened by global climate change pressures of such as increased sea surface temperatures, ocean acidification due to increased dissolution of one-quarter of atmospheric carbon dioxide (CO_2) dissolution by world oceans annually (Figure 2) causing measurable declines in ocean pH (increase in H^+ ions), carbonate ion concentration ($[CO_3^{2-}]$) and saturation state (Le Quéré et al., 2015). This process, referred to as ocean acidification (OA), represents a major threat to marine ecosystems (McClanahan et al., 2011 see Figure 1).

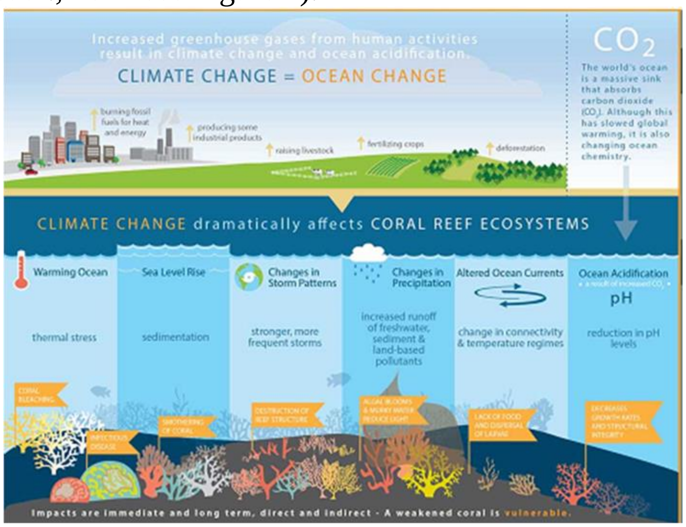

Figure 1 Coral reef ecosystems and the negative impacts of global climate change (Modified from Adipudi et al., 2017)

Currently, no studies on the effects of OA and its interaction with local disturbances and the response of critical marine ecosystems and habitat in the WIO region have been conducted (Hilmi et al. 2013). Ocean acidification studies are therefore needed to highlight the impacts of ocean OA in order to develop strategies for mitigation and adaptive strategies.

CORAL REEFS AND CLIMATE CHANGE IN WIO REGION

The Western Indian Ocean (WIO) region comprises the Eastern African coastal states of Kenya, Mozambique, Somalia, South Africa and Tanzania as well as the island states of Comoros, Madagascar, Mauritius, Seychelles and the overseas French territories of Mayotte and Reunion (Figure 3) is home to a number of LMEs.

Its environmental gradient from tropical to temperate conditions and ocean current systems provides a unique opportunity to study climate change impacts on ecosystems and human well-being (McClanahan et al., 2011).

	Glacial	Pre-industrial	Present	$2XCO_2$	$3XCO_2$	Change from pre-industrial to $3XCO_2$
$CO_{2(g)}$ pCO_2	180	280	380	560	840	200%
Gas exchange						
$CO_{2(aq)} + H_2O \rightleftharpoons H_2CO_3$ Carbonic acid	7	9	13	18	25	178%
$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$ Bicarbonate	1666	1739	1827	1925	2004	15%
$HCO_3^- \rightleftharpoons H^+ + CO_3^{-2}$ Carbonate	279	222	186	146	115	- 48%
DIC	1952	1970	2026	2090	2144	8.8%
$pH_{(sws)}$	8.32	8.16	8.05	7.91	7.76	- 0.4
$\Omega_{calcite}$	6.63	5.32	4.46	3.52	2.77	- 48%
$\Omega_{aragonite}$	4.26	3.44	2.90	2.29	1.81	- 47%

Figure 1 Concentrations of carbon species (µmol kg^{-1}), pH values, and aragonite and calcite saturation states of average surface seawater for pCO_2 concentrations (ppmv) during glacial, preindustrial, present day, two times pre-industrial CO_2, and three, times pre-industrial CO_2 (from Fabry et al., 2008).

Figure 3 Map of the Western Indian Ocean (WIO) countries including the island states of Madagascar, Reunion and Mayotte, Mauritius, Comoros, Seychelles.

Societal issues and regional importance of OA

Although the livelihoods of coastal communities in the WIO region are inextricably linked to the quality of coastal resources, there has been no studies on the impacts of ocean acidification on these resources. Previous research on climate change impacts has focused almost exclusively warming (Spencer et al., 2000; McClanahan et al., 2011). Ocean acidification interferes with the production of $CaCO_3$ in organisms with carbonate shells and skeletons while Sumaila et al. (2011) discussed the potential direct impacts of OA in the WIO

Vulnerability and OA impacts on coral reefs

Future warming and OA are expected to lower coral reef resilience, resistance to stress, recovery as well as shift from net accretion to net dissolution and bioerosion (Kleypas et al. 1999; Sumaila et al 2011). Further, increase in OA will also cause global mean sea surface temperature and, increase the frequency and intensity of bleaching and storms as well as weakening of reef framework (Silverman et al. 2009) and lowering. Additionally, OA also lowers the abundance of other key carbonate producers such as crustose coralline algae.

Knowledge gaps, data and information needs and capacity building

Currently, there is very little information and data on OA and its impacts on marine ecosystems and human populations in the WIO region. There is therefore need for studies to

- understand the relation between changes in the marine environment and socio-economic impacts,
- determine the vulnerability of different populations including humans, species and processes.
- understand food web dynamics, plankton composition (including harmful algal blooms HABs) and transfer of energy to higher trophic levels.
- establish regional and global long-term investigations on the impacts of OA.
- model the impacts of ocean acidification and response of communities and ecosystems.

Potential research ideas and questions

- What attributes of species (e.g., tropical or temperate, sessile or motile, etc.) make them particularly sensitive to stressors attributable to climate change, particularly, OA stress.
- Will open ocean be impacted the same way as nearshore ocean environments?
- Identification of local stressors most likely to interact with OA. Mitigating the effects of these will likely minimize the impacts of OA.
- How will different coastal ecosystems, organisms and communities respond to the impacts of climate change and what community characteristics will help them adapt

Policy Strategies and Recommendations

- There is need to formulate strategies to boost communities and ecosystem health so that they can better cope with local stress and the promotion of seagrass restoration and seaweed farming and culture of OA adapted/resistant organisms.
- Establishment of a coordinated regional/global integrated coastal ocean acidification observing network as well as capacity building in OA research. Increase international cooperation and contribute to the international framework of data sharing
- Sensitization and capacity building of vulnerable marine resource-dependent communities and those impacted by OA (exposure, sensitivity adaptive capacity) through public awareness activities at regional and national levels**.**
- Promotion of management strategies for restoration of marine ecosystems that have been degraded, and developing last-resort technologies to cope in the worst-case scenario.
- Initiate policies and strategies that promote collaboration between institutions and countries of the region to create infrastructure and standardized methods for generating scientific information and data to critically address the impacts of OA

While these recommendations may not salvage reefs globally, they may do so at the local to regional levels by helping to mitigate the decline in reef ecological condition and value. Not every effort would however preserve the full suite of goods and services provided by healthy coral reef ecosystems but a mosaic of resource-intensive interventions would likely do the trick.

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