Volume 1
Issue 1
Jan – Dec 2022
ISSN: 2953-2604

Nairobi Convention
and WIOMSA

WIO Science to Policy Platform Series

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Volume 1
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Jan – Dec 2022

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NAIROBI CONVENTION

WIOMSA
Coasts Ocean and People

WIO
science to policy
platform series

Published by the Western Indian Ocean Marine Science Association (WIOMSA).

Coordinators for the production of this Issue: Jared Bosire, Timothy Andrew, Arthur Tuda and Julius Francis

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Graphic design and layout: Cláudia Baeta

Cover photo: Lina Mtwana Nordlund Data collection in Nungwi, Zanzibar by the Indo-Pacific Seagrass Network

Citation: WIOMSA and Nairobi Convention 2022. WIO Science to Policy Platform Series Vol 1 Issue 1. WIOMSA and Nairobi Convention, 197p

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Foreword

It is indeed my pleasure and great honour to Launch the maiden Western Indian Ocean Science to Policy Platform Series in my Capacity as the Minister for Environment and Sustainable Development in the Government of Madagascar. I note that this Series responds to a number of CoP Decisions by the Contracting Parties of the Nairobi Convention on the need to strengthen the linkages between science and policy for evidence-based decision towards the conservation of the coastal and marine resources of the Western Indian Ocean region.

The Western Indian Ocean (WIO) region, comprising the ten countries of Comoros, France (Réunion), Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, South Africa and Tanzania, has a total coastline of approximately 15,000 km and a continental shelf area of some 450,000 km^2, supporting an estimated population of 220 million people, of which over 60 million live within 100km of the shoreline. The annual "Gross Marine Product" (equivalent to the Gross Domestic Product of a country) of the WIO region is least US$ 20.8 billion, showing the substantial economic value of coastal and marine resources in the region.

However, the coastal and marine environment of the WIO region is showing signs of degradation and loss of biodiversity. This trend can be attributed to global anthropogenic factors such as climate change, as well as more localised activities including coastal development, overfishing, sand mining, dredging and pollution from sea-based and land-based sources and activities. This situation is further exacerbated by the failure to fully incorporate scientific information about the status of the marine and coastal resources and impacts into policy and management strategies.

Given the growing threats to coastal and marine resources, sound scientific knowledge is required to assist policymakers and resource manager in decision making. While acknowledging the important role that science plays in policy and decision making, it is also recognized that there are barriers between the two domains that limit the uptake of science into policy. These include the technical nature of scientific information provided to policy/decision-makers, which may not be easily understood by non-experts in the field, and inadequate communication of research needs and priorities to the scientific community by policy makers and managers to enable them to tailor research to address these needs and priorities. There is, therefore, need for proper integration of scientific knowledge into language and format readily understood by policymakers and decision-makers to effectively influence policy and decision-making. Also important are mechanisms for providing information on research needs and priorities to the science community.

At the fourth Conference of the Parties (COP) of the Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Western Indian Ocean Region (the Nairobi Convention) held in Antananarivo, Madagascar in July 2004, the Secretariat of the Convention (UNEP) was directed to facilitate the establishment of a network of academic and research institutions in the Convention area in collaboration with other organizations. The Network would be a "consultative, communication and advisory body accountable to the Contracting Parties of the Nairobi Convention in the assessment and science-based management of marine and coastal environment". The decision was taken to address the challenges of the absence of a mechanism for linking research and academic institutions with decision-making processes at the regional level; the inadequate visibility of research institutions in the region; the inadequate sharing and exchange of information amongst academic and research institutions in the region; and the inadequate involvement of regional institutions in regional initiatives. The Nairobi Convention Secretariat was also directed to "take the offer made by the Western Indian Ocean Marine Science Association (WIOMSA) to serve as the Secretariat of such a Network", a role which WIOMSA has and continues to play in an exemplary manner.

The Science to Policy Platform (SPP) was established in 2019 by the Contracting Parties as a formal structure within the Convention to serve as "a multi-stakeholder platform comprising of

representatives of formal and informal knowledge-generating institutions, practitioners, policymakers, communities and the private sector within the WIO region. It serves as an intermediary body to bridge the gaps between science and policy and catalyse implementation. The SPP is intended to support the efforts of the Contracting Parties of the Nairobi Convention to integrate relevant scientific evidence and findings into their efforts to protect, manage and develop their coastal and marine environment sustainably. It is also expected to act as an intermediary or boundary agent between science and society and to facilitate and promote a better understanding of on-going and emerging regional environmental challenges and opportunities and of the strategies needed to address them.

The Nairobi Convention in partnership with WIOMSA called on partners in the WIO region to develop discussion papers on various coastal and marine issues affecting the WIO region that would be presented and discussed at the Science to Policy meeting that was held on 23-25 March 2021. It was envisaged that the discussion papers would provide a scientific basis for decision making at national and regional levels.

The papers addressed the following workshop themes: sustainable port development, marine spatial planning and data management, water quality management including marine litter, municipal wastewater, climate change including resilience, adaptive capacity of communities, ocean acidification, regional priorities towards the Decade on Ocean Science, private sector engagement: challenges and opportunities, economic valuation for policy and management decision making, directing financial flows for sustainability, ocean governance and blue economy, ecosystem monitoring, progress towards SDGs and ecosystem approach to fisheries.

The first series of the Science to Policy articles have been developed from the papers presented at the 23-25 March 2021 Science to Policy meeting. It is envisioned that these papers will facilitate proper integration of scientific knowledge into language and format readily understood by policymakers and decision-makers to effectively influence policy and decision-making in WIO Region. This will aid in conservation and restoration of the coastal and marine environment within the region. I am happy to note that a number of policy recommendations from these papers did in fact inform important areas of decisions during COP 10.

On behalf of the Contracting Parties, I wish to acknowledge and thank the Nairobi Convention Secretariat for the overall coordination of the process of preparation and production of The WIO Science to Policy Platform Series under the GEF funded Projects on the Implementation of the Strategic Action Programme for the protection of the Western Indian Ocean from land-based sources and activities (WIO-SAP), Strategic Action Programme Policy Harmonisation and Institutional Reforms (SAPPHIRE), the "Partnership project for marine and coastal governance and fisheries management for sustainable blue growth (NC-SWIOFC); and the EU Capacity Building Related To Multilateral Environmental Agreements (EU-MEAs) Project, in collaboration with WIOMSA. I commend the authors for the timely science articles that have clear policy recommendations that can be adopted by the Contracting Parties to the Nairobi Convention in the conservation and restoration of the costal and marine environments.

Hon. VINA Marie Orléa,
Minister
Ministry of Environment and Sustainable Development
Republic of Madagascar

Introduction

It is with great pleasure that we introduce the first volume of the Western Indian Ocean (WIO) Science-Policy series, aptly themed *'Transitioning to a Sustainable Blue Economy in the WIO region: Addressing the challenges and harnessing opportunities*'. This series is produced by the Nairobi Convention and WIOMSA. The Contracting Parties of the Nairobi Convention, through various COP Decisions, have emphasized the need to strengthen the linkage between science and policy for evidence-based decisions to conserve coastal and marine resources in the WIO region. In this issue, we have selected articles to reflect the ongoing initiatives in the region to bring science and policy together and the ongoing discussions regarding how WIO scientists can contribute to Blue growth in the region over the long term. Our congratulations go out to the authors for making significant contributions that advance the science-policy connection.

While there have been ongoing science-policy interactions in the WIO over the last 15 years, these have generally been of an ad hoc nature and driven by specific projects or programmes. It was the Eighth Meeting of the Contracting Parties to the Nairobi Convention held in 2015 that approved the decision to establish a dialogue platform to strengthen the links between science, policy and action (CP8/12). Thereafter, the Platform structure and its procedures were developed and approved leading to its first meeting on 23rd-25th March 2021. The first meeting was held virtually and attended by 174 participants and 33 policy discussion papers were presented, 29 of which are included in the first issue of this volume. This series is intended to record the deliberations of this formalized structure going forward to ensure these important contributions are widely disseminated.

It is generally accepted that Science and Policy are two sides of the same coin. The two are intricately related, yet their synergies are not always mutually reinforcing. The need to bring these seemingly disparate archetypes of knowledge together has never been so urgent, not least because of the importance of evidence-informed policymaking. Similarly, to smelt policy from science, policy-smiths may need to reach the depths of understanding the science and implications, alongside the associated uncertainties. In fact, no matter where or why they are being conducted, scientific research in the sustainability sector must, of necessity, have policy relevance, a quest that the scientists must pursue.

Science plays an important role in policy and decision-making, but there are barriers between the two domains that limit its uptake. For example, it may be difficult for non-experts in the field to understand the technical nature of scientific information provided to policymakers/decision-makers, as well as inadequate communication of research needs and priorities by policymakers and managers so that research can be tailored to meet these needs and priorities. To effectively influence policy and decision-making, it is necessary to integrate scientific knowledge into a language and format that policymakers and decision-makers can understand. Mechanisms must also be put in place for releasing information to the scientific community about research needs and priorities.

As a whole, the papers in the first issue of the series acknowledge the challenges to achieving sustainable marine environments in the region and the policy and implementation gaps. Conversely, they also describe successful policy interventions. The issue highlights emerging issues that are receiving significant attention, perhaps because of their relevance to the regional context. It also highlights gaps in awareness and understanding of emerging issues that may require further policy-relevant research. This publication brings together contributors from academia, government, and the private sector to harness scientific knowledge for blue economy transformation in the WIO region.

In this issue, discussion papers were categorized into four broad thematic areas to which papers were allocated to the most closely related theme. The 'Species and ecosystems' category was one of the two that had the highest contribution. This group comprised policy recommendations on different ecosystems and species. While sharks, rays, mangroves and corals are the only ones represented in the issue, they represent species on coastal land from shallow to deep sea. Moreover, the common policy

recommendations for this theme were more knowledge of the species, stricter and more effective protection, and the formation of special groups of experts or a community of practice. In particular, most recommendations were also targeted at regional institutions (i.e., Nairobi Convention and WIOMSA). Climate change is a concern for the ecosystems. The main recommendations were to identify the capacity for species persistence through climate change and to enhance our understanding through common harmonized monitoring methods as a priority for biodiversity conservation.

A significant amount of attention was paid to water quality and land-based pollution. Under this theme, most papers were on plastics and marine litter, perhaps illustrating the magnitude of plastic pollution as an issue in the region. Notably, public and private players in this sector were represented, and representatives from the private sector also contributed. As a result of the development of the circular economy in this sector, private companies are generating secondary products and recycling waste to benefit waste management. This is an excellent example of how profitable business models can be developed to address environmental concerns in other sectors. Most, if not all, of the papers on plastic waste were from South Africa, which perhaps demonstrates the relative successes that have been made in South Africa compared to other countries in the region. Despite marine litter dominating this theme, two discussion papers were dedicated to the broader land-based pollution and integrated coastal zone management described by Celliers et al as 'wicked' problems. Both Taljaard et al and Celliers et al recommend the establishment of thematic taskforces to provide direction on specific issues within the broader theme, and more efforts in bringing all the stakeholders to the table in addressing the wicked integrated problems of the land-sea were recommended.

Also presented as a theme in this volume is area-based conservation measures, particularly marine protected areas (MPAs). Policy recommendations under this theme highlight a need to review the effectiveness of MPA management and promote a more inclusive approach to MPA management by considering access, use rights, and cultural and historical values of local communities. Overall, a systematic framework for conservation planning is proposed for MPA expansion and part of implementing the new post-2020 global biodiversity policy framework and UNEP-Nairobi Convention Conference of Parties decisions relating to Marine Spatial Planning (MSP). In this regard, recommendations recognize the role of Other Effective Area-based conservation measures (OECMs) in enhancing the socioeconomic benefits of MPAs and advocate for their wider implementation. These can be done within the broader harmonized MSP efforts at a national level. As explained in Lombard et al, these are best implemented using a harmonized regional approach at the national level.

Also covered in the discussion papers are cities, the Blue Economy, and fish and fisheries. Significantly, the role of the private sector in the blue economy was highlighted. If successes discussed in the circular economy solution to marine litter are anything to go by, private partner engagement in the blue economy will more likely bring success in the sector. Indeed, supporting investments that directly address sustainability issues is a cost-effective strategy for advancing the cause. For example, the global fund for coral reefs (GFCR) is an investment vehicle at a global level, a development bank of sorts, where businesses that benefit coral reefs can access funding in the form of repayable grants, capital injections, debt and other financial instruments. Similar approaches can facilitate de-risking and catalyzing investments in the Blue Economy.

'Good data is always better than no data at all' and 'garbage in, garbage out' are some of the common adages when dealing with data concerns. In many cases, policymakers are forced to formulate policies with information based on little or incomplete data. Developing policies can be hampered by it, much like driving in the dark without headlights. This is a reality in many emerging sectors of marine environment sustainability in the region. For example, Roberts et al note that as part of IUU regulation, there is an 'urgent need for information, analysis of data, sharing of data and collaboration to improve monitoring of small-scale fleets and small-scale fishing practices. Inherently linked to data scarcity is the capacity to develop tools and models that can make sense of the data. In this regard, Hauke et al propose setting up a community of practice comprised of the regional inter-sectoral expert panel overseeing the archiving data and standards. Increased capacity for generating information from data and its communication is key to evidence-based policy implementation and assessments of gaps in the effectiveness of management strategies.

Perhaps reinforcing this perception is the unanimous acceptance that climate change poses a threat in ways observed and monitored, with future changes largely remaining unknown. Besides the information provided in IPCC reports, there is no country-level synthesis on how climate change might affect different sectors, even as most sectors are reeling from climate impacts. As noted by Rahmesur et al, more could be done to communicate climate change as a threat to the public while developing the capacity of the top echelons of decision-making and opinion leaders. Given that the climate impacts on social and economic systems and overall well-being are expected to have far-reaching consequences, transformative adaptation actions are necessary. Rare extreme events, such as those presented by COVID-19, provide a glimpse of how communities might adapt to environmental shocks. Obura et al opine that 'alleviators or actions that may lead to reducing the potential impact, such as cooperation, empowered communities, and inspired youth leaders, should be strengthened. On the other hand, 'exacerbators', such as unsupportive political environments, siloed thinking, and a tendency towards business, may need to be discouraged for an effective, transformative adaptation.

Joseph M Maina
Guest Editor

Species and ecosystems

Working towards a better understanding of Western Indian Ocean deep-sea ecosystems

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Summary

The deep sea is globally recognised as providing benefits for all humanity for example, as an essential carbon sink and temperature regulator. This environment maintains ecosystem health and enables unique biodiversity to thrive. Although this blue space comprises much of the volume of our planet, it is mostly under-researched, and our understanding of its life and processes is limited. The Western Indian Ocean's (WIO) deep sea is one of the world's least explored habitats due to a lack of readily available technology, expertise, and funding. With a growing coastal population and an increasing global interest in exploiting deep-sea resources, such as fisheries and minerals, it is essential to increase the understanding of these habitats and their value. This will inform management strategies for the sustainable use and stewardship of these ecosystems.

Background

The deep sea is the waters below 200 m and their habitats comprise 95 per cent of habitable space on the planet. The deep sea convey many benefits to society (Danovaro and others, 2017) for example climate regulation and nutrient cycling. The deep sea is heterogeneous. It comprises unique habitats like hydrothermal vents, cold-water coral reefs, creating a patchwork of environments (Stuart and others, 2003) created by the complex interactions of historical (e.g., tectonic shift) and contemporary factors (e.g., ocean currents). Although less studied than shallow water systems, the deep sea is equally essential for the prosperity of the global population. Its ecosystem services vary from the regulation of the climate to the provision of protein and as a place that creates wonder and inspiration (Armstrong and others, 2012).

Despite being remote, out of sight and largely out of mind, deep-sea habitats are impacted by the consequences of human activities (Ramirez-Llodra and others 2011). These span global threats such as the effects of climate change, to the damaging practices of some fisheries and newer activities such as mineral mining and extraction. The deep sea is not pristine or untouched and has been of scientific interest for decades (Boos and others, 2019).

Acknowledging that the deep sea is three-dimensional, interconnected, and heterogeneous, global extrapolations are unlikely to provide the appropriate information at a scale relevant for the management and protection of the WIO. Therefore, data should be drawn from deep-sea surveys of the WIO. This paper investigates the published research that has been conducted in the region on the biology and ecology of deep-sea systems and synthesises findings with some recommendations for consideration.

Although the deep sea is rarely mentioned in international treaties, it is integral to many as a vast and essential area. All Nairobi Convention (NC) contracting parties have exclusive economic zones (EEZ) that include the deep sea, but in the WIO, most of the deep sea is in the high seas. Pertinent is the ongoing negotiations for a legally binding instrument under the United Nations Convention on the Law of Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (BBNJ). These negotiations focus on the high seas and cover technology

http://dx.doi.org/1x.xxx/wio.1

transfer, marine genetic resources, and environmental impact assessments, among other issues.

The deep sea is implicitly and explicitly included in several globally recognised targets (Table 1). However, these targets require more and better deep-sea data to support countries endeavours for adequate implementation. Finally, The Decade of Ocean Science for Sustainable Development (UN Ocean Decade) is running from 2021-2030. The implementation plan (UNESCO-IOC 2021) highlights the importance of deep-water environments and the life they support. As such, this paper supports objectives 1.1 and 2.1 of this initiative.

62 references. These publications were screened for relevance leaving 43 articles within this review. Papers are reported by publishing year and academic field for each NC nation and the high seas. The focal taxonomic group is reported by class or the next lowest taxonomic group when more appropriate. NC parties' population size used UN projections (United Nations, Department of Economic and Social Affairs, Population Division 2019) but only included residents of the WIO. The Exclusive Economic Zone (EEZ) area was taken from Marine Regions v11 (Flanders Marine Institute 2021). We included any overlapping claims, and French and S African EEZ sizes were scaled to represent the area within the WIO only (Flanders Marine Institute 2020).

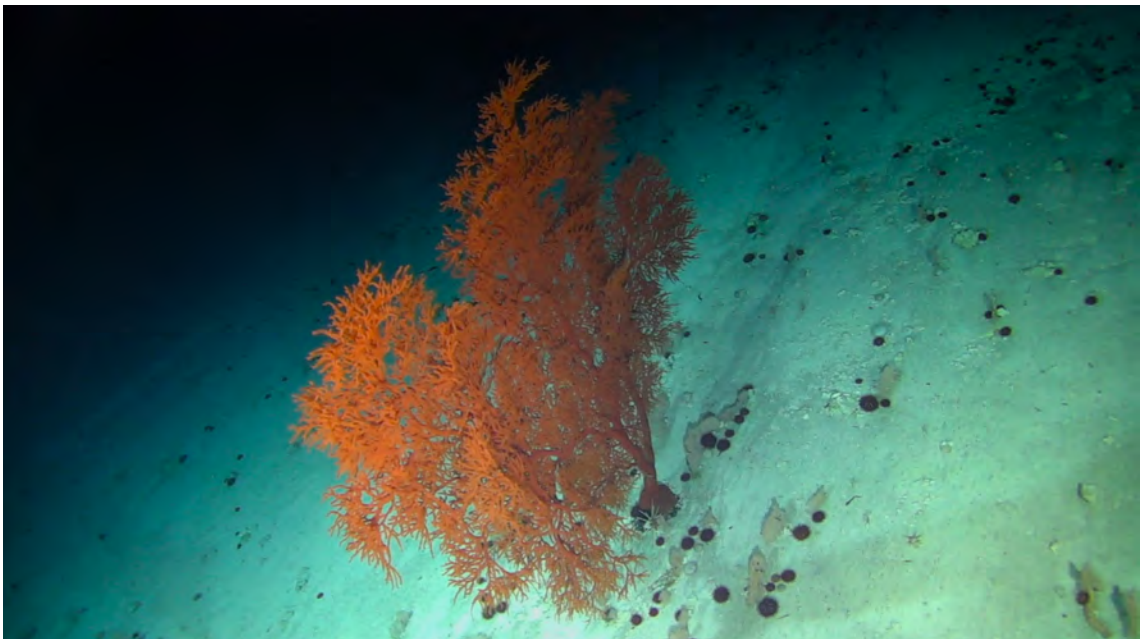

Figure 1: Black coral (Leiopathes) taken at 250m in the Outer Island of Seychelles (Seychelles First Descent)

Advances

Decision-makers rely in part on having access to usable information. This paper reviews the literature available using a systematic search on SCOPUS as a proxy for this information (SCOPUS is a citation and abstract database). This review intends to present a preliminary overview of past deep-sea biology studies. This paper excludes; grey literature and documents that were not written or translated into English.

The search terms [deep sea] or [deep-sea] and [Western Indian Ocean] or one of the contracting parties of the Nairobi Convention and [ecology] or [biology] were used and limited to papers in the fields of environmental or biological sciences. The initial search revealed

Literature included studies conducted in all the waters of all contracting parties of the NC, with around a quarter (28 per cent) being undertaken in the high seas (Figure 2). Few studies were found. The spread of research effort is not equal across all countries, and neither is it proportional to EEZ or population size (Figure 3). The island nations of Mauritius and Seychelles are under-represented in studies considering the size of their EEZ. When the population is considered, Tanzania and Kenya are also under-represented. **This preliminary analysis illustrates that research opportunities and survey efforts are not equally distributed and remain very low overall.**

Table 1: Examples of global policy frameworks that reference marine ecosystems and biodiversity in a manner that includes the deep sea.

Programme / Instrument	Target	Aim
UN Sustainable Development Goals	14.2	Manage, protect, and restore ecosystems
	14.4	Increase measures to increase sustainable fishing
	14.5	Conserve at least 10 per cent of coastal and marine areas
	14.7	Increase the economic benefits from the sustainable use of marine resources
	14.a	Increase scientific knowledge, research, and technology for ocean health
	14.c	Implement and enforce international sea law
Convention of Biological Diversity (CBD/WG2020/3/3)	1	All land and sea areas globally to be under integrated biodiversity-inclusive spatial planning
	2	Restore at least 20 per cent of degraded ecosystems
	3	Conserve at least 30 per cent of areas
	5	Harvest of wild species is sustainable and legal
	6	Invasive species
	13	Fair access to genetic resources
	14	Integrate biodiversity values
	15	Businesses to assess and report their impact on biodiversity
	16	Inform people so they can make a responsible choice in their consumption
	20	Increase knowledge for effective management of biodiversity

Over the last 10 years, there appears to have been a steady increase in the number of publications (Figure 4) resulting from deep-sea surveys within the WIO. However, with so few papers published per year, this increase could have resulted from a very small increase in expeditions and grants. Furthermore, the historical lack of publications means that it is challenging to understand the temporal-biological trends of the region. **It is evident from the publication record that deep-sea biology is understudied within the WIO.**

Twenty-three taxonomic groups were represented across the studies. The crustaceans Malacostraca are the focus of most studies (20 per cent) (Figure 5). This is the largest of the classes of crustaceans and includes crabs, lobster, and shrimp, which are of fisheries interest. Notably, fifteen taxa are only represented once, and communities of organisms (macrofauna, megafauna and micronekton) focused on only five studies in total. **Analysis suggests that all taxa are understudied within the WIO region**.

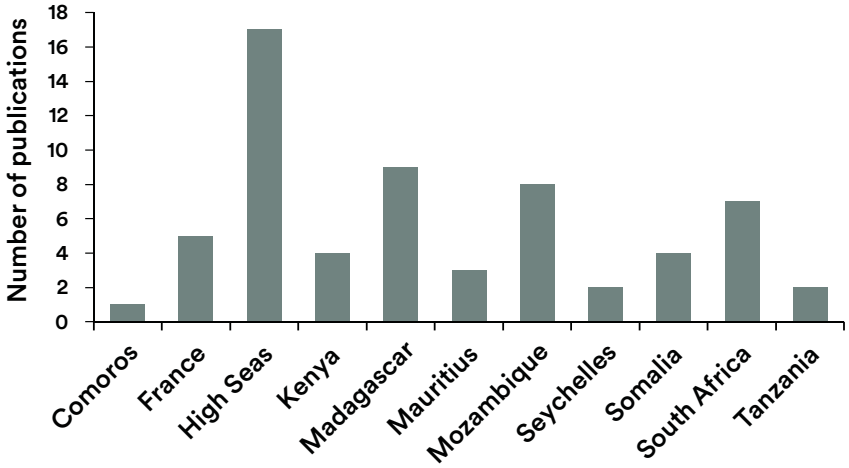

Figure 2: Proportion of peer-viewed publications on deep-sea biology that have been conducted across WIO nations.

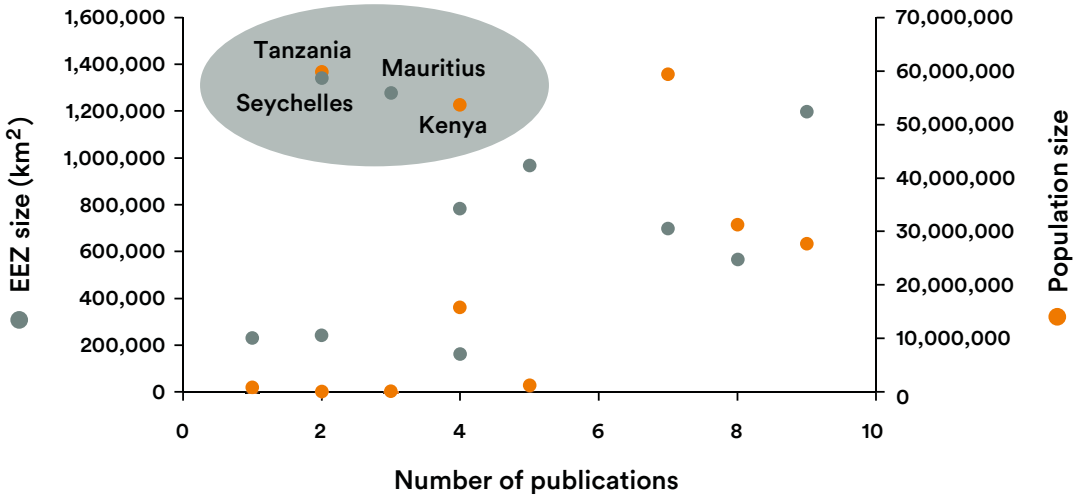

Figure 3: Correlation of deep-sea publication with EEZ and population size of WIO nations. Points within the great shaded area denote under-representation of studies

Most studies (58 per cent) investigated systematics or taxonomy. In most cases, there was a strong focus on new species descriptions, often from material collected at least a decade ago. The delay between specimen collection and species descriptions is a global phenomenon primarily due to a lack of resources and expertise to conduct this type of research (Scheltema 1996). While essential in helping to support biodiversity research, taxonomic studies alone do not contribute to a better understanding of ecological communities, habitats and processes. Community ecology is considered especially important for marine biodiversity management (Mangel and Levin 2005). Still, only six such studies have been conducted in the WIO deep sea, representing sediment, benthos, and pelagic assemblages. Each study focused on a different location and taxonomic group; therefore, no comparisons of assemblages could be made. No WIO deep-sea temporal studies were discovered during this systematic review. Temporal biodiversity data are needed to identify trends and changes in communities, which are essential to understand the influences of changes in use and the consequences of stressors. **Our findings suggest that further studies on deep-sea systems, which provide information for policymakers, are required in the WIO region.**

Outlook for the region and globally

Globally there is a recognised dearth of deep-sea data (McClain 2007), and the available data are biased to northern hemisphere locations (Menegotto and Rangel 2018). There needs to be a coordinated global program of deep-sea science to provide new knowledge to answer the fundamental questions about the deep sea and support a sustainable future for the deep ocean (Howell and others 2021).

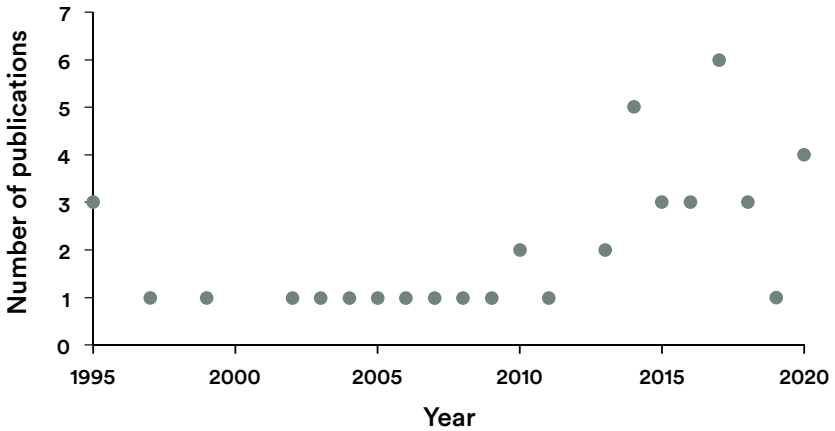

Figure 4: Change in WIO focused deep-sea publications from 1995 to 2020. 1995 was the date of the earliest study.

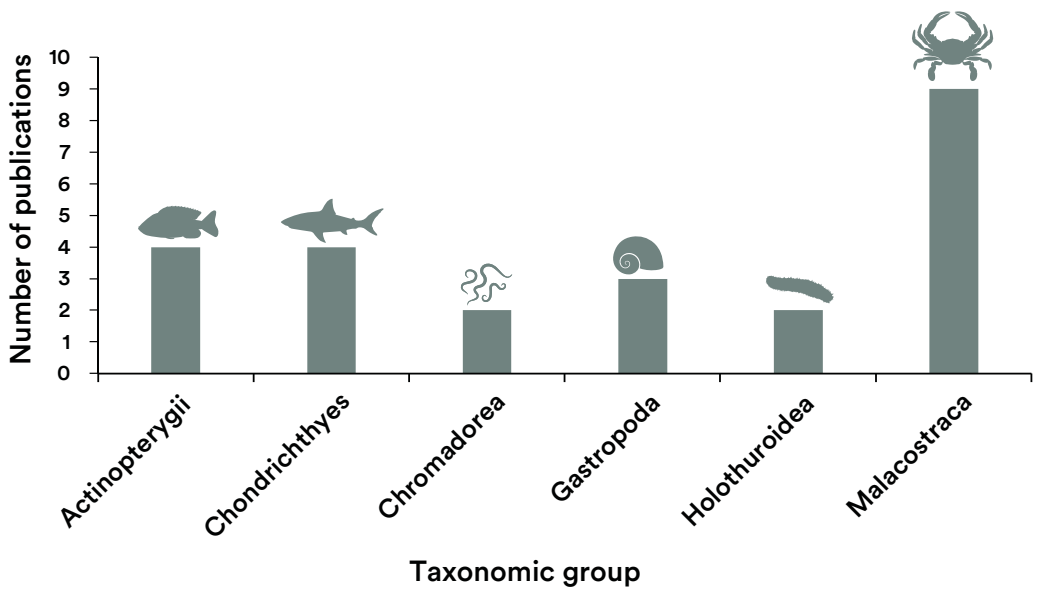

Figure 5: Number of papers per taxonomic group drawn from surveys of the WIO (only taxa with articles >1 are shown).

Recognising the historical inequalities in deep-sea science and the logistical challenges to access this space, it is unsurprising that we identified all regions, taxa and fields of study under-represented in the published literature on the deep-sea biology of the WIO. The extensive nature of this knowledge gap means a lack of usable information is available for policymakers.

This brief review was not intended to capture an exhaustive list of publications but instead act as an opportunity to identify knowledge gaps. Based on this work, we make the following recommendations to help direct future policy decisions that will support a sustainable and thriving WIO region.

1. Amplify deep-sea literacy and understanding
2. Increase data and knowledge of the deep sea
3. Increase opportunities for deep-sea research and stewardship

Technical Recommendations

1. The services of the deep sea provided by ecosystems and organisms that inhabit them should be communicated to parties. Opportunities could be available through WIOMSA, FARI or other suitable organisations. This work supports the UN Ocean Decade objectives 3.1 and 3.2.

2. A comprehensive review of deep-sea biological data (inc. grey literature and traditional knowledge) should be conducted to provide knowledge gaps and to help prioritise activities. This work supports the UN Ocean Decade objectives 1.1, 1.4, 1.5 and 2.2.

Policy recommendations

1. A deep-sea working group should be established within the mechanism of the NC to lead the advancement of deep-sea research and data usage in the WIO. This work supports the UN Ocean Decade objectives 2 and 3.

2. Parties should continue to have strong representation in the BBNJ negotiations. The deep sea is valuable for the prosperity of NC nations now and in the future.

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Protecting threatened sharks and rays in the Western Indian Ocean

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Summary

The Western Indian Ocean (WIO) is a global priority for the conservation of sharks and rays. Yet, there is limited policy in place in the WIO for their effective management and conservation. This paper provides a list of shark and ray species recommended for protection or regulated harvesting at national and regional levels within the WIO, based on retention bans or harvest regulations defined under one or more environmental agreements or fisheries bodies.

Background and rationale: Sharks and rays in the Western Indian Ocean

The WIO is known for its rich marine life and is considered a global hotspot for shark and ray diversity (Dulvy and others, 2014). At least 225 shark and ray species have been recorded in the WIO to date, many of which are found nowhere else in the world (Dulvy and others, 2014, Stein and others, 2018).

The WIO is also characterised by extensive fisheries, from artisanal fishers to industrial fleets and illegal, unreported and unregulated (IUU) fishing, all of which take sharks and rays as a target or incidental catch. There is a high demand for shark and ray products, particularly shark meat, for local consumption, and legal and illegal trade in the fins of sharks and shark-like rays (wedgefishes, guitarfishes and sawfishes), for the global shark fin trade. However, most shark and ray species grow very slowly, produce few offspring and become sexually mature only after many years. Hence, population growth is slow, making them highly susceptible to the impacts of overfishing (Worm and others, 2013).

Many shark and ray species have suffered significant stock declines, primarily due to overfishing and other human impacts (Dulvy and others, 2014, Pacoureau and others, 2021). According to the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species, 83 of the shark and ray species in the WIO (37 per cent, an increase from 22 per cent over the past 15 years) are facing a high to extremely high risk of extinction in the wild (IUCN 2021). There has also been a considerable increase over the past 15 years in the proportion of WIO endemic shark and ray species (species found only in this region) that are classified as threatened or near-threatened, from 10 to 20 per cent.

Overexploitation of shark and ray species can have direct impacts on their populations and indirect impacts on their ecosystems and food webs. Thousands of people living in coastal communities within the WIO depend on marine resources, including sharks and rays, for their income and livelihoods, making this a social and ecological issue. However, the catches of shark and ray species are currently poorly recorded, and the actual total quantities caught, particularly in artisanal, small-scale and IUU fisheries, remain unknown (Worm and others, 2013). Furthermore, human populations and the demand for marine resources are increasing throughout the WIO, with evidence of human migrations to and among coastal areas in search of improved food security and livelihoods (Barnes-Mauthe and others, 2013). There is thus a continued threat to WIO shark and ray species, the severity of which is increasing. Consequently, there is a critical need for corrective management and improved conservation of WIO shark and ray species, particularly those already threatened or likely to become threatened.

http://dx.doi.org/1x.xxx/wio.2

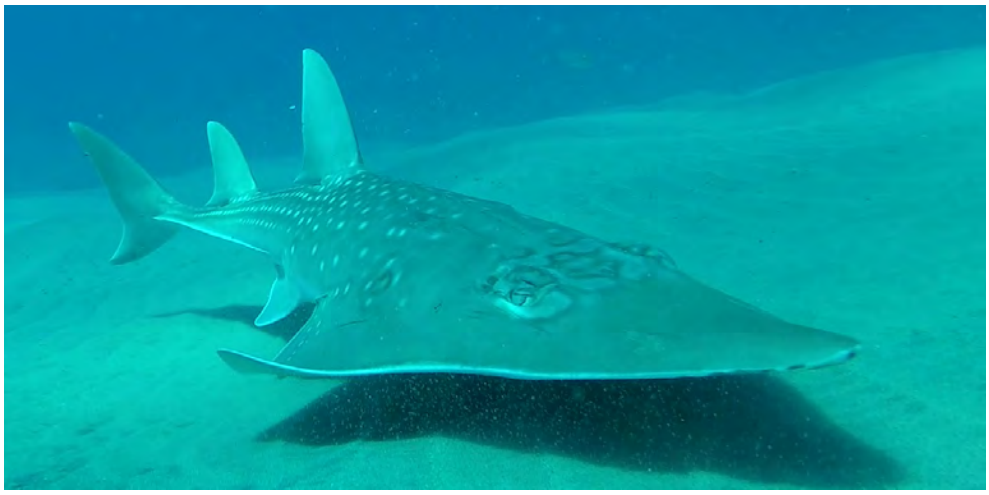

Figure 1. Rhynchobatus_djiddensis_Wildlife_Conservation_Society - A Critically Endangered whitespotted wedgefish Rhynchobatus djiddensis approaches an underwater research camera, southern Mozambique (Credit: Wildlife Conservation Society, Mozambique).

This paper responds to these issues as they relate to the WIO, particularly the Member States of the *Nairobi Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region* (UNEP 1985). The paper is intended to encourage improved protection and stricter harvesting regulations for threatened shark and ray species in the WIO through (1) the listing of appropriate shark and ray species on the Annexes of the Nairobi Convention *Protocol concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region* and (2) the protection or regulated harvesting of relevant species at the national level. Therefore, the paper identifies (i) binding shark and ray protection commitments imposed by multilateral environmental agreements and regional fisheries bodies to which Nairobi Convention Member States are party and (ii) shark and ray species that warrant protection or harvesting regulations by virtue of their threatened conservation status.

Advances: Instruments for the management of shark and ray populations

Addressing these issues at the international level

The IUCN *Red List of Threatened Species* assesses species according to their population trends and threats faced (such as fishing impacts). The Red List categories of Vulnerable, Endangered and Critically Endangered are considered "threatened" categories and include species facing a high to extremely high risk of extinction in the wild (IUCN 2001). Near Threatened species do not currently meet the criteria for any of the threatened categories but may do so in the near future. The IUCN categories impose no regulatory actions on governments; however, they provide a standardised and objective classification of the conservation status of each species, while the precautionary approach suggests that the harvesting of threatened species should be prohibited or regulated. In the Nairobi Convention area of the WIO, there are 13 Critically Endangered, 26 Endangered, 44 Vulnerable and 30 Near Threatened species (IUCN 2021).

Numerous shark and ray species are now listed on the Appendices of the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS 1979) and the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES 1983), thus increasing the mandate of governments to address their conservation and management needs. The Indian Ocean Tuna Commission (IOTC 2021) has also developed specific conservation and management measures relating to several shark and ray species that are considered to be under threat from the IOTC-linked fisheries directed at tuna and tuna-like species.

The *Convention on the Conservation of Migratory Species of Wild Animals* (CMS) is an environmental treaty of the United Nations, which provides a global platform for the conservation and sustainable use of migratory animals and their habitats. CMS brings together the "Range States" of migratory species to lay a legal foundation for internationally co-ordinated conservation measures for such species.

CMS Appendix I lists migratory species threatened with extinction. CMS Parties strive towards strictly protecting species listed in Appendix I, conserving or

Table 1: Shark and ray species in the Nairobi Convention area of the WIO that are listed under the Convention on the Conservation of Migratory Species of Wild Animals (CMS; I and II indicate relevant CMS Appendices), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; I and II indicate relevant CITES Appendix), or a prohibiting Indian Ocean Tuna Commission (IOTC) resolution, along with IUCN Red List status (CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened. *Presence in Nairobi Convention area uncertain: possibly along Indian Ocean coastline of Somalia).

Species name	Common name	CMS Appendix	CITES Appendix	IOTC Resolution	IUCN Red List
Alopiidae	**Thresher sharks**				
Alopias pelagicus	Pelagic thresher shark	II	II	12/09	EN
Alopias superciliosus	Bigeye thresher shark	II	II	12/09	VU
Alopias vulpinus	Common thresher shark	II	II	12/09	VU
Carcharhinidae	**Requiem sharks**				
Carcharhinus falciformis	Silky shark	II	II	-	VU
Carcharhinus longimanus	Oceanic whitetip shark	I	II	13/06	CR
Carcharhinus obscurus	Dusky shark	II	-	-	EN
Prionace glauca	Blue shark	II	-	-	NT
Cetorhinidae	**Basking shark**				
Cetorhinus maximus	Basking shark	I/II	II	-	EN
Glaucostegidae	**Giant guitarfishes**				
Glaucostegus halavi	Halavi guitarfish	-	II	-	CR
Lamnidae	**Mackerel sharks**				
Carcharodon carcharias	Great white shark	I/II	II	-	VU
Isurus oxyrinchus	Shortfin mako shark	II	II	-	EN
Isurus paucus	Longfin mako shark	II	II	-	EN
Lamna nasus	Porbeagle shark	II	II	-	VU
Mobulidae	**Mobulid rays**				
Mobula alfredi	Reef manta ray	I/II	II	19/03	VU
Mobula birostris	Giant manta ray	I/II	II	19/03	EN
Mobula eregoodoo	Longhorned pygmy devil ray	I/II	II	19/03	EN
Mobula kuhlii	Shortfin devil ray	I/II	II	19/03	EN
Mobula mobular	Spinetail devil ray	I/II	II	19/03	EN
Mobula tarapacana	Sicklefin devil ray	I/II	II	19/03	EN
Mobula thurstoni	Bentfin devil ray	I/II	II	19/03	EN
Pristidae	**Sawfishes**				
*Anoxypristis cuspidata**	Narrow sawfish	I/II	I	-	EN
Pristis pristis	Largetooth sawfish	I/II	I	-	CR
Pristis zijsron	Green sawfish	I/II	I	-	CR
Rhincodontidae	**Whale shark**				
Rhincodon typus	Whale shark	I/II	II	13/05	EN
Rhinidae	**Wedgefishes**				
Rhina ancylostomus	Bowmouth guitarfish	-	II	-	CR
Rhynchobatus australiae	Bottlenose wedgefish	II	II	-	CR
Rhynchobatus djiddensis	Whitespotted wedgefish	-	II	-	CR
Rhynchobatus laevis	Smoothnose wedgefish	-	II	-	CR
Sphyrnidae	**Hammerhead sharks**				
Sphyrna lewini	Scalloped hammerhead shark	II	II	-	CR
Sphyrna mokarran	Great hammerhead shark	II	II	-	CR
Sphyrna zygaena	Smooth hammerhead shark	II	II	-	VU

restoring their important habitats, mitigating obstacles to their migration and controlling other factors that might endanger them. Thirteen shark and ray species occur in the WIO, which are listed on CMS Appendix I (Table 1), and which must be protected accordingly. These include 3 Critically Endangered and 8 Endangered species, according to the IUCN Red List (IUCN 2021), highlighting their need for protection, at least among CMS Party nations.

CMS Appendix II lists migratory species that need or could benefit from international co-operation. Therefore, CMS encourages Range States to conclude global or regional agreements on such species, to ensure their appropriate management at multinational levels. There are 25 shark and ray species that occur in the WIO that are listed on CMS Appendix II (including 12 that are also listed in CMS Appendix I) (Table 1). Of the 13 species listed only in Appendix II, 3 are Critically Endangered and 4 are Endangered (IUCN 2021).

The CMS Convention text and Appendices are legally binding on Parties. The Nairobi Convention Member States of Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, South Africa, Tanzania and France (and thereby the French Departments of La Réunion and Mayotte) are party to CMS, and thus bound by commitments prescribed in this Convention. These states are thereby required to protect the 13 shark and ray species that are listed in CMS Appendix I and which occur in the WIO (Tables 1, 2 and Appendix I to this document) and control other factors that might endanger them. However, few of these species are protected within most Nairobi Convention Member States (Table 2). There are also few regional management measures for relevant species listed in CMS Appendix II.

The *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) is an international agreement among governments to ensure that

Table 2: Shark and ray species in the Western Indian Ocean required to be protected at national level through listing in Appendix I of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) or prohibited from capture in specific fisheries through an Indian Ocean Tuna Commission (IOTC) resolution, and countries in which these species are fully protected (1), prohibited in IOTC-related fisheries through permit conditions, present but receive no protection (X) or absent (-). (IUCN Red List status: CR = Critically Endangered, EN = Endangered, VU = Vulnerable). (Alpha-2 country codes: KM: Comoros, KE: Kenya, MG: Madagascar, MU: Mauritius, MZ: Mozambique, RE: La Réunion, YT: Mayotte, SC: Seychelles, So: Somalia, ZA: South Africa, TZ: Tanzania. *Presence in Nairobi Convention area uncertain: possibly along Indian Ocean coastline of Somalia).

Species name	Common name	IUCN	CMS	IOTC	KM	KE	MG	MU	MZ	RE	YT	SC	SO	ZA	TZ
Alopiidae	**Thresher sharks**														
Alopias pelagicus	Pelagic thresher shark	EN		12/09	2	2	2	2	1	X	X	2	X	1	1
Alopias superciliosus	Bigeye thresher shark	VU		12/09	2	2	2	2	1	X	X	2	X	1	1
Alopias vulpinus	Common thresher shark	VU		12/09	2	2	2	2	1	X	X	2	X	1	1
Carcharhinidae	**Requiem sharks**														
Carcharhinus longimanus	Oceanic whitetip shark	CR	I	13/06	X	1	2	2	1	X	X	2	X	2	2
Cetorhinidae	**Basking shark**														
Cetorhinus maximus	Basking shark	EN	I		-	-	-	-	-	-	-	-	-	1	-
Lamnidae	**Mackerel sharks**														
Carcharodon carcharias	Great white shark	VU	I		X	1	X	2	1	1	1	X	-	1	X
Mobulidae	**Mobulid rays**														
Mobula alfredi	Reef manta ray	VU	I	19/03	X	-	2	-	1	-	1	1	-	1	2
Mobula birostris	Giant manta ray	EN	I	19/03	X	2	2	2	1	1	1	1	X	1	2
Mobula eregoodoo	Longhorned pygmy devil ray	EN	I	19/03	X	2	2	2	1	1	1	1	X	2	2
Mobula kuhlii	Shortfin devil ray	EN	I	19/03	X	2	2	2	1	1	1	1	X	2	2
Mobula mobular	Spinetail devil ray	EN	I	19/03	-	2	2	-	1	-	1	-	X	2	2
Mobula tarapacana	Sicklefin devil ray	EN	I	19/03	-	-	2	2	1	1	-	-	-	2	2
Mobula thurstoni	Bentfin devil ray	EN	I	19/03	-	-	2	-	1	-	-	-	-	2	2
Pristidae	**Sawfishes**														
*Anoxypristis cuspidate**	Narrow sawfish	EN	I		-	-	-	-	-	-	-	-	X	-	-
Pristis pristis	Largetooth sawfish	CR	I		-	X	X	X	1	1	-	X	X	1	1
Pristis zijsron	Green sawfish	CR	I		-	X	-	X	1	1	-	-	X	1	1
Rhincodontidae	**Whale shark**														
Rhincodon typus	Whale shark	EN	I	13/05	X	1	2	2	1	X	X	1	X	1	1

international trade in specimens of wild animals and plants does not threaten their survival. CITES-listed species are subjected to international trade controls, through listing in three Appendices, according to the degree of protection needed (there are currently no marine shark or ray species listed on Appendix III, so this is not discussed further herein).

CITES Appendix I includes species threatened with extinction. International trade in specimens of these species is generally prohibited but may be permitted only in exceptional circumstances. No commercial trade is permitted for CITES Appendix I species. Of the 52 shark and ray species listed globally on the three CITES Appendices, just five (all from the family Pristidae – sawfishes) are listed on Appendix I, including two species previously known from much of the WIO – the largetooth sawfish *Pristis pristis* and the green sawfish *P. zijsron* (Table 1). However, these two Critically Endangered species have been classified as locally extinct in some places, such as South Africa (Everett and others, 2015), and whether they persist in the WIO is not certain. These species must be prohibited from commercial trade, and, as these species are also listed on CMS Appendix I, they should be prohibited from capture.

CITES Appendix II is intended to include species not necessarily threatened with extinction currently, but in which trade must be controlled to avoid utilisation incompatible with their survival. However, all 25 chondrichthyan species listed in CITES Appendix II, that are found in the WIO, are already threatened according to the IUCN Red List, including 7 Critically Endangered, 12 Endangered and 6 Vulnerable species (Table 1). At least 20 of these are (or were previously) also significant components of artisanal and/or commercial fisheries in the region. No international trade in Appendix II species is permitted without evidence that the trade does not detrimentally affect wild populations (CITES 1983), which requires a formal Non-Detriment Findings (NDF) assessment, of which the result must be positive to permit trade. However, while shark and ray species listed on this Appendix are known to be exported from the WIO countries, there are no publicly available records of NDF assessments having been developed for any CITES Appendix II shark or ray species, in any WIO country.

CITES and its Appendices are legally binding on Parties. All ten Nairobi Convention Member States are party to CITES and are thereby bound by the trade control commitments prescribed in this Convention, as they relate to shark and ray species listed in the relevant CITES Appendices. All Nairobi Convention Member States are therefore obliged to control and monitor trade in the 27 CITES-listed shark and ray species that occur in the WIO (Table 1), ensure trade is not detrimental to wild populations of these species and prevent the commercial trade in CITES Appendix

Figure 2. Sphyrna lewini_Christelle Razafindrakoto_WCS Madagascar NW2: A Critically Endangered scalloped hammerhead shark Sphyrna lewini is landed on the beach at Ankivonjy, northwest Madagascar (Credit: Christelle Razafindrakoto, Wildlife Conservation Society, Madagascar)

I species. However, the 2021 *Status of Legislative Progress for Implementing CITES* indicates that few Nairobi Convention Member States are implementing CITES effectively (CITES 2021).

The Indian Ocean Tuna Commission (IOTC) is an intergovernmental regional fisheries management organisation (RFMO), under the Food and Agriculture Organization (FAO) of the United Nations, responsible for the management of tuna and tuna-like species in the Indian Ocean (Anon. 1993). The management mandate of the IOTC is tuna and tuna-like species; however, data are also collated on non-target, associated and dependent species affected by tuna fishing operations, including sharks and rays. To ensure the sustainability of these species, the IOTC imposes Conservation and Management Measures on its Member States, which include several specific *Resolutions* on the fishing, handling, retention and reporting of selected shark and ray species or groups, or through inclusion of new or updated national legislation or policy to uphold these management measures. Retention bans are imposed for all thresher sharks (Family Alopiidae, IOTC 2012), whale sharks *Rhincodon typus* (IOTC 2013a), oceanic whitetip sharks *Carcharhinus longimanus* (IOTC 2013b) and all mobulid rays (Family Mobulidae, IOTC 2019) in IOTC-managed fisheries (Tables 1, 2).

All ten Nairobi Convention Member States are members of the IOTC and are thereby bound by the protective commitments detailed in published IOTC Resolutions. This includes prohibiting catches, by their relevant fisheries and fishing vessels, of the 12 shark and ray species that occur in the WIO which are listed as prohibited in the IOTC Resolutions (Tables 1, 2, and see Appendix I). However, few of these species are protected in most Nairobi Convention Member States (Table 2), and most of these states fall short of their binding commitments to the IOTC.

Addressing these issues in the Western Indian Ocean Region

The Nairobi Convention *Protocol concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region* (hereinafter Nairobi Convention Protocol) stresses the importance of sustainable utilisation of East Africa's fauna and flora. Article 4 of the Protocol: *Species of Wild Fauna Requiring Special Protection* calls on Contracting Parties to "take all appropriate measures to ensure the strictest protection of the endangered wild fauna species listed in annex II". Article 5 of the Protocol: *Harvestable Species of Wild Fauna* states that "Contracting Parties shall take all appropriate measures to ensure the protection of the depleted or threatened wild fauna species listed in annex III" and that "such wild fauna species shall be regulated in order to restore and maintain the populations at optimum levels" (UNEP 1985). These Annexes therefore provide an objective, centralised list of species, to inform resource managers of Member States which species warrant management or legal protection at national level. Following these Nairobi Convention Protocol articles, and considering their very high risk of extinction, species listed as Critically Endangered and Endangered on the IUCN Red List should be protected, while the harvesting of Vulnerable and Near Threatened species should be regulated, to avoid further population reductions. Listing of appropriate shark and ray species on the Protocol Annexes would provide a legal mechanism for such regulation; however, there remain no shark or ray species listed on the Annexes of this Protocol.

Recognising increasing global concern regarding the declining status of sharks and rays, and the mounting evidence of threats to shark and ray species in the WIO, the Nairobi Convention Member States agreed at their 7th Conference of the Parties (CoP7, Maputo, Mozambique, December 2012), to include sharks (understood to include rays) in the Convention's Programme of Work for 2013-2017 (Decision CP7/1). The Parties also adopted Decision CP7/12: *Conservation of Sharks*, calling for regional collaboration on the conservation and management of sharks, including with CITES, CMS, regional fisheries management organisations, and other partners. While IUCN Red List categories carry no legal requirement for action, the regulations and protective measures for threatened species imposed by CITES, CMS and IOTC are legally binding on Member States. However, many Nairobi Convention Member States currently fail to meet these binding commitments and so fall short in their obligations to implement such multilateral agreements. Mozambique is the only Nairobi Convention Member State that fully protects all CMS Appendix I and IOTC-prohibited shark and ray species; Kenya fully protects just three of these but also formally recognises the IOTC resolutions on thresher sharks (Alopiidae) and mobulid rays (Mobulidae), which thereby apply to all Kenyan fishing vessels on the IOTC Record of Authorised Vessels; Seychelles, South Africa and Tanzania protect fewer than half of these species; while Comoros, Madagascar, Mauritius, Somalia and France (French WIO Departments) protect none of these species (Table 2).

Figure 3. Sphyrna lewini_Christelle Razafindrakoto_WCS Madagascar SW2: A juvenile Critically Endangered scalloped hammerhead shark Sphyrna lewini lies on a fisher's oar, near Andavadoaka, southwest Madagascar (Credit, Christelle Razafindrakoto, Wildlife Conservation Society, Madagascar).

Outlook: recommendations for the Western Indian Ocean Region

Considering that more than one third of WIO shark and ray species are threatened, there is an urgent need for improved legislation for and management of sharks and rays at regional and national levels in the WIO, to reduce the impacts of fishing on these threatened species. However, there is generally limited legislation for sharks and rays in most WIO countries. There is also a need to improve adherence to the multilateral agreements to which Nairobi Convention Member States are party. There is also a need to list relevant shark and ray species, whose populations within the WIO require stricter management or warrant full protection, under the Annexes of the Nairobi Convention Protocol.

To address these objectives and provide a legal framework for the appropriate management and conservation of WIO shark and ray species, this discussion paper presents a list of species proposed for inclusion on the relevant Annexes of the Nairobi Convention Protocol. This list, *Recommendations for Shark and Ray Listings in the Annexes of the Nairobi Convention Protocol Concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region*, presented as Appendix I to this document, lists individual shark and ray species recommended for each Protocol Annex, including justifications for such listing.

Species are recommended for listing on Annexes II, III and IV, as follows:

II. Overall, 23 shark and 20 ray species are proposed for listing on Annex II of the Protocol (see Table A1 in Appendix I), based on their listing on CITES Appendix I, CMS Appendix I, being the subject of an IOTC retention ban or falling within the Critically Endangered or Endangered IUCN Red List categories. This list includes 13 Critically Endangered and 26 Endangered species.
III. Furthermore, 51 shark species and 19 ray species are recommended for listing on Annex III of the Protocol (see Table A2 in Appendix 1), due to their being listed on CITES Appendix II, on CMS Appendix II, or as Vulnerable or Near Threatened on the IUCN Red List of Threatened Species.
IV. Finally, 43 shark species and 25 ray species are proposed for listing on Annex IV of the Nairobi Convention Protocol (which calls for co-ordinated efforts for the protection of migratory species listed in Annex IV), based on their listing on CMS Appendix I and/or II, Annex I of the CMS Sharks Memorandum of Understanding (CMS 2018), identification as being migratory or possibly migratory (Fowler 2014), or their listing on Annex I ("highly migratory species") of the United Nations Convention on the Law of the Sea (UNCLOS, UN 1982). Several species proposed for listing on Annexes II or III are also proposed here for listing in Annex IV, as Annex IV listing is based on the species' migratory ecology, rather than threat status, thus warranting separate listing (see Table A3 in Appendix I to this document).

Recalling Decision CP7/12: *Conservation of Sharks*, Article 4 of the Nairobi Convention Protocol: *Species of Wild Fauna Requiring Special Protection* and Article 5 of the Nairobi Convention Protocol: *Harvestable Species of Wild Fauna*, the Nairobi Convention Member States are urged to take the following steps, to reduce impacts on shark and ray populations in the WIO, for their improved conservation status:

1. List appropriate shark and ray species on the respective Nairobi Convention Protocol Annexes, as proposed in Appendix I to this document.
2. Implement all binding commitments in terms of species protections and trade controls at national level, as imposed by the multilateral agreements to which they are party, including (among others):
   a. protection of all shark and ray species listed in CMS Appendix I;
   b. protection of all shark and ray species prohibited in IOTC Resolutions;
   c. trade controls for all shark and ray species listed in CITES Appendices.
3. Voluntarily implement species protections and catch restrictions for threatened species and species subject to trade controls, which are not already required to be protected under other multilateral agreements, through:
   a. Following the guiding text of the Nairobi Convention Protocol, in terms of strictly protecting endangered wild fauna species;
   b. Protecting and managing species listed in Nairobi Convention Annexes;
   c. Protecting species listed under CITES Appendix I, for which commercial trade bans should already be in place;
   d. Protecting all IUCN Critically Endangered and Endangered species.
4. Develop and implement appropriate national and regional management plans and management measures for shark and ray species that require improved management, through:
   a. Developing regional management plans for species listed in CMS Appendix II;
   b. Developing management measures for IUCN Vulnerable and Near Threatened species.

Conclusions

There is a critical need for corrective management and improved conservation of threatened WIO shark and ray species. However, few of these species are protected in the WIO and there are few regional management measures or plans in place. By virtue of their being Parties to CMS, IOTC and CITES, Nairobi Convention Member States are obliged to protect, regulate the harvesting of, or control and monitor the trade in the numerous shark and ray species listed through these instruments (Table 1). However, the level of implementation of these agreements will need to be improved, as few of these species are protected or adequately managed and their trade is poorly regulated in most Nairobi Convention Member States, with most of these states falling short of their binding commitments thereto.

Many of these issues could be overcome, and WIO shark and ray populations could be better managed, through several national and regional actions, including i) the listing of appropriate shark and ray species on the respective Nairobi Convention Protocol Annexes to provide a legal framework for their improved management; ii) the implementation (or improvement therein) of binding commitments in terms of species protections and trade controls at national level; iii) the voluntary implementation of species protections and catch restrictions for threatened species not elsewhere protected or regulated; and iv) the development and implementation of appropriate management plans and management measures for shark and ray species that require improved management. The recommendations for species to be listed on the Nairobi Convention Protocol Annexes appear in Appendix I to this document, and their listing should receive appropriate consideration.

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Appendix 1

Recommendations for Shark and Ray Listings in the Annexes of the Nairobi Convention Protocol Concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region

Introduction

At the 7th Conference of the Parties (CoP7) to The Nairobi *Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region*[1] (Maputo, Mozambique, December 2012), the Member States, recognising increasing global concern regarding the declining status of sharks and batoids (rays, skates, wedgefishes, sawfishes), agreed to include sharks (understood to include batoids) in the Convention's Programme of Work for 2013-2017 (Decision CP7/1) and adopted Decision CP7/12: *Conservation of Sharks*, calling for regional collaboration on the conservation and management of sharks, including with CITES, CMS, regional fisheries management organisations, and other partners, and for preparation by the Secretariat, in collaboration with the Contracting Parties, of a regional status report on the state of sharks and batoids in the Western Indian Ocean[2] (WIO). The Wildlife Conservation Society (WCS), in collaboration with the Nairobi Convention Secretariat, initiated in 2014 a project to compile a regional status report in support of Decision CP7/12 and guide discussions at CoP8.

A parallel objective linked to the regional status report was to identify shark and batoid species for consideration for listing on the Annexes of the *Nairobi Convention Protocol Concerning Protected Areas and Wild Fauna and Flora in the East African Region* (hereinafter referred to as the Nairobi Convention Protocol). The listing of species on the Nairobi Convention Protocol is intended to provide a legal instrument, in this case a centralised list of species, from which resource managers of member states can identify shark and batoid species that warrant specific management or legal protection.

There is a great need to improve the knowledge base and understanding of the status of sharks and batoids and their fisheries in the WIO; however, existing information from a range of assessments, such as those completed by the shark specialist group (Dulvy and others, 2014[3]) of the International Union for the Conservation of Nature[4] (IUCN), provide a basis for considering species for inclusion in the Annexes of the Nairobi Convention Protocol. Numerous shark and batoid species have also been listed in recent years on the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora[5] (CITES) and the Appendices of the Convention on the Conservation of Migratory Species of Wild Animals[6] (CMS), thus increasing the mandate of governments and their environment and fisheries agencies to address the conservation and management needs of these species. The Indian Ocean Tuna Commission[7] (IOTC) also lists several shark and batoid species that may not be captured or retained by the IOTC-linked fisheries directed at tuna and tuna-like species.

This document presents recommendations for the listing of shark and batoid species in Annexes II, III, and IV of the *Nairobi Convention Protocol Concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region.* Due to the dynamic nature of threats to these species, and considering both declining populations and improving conservation measures, and as new data become available, it is likely that classifications such as CITES listings and IUCN Red List status will change over time. Therefore, the proposed listings should be treated as dynamic and adaptive, in order that they may be amended in the future as deemed necessary.

Recommendations for Listing of Sharks and Batoids in Annex II of the Nairobi Convention Protocol

Article 4 of the Nairobi Convention Protocol: *Species of Wild Fauna Requiring Special Protection* stipulates: "The Contracting Parties shall take all appropriate measures to ensure the strictest protection of the endangered wild fauna species listed in annex II. To this end, each Contracting Party shall strictly regulate and, where required, prohibit activities having

[1] UNEP. 1985. Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region. United Nations Environment Programme, Nairobi. United Nations.

[2] The geographic area referred to here by the term Western Indian Ocean includes the Indian Ocean territorial waters of the ten Nairobi Convention member states, from South Africa (including the Eastern Cape Province and Kwazulu-Natal Province only) in the southwest, to Somalia in the northwest, and to Mauritius in the east, following the delineation of the Indian Ocean by the International Hydrographic Organization (2002), and excludes the marginal seas to the north.

[3] Dulvy, N.K., S.L. Fowler SL, and J.A. Musick. 2014. Extinction risk and conservation of the world's sharks and rays. eLIFE 3:e00590. http://dx.doi.org/10.7554/eLife.00590

[4] IUCN 2020. The IUCN Red List of Threatened Species. Version 2020-2. http://www.iucnredlist.org

[5] www.cites.org

[6] www.cms.int/en

[7] www.iotc.org

adverse effects on the habitats of such species. In particular, the following activities shall, where required, be prohibited with regard to such species:

a. all forms of capture, keeping or killing;
b. damage to, or destruction of, critical habitats;
c. disturbance of wild fauna, particularly during the period of breeding, rearing and hibernation;
d. destruction or taking of eggs from the wild or keeping these eggs even if empty;
e. possession of and internal trade in these animals, alive or dead, including stuffed animals and any readily recognisable part or derivative thereof."

Following this definition, species proposed for listing under Annex II of the Nairobi Convention Protocol were identified based on their listing on one or more of the following:

I. **Convention on the Conservation of Migratory Species of Wild Animals (CMS) Appendix I – Endangered migratory species[8]:** This Appendix "comprises migratory species that have been assessed as being in danger of extinction throughout all or a significant portion of their range. The Conference of the Parties has further interpreted the term "endangered" as meaning "facing a very high risk of extinction in the wild in the near future" (Res. 11.33 paragraph 1)." Noting that CMS Appendix I requires that Parties *"that are a Range State to a migratory species listed in Appendix I shall endeavour to* ***strictly protect*** *them by: prohibiting the taking of such species*, with very restricted scope for exceptions; conserving and where appropriate restoring their habitats; preventing, removing or mitigating obstacles to their migration and controlling other factors that might endanger them". Thus, species listed on CMS Appendix I should be strictly protected in CMS signatory states.

II. **Indian Ocean Tuna Commission (IOTC) Prohibited Species:** IOTC resolutions prohibit the capture/retention of several species of sharks and batoids by Contracting Parties and Cooperating Non-Contracting Parties. Thus, *all such species should be* ***prohibited from capture*** in IOTC fisheries of IOTC Parties.

III. **International Union for the Conservation of Nature (IUCN) Red List of Threatened Species[9]:** species that are Critically Endangered (CR) or Endangered (EN)[10]:
   a. Critically Endangered (CR) species are "considered to be facing an extremely high risk of extinction in the wild";
   b. Endangered (EN) species are "considered to be facing a very high risk of extinction in the wild".

IV. **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix I[11]:** This Appendix lists species that are "threatened with extinction and CITES prohibits international trade in specimens of these species". Thus, *species listed in CITES Appendix I should be prohibited from international trade*, from or to a signatory state.

In total, 43 species (23 shark species and 20 batoid species, Table A1), of the 225 shark and batoid species identified to date in the Nairobi Convention area of the WIO, are recommended for consideration for strict protection under Annex II of the Nairobi Convention Protocol, due to meeting one or more of the above criteria. Those species meeting criteria for both Annexes II and III are proposed here for listing under Annex II (i.e., requiring a higher level of protection).

[8] https://www.cms.int/en/page/appendix-i-ii-cms

[9] IUCN 2021. The IUCN Red List of Threatened Species. Version 2021-1. http://www.iucnredlist.org, accessed 29 July 2021

[10] IUCN 2001. *IUCN Red List Categories and Criteria: Version 3.1*. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, United Kingdom: 30 pp

[11] https://www.cites.org/eng/app/appendices.php

Table A1: Shark and batoid species recommended for listing on Nairobi Convention Annex II, based on their listing either in CMS Appendix I (CMS I), as an IOTC prohibited species (IOTC), in CITES Appendix I (CITES I), or on the IUCN Red List of Threatened Species as Critically Endangered (IUCN CR) or Endangered (IUCN EN). The current IUCN Red List status for each species is also presented (CR = Critically Endangered, EN = Endangered, VU = Vulnerable).

Family	Species	Common name	Taxonomic reference	IUCN Red List	Criteria for listing on Annex II
Sharks					
Alopiidae	*Alopias pelagicus* [a]	pelagic thresher shark	Nakamura, 1935	EN	IOTC; IUCN EN
Alopiidae	*Alopias superciliosus* [a]	bigeye thresher shark	Lowe, 1841	VU	IOTC
Alopiidae	*Alopias vulpinus* [a]	common thresher shark	(Bonnaterre, 1788)	VU	IOTC
Carcharhinidae	*Carcharhinus amblyrhynchos*	grey reef shark	(Bleeker, 1856)	EN	IUCN EN
Carcharhinidae	*Carcharhinus longimanus* [b]	oceanic whitetip	(Poey, 1861)	CR	CMS I; IOTC; IUCN CR
Carcharhinidae	*Carcharhinus obscurus*	dusky shark	(Lesueur, 1818)	EN	IUCN EN
Cetorhinidae	*Cetorhinus maximus*	basking shark	(Gunnerus, 1765)	EN	CMS I; IUCN EN
Centrophoridae	*Centrophorus granulosus*	gulper shark	(Bloch & Schneider, 1801)	EN	IUCN EN
Centrophoridae	*Centrophorus lesliei*	African gulper shark	White, Ebert & Naylor 2017	EN	IUCN EN
Centrophoridae	*Centrophorus squamosus*	leafscale gulper shark	(Bonnaterre, 1788)	EN	IUCN EN
Centrophoridae	*Centrophorus uyato*	little gulper shark	(Rafinesque, 1810)	EN	IUCN EN
Echinorhinidae	*Echinorhinus brucus*	bramble shark	(Bonnaterre, 1788)	EN	IUCN EN
Ginglymostomatidae	*Pseudoginglymostoma brevicaudatum*	shorttail nurse shark	Günther, 1867	CR	IUCN CR
Lamnidae	*Carcharodon carcharias*	great white shark	(Linnaeus, 1758)	VU	CMS I
Lamnidae	*Isurus oxyrinchus*	shortfin mako shark	Rafinesque, 1810	EN	IUCN EN
Lamnidae	*Isurus paucus*	longfin mako shark	Guitart Manday, 1966	EN	IUCN EN
Pentanchidae	*Holohalaelurus favus*	honeycomb izak	Human, 2006	EN	IUCN EN
Pentanchidae	*Holohalaelurus punctatus*	whitespotted izak	(Gilchrist, 1914)	EN	IUCN EN
Rhincodontidae	*Rhincodon typus* [c]	whale shark	Smith, 1828	EN	CMS I; IOTC; IUCN EN
Sphyrnidae	*Sphyrna lewini*	scalloped hammerhead	(Griffith & Smith, 1834)	CR	IUCN CR
Sphyrnidae	*Sphyrna mokarran*	great hammerhead	(Rüppell, 1837)	CR	IUCN CR
Stegostomatidae	*Stegostoma tigrinum*	zebra shark	(Hermann, 1783)	EN	IUCN EN
Triakidae	*Mustelus manazo*	starspotted smoothhound	Bleeker, 1855	EN	IUCN EN

[a] IOTC Resolution 12/09 (http://www.iotc.org/cmm/resolution-1209-conservation-thresher-sharks-family-alopiidae-caught-association-fisheries-iotc) "Fishing Vessels flying the flag of an IOTC Member or Cooperating Non-Contracting Party (CPCs) are prohibited from retaining on board, transhipping, landing, storing, selling or offering for sale any part or whole carcass of thresher sharks of all the species of the family Alopiidae"

[b] IOTC Resolution 13/06 (http://www.iotc.org/cmm/resolution-1306-scientific-and-management-framework-conservation-sharks-species-caught) "CPCs shall prohibit, as an interim pilot measure, all fishing vessels flying their flag and on the IOTC Record of Authorised Vessels, or authorised to fish for tuna or tuna-like species managed by the IOTC on the high seas to retain onboard, tranship, land or store any part or whole carcass of oceanic whitetip sharks"

[c] IOTC Resolution 13/05 (http://www.iotc.org/cmm/resolution-1305-conservation-whale-sharks-rhincodon-typus) CPC's "shall prohibit their flagged vessels from intentionally setting a purse seine net around a whale shark in the IOTC area of competence, if it is sighted prior to the commencement of the set" and that "in the event that a whale shark is unintentionally encircled in the purse seine net, the master of the vessel shall: a) take all reasonable steps to ensure its safe release"

Table A1 continued

Family	Species	Common name	Taxonomic reference	IUCN Red List	Criteria for listing on Annex II
Batoids (rays, skates, wedgefishes, sawfishes)					
Glaucostegidae	*Glaucostegus halavi*	Halavi guitarfish	Forsskål, 1775	CR	IUCN CR
Mobulidae	*Mobula alfredi* [d]	reef manta ray	(Krefft 1868)	VU	CMS I; IOTC
Mobulidae	*Mobula birostris* [d]	giant manta ray	(Walbaum 1792)	EN	CMS I; IOTC; IUCN EN
Mobulidae	*Mobula eregoodoo* [d]	longhorned pygmy devil ray	(Cantor 1849)	EN	CMS I; IOTC; IUCN EN
Mobulidae	*Mobula kuhlii* [d]	shortfin devil ray	(Valenciennes, 1841)	EN	CMS I; IOTC; IUCN EN
Mobulidae	*Mobula mobular* [d]	spinetail devil ray	(Bonnaterre, 1788)	EN	CMS I; IOTC; IUCN EN
Mobulidae	*Mobula tarapacana* [d]	sicklefin devil ray	(Philippi, 1892)	EN	CMS I; IOTC; IUCN EN
Mobulidae	*Mobula thurstoni* [d]	bentfin devil ray	(Lloyd, 1908)	EN	CMS I; IOTC; IUCN EN
Myliobatidae	*Aetomylaeus bovinus*	duckbill ray	(Saint-Hilaire, 1817)	CR	IUCN CR
Myliobatidae	*Aetomylaeus vespertilio*	ornate eagle ray	(Bleeker, 1852)	EN	IUCN EN
Myliobatidae	*Myliobatis aquila*	common eagle ray	(Linnaeus, 1758)	CR	IUCN CR
Pristidae	*Pristis pristis*	largetooth sawfish	(Linnaeus, 1758)	CR	CMS I; IUCN CR; CITES I
Pristidae	*Pristis zijsron*	green sawfish	Bleeker, 1851	CR	CMS I; IUCN CR; CITES I
Rajidae	*Raja ocellifera*	twineyed skate	Regan, 1906	EN	IUCN EN
Rajidae	*Rostroraja alba*	spearnose skate	(Lacepède, 1803)	EN	IUCN EN
Rhinidae	*Rhina ancylostomus*	bowmouth guitarfish	Bloch & Schneider, 1801	CR	IUCN CR
Rhinidae	*Rhynchobatus australiae*	bottlenose wedgefish	Whitley, 1939	CR	IUCN CR
Rhinidae	*Rhynchobatus djiddensis*	whitespotted wedgefish	(Forsskål, 1775)	CR	IUCN CR
Rhinidae	*Rhynchobatus laevis*	smoothnose wedgefish	(Bloch & Schneider, 1801)	CR	IUCN CR
Rhinobatidae	*Acroteriobatus leucospilus*	greyspot guitarfish	Norman, 1926	EN	IUCN EN

[d] IOTC Resolution 19/03 (https://iotc.org/cmm/resolution-1903-conservation-mobulid-rays-caught-iin-association-fisheries-iotc-area-competence) CPC's "shall prohibit all vessels from intentionally setting any gear type for targeted fishing of mobulid rays in the IOTC Area of Competence, if the animal is sighted prior to commencement of the set" and "shall prohibit all vessels retaining onboard, transhipping, landing, storing, any part or whole carcass of mobulid rays caught in the IOTC Area of Competence" and "shall require all their fishing vessels, other than those carrying out subsistence fishery, to promptly release alive and unharmed, to the extent practicable, mobulid rays as soon as they are seen in the net, on the hook, or on the deck, and do it in a manner that will result in the least possible harm to the individuals captured".

Recommendations for Listing of Sharks and Batoids in Annex III of the Nairobi Convention Protocol

Article 5 of the Nairobi Convention Protocol: *Harvestable Species of Wild Fauna* stipulates:

1. The Contracting Parties shall take all appropriate measures to ensure the protection of the depleted or threatened wild fauna species listed in annex III.
2. Any exploitation of such wild fauna species shall be regulated in order to restore and maintain the populations at optimum levels. Each Contracting Party shall develop, adopt and implement management plans for the exploitation of such species which may include:
   a. the prohibition of the use of all indiscriminate means of capture and killing and of the use of all means capable of causing local disappearance of, or serious disturbance to, populations of a species;
   b. closed seasons and other procedures regulating exploitation;
   c. the temporary or local prohibition of exploitation, as appropriate, in order to restore viable population levels;
   d. the regulation, as appropriate, of sale, keeping for sale, transport for sale or offering for sale of live and dead wild animals;
   e. the safeguarding of breeding stocks of such species and their critical habitats in protected areas designated in accordance with article 8 of this Protocol;
   f. exploitation in captivity."

Following this definition, species proposed for listing under Annex III of the Nairobi Convention Protocol were identified based on their listing on one or more of the following:

I. **IUCN Red List of Threatened Species**[12]**:** those species assessed as either Vulnerable (VU) or Near Threatened (NT)[13]:
   a. Vulnerable (VU) species are "considered to be facing a high risk of extinction in the wild";
   b. Near Threatened (NT) – a Near Threatened species "does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future".

II. **CMS Appendix II – Migratory species conserved through Agreements**[14]**:** This Appendix comprises "migratory species that have an unfavourable conservation status and that require international agreements for their conservation and management, as well as those that have a conservation status which would significantly benefit from the international cooperation that could be achieved by an international agreement. The Convention encourages the Range States to species listed on Appendix II to conclude global or regional Agreements for the conservation and management of individual species or groups of related species." This list excludes those species listed in CMS Appendix II that are also listed on CMS Appendix I and have already been included in the preceding section as proposed for inclusion on Annex II of the Nairobi Convention.

III. **CITES Appendix II**[15]**:** This Appendix lists species that are "not necessarily now threatened with extinction but that may become so unless trade is closely controlled".

In total, 70 species (51 shark species and 19 batoid species, Table A2) are recommended for listing on Annex III of the Nairobi Convention Protocol, due to their being listed as Vulnerable or Near Threatened on the IUCN Red List of Threatened Species, on CITES Appendix II or on CMS Appendix II. This list excludes those species already included in the preceding section as proposed for inclusion on Annex II of the Nairobi Convention.

[12] IUCN 2017. The IUCN Red List of Threatened Species. Version 2017-3. http://www.iucnredlist.org, accessed 26 June 2018

[13] IUCN 2001. *IUCN Red List Categories and Criteria: Version 3.1*. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, United Kingdom: 30 pp

[14] https://www.cms.int/en/page/appendix-i-ii-cms

[15] https://www.cites.org/eng/app/appendices.php

Table A2: Shark and batoid species recommended for listing on Nairobi Convention Annex III, based on their listing on the IUCN Red List of Threatened Species as Vulnerable (IUCN VU) or Near Threatened (IUCN NT), in CMS Appendix II (CMS II) or CITES Appendix II (CITES II). Current Red List status is also presented.

Family	Species	Common name	Taxonomic reference	IUCN Red List	Criteria for listing on Annex III
Sharks					
Carcharhinidae	*Carcharhinus albimarginatus*	silvertip shark	(Rüppell, 1837)	VU	IUCN VU
Carcharhinidae	*Carcharhinus altimus*	bignose shark	(Springer, 1950)	NT	IUCN NT
Carcharhinidae	*Carcharhinus amblyrhynchoides*	graceful shark	(Whitley, 1934)	NT	IUCN NT
Carcharhinidae	*Carcharhinus amboinensis*	pigeye shark	(Müller & Henle, 1839)	NT	IUCN NT
Carcharhinidae	*Carcharhinus brachyurus*	copper shark	(Günther, 1870)	VU	IUCN VU
Carcharhinidae	*Carcharhinus brevipinna*	spinner shark	(Valenciennes, 1839)	VU	IUCN VU
Carcharhinidae	*Carcharhinus falciformis*	silky shark	(Müller & Henle, 1839)	VU	CMS II; CITES II; VU
Carcharhinidae	*Carcharhinus leucas*	bull shark	(Valenciennes, 1839)	NT	IUCN NT
Carcharhinidae	*Carcharhinus limbatus*	blacktip shark	(Valenciennes, 1839)	NT	IUCN NT
Carcharhinidae	*Carcharhinus macloti*	hardnose shark	(Müller & Henle, 1839)	NT	IUCN NT
Carcharhinidae	*Carcharhinus melanopterus*	blacktip reef shark	(Quoy & Gaimard, 1824)	VU	IUCN VU
Carcharhinidae	*Carcharhinus plumbeus*	sandbar shark	(Nardo, 1827)	VU	IUCN VU
Carcharhinidae	*Carcharhinus sorrah*	spottail shark	(Valenciennes, 1839)	NT	IUCN NT
Carcharhinidae	*Negaprion acutidens*	sicklefin lemon shark	(Rüppell, 1837)	VU	IUCN VU
Carcharhinidae	*Prionace glauca*	blue shark	(Linnaeus, 1758)	NT	IUCN NT; CMS II
Carcharhinidae	*Rhizoprionodon acutus*	milk shark	(Rüppell, 1837)	VU	IUCN VU
Carcharhinidae	*Scoliodon laticaudus*	spadenose shark	Müller & Henle, 1838	NT	IUCN NT
Carcharhinidae	*Triaenodon obesus*	whitetip reef shark	(Rüppell, 1837)	VU	IUCN VU
Carchariidae	*Carcharias taurus*	ragged-tooth shark	Rafinesque, 1810	VU	IUCN VU
Centrophoridae	*Centrophorus moluccensis*	smallfin gulper shark	Bleeker, 1860)	VU	IUCN VU
Centrophoridae	*Deania calceus*	birdbeaked dogfish	(Lowe, 1839)	NT	IUCN NT
Centrophoridae	*Deania profundorum*	arrowhead dogfish	(Smith & Radcliffe, 1912)	NT	IUCN NT
Centrophoridae	*Deania quadrispinosa*	longsnout dogfish	(McCulloch, 1915)	VU	IUCN VU
Dalatiidae	*Dalatias licha*	kitefin shark	(Bonnaterre, 1788)	VU	IUCN NT
Galeocerdidae	*Galeocerdo cuvier*	tiger shark	(Peron & Lesueur, in Lesueur, 1822)	NT	IUCN NT
Ginglymostomatidae	*Nebrius ferrugineus*	tawny nurse shark	(Lesson, 1830)	VU	IUCN VU
Hemigaleidae	*Hemigaleus microstoma*	sicklefin weasel shark	Bleeker 1852	VU	IUCN VU
Hemigaleidae	*Hemipristis elongata*	snaggletooth shark	(Klunzinger, 1871)	VU	IUCN VU
Hemigaleidae	*Paragaleus leucolomatus*	whitetip weasel shark	Compagno & Smale, 1985	VU	IUCN VU
Hexanchidae	*Heptranchias perlo*	sharpnose sevengill shark	(Bonnaterre, 1788)	NT	IUCN NT
Hexanchidae	*Hexanchus griseus*	bluntnose sixgill shark	(Bonnaterre, 1788)	NT	IUCN NT
Hexanchidae	*Hexanchus nakamurai*	bigeyed sixgill shark	Teng, 1962	NT	IUCN NT
Hexanchidae	*Notorynchus cepedianus*	broadnose sevengill shark	(Peron, 1807)	VU	IUCN VU
Odontaspididae	*Odontaspis ferox*	smalltooth sand tiger shark	(Risso, 1810)	VU	IUCN VU

Table A2 continued

Family	Species	Common name	Taxonomic reference	IUCN	Criteria for Annex III
Oxynotidae	*Oxynotus centrina*	angular rough shark	(Linnaeus, 1758)	VU	IUCN VU
Pentanchidae	*Bythaelurus hispidus*	bristly catshark	(Alcock, 1891)	NT	IUCN NT
Pentanchidae	*Halaelurus boesemani*	speckled catshark	Springer & D'Aubrey, 1972	VU	IUCN VU
Pentanchidae	*Halaelurus natalensis*	tiger catshark	(Regan, 1904)	VU	IUCN VU
Pentanchidae	*Haploblepharus fuscus*	brown shyshark	Smith, 1950	VU	IUCN VU
Pentanchidae	*Haploblepharus kistnasamyi*	Natal shyshark	Human & Compagno, 2006	VU	IUCN VU
Scyliorhinidae	*Cephaloscyllium sufflans*	balloon shark	(Regan, 1921)	NT	IUCN NT
Scyliorhinidae	*Scyliorhinus capensis*	yellowspotted catshark	(Müller & Henle, 1838)	NT	IUCN NT
Somniosidae	*Centroscymnus coelolepis*	Portuguese shark	Barbosa du Bocage & de Brito Capello, 1864	NT	IUCN NT
Somniosidae	*Centroscymnus owstoni*	roughskin dogfish	Gaman, 1906	VU	IUCN VU
Somniosidae	*Centroselachus crepidater*	longnose velvet dogfish	(Barbosa du Bocage & de Brito Capello, 1864)	NT	IUCN NT
Sphyrnidae	*Sphyrna zygaena*	smooth hammerhead	(Linnaeus, 1758)	VU	IUCN VU; CITES II
Squalidae	*Squalus acutipinnis*	bluntnose spurdog	Regan, 1906	NT	IUCN NT
Squatinidae	*Squatina africana*	African angelshark	Regan, 1908	NT	IUCN NT
Triakidae	*Mustelus mosis*	Arabian smoothhound	Hemprich & Ehrenberg, 1899	NT	IUCN NT
Triakidae	*Mustelus mustelus*	common smoothhound	(Linnaeus, 1758)	VU	IUCN VU
Triakidae	*Scylliogaleus quecketti*	flapnose houndshark	Boulenger, 1902	VU	IUCN VU
Batoids (rays, skates, wedgefishes, sawfishes)					
Anacanthobatidae	*Anacanthobatis marmorata*	spotted legskate	(Von Bonde & Swart, 1923)	NT	IUCN NT
Aetobatidae	*Aetobatus ocellatus*	Indian eagle ray	(Kuhl, 1823)	VU	IUCN VU
Dasyatidae	*Dasyatis chrysonota*	blue stingray	(Smith, 1828)	NT	IUCN NT
Dasyatidae	*Himantura leoparda*	leopard whipray	Manjaji-Matsumoto & Last, 2008	VU	IUCN VU
Dasyatidae	*Himantura uarnak*	coach stingray	(Gmelin, 1789)	VU	IUCN VU
Dasyatidae	*Maculabatis ambigua*	Baraka's whipray	Last, Bogorodsky, & Alpermann, 2016	NT	IUCN NT
Dasyatidae	*Pateobatis fai*	pink whipray	(Jordan & Seale, 1906)	VU	IUCN VU
Dasyatidae	*Pateobatis jenkinsii*	Jenkins' whipray	(Annandale, 1909)	VU	IUCN VU
Dasyatidae	*Taeniurops meyeni*	blotched stingray	(Müller & Henle, 1841)	VU	IUCN VU
Dasyatidae	*Urogymnus asperrimus*	porcupine ray	(Bloch & Schneider, 1801)	VU	IUCN VU
Dasyatidae	*Urogymnus granulatus*	mangrove whipray	(Macleay, 1883)	VU	IUCN VU
Gymnuridae	*Gymnura poecilura*	longtail butterfly ray	(Shaw, 1804)	VU	IUCN VU
Narkidae	*Heteronarce garmani*	Natal electric ray	Regan, 1921	NT	IUCN NT
Rajidae	*Dipturus campbelli*	blackspot skate	(Wallace, 1967)	NT	IUCN NT
Rajidae	*Dipturus crosnieri*	Madagascar skate	(Séret, 1989)	VU	IUCN VU
Rajidae	*Leucoraja wallacei*	yellowspotted skate	(Hully, 1970)	VU	IUCN VU
Rajidae	*Raja clavata*	thornback skate	Linnaeus, 1758	NT	IUCN NT
Rhinobatidae	*Acroteriobatus annulatus*	lesser guitarfish	Smith, 1841	VU	IUCN VU
Rhinobatidae	*Acroteriobatus zanzibarensis*	Zanzibar guitarfish	(Norman, 1926)	NT	IUCN NT

Recommendations for Listing of Sharks and Batoids in Annex IV of the Nairobi Convention Protocol

Article 6 of the Nairobi Convention Protocol: Migratory Species stipulates: "The Contracting Parties shall, in addition to the measures specified in articles 3, 4 and 5, co-ordinate their efforts for the protection of migratory species listed in annex IV whose range extends into their territories. To this end, each Contracting Party shall ensure that, where appropriate, the closed seasons and other measures referred to in paragraph 2 of article 5 are also applied with regard to such migratory species."
Following this definition, species proposed for listing under Annex III of the Nairobi Convention Protocol were identified based on their listing on one or more of the following:

CMS[16] Appendix I – Endangered migratory species (CMS Appendix I) or Appendix II – Migratory species conserved through Agreements: The appendices of CMS list threatened migratory species, including sharks and batoids. Therefore, all species listed on these two CMS appendices are proposed for Annex IV of the Nairobi Convention Protocol.

CMS Memorandum of Understanding on the Conservation of Migratory Sharks (CMS Sharks MOU), Annex I: In addition to the listing of shark and batoid species on Appendices I and II of CMS, a taxon-specific MOU was developed for migratory shark and batoid species (CMS Sharks MOU). This MOU provides an instrument under the CMS for achieving a favourable conservation status for migratory sharks and batoids. The CMS Sharks MOU is non-binding, but encourages signatories "to strengthen and improve their role in taking measures to improve or restore a favourable conservation status of sharks listed in Annex 1 of the Memorandum of Understanding". Annex I lists migratory species of sharks and batoids for which this conservation measure is intended to apply, including 25 species of sharks and batoids that occur in the WIO.

Fowler[17] (2014): In a global review of migratory chondrichthyan fishes, Fowler (2014) identified and listed a number of shark and batoid species that can be defined as migratory or possibly migratory. These include 29 migratory shark species and 13 migratory batoid species, as well as 12 possibly migratory shark species and 9 possibly migratory batoid species, that occur within the WIO. Fowler (2014) used the definitions presented in CMS Article I[18] and defined "migratory species" as species for which "the entire population or any geographically separate part of the population of any species or lower taxon of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries".

The United Nations Convention on the Law of the Sea[19] (UNCLOS) Annex I *Highly Migratory Species*[20]: UNCLOS Annex I lists three species of sharks as being, and four families of sharks as containing, "highly migratory species", most of which were also identified by Fowler (2014).
The following table (Table A3) lists 68 shark and batoid species (43 shark species and 25 batoid species) that are proposed for listing on Annex IV of the Nairobi Convention Protocol, based on their listing on CMS Appendix I and/or II, the CMS Sharks MOU Annex I, identification by Fowler (2014) as migratory (M) or possibly migratory (PM), or their listing on UNCLOS Annex I at the family level (UNCLOS) or species level (UNCLOS species) as "highly migratory species". Several species proposed for listing on Annexes II or III are also proposed here for listing in Annex IV, as Annex IV listing is based on the species' migratory ecology, rather than threat status, thus warranting separate listing.

[16] https://www.cms.int/en/page/appendix-i-ii-cms

[17] Fowler, S. 2014. *The Conservation Status of Migratory Sharks*. UNEP/CMS Secretariat. Bonn, Germany. 30pp.

[18] https://www.cms.int/en/convention-text

[19] http://www.un.org/depts/los/convention_agreements/convention_overview_convention.htm

[20] http://www.un.org/depts/los/convention_agreements/texts/unclos/annex1.htm

Working towards a common regional vision for mangrove conservation

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Summary

Mangroves are unique ecosystems located along intertidal coastlines. Mangrove ecosystems play important life-sustaining functions in the Western Indian Ocean (WIO) region. Still, they are critically exposed to degradation and loss from the anthropogenic pressures, exacerbated by the negative impacts of climate change. Strong governance of natural resources in general and implementation of environmental policies and laws, as well as good coordination and coherence at the institutional level, coupled with financial and technical capacities, contribute to healthy mangrove ecosystems and improved livelihoods. Coordinated action is important to secure mangroves in the WIO region. A joint mangrove vision could be instrumental in achieving this, thereby aiding the implementation of the Nairobi Convention Conference of Parties (COP) Decision CP9/11. Creating awareness and strengthening governance capacities at the regional, national and local levels and exchanging information between the scientific community and policymakers can help ensure coordinated and cooperative protection of mangroves. The Nairobi Convention COPs offer a pivotal opportunity to rally the regional actors around the need to have a joint regional approach regarding our common mangroves. The joint development of a regional mangrove vision would create synergy with the Multilateral Environmental Agreements (MEAs) in addressing mangrove ecosystem conservation and restoration priorities within the WIO and fostering regional commitments on mangrove conservation. This approach would only be possible if an intensified and strengthened partnership is in place among actors in the WIO through, for example, the formation of a Regional Advisory Group. This group would support synergies between mangrove-related initiatives, provide strategic guidance and support a regional policy dialogue between WIO countries within the framework of the Nairobi Convention process. A strong common WIO mangrove vision, adopted by governments and key actors at regional and international policy fora and backed by commitments, can make the WIO region an internationally recognised "mangrove champion" and earn attention for priority needs.

Background

Mangroves are unique ecosystems along intertidal coastlines, forming the interface between land and sea in tropics and subtropics. According to the Global Mangrove Watch, the global mangrove habitat was 135 881 km^2 in 2016, representing a linear coverage of 12 per cent of the 1 634 701 km of the global coastline. Over 700 000 ha of mangroves cover the WIO region (Spalding and others 2021), approximately 5 per cent of the global mangrove coverage. Four countries, namely Mozambique, Madagascar, Tanzania and Kenya, contain 99 per cent of these mangroves, mainly occurring in deltas and estuaries (Bosire and others, 2016).

Mangroves deliver substantial ecosystem goods and services that play a critical role in supporting human well-being through climate regulation, disaster risk reduction, food security and poverty reduction for more than 120 million people living in tropical coastal (UNEP 2014) areas. Despite their substantial value, mangrove ecosystems have experienced net losses in cover in the past decades (Spalding and Leal 2021). The critical need to conserve, manage, and restore

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functioning mangrove forests and related coastal ecosystems are recognised in various Multilateral Environmental Agreements (MEAs), including the Ramsar Convention on Wetlands of International Importance, especially as Waterfowl Habitat, 1971; the Convention on Biological Diversity (CBD), 1992; the United Nations Framework Convention on Climate Change (UNFCCC), 1992; the United Nations Convention on the Law of the Sea, 1982; and the United Nations Watercourses Convention, 1997 as well as in global commitments such as the Sustainable Development Goals (SDGs). However, the potential of mangrove conservation in contributing towards serving such international commitments is still only marginally realised and utilised.

Besides climate change, the main drivers of environmental and ecosystem degradation at the global level are the increasing human demand for natural resources such as land, food, energy etc., pollution and unsustainable practices (Goldberg and others, 2020). Weak governance frameworks exacerbate them for nature, particularly for mangrove habitats, hence the importance of global policy action. Nature-based Solutions (NbS) (IUCN 2020), and mangrove conservation, in particular, is recognised for supporting sustainable development along global coastlines, addressing multiple societal challenges by simultaneously securing human well-being and biodiversity benefits. The 2019 Nature-Based Solutions for Climate Manifesto underscores the need for a shift in international governance to value nature and realise the potential of NbS.

The WIO region is characterised by high coastal and marine biodiversity, both in terms of species and ecosystems, which places it as one of the world's richest and most interesting ocean regions. The region has 60 million coastal inhabitants and an estimated annual economic value of US$20.8 billion, and a US$333.8 billion ocean asset base (Obura 2017). However, high poverty rates among the coastal population have led to a high resource dependence and overexploitation of coastal and marine resources and ecosystem services. Mangrove habitats are ecosystems with essential life-sustaining functions, yet they are threatened by anthropogenic pressures, which are exacerbated by the impacts of climate change, such as sea-level rise and sedimentation.

Mangrove loss rates vary immensely between regions, particularly when their distribution and health are non-linear at national and local levels. That isn't surprising in the WIO region, where four countries - Kenya, Tanzania, Mozambique and Madagascar - hold approximately 99 per cent of its mangrove cover (Bosire and others, 2016). The coastal areas of the WIO region have experienced increasing loss rates of mangrove cover over the past decades, resulting in a shortage of mangrove products, reduction in fisheries, shoreline change, pollution, and loss of livelihoods for communities living adjacent to mangrove ecosystems. A change in that trend started only to manifest in recent years (Bosire and others, 2016).

Advances – state of the art

Strong governance of natural resources in the general and adequate implementation of environmental policies and laws and good coordination and coherence at the institutional level, coupled with financial and technical capacities, contribute to improving mangroves' situation – and that of the people relying on them for their livelihoods. Significant advances have been made at the national level, for example, the national mangrove strategies currently in place in Kenya, Mozambique, Madagascar and Tanzania. Furthermore, WIO actors have expressed the need for a regional dialogue for a joint mangrove vision that may be instrumental in supporting coordinated action for securing mangroves in the WIO region as a whole and aiding the implementation of key strategies. For example, the Nairobi Convention COP Decision CP9/11 supports the implementation of marine protected areas and critical habitats outlooks. Creating awareness and strengthening governance capacities at the regional, national and local levels and exchanging data and information between the scientific community and policymakers can help ensure coordinated and cooperative protection of mangroves grounded in science and takes transboundary conservation needs into account. Dialogue is vital between scientists and decision-makers and at the institutional level among the different government agencies (Slobodian and Badoz 2019). See Figure 1 for coherent and integrated policy-making and a shared vision. Dialogue should happen at the national as well as the regional level. However, cooperation and the development of joint visions may not be realised without political will and buy-in.

Linkage to regional and global processes

Despite the focus on mangrove ecosystems in this paper, the interaction between broader coastal ecosystems is crucial. Both international, regional, and national policy-making must reflect them. In relation to climate change, especially at a global policy level,

promoting joint conservation of mangroves with other ecosystems such as coral reefs and seagrass meadows will increase effectiveness. The "Super Year 2020", now shifted to 2021 due to Covid-19, provides an opportunity to have a common vision and synergistic agenda between the various Multilateral Environmental Agreements (MEAs), eg new CBD targets and revised UNFCCC Nationally Determined Contributions. Such synergy will align and accelerate action on the ground, both in terms of overall political commitment and smart planning and implementation processes, including finance. The WIO region would benefit greatly from this opportunity if its key governments, institutions, partners, and stakeholders can establish dialogue discussions, adopt a joint approach, vision and strategies, and speak with one voice at the international stage. The Nairobi Convention COPs offer a key opportunity to rally the regional actors around the need to have a joint regional approach and voice concerning our common mangroves. The joint development of a regional mangrove vision could help to make the conservation of coastal ecosystems, such as mangroves, a priority in policy-making and to increase the acknowledgement of marine and coastal nature-based solutions in national and regional land-use planning, disaster risk management, climate change and sustainable development policies in the WIO region.

Additionally, after hosting the first global Blue Economy Conference in 2018, the WIO region is now fully engaged on the road to unlocking the potential of its blue economy. Such an economy represents great promises for the region in terms of economic benefits. Nevertheless, it is paramount that healthy oceans and good governance are developed based on sustainable premises that will ultimately enable the conservation of the region's blue natural capital and directly benefit local communities. In that regard, the role of mangroves in fisheries enhancement, coastal protection, local livelihoods, and its potential to develop innovative financing mechanisms (including those related to the carbon finance sector) is critical. It is, therefore, a crucial nature-based solution to the successful development of the blue economy. As such, efforts contributing to sustainable mangrove conservation and restoration in the region will also directly contribute to developing a sustainable, inclusive and resilient blue economy.

A regional mangrove vision would create synergy with the MEAs in addressing mangrove ecosystem conservation and restoration priorities within the WIO and foster the development of more specific agreements and regional commitments on mangrove conservation. Such agreements could take the form of specific policy frameworks for mangrove conservation at the national and regional level, such as a Cooperative Agreement on the Conservation of Mangrove Ecosystems within the Western Indian Ocean. Notably, the vision may be anchored to protecting rivers and coastal ecosystems associated with mangroves within regional and sub-regional institutions, including River Basin Organisations and Regional Economic Communities (RECs), which might serve as platforms for dialogue and promotion of environmental goals.

The subject matter to be addressed

In the WIO region, dealing with mangroves at a regional level is essential since the countries hosting this type of ecosystem share similar challenges at various levels (ecological, socio-economic, governance, etc) (Bosire and others, 2016). In that regard, dialogues and efforts to cooperate should aim at designing standard policy and legislative frameworks to manage and govern these resources in a coordinated and effective manner. For that reason, we suggest fostering the joint development of a regional mangrove vision that will pave the way towards the frameworks mentioned above. Moreover, the support of the international policy and donors' communities to a given region will be eased and most efficient when a region coalesces around a common vision. Such joint vision development is a prerequisite to regional integration and cohesion, which is important to inform and foster the development of global international policy processes. At the same time, international processes are essential to inform and guide the development of regional and national instruments and actions.

Therefore, developing a regional mangrove vision and support needs is a responsibility that all levels of governance within the WIO region should take on. Furthermore, it is vital for better recognition of the WIO region at the global policy and donor's level. In doing so, the region should simultaneously take the advantage to build a strong case for enhanced mangrove conservation goals – included in a common vision and/or an agreement with clear targets and indicators – in the space of the international community. It is worth highlighting that the development of such a regional vision should strongly correlate with national policy-making. There will be increased government commitment for mechanisms such as SDG14, GLISPA, or the Bonn Challenge. Funding and implementation

needs will be identified while ensuring harmonization to fill gaps and avoid redundant efforts. Preferably the government commitments take account of aspirations of non-state actors and local communities.

The international mangrove initiative "Save Our Mangroves Now!" (SOMN), launched by the German Federal Ministry for Economic Cooperation and Development (BMZ), the World Wide Fund for Nature (WWF), and the International Union for Conservation of Nature (IUCN), and joined by Wetlands International in its second phase (2020-2022) has the goal to reverse the decrease of mangrove habitats with a strong focus on the WIO region. Therefore, SOMN offers its capacities to support mangrove conservation by promoting a regional policy dialogue to foster a WIO-wide collective effort to developing a regional mangrove vision.

Such a vision would be most powerful if it encapsulates the region's commitments and priority needs. With the support of the Nairobi Convention Secretariat, Parties and projects (eg, WIOSAP, SAPPHIRE), as well as SOMN and other stakeholders, the WIO region promises to become a global example, a so-called "champion" on mangrove conservation. Achieving the status may lead to further successes on enhanced protection and sustainable use of mangroves. The successful conservation of mangroves in the WIO can inform other regions and promote replication of conservation approaches.

The approach described above would only be possible if an intensified and strengthened partnership is in place among actors in the WIO. Strong collaboration can be achieved, for example, through a Regional Advisory Group and the Community of Practice (CoP) platform. The latter would support synergies between mangrove-related initiatives, provide strategic guidance and support a regional policy dialogue between WIO countries within the framework of the Nairobi Convention process. The CoP enhances networking

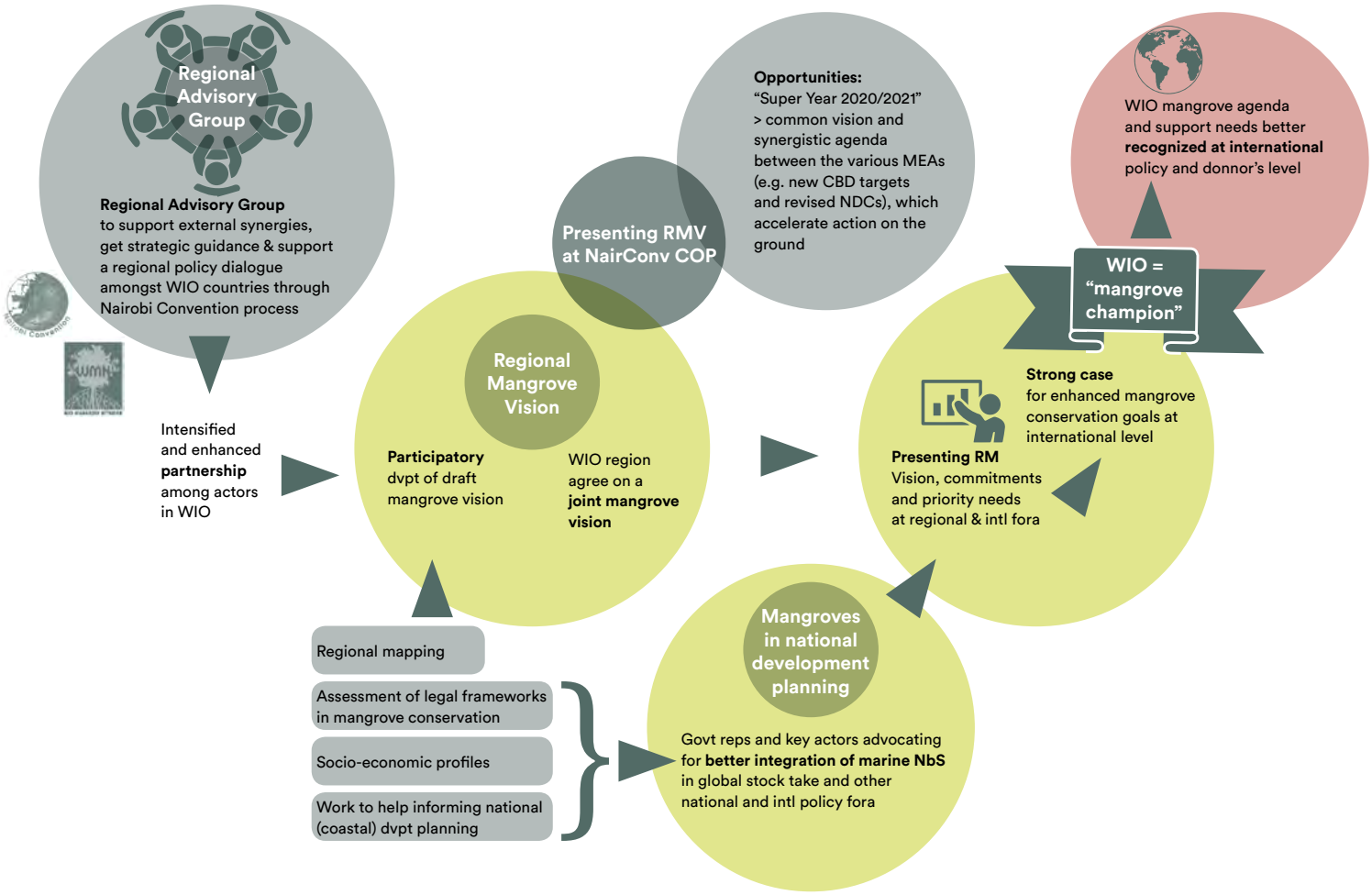

Figure 1. Suggested theory of change towards a regional mangrove vision and better recognition of the WIO region at the international level (abbreviations: WMN: Western Indian Ocean Mangrove Network, RMV: regional mangrove vision). Source: Save Our Mangroves Now!

among experts within the WIO region by providing opportunities for dynamic interactions among the different technical task forces, forums and committees of Nairobi Convention Contracting Parties. A set of activities are underway in SOMN's four target countries: Kenya, Tanzania, Mozambique and Madagascar, to support the proposed regional policy dialogues. The SOMN project is already supporting institutional capacity development of the WIO Mangrove Network (WIOMN) through the successful legal registration in March 2021. The Network has already pooled regional mangrove stakeholders (Bosire and others, 2016; UNEP 2020). It can thus become an umbrella body to host such a Regional Advisory Group as one of its subsidiary bodies as provided for by the Network's Constitution.

Institutional strengthening of the WIOMN through such an advisory group will enhance its role as provider of policy options. A strong WIOMN may also be supported by SOMN's ongoing activities on developing mangrove socio-economic profiles and a regional mangrove mapping tailored to serve national and, specifically, coastal development planning.

Policy Recommendations

A strong common WIO mangrove vision, adopted by governments and key actors at regional and international policy fora and backed by commitments, can make the WIO region an internationally recognised "mangrove champion" and earn attention for priority needs.

To achieve this, we:

- Call on the Nairobi Convention Parties to develop a regional mangrove vision (and related strategic framework as needed) that encapsulates the region's commitments and priority needs, which will accelerate action on the ground in terms of political commitment overall and also overall planning and implementation processes, including finance.
- Call on the Nairobi Convention Parties to facilitate the mainstreaming of mangroves in national development planning, eg Nationally Determined Contributions (NDCs).
- Call on the Nairobi Convention Secretariat and Parties and the WIO Mangrove Network to establish the relevant institutional structures. For example, the proposed Regional Advisory Group can support synergies between mangrove-related initiatives, craft the regional mangrove vision elements, and support regional policy dialogue on mangroves.
- Call on the Nairobi Convention Secretariat to intensify and enhance partnership among stakeholders and actors in WIO through, for example, the Community of Practice (CoP) platform to reinforce mangrove commitments and priorities in the region.
- Urge the Nairobi Convention Secretariat, Parties and partners to create a strong case for the regional mangrove vision through regional and global dialogues (beyond the discussions in the proposed Regional Advisory Group) to enhance mangrove conservation goals, commitments and priority needs at regional and international level. This will help profile the WIO region as a "mangrove champion" globally.

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Prioritization of climate refugia in the Western Indian Ocean

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Summary

Coastal dynamics over long periods of geological time in the western Indian ocean (WIO) have created a mosaic of habitats and species distributions that will continue to change as the impacts of climate change accelerate. Changes in sea level and in ocean heat and chemistry will force these ongoing changes. Therefore, it behooves coastal and Blue Economy decision makers to develop systems of management that will keep habitats such as coral reefs and linked ecosystems productive and with viable species populations. The current patterns of coral reef species distributions and centers of diversity and sanctuaries are now becoming better understood in the WIO. This knowledge provides a basis for prioritization of locations and management that can affect future states and where climate and human impacts are both reduced to sustain the region's rich habitat and diversity. These priority locations run along a coastal belt from northern Madagascar to northern Mozambique and extending north to southern Kenya. Prioritization of these areas for protection and management is needed through implementation of policies which have been shown to be a mixture of fisheries restrictions, coastal and riverine protection, and spatial planning.

Background

The Western Indian Ocean is the largest and most diverse marine and coastal region on the African continent. The coastal and marine ecosystems of the WIO not only have very high biodiversity but are important for livelihoods and national economies. The WIO's coastal and marine areas are experiencing rapid change with increased human population and expansion of fishing, tourism, shipping, and energy extraction. Climate change is projected to have large-scale impacts, including elevated sea surface temperatures, sea-level rises, changes in monsoonal systems and cyclones and coastal flooding. Coastal ecosystems such as coral reefs, seagrasses and mangroves will bear the brunt of climate change impacts. This combination of local and global stressors results in environmental degradation and undermines the ecosystem services and livelihoods of millions of local people and national economies that rely on marine natural resources in the WIO.

One solution is the establishment of marine protected areas (MPAs). Most WIO countries have established MPAs mainly focusing on nearshore ecosystems and committed to the Convention on Biological Diversity's (CBD) Aichi 11 target to protect 10 per cent of coastal and marine areas. The target has been a key driver of the rapid expansion of national marine conservation efforts in the last decades. Yet, marine and coastal ecosystems and species continue to decline in the WIO affecting coastal economies and the wellbeing of communities. A crucial policy window, the Post-2020 Global Biodiversity Framework, is currently being negotiated by the Parties to the CBD to increase protection to 30 per cent by 2030. This will require a rapid expansion of protected area coverage for many WIO nations, although some like Seychelles have already met this target. Establishing large-scale MPAs such as transboundary conservation areas (TBCA) and other large wilderness sanctuaries is one of the few tools available to achieve this area target. The benefits of large area-based management include the ability to act at the ecosystem and landscape spatial scale; conservation and management of ecosystems, species and fisheries stocks that cross national jurisdictions; promotion of integrated management and conflict resolution; and the ability to increase climate resilience on a large scale.

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Studies in the WIO have identified several potential climate refugia (see Section 3 below), including the proposed TBCA on the Kenya Tanzania border. Protection of these climate refugia confers the benefits of managing at a large spatial scale and serve as potential climate mitigation measures. The global level pact (High-level panel for a sustainable ocean economy; www.oceanpanel.org) signed by 14 nations, including Kenya, to protect and sustain ocean health provides additional impetus for their establishment, as do calls of improved ocean governance (AU and WIO regional Ocean Governance workshop), local and national marine spatial planning (MSP) efforts and contributes to meeting national blue economy (BE) aspirations.

This paper summarizes the science that has been undertaken in the WIO on climate refugia and recommends immediate action to establish large MPAs, TBCAs and other sanctuaries and wilderness areas prioritizing the areas identified in the WIO that have the conditions that serve as critical climate refugia in the face of modern climate change.

Linkage to regional and global processes

The issue under discussion aligns with several initiatives in the WIO, including regional, national, and local marine spatial planning, development of strategies for the BE, the Post-2020 global biodiversity framework, and other issues summarized below:

Marine area-based planning and management: There are an estimated 149 MPAs in the WIO. However, these are often small and rarely considered ecosystem representativeness, size, and irreplaceability in their design. Most countries that have signed the CBD convention have yet to meet the 10 per cent Aichi marine and coastal target. In addition, many MPAs lack the resources and capacity for effective management and hence fail to achieve conservation and sustainable management goals. Yet, the Post 2020 framework negotiations are underway to increase coverage to 30 per cent. This cannot be met without establishing and managing large ocean areas such as TBCAs that involve multiple nations, sectors, and jurisdictions. There is little experience in establishing TBCAs. Previous efforts to establish one in the Mnazi bay/Quirimbas complex between Tanzania and Mozambique were unsuccessful and the proposed TBCA between Kenya and Tanzania is in the early stages of planning. Many WIO nations have also embarked on national and local MSP (e.g. Seychelles, Mauritius, Kenya). A recently launched process for a Regional Strategy for Marine Spatial Planning for the WIO reflects the aspiration and desire for sustainable use and management of the ocean in the region. Therefore, the identified climate refugia must be recognized and prioritized for protection at these national and regional levels. The current MPA's especially those located in the climate refugia areas (see Section 3 below), will also require the resources to ensure that they are more effectively managed.

Blue economy: The countries of the WIO also view the Blue Economy (BE) as the next economic frontier and are developing BE strategies with a focus primarily on fishing, tourism, shipping, and mining. These are commercial sectors that are regional and global and have the potential to significantly boost national economies. However, these could also conflict with natural resource management and potentially negatively affect the livelihoods and wellbeing of coastal peoples. The challenge for large scale ocean governance will be balancing the competing interests for development and avoiding irreversible environmental loss. The BE agenda in WIO countries are often driven at a relatively high level of government. Therefore, it is important to ensure that discussions are held across all sectors and administrative levels and across borders to ensure coordination, integration, and inclusion. The discussions should also be coordinated and mainstreamed with national and regional MSP processes and align with Ecologically or Biologically Significant Marine Areas (EBSAs) and Area Beyond National Jurisdiction (ABNJs).

The Nairobi Convention (NC) for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (UNEP 1985) is the anchoring convention for the WIO. Other regional and global conventions and processes that align and can contribute to this issue include the Post-2020 Global Biodiversity Framework and Sustainable Development Goal (SDGs) 14, the African Union (AU) climate strategy and Agenda 2063 AU Blue Economy Strategy, the Paris agreement on climate change, the UN Decade of Ocean Science for sustainable development, the NC climate change strategy and the International Coral Reef Initiative's call to action amongst others.

Using climate science to manage climate impacts

Climate change and biodiversity are closely linked in the WIO. A flurry of recent research unveils how historical forces of slow geological and faster climate variability have shaped the region's diversity patterns.

Understanding this variability is critical to making intelligent decisions about ocean management that will affect people reliant on this diversity for centuries.

Changing diversity is best viewed as the expansion and contraction of species ranges as suitable conditions for species follow the spatial distribution of these pulses. Climate and ocean processes oscillate between severe and more benign conditions dependent on the severity of the back and forth of warm and cold-water current movements. These oscillations are associated with heating and cooling, which in temperate climates are driven by expanding and contracting glaciers. Glaciation effects are seen in sea levels and shorelines, even in the tropics, but the same heating and cooling also affects tropical ocean oscillations, which then drive species distributions. It also affects tropical rainfall, high-mountain glaciers, and runoff into the nearshore mangroves, seagrasses, and coral reefs.

When the climate becomes severe, as is the current situation, diversity contracts and is maintained in a few areas that are not so impacted by climate, known as climate refugia or, more importantly, sanctuaries for species. When the climate is benign, species expand and are found far from these sanctuaries. This process of pulsing in space and time has been ongoing for at least the past 3 to 4 million years and has produced the WIO's geographic patterns of diversity. Thus, while most of the species in the WIO evolved before the recent glaciation, their distributions changed and pulsed in space in response to climate oscillations. Some of these pulses and species expansions may be extensive, ranging from Indonesia to East Africa. In contrast, others are smaller and contained within the African coastline and associated large and small islands.

The current challenge is that overlain with this contraction process and expansion of reef diversity is the increasing human use and dependence on reef resources, particularly fisheries. Fisheries affect the abundance of many utilized species. Thus, many species are experiencing a contraction in their ranges and their abundances through fishing. Consequently, the key action we can take in managing species is to protect species in these climate sanctuaries.

So, where are these sanctuaries? Many but not all sanctuaries can be found by examining the distribution of species diversity. The more diverse areas often represent sanctuaries because these places are the core locations or origins of this expanding and contracting diversity in recent times. Diversity of hard corals shows the highest numbers of species generally exist around 10°S of the equator but more specifically in discrete locations in southern Kenya–northern Tanzania, southern Tanzania–northern Mozambique and northwestern Madagascar–Mayotte. These locations are the likely climate refugia and species sanctuaries where species persisted during the severe climate.

The above three areas are the highest priorities for protection. Several historical and recent efforts to establish protection in these areas can be strengthened by expansion to larger TBCAs or sanctuaries. These include the older established MPAs and reserves in northern Tanzania (Chumbe, Dar es Salaam), and in southern Kenya (Kisite-Mpunguti Marine Park and Reserve) and the more recent MPAs including the Tanga Coelacanth Reserve, the Tanga marine Reserve systems in northern Tanzania that are encompassed within the proposed Kenya -Tanzania TBCA. In the Madagascar-Mayotte area, the Mayotte Marine Reserve and the two reserves in northern Madagascar, namely Ankarea and Ankivonji, are also potential climate sanctuaries. Along the Tanzania and Mozambique borders are the historical efforts in the Mnazi Bay and Quirimbas MNPs that although unsuccessful as a trans-boundary conservation marine area, could be revisited given the need to protect potential climate refugia. In addition, the emerging northern Mozambique channel initiative has the potential to promote large-scale ocean management. Although many of these protected areas within the climate sanctuaries have many challenges and are in various states of ecological health, they form the potentiality for expansion through MSP into larger marine protected area planning frameworks such as TBCAs etc.

Recommendations for the Nairobi Convention Conference of Parties

Environmental impacts on the marine and coastal ecosystems of the WIO are projected to increase, due to climate change, rapidly expanding coastal development and the drive to develop the BE. There is an urgent need to ensure that this is balanced with enhanced ocean governance and mitigation of the threats from climate change. Taking into consideration discussions at the Nairobi Convention conference of parties meeting (Mombasa 2018) and other regional and global commitments for protecting marine and coastal ecosystems and species, the following actions are recommended:

Technical recommendations

- Urge member states to evaluate and improve the effectiveness of MPAs across the WIO, focusing on the MPAs in the areas identified as climate refugia.

- Urge Parties and relevant organizations to collaborate to identify, map, designate and develop management strategies to protect the climate refugia in the WIO.

Policy recommendations

- Encourage member states to implement approaches that ensure coordination, integration, and inclusion of all sectors in developing local and national MSP and BE initiatives
- Urge Parties when undertaking MSP, marine conservation planning and BE initiatives, especially large-scale developments such as ports and oil and gas, to consider climate refugia and mitigation measures.
- Encourage member states to implement their global and regional binding commitments to protect and manage the coastal zone and ocean governance.

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Using the IUCN Red List of Ecosystems Assessment to support national and regional alignment in coral reef management

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Summary

The IUCN Red List of Ecosystems framework provides a standard for measuring risks of ecosystem collapse, providing critical information to inform policy. The approach assesses ecosystem area and integrity, meeting the need for both metrics in national, regional and global policies for biodiversity and sustainability. We applied it to assess risks of ecosystem collapse at regional and ecoregional scales across coral reefs in the Western Indian Ocean (WIO). Overall, WIO coral reefs were classified as Vulnerable. In contrast, reefs in 11 nested ecoregions ranged from Critically Endangered (islands, driven by future warming) to Vulnerable (continental coast and Seychelles North, caused by fishing pressure). The threatened status of coral reefs reinforces the urgent need for national and regional policy responses that include mitigating and building resilience to climate change and implementing ecosystem-based management of coral reefs to reduce risks of ecosystem collapse.

Background

The Western Indian Ocean (WIO) contains 16 per cent of the world's coral reefs, and the region is a globally important hotspot for coral reef biodiversity. Coral reef ecosystems underpin the economies of the countries in the region, particularly fisheries and tourism sectors. They provide livelihood opportunities and income for local communities to the tune of an estimated US$ 8.4 billion annually and have an estimated asset value of U$ 18.1 billion.

Despite these benefits, coral reefs are highly threatened, with up to 50 per cent already considered degraded globally (IPBES 2019). The weight of evidence suggests that increasing local (fishing, pollution, coral diseases, cyclones) and global (warming, acidification) stressors give a window of only several decades (Beyer and others, 2018) before the possible collapse of this flagship ecosystem. This would have severe consequences on coastal food security, economies, and jobs. Within the WIO, widespread decline

http://dx.doi.org/1x.xxx/wio.5

during global bleaching events has occurred in 1998 and 2016 (Gudka and others, 2020), with lesser events occurring in 1983, 2005, 2007 and 2010. Fishing and other environmental stressors have compounded the stress on reefs presenting complex patterns of decline and partial recovery (McClanahan and others, 2015).

Developing coherent conservation actions for coral reefs is complicated by the large quantities of contrasting information on the state of reefs.

Addressing this need, the International Union for the Conservation of Nature's (IUCN) Red List of Ecosystems (RLE, www.iucnrle.org) is emerging as a framework to assess the risk of ecosystem collapse (Keith and others, 2013). It provides a consistent information base to inform management and policy responses to reduce the risks of ecosystem collapse (Alaniz and others, 2019). The RLE builds on the success of the IUCN Red List of Threatened Species, which for over 50 years has been the global standard for assessing the risk of species extinction. The RLE adapts this approach to assess the risk of collapse for ecosystems (Figure 1).

We applied the RLE framework to assess risks of ecosystem collapse at regional and ecoregional scales across coral reefs in the WIO, covering nine out of the ten Nairobi Convention member countries. The analysis used indicators of ecosystem extent, distribution, response to future warming, and interactions among key ecosystem compartments (corals, algae, parrotfish and groupers) (Obura 2021).

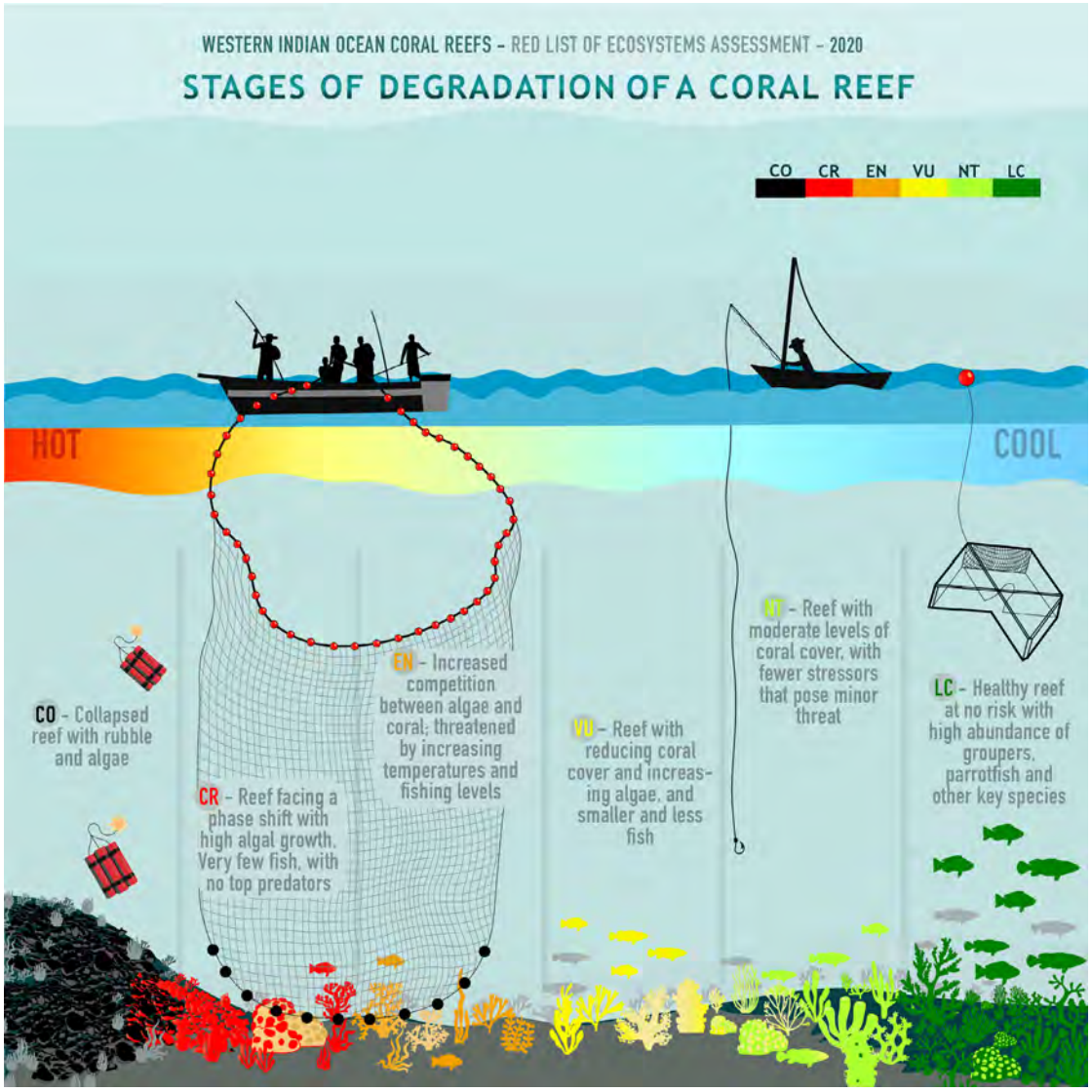

Figure 1. The stages of degradation of a coral reef, as contained in the Red List of Ecosystems. The illustration illustrates the primary drivers assessed (thermal stress, fishing) and the state of the reef system. The stages shown include: LC, Least Concern; NT, Near Threatened; VU, Vulnerable; EN, Endangered; CR, Critically Endangered; CO, Collapsed.

The assessment has produced some important advances: i) an up-to-date regional-scale analysis of reef regions most at risk; ii) a diagnosis of the dominant threats among these; iii) increased robustness and relevance of results for decision-support for coral reef management and policy; iv) updated the coral reef database compiled by the Global Coral Reef Network's (GCRMN) regional network under the Coral Reef Task Force (CRTF) of the Nairobi Convention, and v) introduced a novel assessment approach to the region that can be adapted to other critical ecosystems, such as mangroves and seagrass beds.

Advances

A key value of this analysis and the standardised outputs is promoting consistent actions and policies within ecoregions and countries at smaller scales (Momanyi 2016). This analysis is consistent with policy, actions, and processes within the Nairobi Convention, particularly through activities of the projects of the Convention supporting coherent work at local and national scales among Parties (see next section).

Western Indian Ocean coral reefs, covering 11 919 km^2 and comprising about 5 per cent of the global total (Figure 1), are Vulnerable (VU) to ecosystem collapse (Obura 2021). We assessed four of five criteria of the RLE over 50 years: decline in ecosystem extent (Criterion A), vulnerability due to restricted geographic distribution (B), and ecosystem disruption resulting from the decline in the quality of abiotic (C) and biotic factors (D). Criterion E was Not Evaluated as a quantitative model could not be applied. Two criteria (C, D) returned a result of VU (Figure 1, Table 1) based on future warming using a likely pathway for global greenhouse gas emissions (Criterion C, RCP 6.0) and biotic disruption based on reduction in piscivorous fishes indicative of fishing pressure (D). The other two criteria (A, B) returned a result of Least Concern (LC). The RLE assigns the most threatened result (VU) as the final status (Rodriguez and others, 2015).

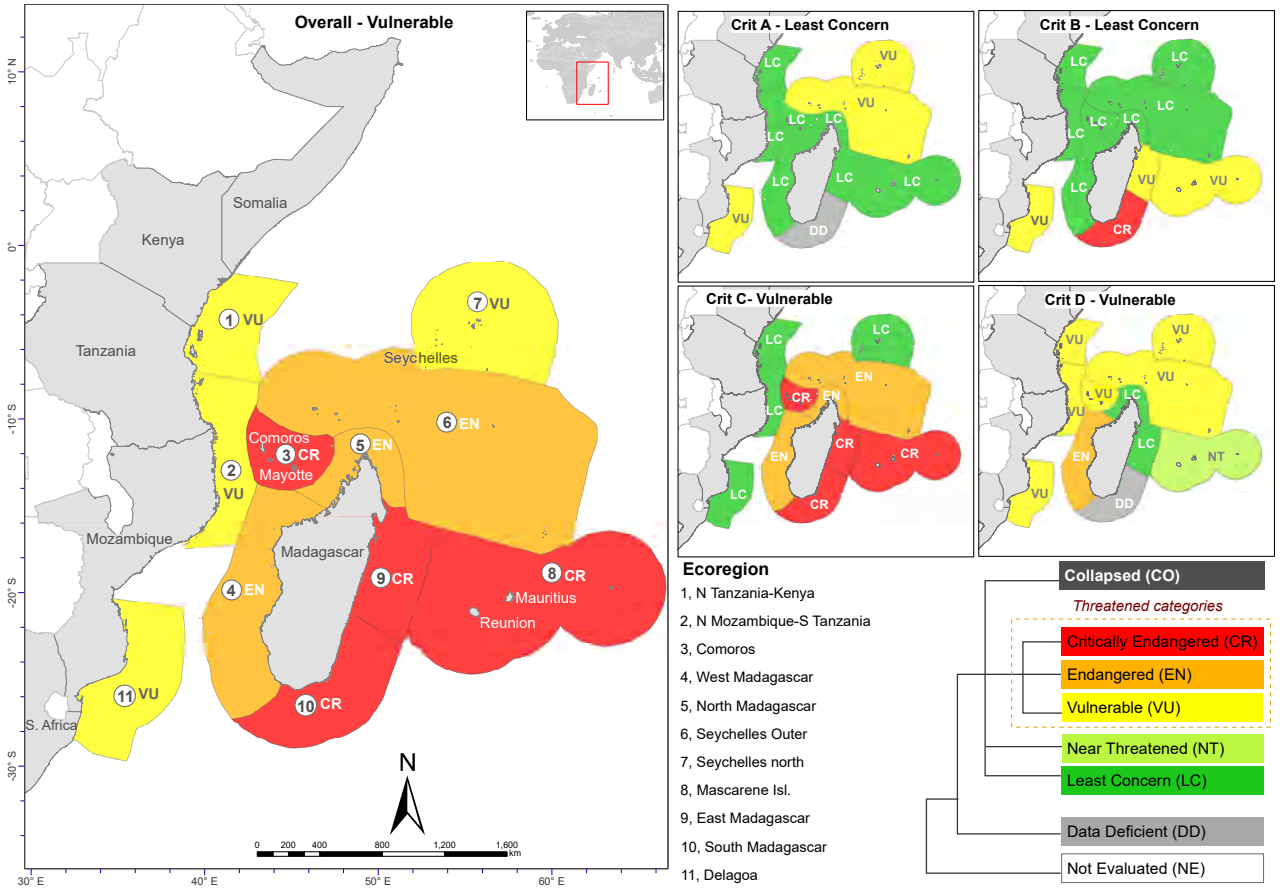

Figure 2. Coral reefs in the Western Indian Ocean and 11 of its ecoregions were evaluated using the Red List of Ecosystems (RLE). The overall risk level for each ecoregion is shown (left) and for each Criterion assessed: A, B, C and D (panels in the upper right, see also Table 2). Coral reefs in the Somali Ecoregion were Not Evaluated (NE). The ecoregion names and RLE categories hierarchy and colour codes used throughout the study are shown in the lower right—figure from Obura and others 2021.

Table 1. Risk of the collapse of Western Indian Ocean coral reef ecosystems in 11 ecoregions, across Criteria A–D of the Red List of Ecosystems. The overall result lists the final risk level and in parenthesis the criteria and subcriteria on which it is based. DD, Data Deficient; LC, Least Concern; NT, Near Threatened; VU, Vulnerable; EN, Endangered; CR, Critically Endangered. For details behind these results and the sub-criteria coding, see SI3-6). Table from Obura and others 2021.

Region		A	B	C	D	Overall
WIO region		LC	LC	VU	VU	VU(C2a,D1a)
Ecoregions						
1	N.Tanzania-Kenya	LC	LC	LC	**VU**	VU(D1a)
2	N.Mozambique-S.Tanzania	LC	LC	LC	**VU**	VU(D1a)
3	Comoros	LC	LC	**CR**	VU	CR(C2a)
4	West Madagascar	LC	LC	**EN**	VU	EN(C2a)
5	North Madagascar	LC	LC	**EN**	LC	EN(C2a)
6	Seychelles.Outer	VU	LC	**EN**	VU	EN(C2a)
7	Seychelles North	**VU**	LC	LC	**VU**	VU(A1,D1a)
8	Mascarene Islands	LC	VU	**CR**	NT	CR(C2a)
9	East Madagascar	LC	VU	**CR**	LC	CR(C2a)
10	South Madagascar	DD	EN	**CR**	DD	CR(C2a)
11	Delagoa	**VU**	**VU**	LC	**VU**	VU(A1,B1a(iii)b,B2,D1a)

At a finer geographic scale, there was considerable variation in the risk of ecosystem collapse among 11 coral reef ecoregions within the WIO (Figure 1, Table 2). The highest levels of risk were scored for seven ecoregions (four Critically Endangered (CR) and three Endangered (EN)) due to future warming in the island ecoregions spread across Madagascar, Comoros, outer Seychelles and the Mascarene Islands (Mauritius and Reunion) (Figure 2). The remaining four ecoregions were assessed as VU. Of these, reefs in the large continental ecoregions (N. Tanzania-Kenya and N. Mozambique-S. Tanzania) were Vulnerable based on declining populations of piscivorous fishes. In contrast, reefs in Seychelles North and Delagoa (southern Mozambique - northern South Africa) were Vulnerable due to a decline in reef areal extent, and in Delagoa also to the limited geographic distribution of reefs (Table 1).

Policy implications

Based on the findings, a wide range of policy and management options are available to conserve coral reefs in countries of the WIO (Table 2). Potential actions range from mitigating climate warming and minimising its impact to implementing ecosystem-based management at local scales to build the resilience of coral reefs to climate change.

Local management actions will have significant scope to maintain or improve reef health at ecoregions less threatened by future warming, ie on the mainland coast (McLeod and others, 2019). Actions should target alleviating fishing pressure (indicated here by grouper decline) and promoting coral recovery after major die-offs, such as reducing pollution in coastal waters to prevent the proliferation of algae. In addition, some of these ecoregions show strong levels of larval supply to more vulnerable ecoregions in the WIO (Crochelet and others, 2016; Gamoyo and others, 2019; Maina and others, 2020), and may therefore play a key role in the recovery of reefs through larval connectivity.

Global actions under the UNFCCC to reduce carbon emissions are essential. The most recent commitments made by countries in their NDCs in 2020 correspond to an emissions scenario greater than RCP 4.5, which will endanger most of the reefs in the region. The need for decarbonisation is reinforced by the fact that for the carbon emissions pathway RCP 2.6 (i.e. achieving the Paris Agreement), all ecoregions were assessed as Least Concern (LC), while under pathway RCP 8.5 (Business as Usual), all were considered as Critically Endangered (CR) (Obura, 2021). For the island ecoregions more threatened by warming, the next 2–3 decades will still be significant for reducing local reef threats and reef vulnerability:

a. to maintain ecosystem function and resilience to buy time for coral populations to adapt to warmer conditions through compositional shifts and/or genetic changes (McLeod and others, 2019),

Table 2. Portfolio of policy and management responses to address the main drivers of risk of collapse of Western Indian Ocean coral reefs. Given the broad scale of this assessment at ecoregional levels, multiple responses across climate and ecosystem-focused actions will likely be required within any country. VU, Vulnerable; EN, Endangered; CR, Critically Endangered; MPA, Marine Protected Areas; NDC, Nationally Determined Contribution; OECM, Other Effective Conservation Measures. Table from Obura and others (2021).

Risk level and critical factor	Ecoregions and specific indicators of risk	Range of policy and management responses to alleviate critical risk factors	
Climate, EN-CR (C2a, SST warming)	• Comoros, Mascarene Islands, East Madagascar & South Madagascar (CR) • North Madagascar (EN)	• Commit to strong climate change mitigation through the Paris Agreement/NDCs and national implementation of emission reductions and adaptation plans relevant to coral reefs. • Use scenarios in policy and management planning to consider higher and lower risk levels to maintain future options. • Establish climate adaptation plans, eg: . optimise benefit flows (on 20–30 yr. time frames) until coral reefs transition to an alternative state; . develop ecosystem and resource use policies anticipating potential alternative states of reefs, to maximise biodiversity and benefits after a transition; . identify and develop ‚climate smart' fisheries with reduced ecosystem impacts and more secure livelihood benefits; . identify alternative livelihood options and diversified income streams in coral reef landscapes; • Identify and protect climate refugia and connectivity nodes through MPAs and OECMs. • Invest in local (co)management (OECMs) to reduce synergistic threats, maximise climate resilience and buy time for adaptation. • Improve management of species and pressures that disrupt ecosystem processes, such as fisheries, land-based impacts to coral reefs, direct damage from the tourism, etc. • Develop guidance and best practices on enhancing recovery of reefs through alleviating pressures, understanding the role of herbivory, assisted restoration efforts, etc.	Climate and change-focus <<– – – – – – – – – –>> Ecosystem resilience focus
Climate with biotic disruption, EN-VU	• Seychelles Outer (climate, EN ; coral, VU) • West Madagascar (climate, EN; herbivores & piscivores, VU)		
Biotic disruption, VU (D1a)	• N.Tanzania-Kenya, N.Mozambique-S.Tanzania (piscivores, VU) • Seychelles North (coral & piscivores, VU) • Delagoa (coral, algae & herbivores, A & B1/B2, VU) • Algae is not a significant driver of the higher threat alone, but in synergy with other factors (N.Tanzania-Kenya, Delagoa)		

b. to sustain the valuable current economic and livelihood benefits coral reefs provide (Groeneveld, 2015) for as long as possible, and
c. as part of a broader integrated and ecosystem-based management approach delivering cleaner waters, adjacent ecosystem protection, and linked recreational and economic opportunities.

Outlook – regional and global processes

Reginal processes - Nairobi Convention Decisions and Work programme elements

The importance of coral reefs is highlighted in decisions, products and ongoing projects of the Nairobi Convention and supported by this work:

- Starting with the 3rd Conference of Parties to the Nairobi Convention in Maputo, 2001, Decision CP. 3/2 recognising that "coral reefs and related fragile ecosystems of the region are increasingly under stress from both localised human threats and global climate change and thus are a major cause for concern", a number of COP decisions have been made relevant to coral reefs (Box A);

Box A – prior COP decisions focused on coral reefs:

Decision CP. 3/2: Protection of coral reefs and associated ecosystems

Decision CP7/6: Strengthening Marine and Coastal Ecosystems Based Management, Valuation of Ecosystems Goods and Services and Assessments (*in relation to management and strengthening networks of experts*)

Decision CP8/13: Enhancing Cooperation, Collaboration and Support with Partners (*in relation to the regional coral reef status report published in 2017*)

Decision CP.9/11: Development of marine protected areas and critical habitat outlooks.

- Under the Nairobi Convention work programme for 2018–2022, under the "Assessments and capacity development section", paragraph 39 cites: "promoting the uptake of information, outputs and outcomes and the use of these in policymaking: (a) Collecting and synthesising the data on coastal habitats and their threats, necessary to support a regional analysis and development of outlooks on thematic areas such as critical habitats, marine protected areas

(MPA), climate change, environmental policy, disaster planning and management, and economic performance, (b) Supporting the development of decision support tools related to the WIO regional state-of-the-coast report". Coral reefs are a key ecosystem in the Critical Habitats and MPA Outlook reports published for the current Conference of Parties of the Nairobi Convention. The results of this analysis add to their findings and can be used in planning the following Workplan of the Convention.

- The 2015 WIO State of the Coasts report highlighted coral reefs as a critical ecosystem for biodiversity, fisheries and other economic benefits (Obura, 2015).

These provide a framework for policy responses at national levels (Table 2, and see recommendations below) to be coordinated and aligned, to make the most of the comparatively good outlook for coral reefs of the WIO compared to many other reefs globally (Beyer and others, 2018; Hoegh-Guldberg and others, 2018).

The Nairobi Convention serves as a regional platform for its Parties to integrate commitments and initiatives linked to the above and other global initiatives. It is a flagship/model region relating to other regional fora – such as the Marine Regions Forum and the International Ocean Governance forum supported by the EU. The RLE for coral reef ecosystems of the WIO is a global pioneer, developed using the data and processes established under the Nairobi Convention CRTF as a regional node for the GCRMN. It thus establishes the WIO as a pioneering region for coral reef assessments and policy development. It can stimulate similar assessments in other regions through all the regional and global mechanisms listed above.

Global processes

Current consultations on new decadal targets for the Convention on Biological Diversity (CBD), called the *post-2020 Global Biodiversity Framework (GBF)*, include greater attention to ecosystem targets (Watson and others, 2020) than in the prior Strategic Plan for Biodiversity and its associated Aichi Targets (from 2011 to 2020). They strongly recommend separate measures of area and integrity for quantifying ecosystem health to guide actions to protect or restore ecosystems effectively (Diaz, 2020; Díaz and others, 2020). The RLE meets these criteria and has been proposed as a potential indicator in the monitoring framework of the GBF by the International Coral Reef Initiative (ICRI, 2020) , among others.

These new CBD indicators will also likely be applied to the Sustainable Development Goal indicator framework to replace those based on the Aichi Targets due in 2020, enabling revised indicators and milestones for 2030. An IUCN motion (74) adopted for the 2021 IUCN World Conservation Congress on adopting the ecosystem typology developed to support the RLE will further support replicating this RLE analysis across coral reefs globally.

The *global status of reefs report of the GCRMN,* launched in September 2021 (Souter and others, 2021), provides a globally consistent dataset compatible with this analysis. As a result, the RLE can be applied consistently across the ≥ 100 ecoregions (Spalding and others, 2007) that contain coral reefs globally, providing a consistent metric of reef status across all countries.

The coming decade is a critical one for biodiversity globally and thus also for coral reefs. Key 'decades' include the *Decade of Action and Delivery for sustainable development* (2020-2030), the *UN Decade of Ocean Science*, and the *UN Decade of Ecosystem Restoration*. The United Nations Environment Assembly (UNEA) has passed multiple resolutions on marine and coastal issues. Under the Paris 2015 Agreement of the UN Framework Convention on Climate Change (UNFCCC), countries are currently revising their Nationally Determined Contributions (NDCs) to include specific mention of sensitive ecosystems and ecosystems critical for human well-being, such as coral reefs.

The RLE can serve as a key indicator of coral health and contributions to these processes and evaluate country actions under them.

Recommendations from the RLE assessment of coral reefs of the Western Indian Ocean

Recommendations here focus on the Parties to the Convention and support provided by the Nairobi Convention Secretariat and partners such as the members of the Consortium for the Conservation of the Western Indian Ocean (WIO-C). These recommendations acknowledge past decisions from the COPs on coral reefs (Box A) and a wide range of possible management policy responses (Table 2). Our recommendations focus on improving the development

and integration of capacity and technical information within policy instruments and processes:

Policy

1. Build on the findings of the Red List of Ecosystems, the 2017 regional and 2021 global GCRMN coral reef status reports, and other science, to identify priority reef areas requiring effective protection through protected areas or other effective conservation measures (OECM), thereby addressing international conservation area targets in the Western Indian Ocean in a way that is compatible with sustainable use and equity at local levels.

2. Embed coral reefs as a flagship ecosystem for sustainable development within national and sub-national Marine Spatial Planning and Sustainable Blue Economy processes in countries of the WIO to resolve local stressors (ranging from fisheries to land-based development).

Technical

1. Capitalise on the findings from the Red List of Ecosystems assessment to stimulate support for national policy processes related to coral reef and marine ecosystem conservation and sustainable management eg national coral reef action or management plans and strategies

2. Formally acknowledge the RLE result within the Nairobi Convention and promote the inclusion of the Red List of Ecosystems as a component indicator in the Global Biodiversity Framework of the Convention on Biological Diversity, thus establishing its relevance for monitoring Sustainable Development Goal 14 and of national reporting in convention processes.

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Regional framework for ecosystem monitoring in the Western Indian Ocean

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Summary

Ecosystem monitoring is a tool to assess the status and trends of both ecosystems health and management blueprints over long periods. Monitoring of ecosystems is undertaken through continuous and long-term data collection of relevant regional and national indicators to evaluate the environmental status and trends and sustainable ecosystem services usage. "*The Regional Framework for Ecosystem Monitoring in the Western Indian Ocean*" represents a guideline for the Contracting Parties of the Nairobi Convention and partners. It aims to provide a standardised approach to developing national activities to support ocean ecosystem monitoring in the region. The framework encourages developing and reviewing long-term monitoring programmes through integrated, coordinated, collaborative, and effective partnerships across the Western Indian Ocean region. It has been designed in line with the 2030 Agenda and the Sustainable Development Goals (SDG), the post-2020 Global Biodiversity Framework. It is also directly linked to Step 2 of the UN Decade of Ocean Science for Sustainable Development. Relevant priority issues and concerns identified in the regional Transboundary Diagnostic Analysis (TDA) were also considered for incorporation into National Planning. A list of 30 priority indicators has been selected to assist the Contracting Parties in addressing these issues and leading their strategies to target their commitments to global and regional initiatives on conservation of biodiversity, sustainable blue economy and human development. These indicators may be used for reporting relevant data on the Ocean's ecosystem health and environmental management strategies. Recommendations are provided to consolidate the importance of synchronised and efficient initiatives nationally and regionally by incorporating this framework into national planning for promoting and uplifting the economic, cultural and social potential of coastal communities and ecosystem services of the Western Indian Ocean.

Background

The Western Indian Ocean (WIO) Region comprises the Agulhas and Somalian Current Large Marine Ecosystems (LME) and the recently recognised Mascarene Plateau LME. It incorporates the coastal waters and currents, management and governance boundaries adjacent to the continent from Somalia to southeast South Africa (15 000 km extension), sharing cultural, political and biological history. The region has a unique biodiversity and abundant natural resources of socio-economic relevance for the local communities and national economies. Coral reefs, seagrass meadows, rocky shores, estuaries and dunes are some of the habitats that provide ecosystem services for activities such as coastal agriculture, mining and energy, maritime trade, fisheries and tourism.

Ecosystem health determines the sustainability and productivity of these activities to support human well-being and, thus, relies on the successful management of the Ocean. Regional ecosystem monitoring provides a tool to assess the status and trends of ecosystems health and management blueprints over long periods. Monitoring of ecosystems is undertaken through constant and long-term data collection of regional and national indicators relevant to evaluating environmental status and trends and sustainable ecosystem services usage (CSIR 2009). It represents a proactive, dynamic and adaptive process continuously under review and refinement regarding the procedures, tools, methods, and approaches used. Thus, it is based on the adaptive management principle (WRC 2016). Difficulties in aggregating available data from

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several countries may be minimised by setting up a standardised framework for the contextualisation, design, implementation and reporting processes. Indeed, ensuring that all generated data are fully reproducible, integrated, comparable and accessible will provide a big picture of the trends and changes in the Western Indian Ocean.

Monitoring is an essential component of the decision-making process because it allows evaluation of the effectiveness of management actions through time and thus reduces uncertainty. Monitoring also helps to determine new threats and issues that may arise over time and to re-prioritise threats and issues. Continuity, consistency, appropriate scale, expertise and effort are central to monitoring (Biber 2013). Therefore, it is expected that conducting effective monitoring can be challenging, especially in areas with limited human and financial capacity. Institutional continuity is needed from public and private institutions to undertake long-term monitoring and ensure that consistent methods are used over time. Scale considerations are also vital since there is usually a mismatch between the jurisdictional scales of an institution's mandate and the scale needed to conduct effective monitoring. An additional challenge can be the lack of uptake of the collected data by management agencies to inform the decision-making process (Cvitanovic and others, 2014; Addison and others, 2015).

The Contracting Parties to the Nairobi Convention have committed under Article 15 (on Scientific and Technical Cooperation) of the Amended Convention to cooperate in scientific research, monitoring and exchanging data and information concerning the Convention and its Protocols. Under Articles 17 and 23, it is stated that the Contracting Parties must prepare a national state of coast reports periodically. These national reports will form the basis of the regional State of Coast report to be produced every five years (Decision CP8/11: National and Regional State of Coast Reports). The Decision CP7/5: Strengthening National Reporting states that the Contracting Parties must agree to use a standard reporting template to report their progress implementing the Convention and its protocols.

The Contracting Parties and partners are currently implementing the Strategic Action Programmes (SAPs) developed by the predecessors of the SAPPHIRE (ASCLME/SWIOFP) and WIOSAP (WIO-LaB) Projects. Both projects identified the need to establish and implement a regional monitoring framework for critical habitats, coasts and shorelines in the WIO region, including inshore, offshore, and Areas Beyond National Jurisdiction (ABNJ), to assist them in addressing their regional and global conventions and commitments. Some international obligations include those under the 2030 Agenda for Sustainable Development and the Convention on Biological Diversity (CBD). The regional framework for ecosystem monitoring should be considered a guide to support Contracting Parties and the region to assess their efforts and progress in achieving them.

Advances – the state of the art

Ecosystem Monitoring Programmes (EMPs) should address priority issues in the region to provide data and information on the progress towards global and regional efforts. A regional coordinated monitoring programme addressing priority regional issues is currently not in place, highlighting a need to link and coordinate regional and national ecosystem monitoring through a pragmatic and agreed Regional Framework.

Coastal and ocean ecosystems of the WIO region face particular issues identified at the national and regional levels through the National Marine Ecosystem (MEDAs) and Transboundary Diagnostic Analyses (TDAs) undertaken by the ASCLME-SWIOFP and WIO-Lab projects. These issues directly impact the supporting, provisioning, regulating, and cultural services that are key to the region's socio-economic development and the Ocean's health. Due to the specificity of each Contracting Party, these transboundary priority issues do not have the same level of importance in each country. Thus some issues may or may not be incorporated into national EMPs if not relevant or of low priority. Regional priority issues that may not be relevant to the national level should still be incorporated into national activities to commit to regional monitoring.

While monitoring programmes are in place in most Contracting Parties, the coverage of the programmes and level of implementation differ among countries. Those parties with existing monitoring programmes do not support specific regional priority issues. This should be addressed through National Planning during the design and implementation of EMPs and/or when reviewing existing programmes. In other countries of the WIO, national monitoring of the ocean ecosystem's health is either under development or has not yet been incorporated into their national strategies

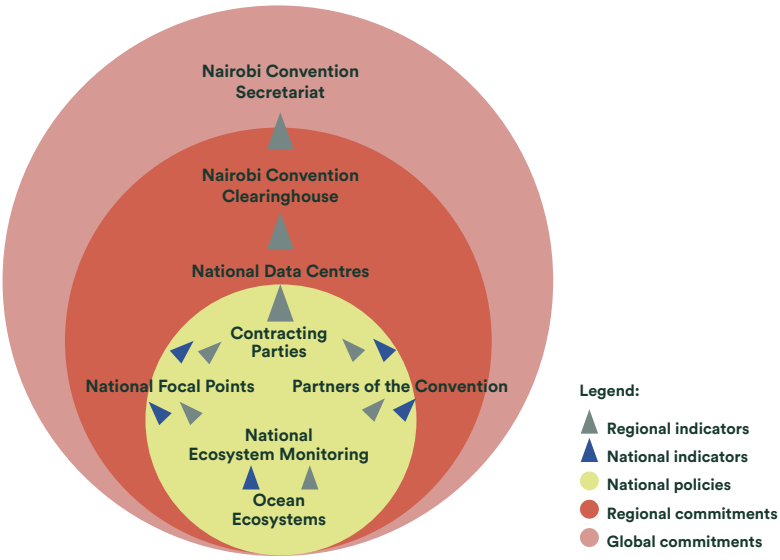

Figure 1. The flow of monitoring data obtained through national ecosystem monitoring programmes and their relationship with national policies, regional and global commitments.

and programmes. National EMPs should include the priority issues of the region in an attempt to provide data and information on the progress towards global and regional commitments, including those related to the Nairobi Convention.

Thirty regional priority indicators were selected in the regional framework and aligned with the issues and concerns identified in the Transboundary Diagnostic Analysis (TDA) of the Western Indian Ocean region. It is suggested that National Planning incorporates these regional issues and concerns during the design and implementation of EMPs and/or when reviewing existing monitoring programmes. Once agreed, the priority indicators will be used for reporting relevant data on the Ocean's ecosystem health and environmental management strategies. Reporting monitoring data will help to oversee gaps in scientific-based information on ecosystem indicators, identify challenges in the capacity for monitoring, help in decision-making, and advise regional initiatives and obligations.

It is proposed that monitoring data derived from national EMPs through the selected regional ecosystem indicators will be reported for regional monitoring. Compilation of monitoring data from national EMPs is imperative to estimate regional indicators required for regional, continental and global commitments on the conservation of biodiversity, sustainable blue economy and development accurately and objectively through national and regional investments. National Data Centres (under the direction of the respective National Data Coordinators) under the Nairobi Convention will be responsible for compiling and updating regionally-relevant monitoring data into the Nairobi Convention Clearing House Mechanism (CHM) on an annual or bi-annual basis. The Secretariat will assess and validate information received from the Contracting Parties and provide the necessary links to regional, continental and global monitoring processes. The relevant data derived from the national EMPs will be available in the CHM for consultation in decision-making processes and guiding regional initiatives.

Outlook for regional and global

The framework aims to provide a guideline on collecting and analysing relevant data to improve the reporting of information at the national and regional levels while ensuring that data production on relevant indicators is comparable across the region. It is also expected that the regional framework will assist Contracting Parties in the formulation and/or review and implementation of their national-level monitoring programmes. The regional framework is developed according to the 2030 Agenda and the Sustainable Development Goals (SDG) and the post-2020 Global Biodiversity Framework. It is also directly linked to Step 2 of the UN Decade of Ocean Science for Sustainable Development.

The framework is designed to guide the Nairobi Convention Contracting Parties on developing activities to support ecosystem monitoring at the national level. These activities will provide essential scientific information and knowledge to current regional and global commitments to keep their obligations and assist with decision making. The regional framework provides a standardised approach to support Contracting Parties in national planning and design and implement national EMPs through a standard methodology and guideline for the reporting and communicating relevant monitoring data at a regional level.

Suggested priority regional indicators were selected according to national, regional and global targets such as the Sustainable Development Goals, the draft post-2020 Global Biodiversity Framework, and its alignment with the aims of the Ocean Decade implementation plan and the Regional Seas Strategic Directive 2017–2020. Their relevance and link to the Transboundary Diagnostic Analysis under the ASCLME-SWIOF Projects.

Recommendations

The following actions for the implementation of this regional framework are proposed for consideration by the Contracting Parties:

Technical

The priority indicators suggested in this framework should be evaluated, discussed and approved by the Contracting Parties to standardise data gathering for the regional monitoring. Each Contracting Party should review the situational assessment and update it accordingly (ie, adding relevant information on ocean ecosystem monitoring).

National Data Coordinators (NDCs) from the National Data Centres of each Contracting Party should be nominated to oversee implementation. NDCs are responsible for conducting national self-assessments on the availability of information for the priority indicators; harmonising data collection methods, ensuring comparability nationally and regionally, facilitating data aggregation; and coordinating the development and implementation of regional indicators.

NDCs should designate Indicator Coordinators, who will evaluate the indicator data, oversee the progress and review the indicator monitoring for quality control and assurance.

The NDCs, Indicator Coordinator and Expert Groups should discuss the specific methodology and parameters to be collected for each of the priority indicators to ensure regional standardisation, continuous updating and evaluation of data.

Policy

After appraisal and suggested amendments, all Contracting Parties should approve and incorporate this framework in their national planning processes.

A capacity development programme is urgently required to support these recommendations. It will strengthen the capacity of National Data Centres to participate and contribute towards regional ecosystem monitoring requirements.

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Data and Tools

Strengthening regional regulatory frameworks and national capacity for handling marine biodiversity data in the Western Indian Ocean

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Summary

Decision-makers need readily-available and accurate biodiversity data to make informed decisions concerning marine ecosystems' protection and sustainable use. This data is often generated by a multitude of unrelated stakeholders with sometimes diverging agendas. In congruence with limited data sharing, this can lead to a duplication of efforts and waste of precious financial and human resources. Eastern African countries' oceans and coastal areas are home to abundant marine biodiversity, with immense ecological and socioeconomic value. Stakeholders have varying interests concerning shared ecosystems. Transboundary conservation goals, marine spatial planning efforts, and harmonised coastal management strategies are of great value for sustaining ecological services for future generations and addressing potential spatial conflict conflicts. For sound coastal governance, decision-makers require access to accurate, current, and comprehensive data on the status of marine biodiversity to act on pressing environmental issues. However, marine biodiversity data may only be partially available for various reasons, including inaccessibility of unpublished or restricted data, dispersed storage locations, or legal requirements preventing the open sharing of data. Under these circumstances, effective data sharing is a most important issue and should be prioritised by policymakers and entities involved in research. Our recommendations are based on the outcomes of several expert workshops, qualitative interviews, and the extensive experience of involved partners in East Africa. Firstly, we propose to align biodiversity and taxonomic data collection, reporting and sharing through common frameworks. Monitoring efforts and data sharing across institutions and borders can be streamlined by creating regional sharing protocols and policies. Additionally, we suggest the installation of a regional inter-sectoral (ie academia, government, policymakers, industry, traditional knowledge holders) expert panel on marine biodiversity information needs and handling/sharing strategies. We recommend that national governments start this process by designating representatives for the proposed regional inter-sectoral expert panel. Those representatives would ideally be part of existing initiatives like the Nairobi Convention Clearinghouse Mechanism or the National Focal Points of the Convention on Biological Diversity. Through regular exchanges, this community of practice could co-design the necessary regulatory frameworks on best practices regarding data collection protocols, sharing agreements and training efforts.

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Background

The ocean is human's most important life-support system. It produces 50% of the oxygen we breathe, supports essential food sources, stabilises the climate and economically supports an immense marine and maritime industry (OECD, 2016). Oceans and coastal areas along the Eastern African shorelines are among the most diverse and productive marine ecosystems worldwide (Obura, 2012). They carry enormous ecological and economic value and help secure the livelihoods of millions of coastal inhabitants (Allison and others, 2009). As natural calamities, climate change and human pressures increase, species extinction or reduction in population is likely to be high in WIO countries, with potentially adverse effects on ecosystem services (Selig and others, 2014). Sustaining the ecological services for future generations and addressing potential competing interests about spatial use as part of sound coastal governance requires careful management of those often fragile ecosystems, especially since stakeholders have different interests concerning the use and protection of marine ecosystems (Pendleton and others, 2020). Fundamental to evidence-based management is the availability of information and data, which can now be generated at an incredible rate through a manifold of initiatives monitoring, scientific studies, citizen science, open-source technology, satellite and other remote sensing efforts (UNESCO, 2017).

There are now many opportunities to expedite providing biodiversity data to relevant decision-making institutions at a much faster rate than previously known. Our ability to model and predict changes in ocean systems and biospheres has also made significant progress. However, despite all the advances in data science, it is still challenging to get hold of the data and get results in the decision-maker's hands in a relevant and helpful format to make sustainable management decisions. There are technical and logistical constraints, institutional and governmental policies, missing scientific capacities or general issues in knowledge sharing that hinder the collection and sharing of in-situ biodiversity data. Additionally, especially in the case of biodiversity data, expert taxonomy knowledge is missing in many geographic areas, which leads to unwanted dependencies from external experts. Existing marine worldwide operable databases are frequently only useful as references but may not provide practical knowledge at national operational levels for individual habitat or coral reef management. Here, viable and usable marine species and biodiversity databases relevant at the regional to the national level are missing as decisions need local information and integration on the broader biodiversity context. To meet future conservation and management goals, we will need to identify common monitoring strategies and agree on the essential variables (biodiversity and taxonomic data) that should be observed and routinely exchanged and shared. Through actions like this, Africa could take the lead in increasing the pace at which scientific and monitoring data is being made available in a usable way to decision-makers and other interested stakeholders. To provide data for evidence-based decision-making, all sectors and processes, such as policymakers, scientists, local communities, small-scale fisheries, tourism, or the maritime sector, must be addressed. In the end, there will be no proper management without the correct measurements. Therefore, the proposed framework addresses several central themes of the Nairobi Convention Science-to-Policy Platform, including informing MSP efforts and data management and standardised monitoring efforts to simplify ecosystem monitoring and ecosystem approaches to fisheries.

Advances

Timely and accurate biodiversity data is essential for informed and science-based decisions concerning marine resource use and sustainable extraction of marine resources. It is also crucial in potential risks to coastal ecosystems by development projects, as exhaustive and encompassing biodiversity information is necessary for decisions regarding, eg the designation of shipping lanes and other use areas. All coastal and marine spatial planning efforts rely on information concerning marine biodiversity.

Biodiversity data is generated and used by a multitude of stakeholders and institutions. Resource management, such as park and fisheries authorities, need data for immediate management decisions and long-term planning efforts. When they notice environmental changes and must react accordingly to avoid or mitigate damage (ie during coral bleaching or pollution events) and supervise subsequent restoration and recovery, recent and readily available biodiversity data can facilitate the allocation of resources and set priorities. Small fishing communities that autonomously manage parts of their coastal areas also rely on that data, eg on stock assessments and habitat status. In policy and decision-making, processed data that presents comprehensive and summarised information

on biodiversity issues is needed to inform decisions and new policies on all levels. Ideally, this information is up to date and readily available.

Similarly to resource managers, policy and decision-makers may not be trained or have the time to analyse complex scientific studies. Instead, they require condensed and timely findings informing their decisions to identify conservation priorities, address conflicts, and shape legislation. At the regional level, policymakers use biodiversity data for regional ocean governance, ie creating strategies to manage and conserve transboundary marine ecosystems. Scientific projects generate primary data and knowledge per the proposed project details. Moreover, access to data collected in other projects may help them conduct further analyses or validate previous findings. While processed or metadata may be sufficient to support specific scientific questions, some researchers may depend on access to primary data, which allows for a greater variety of scientific and practical applications.

Additionally, there are monitoring efforts that government institutions regularly conduct to meet national or international reporting needs. Non-governmental organisations also frequently collect monitoring data for outreach and campaign activities. Despite international efforts, few regional regulatory frameworks regarding biodiversity monitoring, data management, and data sharing are currently in place. Besides, there are many pressing issues in biodiversity data handling and sharing that have not been resolved yet. These issues are not restricted to Africa, but the IOC-UNESCO Decade of Ocean Science for Sustainable Development and initiatives such as the UNEP Nairobi Convention offer excellent opportunities for African partners to be at the forefront in solving them.

It is mandatory to integrate existing initiatives into strengthening regional regulatory frameworks and national capacity for handling marine biodiversity data in the Western Indian Ocean. To prevent paralleled efforts, it will be crucial to identify already drafted or developed topics, standards and policy ideas that apply to the region and modify them to the needs of the Western Indian Ocean. It is also noteworthy that many commemorated efforts have been made in the region to improve the uptake of scientific biodiversity information into political decision-making processes.

The Nairobi Convention Clearinghouse Mechanism acts as a 'data reference centre' in the Western Indian Ocean region to provide accurate and relevant data and information for improved management and protection of the coastal and marine environment in the region. It will be one of the main aims of the present proposal to support the Clearinghouse activities in its efforts. All activities proposed here should be conducted in close cooperation with the Nairobi Convention. The recently instated Marine Spatial Planning (MSP) technical working group can facilitate the integration of biodiversity data and best practices into MSP decision support systems (eg WIOSym). This proposed framework can supplement essential biodiversity data.

Additionally, regional and global databases have large datasets on the WIO region (eg: Ocean Biodiversity Information System, OBIS; Tanzania Biodiversity Information Facility, TanBIF; Global Biodiversity Information Facility, GBIF). Those databases are important institutions in developing regionally binding standardised monitoring frameworks and sharing standards, such as the Darwin Core, and developing and maintaining the taxonomic expertise in the region. They are also essential in generating ideas on how to integrate traditional and indigenous knowledge into those efforts.

Regional regulatory frameworks and national capacities for handling marine biodiversity data in the Western Indian Ocean, developed in a participatory process while respecting the needs of all involved stakeholders, will streamline the flow of biodiversity information into decision-making processes as well as support national reporting goals such as the National Biodiversity Strategy and Action Plans (NBSAP) or international initiatives such as the Sustainable Development Goals (especially SDG 14). They will also support any eventual follow-ups to the Aichi targets and the Convention on Biological Diversity post-2020 biodiversity strategy. The IOC-UNESCO Decade of Ocean Science for Sustainable Development also offers an excellent opportunity to advance this topic, as data acquisition, handling, and provision are key aspects of any efforts under its banner.

Regional and global outlook

The overall aim is to develop a roadmap vision for the Western Indian Ocean region to become a model region for monitoring, handling, and sharing marine biodiversity data for sustainable resource use in support of the Nairobi Convention and its member states (Figure 1).

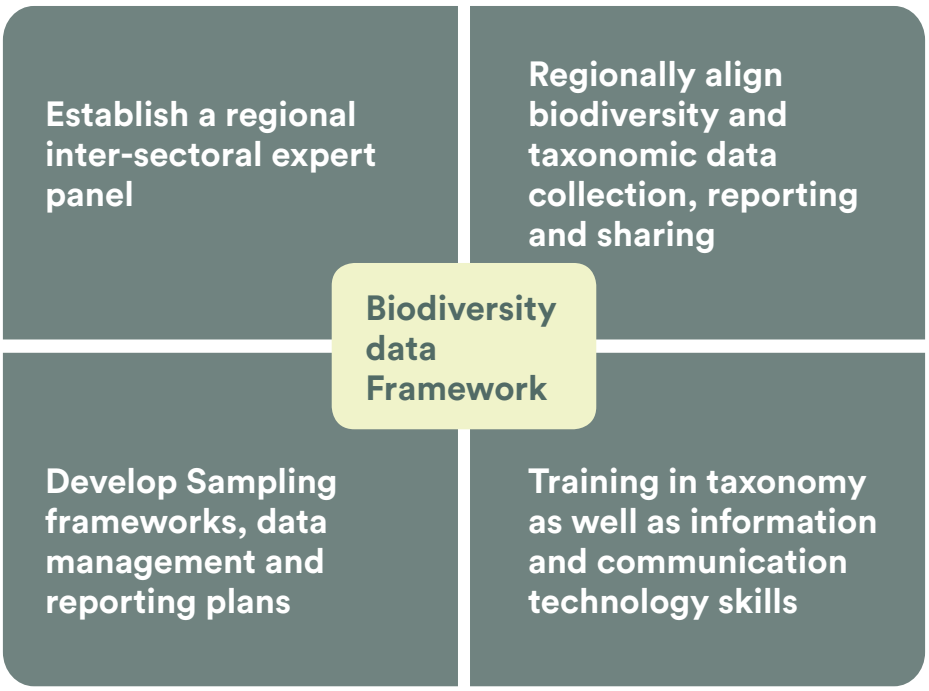

Figure 1: Main technical and policy recommendations towards and improved regional biodiversity data handling framework

Technical recommendations

We propose establishing a regional inter-sectoral (ie academia, government, policymakers, industry, traditional knowledge holders) expert panel on marine biodiversity information needs and handling/sharing strategies. This could be achieved through an exchange platform for policymakers and researchers to co-design and co-implement projects and discuss data needs for adaptive and timely management solutions. First, the established panel could create a database of experts and identify and register a review body on internationally accepted research and monitoring methods. It would also develop the underlying concepts, observed variables, data collection methods, sampling frameworks, and data management and reporting plans. Once concepts and frameworks are agreed upon, those can be rigorously tested in identified model regions. As a continuous effort, the panel can also support the development of technical, taxonomical and methodological capacities of researchers and decision-makers in and from within the region.

Policy recommendations

Regionally align biodiversity and taxonomic data collection, reporting and sharing through common frameworks. Monitoring efforts and data sharing across institutions and borders can be streamlined by creating regional sharing protocols and national data sharing policies based on proven and internationally recognised standards. Formal sharing agreements with governments and project donors could make timely data sharing a provision for issuing research permits or granting funds to increase reporting to national bureaus of statistics, local communities, or other data users. Aligned reporting mechanisms to assess and track developments in coastal ecosystems are indispensable to evaluate investments, monitor changes, and inform policy- and decision-makers. Those protocols, frameworks and policies should be co-designed to reflect the information needs of a broad spectrum of stakeholders and to be inclusive of under-represented status groups. Regionally aligned biodiversity and taxonomic data collection, reporting and sharing, would also benefit from increased data visibility in the region and streamlined pathways to exchange data and data needs. Given the multitude of organisations involved in ocean management and resource use, robust coordination mechanisms, eg through the Nairobi Convention or the established expert panel, enable science-policy interactions to help prepare society to respond to a regional change in marine ecosystems. Through focal points, such as the Nairobi Convention, efforts and incentives towards effective data communication can be implemented to increase the comprehensibility of research findings.

Workshops should train scientists and data collectors in effective sharing methods, ie compelling narratives, visual tools, field trips, or storytelling techniques. Furthermore, extensive training and capacity-building in taxonomy and information and communication technology skills should be funded and provided for individuals and entities handling marine biodiversity data. It is encouraged to seek alternative funding pathways, eg through public-private partnerships.

We recommend that national governments start this process by designating representatives for the proposed regional inter-sectoral expert panel. Those representatives would ideally be part of existing initiatives like the Nairobi Convention Clearinghouse Mechanism or the National Focal Points of the Convention on Biological Diversity. Through regular exchanges, this community of practice could co-design the necessary regulatory frameworks on best practices regarding data collection protocols, sharing agreements and training efforts under the advice of the identified regional panel of experts.

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WIO Science - Policy Platform Series
(1) 2022 57-62

Overview of oceanographic data and research for improved ocean governance in the Western Indian Ocean Region

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Summary

Oceanographic and other ocean-related research is critical for informing effective ocean governance. Informing the ocean policy requires multi-faceted research and an assortment of data and information. Every country in the Western Indian Ocean (WIO) region has national institutes that carry out ocean science research in national waters, covering all aspects of ocean science, including physical and chemical oceanography, habitats, biodiversity, ecology, and pollution. National datasets are not always readily available on online platforms and are generally scattered over many national institutes. Access to these datasets should be through national or regional data centres. Technological advancement and capabilities of the national data centres vary among countries. These centres face several challenges, including a lack of financial resources and adequate human capacity. While infrastructure is a challenge in most countries, improvements can be made to these centres but not necessarily to the same level in every country. It is recommended that the Contracting Parties of the Nairobi Convention request the Secretariat to support the strengthening of National Data Centres to collect, analyse and share data and information in the region. Such support may include preparing an action plan for the further development and support of National Data Centres under the SAPPHIRE Project; supporting capacity development initiatives aimed at strengthening the capabilities of the National Data Centres; and ensuring linkages between National Data Centres and regional mechanisms, such as the Nairobi Convention Clearinghouse Mechanism, ensuring efficient and effective sharing of regionally-relevant information.

Background

Ocean governance underlies the concept of Sustainable Ocean Economy, which is one of the desirable outcomes for the UN Sustainable Development Goal 14. Innovative and improved ocean governance requires essential data and information obtainable only from oceanographic and other ocean-related research. In line with the ecosystem approach to managing natural resources, ocean governance requires consideration for the ecological assets, the social and economic consequences of management actions, and regulatory agencies' ability to achieve management objectives in the face of external impacts. This requires multi-faceted research and an assortment of data and information.

One of the recommendations from the Second Consultative Meeting on the Development of African Strategy for Ocean Governance, held in October 2020, is that scientists and researchers should play a role in ocean governance. In addition, each state should designate a national science and research institute for the blue economy and ocean governance to undertake research and gather and analyse data to inform policy dialogues, formulation, and implementation. It was proposed that the African ocean governance strategy should include articles on the collection, aggregation and use of Africa's data on the oceans. Establishing an African oceanographic research/data centre or a network of national oceanographic research/data centres is also envisaged. This is in line with the Nairobi

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Convention Conference of Parties decision CP 4/8 on enhancing access to information. The Contracting Parties resolved to develop and/or organise outreach, knowledge and public awareness programmes on marine and coastal issues in collaboration with partners in the region.

Long-term monitoring of natural resources is vitally important for understanding the complex ecological processes that enable ecosystems to function (Likens 1989, Strayer and others, 1986). For scientists and managers to effectively determine reference points and baselines against which changes in the ecosystem can be measured, how the systems respond to management interventions, and the external influences such as climate variability and change, adequate and suitable data on essential ocean variables is indispensable (Likens 1989). The importance of long-term monitoring at the scale of large marine ecosystems was acknowledged during the Agulhas and Somali Current Large Marine Ecosystem (ASCLME) Project. Data centres were established to house data collected by each contributing country during the project's life (ASCLME 2009).

For the regional stocktaking workshop on oceanographic research and data in the WIO Region held in Mauritius in May 2019, some working documents were prepared. These included Koranteng and Everett (2019a), (2019b), and (2019c), which detail the status of data and approaches to the long-term monitoring of oceanographic data and scientific research in the Western Indian Ocean. Here, we consolidate the essential messages in the three reports necessary for the science to policy discourse.

Advances

Assessment of oceanographic data and scientific research in the WIO region

Every country in the Western Indian Ocean (WIO) area has national institutes that carry out ocean science research in national waters, including collecting oceanographic data and other ocean data necessary for good governance. These include government-funded research institutes, university departments and schools, and non-governmental organisations (Figure 1). Notable among these are the Mauritius Oceanography Institute (MOI), the Seychelles Fishing Authority

Figure 1. A schematic of organisations undertaking research in the Western Indian Ocean and the products that they produce. (Adapted from UNEP-Nairobi Convention and WIOMSA 2015)

(SFA), the Kenya Marine and Fisheries Research Institute (KMFRI), the Tanzania Fisheries Research Institute (TAFIRI), the National Fisheries Research Institute (IIP) of Mozambique, the Council for Scientific and Industrial Research in South Africa, the Institut Halieutique et des Sciences Marines of the University of Toliara (Madagascar) and the Oceanographic Research Institute (South Africa).

The research institutes work in the following major disciplines: fisheries science and management, oceanography, ecology, and primary production. A few also look at socio-economics, ocean governance, and recent issues related to the blue economy. While some institutions collect data for the region, it is more common for national institutions to collect and store data on a national or smaller scale. Presently, there is no regional-scale data collection undertaken by the WIO countries. Researchers and decision-makers must rely on external data sources such as satellites operated by American and European space agencies or research vessels outside the region. Two recent exceptions were the ASCLME and the South West Indian Ocean Fisheries Project (SWIOFP), both of which included all the countries of the WIO except Somalia that had observer status due to the political situation in that country at the time. These and other collaborative initiatives collect data for a specific period and/or area.

Many institutions collect oceanographic data globally, mostly remotely through satellite technology or buoys either moored or drifting. Two of these that hold a substantial amount of data for the WIO region are the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA), both of the United States of America. There are also initiatives that work on regional scales; key among these are the EAF-Nansen Programme and the Institut Francais de Recherche pour l'Exploitation de la Mer (IFREMER) of France. Both these initiatives include the use of research vessels in their data collection. The vessels are highly sophisticated and collect many data as they work in countries within the WIO.

Oceanographic data collection in the WIO is carried out on various platforms, including satellites and research vessels, using instruments ranging from shipboard equipment through electronic sensors on automated vehicles to Niskin and Nansen reversing bottles, Secchi disks and other basic tools and implements. Many research institutes monitor Essential Ocean Variables (EOVs) required to establish and assess ocean mean-state and variability.

Available relevant datasets and their management

National datasets cover all aspects of ocean science, including physical and chemical oceanography, habitats, biodiversity, ecology, and pollution. Oceanographic data for a particular country are usually not stored on one server in one locality. Data and samples from regional surveys may be kept or processed at several institutes. In addition to national data, there are many relevant datasets available to researchers in the WIO region; these have been tabulated in Koranteng and Everett (2019a). The datasets differ in their scale, the collection platforms, the sensors used, and the amount of post-collection processing done. The other datasets are generally large and complex, necessitating substantial capital investment in their storage, maintenance, and distribution in the form of servers and personnel. The prominent institutes and multinational commissions that are well-funded tend to have the most accessible data. Examples are from IFREMER, NASA and NOAA.

Data centres are very important facilities that are essentially networks of connected servers. Primary objectives are to secure, store and disseminate data. They ensure that the best available scientific data and local knowledge are shared and incorporated in planning and policy development at the national and regional levels. This is particularly important for large datasets. Data centres are also expected to improve accessibility to data, thus allowing the data to be used for scientific research and management of various ecosystems. Examples of data centres are those established under the IOC of UNESCO's Ocean Data and Information Network for Africa (ODINAFRICA) project, the Southern African Data Centre for Oceanography (SADCO), the Partnership for Observation of the Global Oceans (POGO) and the Indian National Centre for Ocean Information Services (INCOS).

National data centres were established under the IOC/UNESCO IODE programme and further developed during the ASCLME Programme. Often there is an investment in these activities during projects, but when the projects are concluded, the servers and portals are no longer maintained. It seems, therefore, a better option is to incorporate data storage on servers and portals that have proven track records when it comes to longevity. An option for re-establishing a

regional data portal that is already viable is the Nairobi Convention Clearinghouse Mechanism (NCCHM) which has recently been redesigned. The NCCHM is a "data reference centre" that provides a portal to data for six emerging trends, including biophysical environment, human environment, economic activities, policy and governance, planning and management and cost-benefits analyses.

There are also meta-databases in place in the region that can document existing data and/or be collected in the future. For example, the Marine Spatial Atlas for the Western Indian Ocean (MASPAWIO 2021provides an open-access geospatial data repository for the WIO. There is also the South African Environmental Observation Network (SAEON 2021). ODINAFRICA had a GeoNetwork metadatabase and produced a data atlas, but the search functions are no longer operational. There are, however, many datasets included in the atlas. The Food and Agriculture Organization of the United Nations (FAO) also has a GeoNetwork metadatabase that provides ocean data. GeoNetwork is freeware and can be used as a standalone installation that can be synchronised with a regional system, avoiding manual uploading processes.

Assessment of access to and sharing of oceanographic data in the WIO region

National datasets are not always readily available online and are generally scattered over more than one national institute. This makes it more challenging for users to access all the relevant data required. Unless specific institutional/project data policies are in place, data are not made easily discoverable. These data may be stored on local servers or desktop computers. This is particularly the case with smaller projects that may have collected valuable data but are not registered on a metadatabase or an archiving portal.

Koranteng and Everett (2019a) provide an inventory of some of the initiatives and institutes that collect oceanographic data and some indication of the accessibility of the data and the hurdles that need to be overcome to gain access. Generally, agreements exist to protect the organisations involved in data and information gathering and sharing and aim to regulate the relationships between the parties (Koranteng and Everett 2019c). These agreements spell out the responsibilities of both parties, particularly concerning the allocation of responsibilities, financial implications and exploitation of products or data required for use/storage. The agreements are intended to avoid potential uncertainties between parties, and they clarify the nature and scope of the relationships. Monitoring of ecosystem processes relies on data availability; therefore, it is necessary to set up agreements with various organisations and institutions in the WIO region to facilitate data availability for this task. The involvement of these entities in long-term monitoring of the LMEs needs to be formalised through specific funding and collaborative agreements. The type of agreement depends on the nature of the entity and the data and information required.

Relevant national institutions identified can be engaged through small-scale funding agreements

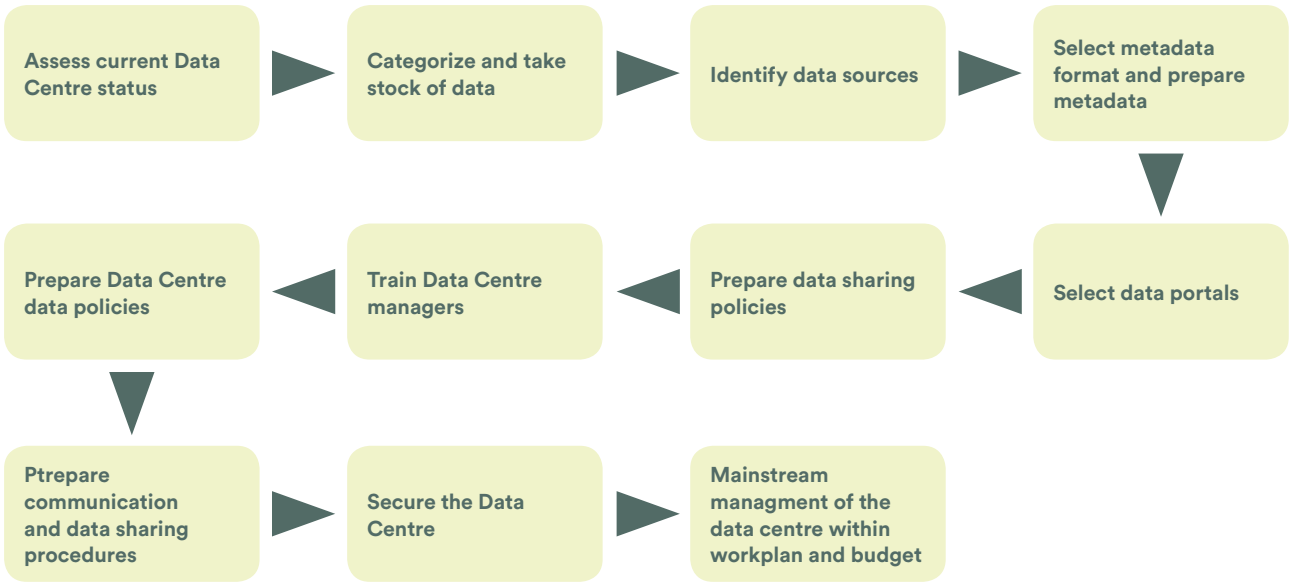

Figure 2: Roadmap to revitalising the national data centres in the Western Indian Ocean (from Koranteng and Everett 2019b)

(SSFA). At the same time, non-profit organisations can enter into collaborative contracts concluded with the Nairobi Convention Secretariat. To secure collaboration with regional bodies that have, among their objectives, long-term conservation and sustainable use of the marine resources, it is necessary to conclude a specific Memorandum of Understanding (MoU) or Letter of Agreement (LOA) where appropriate. Relevant regional technical or subject-matter entities are the Indian Ocean Tuna Commission (IOTC), Southern Indian Ocean Fisheries Agreement (SIOFA), and the South West Indian Ocean Fisheries Commission (SWIOFC).

Reviving the National Oceanographic Data Centres developed during the ASCLME project

The ASCLME-assisted national oceanographic data centres were expected to use internationally accepted standards and best practices for data collection and management. The ASCLME Project offered to support the coordination of effort across the region for the promotion of access to coastal and marine-related information in appropriate forms to underpin informed ecosystem management decisions. At the stocktaking workshop, there were discussions on the state of the data centres established by ASCLME, WIO-LAB and SWIOFP. It became evident that almost all the data centres are still running, although they are in varying advancement and capabilities. Participants noted, however, that the centres are facing several challenges, the most significant being lack of financial resources and adequate human capacity. Generally, operations of the data centres were not mainstreamed in the work plan and budgets of the host institutions and, therefore, not seen as a priority activity that should receive direct funding and staff support.

The participants showed great enthusiasm for the revival of the data centres and noted that this is a vital activity that will benefit the region. It will add substantially to the development of practices that will lead to greater sustainability of ecosystems and their functioning in the region. The meeting noted that provision had been made under the SAPPHIRE programme to help revive the data centres and continue data collection and archiving. This action aims to support the updating of existing national MEDAs, TDA, and National Action Plans (NAP). It was emphasised that it is necessary to re-market the data centres as service providers rather than only data storage units.

In the panel discussions during the stocktaking workshop, the consensus of the panellists was that more emphasis should be placed on providing products that are useful to governance practitioners and processes. By emphasising useable output rather than raw data, the importance of data management and the longevity of data centres will follow. Governments should be seen as the most important clients, followed by regional and global programmes. It was felt that a culture of data sharing among scientists should be encouraged while respecting the ownership rights of the data originators. To this end, it is important to develop data policies to protect the originators and the users.

Koranteng and Everett (2019b) proposed many steps for revitalising the Data Centres (Figure 2), including developing an action plan under SAPPHIRE. The action plan should include the establishment of an ad hoc Working Group on the revitalisation and operation of the data centres. Following proposals were made:

1. Assess the current status of each data centre and the facilities.
2. Categorise data needs and take stock of the required data for each category.
3. Identify sources of data (nationally, regionally, and internationally); historical data should not be forgotten in the enthusiasm of collecting new data and should be revived into useable formats
4. Select a metadata format and prepare metadata of the data and information; re-establish a regional metadata and data portal. The NCCHM comes in handy here.
5. Select data portals; a data portal is "a list of datasets with pointers on accessing data".
6. Prepare data sharing protocols with national, regional and international institutions that hold relevant datasets. The IOC of UNESCO encourages member States to use data centres linked to IODE's National Oceanographic Data Centres (NODCs) and World Data Centre (WDC) networks.
7. Assess and train data centre managers; data management should be the core function of the data managers and not side jobs over and above scientific duties.
8. Prepare a clear Data Policy that defines ownership, access, patent, etc.

Outlook

Several institutes in WIO countries collect good data on essential ocean variables, but many have problems with managing the data. The region's scientists and

policymakers also have access to databases owned by institutions that collect oceanographic data on a global scale and to data from regional research initiatives. However, there appears to be an apparent lack of trust in the data sharing process in the region, but this can be overcome by developing clearly defined policies and protocols for data management and sharing. These policies and procedures should protect the data originators and the data centres from misuse and/abuse of data and provide an element of confidence in the rights and abilities of those involved. Scientists should be encouraged to share their data so that greater benefit will be derived from them than what can be obtained from a single project/product.

Given the UN Decade of Ocean Science for Sustainable Development, revitalising oceanographic data centres in WIO countries is imperative to ensure effective management and sharing of the data we need for the ocean we want.

While infrastructure is a challenge in most countries, improvements can be made to the centres but not necessarily to the same level. Each centre needs to move to a level where it can provide a service to its data user community rather than attain a level beyond its needs and means. Regional standards should be developed for data collection, storage and archiving to enable more fluid data exchange and use. Establishing a regional metadatabase and portal will greatly aid data sharing in the region; the NCCHM can play an important role in providing such service.

It is recommended that the Contracting Parties of the Nairobi Convention requests the Secretariat to support the strengthening of National Data Centres to collect, analyse and share data and information in the region through the following actions:

- Prepare an action plan for the further development and support of National Data Centres as provided under the SAPPHIRE project.
- Support capacity development initiatives aimed at strengthening the capabilities of the National Data Centres and the data centre managers.
- Ensure linkages between National Data Centres and regional mechanisms such as the Nairobi Convention Clearinghouse Mechanism are established to ensure the efficient and effective sharing of and easy access to regionally-relevant information.

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Co-design as the basis for collaboration and science to policy uptake in the Western Indian Ocean Region

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Summary

Nowadays, researchers from different disciplines are expected more and more to collaborate as well as with relevant stakeholders. We must move away from business-as-usual basic research to more applied and transdisciplinary research and the integration of different knowledge. Working across scientific disciplines, regions and societal groups requires new methods and concepts regarding communication, institutional arrangements and funding opportunities. Data provided by international research programs are rarely sufficiently application-oriented or context-specific. Co-design and how to use it is not widely known or intentionally practised in the region yet. However, co-design is an "Iterative and collaborative process involving diverse types of expertise, knowledge and actors to produce context-specific knowledge and pathways towards a sustainable future" (Norström and others, 2020). IOC-UNESCO emphasises the importance of co-design, and co-design was especially highlighted in the context of the Ocean Decade. This paper makes some recommendations to develop a regional vision and guiding principles, build multidisciplinary capacities, and capitalise on the UN Ocean Decade opportunities. These opportunities mainly build knowledge and practice of co-design and embed co-design more broadly across the WIO region. Suggestions for a way forward could be a regional and inter-sectoral Working Group.

Background

Global change and the need for sustainability calls for more integrative research with new strategies and approaches. Research questions need to be defined in interaction with civil society, governments and other stakeholders and should be guided by societal challenges and needs. Researchers from different disciplines are expected to collaborate with relevant stakeholders and focus more directly on producing knowledge to inform society and decision-makers. This means that we must move away from business as usual basic science to more applied and transdisciplinary research and the integration of different knowledge. In this context, Mauser and others argue that integration is an iterative process (Mauser and others, 2013). They propose a framework of co-creation that consists of three stages, throughout which all stakeholders are involved: co-design, co-production and co-dissemination. The term co-design is often used analogously to co-creation and can comprise all three stages.

The UN Decade of Ocean Science for Sustainable Development (Ocean Decade) supports such a transformative process and emphasises the importance of co-design. This is seen as a useful step in illuminating how co-design can shape marine research and policy practice.

The problem

The transition to this relatively new type of research in the marine and policy fields is not without challenges. Working across scientific disciplines, regions, and societal groups requires new methods and concepts regarding communication, institutional arrangements and funding opportunities. Further, co-designing research questions and co-producing knowledge implies all scientists and stakeholders' roles

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and responsibilities. This concerns research projects between the global North and the global South and is also explicitly an issue in integrative and transdisciplinary research projects on the regional and even local level.

However, the problem is illustrated here by the often encountered North-South example. Calls for funding towards collaborative research projects between the global north and global south are usually applied opportunistically due to emerging topics of public interest in the global south (host countries) that increase chances for a successful application. The funding calls themselves often originate from the global north, reflecting the priorities of the global north. Due to legal requirements, project implementation and administration also lie with partners from the global north, further strengthening the imbalance in collaborative research projects and resulting in limited application in the collaborating countries in the global south. In the initial project/proposal conception phase, the process is driven by partners from the global north. The ideas of the "collaborators/partners" are used as sources of inspiration to build on the legitimacy of the process and fulfil the call's requirements.

Moreover, emphasis is put on the submission process, which entails collecting signatures of approval and Memoranda of Understanding (MOUs) from the partners in the global south to justify collaboration and yet offer limited flexibility to these countries to shape the design of the project – presenting "ready-made", predesigned projects to the global south partners. At the end of the project, the original data, in many cases, remain with the collaboration partner from the north with limited access for the partners from the global south for further research or use in science-based decision making. This disparity through all phases of a research project – design, implementation, and generation and translation of results - can lead to frustration and distrust among research partners in the host countries.

Advances – state of the art

In the WIO region, the problems described above are already being addressed by the Nairobi Convention and the Western Indian Ocean Marine Science Association (WIOMSA). Some success with marine research co-design approaches, e.g., as a requirement for collaboration with resource users, has been achieved within The Marine and Coastal Science for Management (MASMA) Programme (WIOMSA 2017). However, co-design and how to use it are not widely known or intentionally practised by many governments, scientists, research organisations, and policy organisations in the region. The current use of co-design in marine research is fragmented but not entirely lacking. But frameworks are missing guiding through co-design processes, and it needs more knowledge of co-design in general practice. Co-design so far is little practised amongst research organisations and even less on the sectoral and policy-making level.

During workshops and interviews conducted in the Western Indian Ocean (WIO) region, interviewees stated that traditional North-South cooperation often neglects the specific needs and expectations of the southern hosts. Other studies (UK Collaborative on Development Sciences 2017; Schmidt and Neuburger 2017) found similar results, highlighting that data provided by international research programs are rarely sufficiently application-oriented or context-specific. The influence of host countries in shaping the focus of international research activities is limited. (World Bank 2016). This erodes trust between partners and can lead to disinterest in further collaborations. Consequently, the projects often don't go beyond the project life but end as soon as the funding comes to a close.

As mentioned before, this disparity is not exclusive to North-South partnerships; regional cross-boundary initiatives, eg research on migratory species or even collaboration among national institutions on the same topic, bear the same risks. Key questions need to be unpacked:

- What are the expectations on critical aspects of the partnership?
- Are the goals consistent on all sides?
- How are the workload and competencies distributed among the partners?
- How is data collected, analysed and shared? It frequently also transcends the project itself.

Co-Design Approaches

Suppose we want to generate innovative science which addresses the current complex human-natural issues. In that case, we will need to integrate the knowledge and traditional wisdom of many diverse stakeholders beyond the scientific community (Wright Morton and others, 2015) and work in a transdisciplinary and inclusive environment. The process of co-designing collaborative inter-and transdisciplinary research projects across complex issues can mitigate many of the

challenges mentioned above. It recognises the importance of non-scientific (e.g. local or traditional) knowledge and the co-production of knowledge by researchers, practitioners, and other stakeholders. The term "co-design" has received considerable attention in several contexts (e.g. knowledge production, product or design development, policy design and dissemination of results) in the past years but is not clearly defined yet (Moser 2016). A recent publication proposes a definition that is based on literature, experiences and perspectives of researchers and practitioners as "Iterative and collaborative process involving diverse types of expertise, knowledge and actors to produce context-specific knowledge and pathways towards a sustainable future." (Norström and others, 2020)

We propose an adaptive framework to jointly develop research projects and policies based on a common agenda and a shared vision. A good example of such an adaptive approach is the four-step approach developed by Future Earth Coasts – Our Coastal Futures, which aims to engage stakeholders for joint problem definition, goal setting and strategy development. A key point of this approach is establishing a reliable partnership among stakeholders, a mandate to act (and an institutional framework for doing so), and a joint definition of targets (Future Earth Coasts 2018). The co-design and co-production will involve scientists, regional decision-makers, the private sector, non-government organisations, and local and indigenous knowledge holders.

Linkage to regional and global processes

Making research relevant for host countries and decision-making processes begins with a joint agenda setting. Projects that base their collaboration on co-design, co-production and co-dissemination are more likely to be context-specific and respond to local (policy) and societal needs. In this way, co-design is an important building block to bridge the science-policy gap and work towards a prosperous and sustainable future. It can support efforts of the Science-Policy Platform of the Nairobi Convention to protect, manage and develop the Western Indian Ocean in partnerships and at the regional level.

As the coordinating body for the upcoming Ocean Decade, IOC-UNESCO has emphasised the importance of co-design. In that regard, IOC organised several regional workshops to prepare the implementation plan to offer opportunities to "co-design mission-oriented research strategies in line with the 2030 Agenda and continental and regional initiatives […]" (IOC UNESCO 2020). Co-design was highlighted in the context of the Ocean Decade by kicking off the Ocean Decade Virtual Series with a session on "Co-designing the science we need for the Ocean Decade". This series emphasised that the Ocean Decade has the

Photo credit: Dr. Hauke Kegler

ambition to trigger a revolution in ocean science by providing a framework for collaborative and participative research and better integrating diverse knowledge systems, disciplines, sectors, and stakeholders.

The "Our Coastal Futures" approach developed by Future Earth Coasts, which aims to provide a forum for regional coastal stakeholders to jointly take transformative actions towards the Sustainable Development Goals, is a regional example of co-design.

Advances – state of art

MeerWissen – African-German Partners for Ocean Knowledge of the German Federal Ministry for Economic Cooperation and Development has integrated a co-design process in its funding program for African-German partnership projects. Proposals for projects to be supported under MeerWissen are developed collaboratively, and a co-design workshop is key to bringing all partners together. For two days, representatives of the African and German institutions involved in the project reflect on their partnership, agree on rules for their collaboration and work jointly on finalising the project concept.

While, for administrative reasons, the funding is channeled only through the German partner, setting up a co-design process helps ensure that the views of all partners are reflected in the project idea. This does not only help build trust among partners and create a basis for a collaboration built on shared responsibility and ownership. It also increases the chances of the research being relevant and useful for all partnering parties and countries. Insights and expertise from the host countries' representatives are essential in designing a project that links well to the political systems, fits the local context and responds to real needs. With this collaborative approach, MeerWissen seeks to set new standards for research collaborations and knowledge transfer in marine sciences.

This co-design approach should evolve beyond the joint design of projects to live a co-design process throughout the project. Such a process needs to include discussion and agreements on data storing and sharing, analysing results and developing capacities, purchasing equipment and questions of ownership, and leading to open dialogue and dissemination of findings among different societal groups. The projects need to also consider the broader picture: Which other stakeholders might be interested in the generated data or results? Are other institutions currently working on a similar topic and might be willing to share resources or expertise? Who else might hold important information or traditional knowledge that might be incorporated into the project? These questions could be addressed by incorporating the "CARE Principles for Indigenous Data Governance", released in 2019 by the Global Indigenous Data Alliance (GIDA). The CARE principles expand on the principles outlined in FAIR (Findable, Accessible, Interoperable, Reusable) data to include Collective benefit, Authority to control, Responsibility, and Ethics, to ensure data guidelines address historical contexts and power differentials (Wikipedia 2020). When designing policies based on project results, it is imperative to incorporate the knowledge and needs of marginalised groups of interest, such as indigenous communities or small businesses.

Recommendations

For the implementation of co-design approaches, an institutionalisation similar to that of participation processes on a regional level may be considered. However, this requires strong political support and the will to eventually anchor such approaches formally if necessary. First and foremost, it remains to be clarified what co-design means in practice and how it benefits political decision-makers, but above all, how the benefits affect the people concerned. If a participatory co-design approach is properly applied:

- Political decision-makers are involved from the very beginning in defining the problem, moving away from purely theoretical research to applied and real-world challenges.
- All relevant actors and their positions are clear from the outset.
- Decision-making strategies can be scientifically substantiated.
- Due to the participatory character, the views of all stakeholders can be directly incorporated
- A common agenda and common vision can be jointly developed from the very beginning reinforcing the potential of a common yet scientific result supporting a quick application, for instance, for political strategies, policy decisions and communications.
- Stakeholders benefit from the transparent decision-making and the opportunity to participate in every step of the research process.

To create the needed political will and support, it is recommended:

- To promote co-designing in ocean science and management as one of the effective ways to

implement the UN Decade Ocean Science for Sustainable Development (2021-2030) in the WIO region.
- To develop a regional vision and guiding principles for co-designing in ocean science and management.
- To initiate short-term and long-term projects/programmes to build multidisciplinary capacities, which are key for continually building and strengthening the co-design approach.
- To capitalise on opportunities provided in the UN Decade Ocean Science for Sustainable Development (2021-2030) and other regional and global initiatives, particularly supporting co-designing approaches.
- To create opportunities for scientists and decision-makers in the marine sector, build knowledge and practice of co-design in a more consistent and coordinated way to support collaboration and science to policy uptake.
- To embed co-design more broadly across the WIO region within marine and coastal research and policy programmes, promoting science-policy uptake.

The second step is to convey a competence base for co-design methods. A knowledge transfer approach with a (digital-) modular system is conceivable, which can be called upon depending on the scientific problem. But to conceptualise and create a competence base in the region, a regional and inter-sectoral Working Group (WG) could be established, which could:
- Design and coordinate the process of phrasing a joint vision.
- Collect and analyse lessons learned and successes in co-design.
- Define criteria for research partnerships in the region (e.g. the Bremen Criteria (ZMT 2015)).
- Test, review, adapt and apply existing guidelines for co-design and promote their implementation.
- Review how research partnerships and co-design approaches in the region can be funded, e.g. through the MASMA programme.
- Create awareness for the relevance of co-design in the research community as well as among decision-makers.
- Support the exchange of experiences as well as the development of capacities of researchers and decision-makers for co-design.
- Proactively approach funding organisations and partners (from the Global North) and encourage funding mechanisms incorporating a co-design and partnership approach.

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Water quality and land-based pollution

Marine litter and microplastics in the Western Indian Ocean: current knowledge and recommendations

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Summary

This review collates available information on marine litter and microplastics in the Western Indian Ocean (WIO) region with a specific focus on the sources, transport and fate of litter, and the resultant ecological and human health impacts. Most litter comes from land-based sources, especially in the case of continental countries, and urgent action is needed to curb the release of local litter into the sea. This can be achieved by promoting reusable items, improving waste management at the municipal level, and educating citizens from the WIO region about the adverse effects of litter on the marine environment. While some litter is also released from land-based sources in WIO island states, a significant proportion originates offshore, either from fisheries or shipping activity or via long-distance drift from foreign nations, mainly in Southeast Asia, which is especially relevant on remote coasts and islands that receive little or no local input of litter. International measures are therefore also needed to address these problems. Given that waste generation in all WIO countries is expected to increase in the future, WIO governments and municipalities should prioritise action plans to curb this socio-environmental problem. At the same time, monitoring programmes should continue to assess the efficacy of the prevention and mitigation measures.

Background

The Western Indian Ocean (WIO) is a region where high biodiversity is increasingly being impacted by anthropogenic marine debris (Ryan and others, 2016a; Abreo and others, 2019; Cartraud and others, 2019), but information about the amounts, types and sources of marine litter are scattered widely in the literature. The last review of the topic across the region was published in 2008 by the United Nations Environment Programme and the Western Indian Ocean Marine Science Association (UNEP and WIOMSA, 2008). The report focused on eight countries within the WIO region (South Africa, Mozambique, Madagascar, Tanzania, Kenya, Mauritius, Comoros and Seychelles). It indicated that most of the litter found in the region likely originates on land. However, a fraction of litter was attributed to at-sea activities such as illegal dumping from ships and fishing activities. The 2008 UNEP/WIOMSA report highlighted large knowledge gaps in all countries in the region except South Africa. Substantially more research on marine litter has been published since this report's publication, and a review of the latest research for the entire WIO region is urgently needed. For instance, while comprehensive national hot-spotting assessments about plastic waste in four WIO continental countries provided up-to-date information on the sources, density, and distribution of plastic waste and recommended interventions

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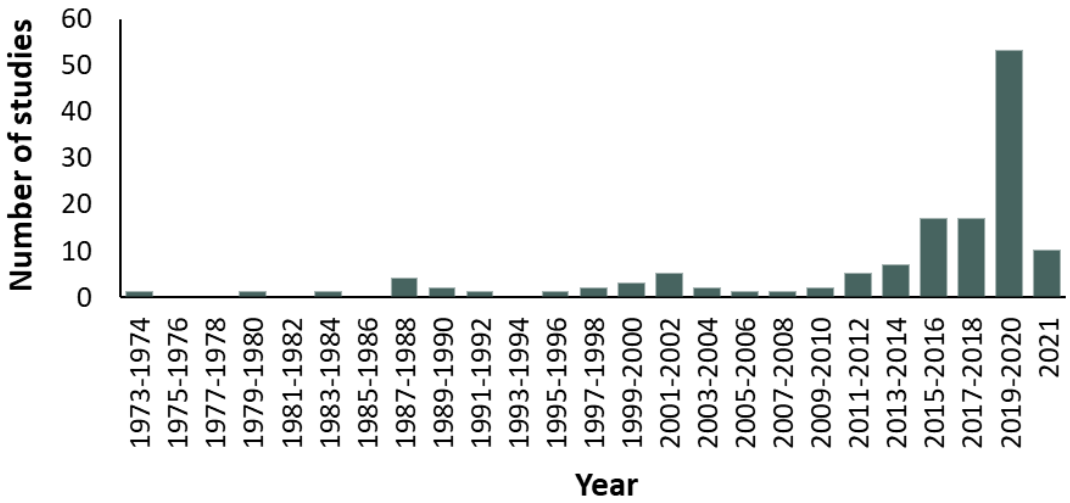

Figure 1. Number of studies reporting data on marine litter or microplastics in the WIO region, grouped by two-year intervals from the first study conducted to the present day.

to curb its generation and release to the environment (IUCN-EA-QUANTIS, 2020a,b,c,d), there has been no recent region-wide review of the densities, distribution, sources, fate and threats of waste plastics. There is also a lack of clarity concerning key knowledge gaps, and there is an urgent need to identify effective mitigation actions to tackle plastic waste at a regional level. Mismanaged plastic waste has been identified as an important issue in WIO continental countries (with mismanagement rates reaching 99 per cent in Mozambique; IUCN-EA-QUANTIS, 2020a,b,c,d), and its amount is predicted to increase significantly (Jambeck and others, 2015; 2018), which could result in even more litter entering the WIO in future. WIOMSA thus commissioned a comprehensive review of the existing literature on the amounts, sources and fate of marine litter and microplastics in the WIO region and their resultant ecological and human health impacts. The main goal of this review is to identify the principal sources of marine litter in the WIO countries, which is essential knowledge for effective prevention and management measures.

Advances – state of the art

To synthesise existing knowledge, we reviewed 136 studies on marine litter and microplastics in the WIO region (79 per cent of articles from peer-reviewed scientific journals, 20 per cent grey literature reports, 1 per cent book chapters). The first study was conducted in 1973, but 71 per cent of studies are from 2015 to 2021 (Figure 1). Studies were mainly from South Africa (57 per cent), followed by Kenya (8 per cent) and Mozambique (5 per cent), while Madagascar, Seychelles, Comoros, Tanzania, Mauritius and La Réunion accounted for smaller proportions; 27 studies (20 per cent) included data from several countries, international waters, or covered seabirds that forage widely across the Indian and Atlantic Oceans. Most studies sampled for macrolitter (>25 mm), but knowledge about the distribution of microplastics on the seashore has also improved since the publication of the 2008 UNEP/WIOMSA review (UNEP and WIOMSA, 2008).

The best-studied coastal habitat was the seashore (mostly sandy beaches), followed by the sea surface. It was often difficult to compare macrolitter and microplastics densities among studies because of differences in sampling methods; for example, most studies reported litter per linear metre of shoreline while some reported densities per unit area. Studies also differed on the lower size limit sampled (for example, using different mesh sizes to sample floating litter), and it was difficult to compare litter densities on shorelines determined for standing stock versus accumulation surveys. Even accumulation studies were sampled at different intervals between repeat surveys. Greater efforts are needed to harmonise survey methods and reporting units (*eg* GESAMP, 2019; Barnardo and Ribbink, 2020).

Amounts and characteristics of marine litter

Macrolitter densities on the seashore were generally greater on urban or popular recreational beaches close to point sources (Swanepoel, 1995; Lamprecht, 2013; Ryan and others, 2014a; Gjerdseth, 2017; Chitaka and von Blottnitz, 2019; Okuku and others, 2020a; Opie, 2020; Ryan, 2020a). In most studies, plastics

dominated, with generally >50 per cent of items being plastics, in terms of number (Pereira and others, 2001; Duhec and others, 2015; Bouwman and others, 2016; Jost, 2019; Dunlop and others, 2020; Okuku and others, 2021a). Of particular concern is plastic packaging, which often dominates litter loads, especially on urban sandy beaches (Ryan and Moloney, 1990; Chitaka and von Blottnitz, 2019; Okuku and others, 2020a; Opie, 2020; Ryan, 2020a), and has been identified as one of the main sources of marine litter in WIO continental countries, at least numerically (IUCN-EA-QUANTIS, 2020a,b,c,d). Litter items on urban and tourist beaches are often smaller and have a faster turnover rate due to increased cleaning efforts targeting large litter, whereas these same large litter items tend to persist for longer periods on rarely cleaned beaches. Therefore, while the number of items on tourist beaches may be higher, the mass of litter is normally concentrated on remote beaches, highlighting the importance of also reporting litter densities by mass (Ryan and others, 2020a).

Data on the density and distribution of meso- (5-25 mm) and microplastics (<5 mm) on the seashore are only available for sandy beaches and estuaries. In both Kenya and South Africa, studies conducted using sieve transects on sandy beaches (that is, to sieve sand along a transect perpendicular to the shoreline to sample meso- and microplastics >2 mm) reported higher densities of plastic litter on beaches closer to populated areas compared to semi-populated and remote regions (Lamprecht, 2013; Ryan and others, 2018; Okuku and others, 2020b; Ryan and others, 2020a). Most research on smaller microplastics on the seashore has been conducted in South Africa, with one study available from Tanzania and one from the Comoros Archipelago. Results of these studies show that microplastics (most of which are microfibres) also tend to be concentrated around large coastal cities (de Villiers, 2018). Still, nearshore surface currents may also influence the distribution of microplastics on the seashore (Nel and Froneman, 2015). One study extrapolated microplastic densities across the entire beach profile and found an average density that completely dwarfed counts of macrolitter or mesolitter but only contributed <0.01 per cent to the total mass of litter (Ryan and others, 2020a), highlighting that a few large items dominate the mass of litter. It is important to remove these large items from beaches before they degrade into microplastics (Ryan and others, 2020a). In South Africa, the average density of mesoplastics and macroplastics increased from 1984 to 1989 (Ryan and Moloney, 1990). In contrast, little change in mesoplastic densities was detected in surveys between the 1990s and the 2010s (Ryan and others, 2018). Trends in the standing stocks of macroplastics on beaches are compromised by changes in beach cleaning efforts (Ryan and others, 2020a). The limited data from accumulation studies suggest increases in some seasons but decreases in others, linked to mitigation efforts to intercept litter in rivers before it reaches the sea (Opie, 2020).

Floating macrolitter has been studied off the coasts of Kenya and South Africa (Ryan, 1988; Ryan, 1990; Ryan and others, 2014b; Okuku and others, 2021b), where densities are much higher than in the Southern Ocean off South Africa (Suaria and others, 2020a), likely due to higher inputs and shorter distances from land-based sources. Twelve studies conducted net tows for floating mesolitter and microlitter (Ryan, 1988; Ryan, 1990; Cózar and others, 2014; Eriksen and others, 2014; Massot Mascaró, 2015; Nel and Froneman, 2015; Jost, 2019; Naidoo and Glassom, 2019; Kerubo and others, 2020; Kosore, 2020; Suaria and others, 2020a; Okuku and others, 2021b), while five collected bulk surface water samples for microplastics (Nel and others, 2017; Kosore and others, 2018; Kerubo and others, 2020; Suaria and others, 2020b; Preston-Whyte and others, 2021). The highest densities of floating mesolitter and microplastics were found in the coastal waters of Kenya (Kosore, 2020; Okuku and others, 2021b). All studies reported that plastics were the most common anthropogenic material caught in the nets. Several studies suggested that ocean currents play a significant role in determining the distribution and accumulation of meso/microplastics (Nel and Froneman, 2015; Naidoo and Glassom, 2019). Microfibres were common in bulk water samples (Nel and others, 2017; Preston-Whyte and others, 2021), although most fibres in surface waters are not synthetic (Suaria and others, 2020b). Nel and others (2017) and Preston-Whyte and others (2021) suggested that harbours may be important sources of microplastics and microfibres because they often receive stormwater and other run-offs from adjacent urban areas, which is in agreement with several studies from other parts of the world (Ballent and others, 2016; Rose and Webber, 2019).

Only one study from the WIO region sampled litter in the water column (along a transect from Cape Town to the Prince Edward Islands; Ryan and others, 2020b), which remains one of the least studied marine habitats. Five studies have surveyed macrolitter on the seafloor (in Mayotte, South Africa, and international waters;

Rundgren, 1992; Woodall and others, 2015; Mulochau and others, 2020; Ryan, 2020a; Ryan and others, 2020c), with highest litter densities found at deep-sea sites along the Southwest Indian Ocean Ridge, >1,300 km south of Madagascar, most of which was fishing gear (Woodall and others, 2015). Macrolitter densities on the continental shelf off the south and west coasts of South Africa were lower (Ryan and others, 2020c). Most of this litter was plastic packaging and disposable plastics, which may have originated from land-based sources or ships (Ryan and others, 2020c). Dive transects on coral reefs in the Comoros Archipelago also found mostly discarded fishing gear, suggesting that most reef litter comes from fishing activity (Mulochau and others, 2020). Three studies reported microplastic densities from bottom sediments in the WIO region (in South Africa and international waters; Woodall and others, 2014; Matsuguma and others, 2017; Preston-Whyte and others, 2021). The highest densities were generally found close to point sources such as sewage overflows, stormwater drains and river mouths (Preston-Whyte and others, 2021).

Sources, transport, and fate of marine litter

Identification of litter types and local concentration around urban source areas indicates that most litter is from local, land-based sources (Gerber, 2017; de Villiers, 2018; Ryan and others, 2018; Mayoma and others, 2020; Okuku and others, 2020a; Ryan, 2020a,b; Ryan and Perold, 2021), reaching the ocean via urban and river run-off or direct deposition by beachgoers. The national hot-spotting assessments implemented in Kenya, Mozambique, South Africa and Tanzania identified low waste collection rates along with high rates of improperly disposed waste as major drivers of mismanaged plastic waste and its leakage into rivers and consequently to the ocean (IUCN-EA-QUANTIS, 2020a,b,c,d). Recent studies show that much litter does not disperse far from the source (Collins and Hermes, 2019; van der Mheen and others, 2020; Ryan and Perold, 2021; Chenillat and others, 2021), suggesting that shorelines in the WIO region are important sinks for litter (although buried plastics in beaches will be exposed as coasts erode due to rising sea levels). The type of habitat and its physical characteristics play a significant role in determining the fate of stranded litter. For example, mangroves and rocky shores are significant sinks for larger or heavier litter items (Weideman and others, 2020a).

Although most macrolitter from land-based sources strands on shorelines close to where it washes into the sea, a small proportion may also be transported offshore (Duhec and others, 2015; Collins and Hermes, 2019; van der Mheen and others, 2020; Chenillat and others, 2021). Land-based sources dominate in areas close to urban centres, especially in continental areas, while offshore inputs dominate away from these sources. As the WIO region is downstream of southeast Asia, ocean models suggest that some of the litter from that region reaches the WIO countries after extended oceanic journeys (van der Mheen and others, 2020). This is supported by reports of Asian-branded packaging covered in epibionts (Duhec and others, 2015; Bouwman and others, 2016; Okuku and others, 2020a; Ryan, 2020b; Ryan and Perold, 2021; Ryan and others, 2021) and the predominance of HDPE bottles and lids from Indonesia (compared to PET bottles from China, Singapore/Malaysia and UAE, many of which are dumped illegally from ships; Ryan, 2020b; Ryan and others, 2021). The problem of sea-based inputs, especially long-distance transport of litter from southeast Asia, is particularly challenging for small island states in the region, where most litter derives from these sources (Duhec and others, 2015; Bouwman and others, 2016; Burt and others, 2020). The lack of data on the characteristics and densities of litter on the seafloor of the WIO region makes it difficult to ascertain to what degree the seafloor acts as the ultimate sink for marine litter, but some studies already confirm accumulations of litter on the seafloor in coastal and offshore regions (Woodall and others, 2015; Mulochau and others, 2020; Ryan and others, 2020c).

Ecological and human health impacts of marine litter

More than one-third of the 136 reviewed studies reported interactions between organisms and marine litter or microplastics (in all countries except mainland Comoros and Somalia), among which ingestion and entanglement were documented most commonly. Plastic ingestion has been recorded in 101 species from the WIO region, including many seabirds (Ryan, 1987; Nel and Nel, 1999; Ryan, 2008; Ryan and others, 2016b; Cartraud and others, 2019), bony fishes (Naidoo and others, 2016; Naidoo and others, 2017; Bakir and others, 2020; McGregor and Strydom, 2020; Naidoo and others, 2020a) and sharks (Cliff and others, 2002). All four species of sea turtles studied have presented plastic debris in stomach contents or faecal samples (Claro and Hubert, 2011; Hoarau and others, 2014; Chebani, 2020), but none of the four species of marine mammals studied had ingested

macrolitter (Ryan and others, 2016b; Chebani, 2020). Invertebrates (mussels, oysters, crabs, sea anemones and some zooplankton) have also been found with microplastics in their guts (Kosore and others, 2018; Awuor and others, 2020; Chebani, 2020; Mayoma and others, 2020; Sparks, 2020; Weideman and others, 2020b). Further studies will likely find microplastic ingestion in virtually all marine species.

Entanglement has been reported for 57 species of seabirds, marine mammals, sea turtles and sharks (Shaughnessy, 1980; Cliff and others, 2002; Hofmeyr and Bester, 2002; Hofmeyr and others, 2002; Ryan, 2018), but few systematic studies have been conducted, and it was difficult to differentiate entanglement of seabirds in marine debris from bycatch in active fishing gear (Ryan, 2018). Of particular concern are fish aggregating devices (FADs) because they are often reported with entangled, dead sea turtles (Balderson and Martin, 2015). Fisheries litter (nets and lines) is often entangled on coral reefs, macro-algae and horny corals (Rundgren, 1992; Schleyer and Tomalin, 2000). Some invertebrates (echinoderms, sea anemones) which use natural objects for shading or camouflage also attach plastics to their body surface (Rundgren, 1992; Spencer, 2020; Weideman and others, 2020a). Ten studies have reported data about organisms growing on marine litter (that is, epibionts, in Kenya, Mozambique, Tanzania, South Africa, Madagascar, Mauritius, and at deep-sea sites east of Madagascar), with floating substrata colonised by various species, including bryozoans, spirorbid worms and six species of goose barnacles (Rundgren, 1992; Whitehead and others, 2011; Fazey and Ryan, 2016; Ryan, 2020b; Ryan and others, 2020c; Ryan and others, 2021). Long-distance transport of some species on floating plastics has been suggested (Barnes, 2004).

The potential impact of marine litter on human health remains severely understudied. One study from Tanzania confirmed high concentrations of human pathogens and multi-drug resistant bacteria growing on waste plastics (Rasool and others, 2021). Other studies identified microplastics in different edible marine organisms throughout the South African, Kenyan and Tanzanian coastlines, including estuarine fish (Naidoo and others, 2020a), mussels (Gerber, 2017; Sparks, 2020), oysters (Awuor and others, 2020), and cockles (Mayoma and others, 2020). While it is unclear what proportion of these microplastics are ingested by humans, their ingestion is potentially harmful to humans because of the toxicity of plastic additives and the sorption of persistent organic pollutants (POPs), which have been detected on the surfaces of polyethylene pellets beached in Mozambique and South Africa (Ogata and others, 2009; Ryan and others, 2012). The transfer of these compounds to humans remains speculative, and the effects of marine litter and microplastics on human health remain a largely unknown and understudied field (Naidoo and others, 2020b; Vethaak and Legler, 2021).

Regional and global outlook

Identification of knowledge gaps and future research priorities

The reviewed information suggests several important knowledge and research gaps about marine litter and microplastics in the WIO region (broadly summarised and prioritised in Table 1). Most studies have been conducted on sandy beaches, while other habitats, such as mangroves, rocky shores, rivers and estuaries, the water column, coral reefs, and the seafloor, lack important information across the region. There is also a geographic gap in marine litter research, with most studies conducted in South Africa. Studies from South Africa also cover the most diverse array of topics and habitats; for example, rivers and drainage systems have only been researched in South Africa, and given the variable rainfall and run-off dynamics within the WIO region, there is a need for better understanding on the amounts, composition, sources and sinks of litter in these habitats in the other countries. To help focus clean-up efforts, knowledge of the fate of litter needs to be improved, whereas sociological research into why people litter can aid understanding and addressing this behaviour. Quantitative data about the impacts of litter on marine organisms at a physiological level (for example, toxicological effects of chemicals associated with plastics, potential diseases caused by litter, increased drag and breakage) and at the population level are lacking, as well as data about impacts on human health (for example, toxic chemicals, dangerous items on the seashore, spreading of diseases such as cholera and malaria, burning of litter, entanglement of propellers, etc). Despite these knowledge gaps, we already know enough to prioritise actions to reduce the amounts of waste plastics entering the environment. Research should also focus on identifying effective mitigation efforts by, for example, testing the impact of programmes to reduce particular types of litter (such as bans on plastic bags), the retention rate of river booms and stormwater traps, and the effectiveness of beach, river, and street clean-up programmes (Ryan and others, 2020d).

Table 1: Main knowledge gaps on marine litter that need to be addressed in the WIO region and their priorities.

Actions to address knowledge gaps in the WIO region	Priority
Determine amounts and types of litter in habitats other than sandy beaches	High
Quantify the amounts of litter from land-based versus offshore sources	High
Determine breakdown dynamics of macroplastics under different conditions	Medium
Determine whether litter aids the spread of diseases	High
Evaluate the health implications of burning litter	High
Improve understanding of the economic costs of marine litter	Low
Improve understanding of the fate of litter to help focus clean-up efforts	Low
Improve understanding of littering behaviour to address it effectively	High

Recommendations for action

The information gathered and presented above (and synthesised in Figure 2), coupled with the results and recommendations of the hot-spotting assessments implemented in Kenya, Mozambique, South Africa and Tanzania (IUCN-EA-QUANTIS, 2020a,b,c,d), highlight the need to address the marine litter problem through locally driven measures and a life cycle intervention approach, emphasising actions on the source and the end-of-life. We recommend a series of actions mostly focused on monitoring/research, prevention, and management that can be implemented at the regional, national and local level in the WIO region (recommendations summarised in Table 2).

First, the regional monitoring programme that has recently been established (Barnardo and Ribbink, 2020) should continue and be extended within countries, given that ongoing litter monitoring is important to (i) help identify the major sources of litter and (ii) provide information to evaluate whether measures and policies aimed at reducing marine litter are effective or not (Ryan and others, 2020d). Policy-making and litter monitoring need to go hand in hand as integral parts in any life cycle intervention approach implemented to curb the release of litter into the environment. Regional monitoring activities should be coordinated and harmonised in terms of protocols

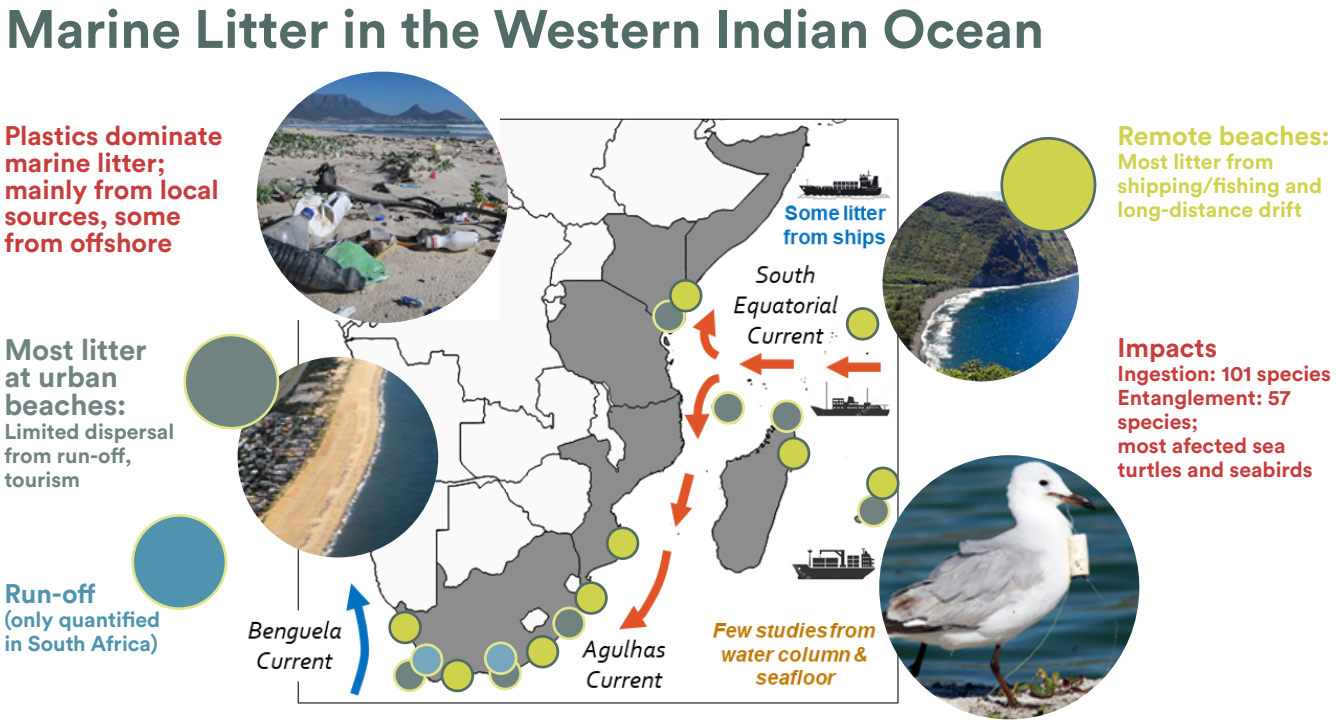

Figure 2. Synthesis of the current knowledge on marine litter, its sources and impacts in the WIO region, and the main oceanic currents that influence its transport. The points show a selection of study sites at urban (black) and remote (dark blue) beaches and sites where urban run-off has been measured (light blue). The countries' outlines on the map were generated using the freeware QGIS.

Table 2: Main recommended actions to address the marine litter and microplastics problem in the WIO region, based on the information gathered in this review and the recommendations provided by the national hot-spotting assessments implemented in Kenya, Mozambique, South Africa and Tanzania (IUCN-EA-QUANTIS, 2020a,b,c,d).

Research and monitoring	Actions for addressing land-based sources			Actions for addressing sea-based sources
	Prevention	Management	Clean-up	
• Extend regional monitoring programme within all WIO countries • Coordinate and harmonise protocols and reporting units within and beyond WIO • Include understudied habitats • Strengthen research of understudied topics • Ensure data availability	• Reduce production and consumption of single-use plastics • Add fiscal incentives to promote re-use or recycling • Promote design, production and consumption of reusable/returnable alternatives • Implement and enforce Extended Producer Responsibility (EPR) • Tax imported plastic products • Promote and carry out educational campaigns	• Ensure appropriate and more frequent waste collection • Increase capacity for proper waste disposal • Increase number of waste bins • Conduct anti-littering campaigns • Increase recycling capacity • Increase waste segregation at households and in public spaces • Ensure plastic waste has enough value to cover collection costs • Reduce open burning of waste	• Promote community-based clean-ups on land • Intercept litter in wastewater and rivers before it enters the sea • Promote and strengthen beach clean-up efforts close to source points (for example, river mouths)	• Implement and enforce stricter international regulations (for example, to ensure adhesion of ships to MARPOL Annex V) • Require that waste audits are conducted on ships upon departure and docking • Adopt a regional and coordinated approach for litter reception facilities in ports, based on a general fee

and reporting units (in coordination with global programmes, such as GESAMP, 2019). All data generated should be readily available, most notably for decision-makers.

Although several major knowledge gaps still need to be addressed (see Section 4.1), we should prioritise efforts to reduce the amounts of waste plastic entering the sea. Given that most marine litter in the WIO region comes from local, land-based sources, especially from the packaging sector (Figure 2), the most effective way to reduce plastic pollution is to prevent the generation of litter at the sources. We recommend modifying and converting the production of single-use plastics to reusable/returnable materials (which could also be reusable/returnable plastics). Promoting designs of alternative materials or processes that favour reuse will be essential (IUCN-EA-QUANTIS, 2020c). Governments should approve, implement, and enforce Extended Producer Responsibility (EPR), including take-back schemes, given that EPR is a fundamental and integral policy tool covering the entire waste life cycle and involving all sectors of society. These types of policies need to be accompanied and supported by educational campaigns directed towards citizens.

At the end-of-life step of the cycle, waste management must be improved at the municipal level, given that the national hot-spotting assessments revealed low rates of collection and proper disposal of waste, which translates to high rates of mismanaged waste (IUCN-EA-QUANTIS, 2020a,b,c,d). This is particularly relevant in Kenya, Mozambique and Tanzania, where 92 to 99 per cent of the generated waste is mismanaged (IUCN-EA-QUANTIS, 2020a,b,d). To improve waste collection and infrastructure, we recommend eliminating unregulated dumpsites and unsanitary landfills, ensuring appropriate waste collection and increasing the capacity for proper disposal. We also recommend additional waste collection, management and clean-up measures (Table 2), which could be helpful mitigation strategies until effective prevention measures are implemented.

In the case of remote beaches and small island states, most litter originates from offshore sources, coming from fishing, shipping, and long-distance drift (mostly from southeast Asia). In addition to local measures, stricter international regulations also need to be put in place and enforced (see Table 2 for examples). Major polluters such as Indonesia and other southeast Asian countries must also pledge their support for small island nations by implementing local measures to curb the release of litter into the sea, which is fundamental to keep litter out of downstream regions such as WIO.

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(1) 2022 83-89

Economic consequences of unmanaged plastics and economic opportunities in the Western Indian Ocean: steps toward action plans

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Summary

The unprecedented accumulation of plastic litter on land and its leakage into the world's seas is a global crisis that is becoming unmanageable. In addition to costing countries economically, it has human and environmental costs, negatively impacts biodiversity, and contributes Green House Gases to the atmosphere. Reports suggest that this global problem will increase dramatically unless decisive concerted actions to combat plastic waste are implemented. The urgency is greater within the countries of the Western Indian Ocean as predictions are that the growth rate of plastic littering in this region will be considerably higher than the global average. An urgent regional response involving all countries is required. It is recommended that National and Regional Action plans should be developed that take a systemic and plastics life cycle approach. In developing such strategies, consideration needs to be given to each step in the upstream, midstream, and downstream components of the plastics value chain, focusing on developing markets for recycled and repurposed plastic waste. Other recommendations include the need for 1) enabling policies and legislation, 2) drawing upon regional expertise to build capacity and promote education at all levels, 3) increasing collaboration and knowledge-sharing by promoting regional networking systems. It is recommended that a guide to developing the national and regional action plans be compiled in a regionally inclusive manner. Further, the guide should contain a decision-making framework that facilitates the adaptation of prescribed actions to differing circumstances within the region.

Background

Recognizing the burgeoning plastic litter management challenges facing the Western Indian Ocean (WIO) countries, the Nairobi Convention and Western Indian Ocean Science Association (WIOMSA) initiated a regional assessment on the status of marine litter and microplastics and their ecological, human health and economic impacts. The focus of the evaluation was on the economic consequences and opportunities of unmanaged plastics. This paper includes abbreviated parts of a more comprehensive assessment that is in preparation.

It is estimated that between eight and twelve million tonnes of plastic enter the seas of the world annually (Jambeck and others 2015; The Pew Charitable Trusts and SYSTEMIQ 2020). The contributions from the Western Indian Ocean (WIO) countries and the rest of Africa have not been quantified (Jambeck and others 2018). Nevertheless, they could be considerable because the Africa Waste Management Outlook (UNEP 2018) shows that unmanaged plastic waste has accumulated over decades in many countries. Every day, newly discarded litter adds to the load already in the environment. The waste management endeavours of coastal cities cannot keep pace with the growth of litter (UNEP 2018). The situation is worsening. If current global trends are not slowed or reversed, plastic waste generation will double by 2040 (The Pew Charitable Trusts and SYSTEMIQ 2020).

Consequently, the amount of plastic waste accumulating on land worldwide will increase on average by 38 per cent of its current load, with an estimated threefold increase of inflow to the seas from the current 11 million metric tonnes per annum (about 350 kgs per second) to 29 million metric tons per year (about 920 kgs per second), by 2040 (The Pew Charitable Trusts

http://dx.doi.org/1x.xxx/wio.11

and SYSTEMIQ 2020). This would result in a four-fold increase in plastic stocks in the ocean (The Pew Charitable Trusts and SYSTEMIQ 2020). The implication is that globally, on average, the flow of plastics into the oceans will treble. In WIO countries, however, a higher than the average growth rate is expected, given that predictions suggest plastic pollution for the middle to low-income countries will grow from 58 per cent in 2016 to 71 per cent by 2040. Reversing this trend will require well-planned, multidisciplinary steps to combat littering (The Pew Charitable Trusts and SYSTEMIQ 2020). The underlying causes are similar to those in other countries of Africa within the low to middle-income bracket. They include increasing population growth, urbanization, increasing proportion of affluent middle-class citizens and economic development (The Pew Charitable Trusts and SYSTEMIQ 2020; UNEP 2018). These contribute to rising per capita waste generation, including significant increases in plastic pollution (Jambeck and others 2018). As WIO countries cannot handle the current challenges of solid waste management (UNEP 2018), capacity building within municipalities is required to cope with the anticipated regional growth of plastics and other waste.

Waste accumulation carries high costs to every country in terms of human and environmental health (Kimani (2007), management costs, the decline in property value, loss of recreational and tourism facilities (Jambeck and others 2018, UNEP 2018) and decreasing general human well-being and quality of life. It also has negative impacts on agriculture and the fishing industries. A Business As Usual (BAU) approach, which does not keep pace with the growing plastic challenges, is unaffordable.

Advances

Call for action plans

A positive development arising from the fourth session of the United Nations Environment Assembly (UNEA-4) of March 2019 is that countries are expected to develop national and regional action plans to manage plastic waste in a coordinated manner (Resolution UNEP/EA.4/L.10, UNEA). Such action plans are essential, but the development of effective evidence-based plans depends upon nations having knowledge of and expertise in a wide range of plastic associated disciplines and the societies in which plastics are to be managed. The fields in which expertise is required range from the chemistry of plastics (including polymer chemistry) to a detailed understanding of key steps of the plastics industry. Fields of economics, socio-economics, the plastics economy (including the principles and practice of the circular economy), retailing, marketing, and consumer behaviour are fundamental to developing management plans. Experts in these core disciplines must be strategically integrated within the societies and communities to represent them in the planning and positively influence societal behaviour.

Moreover, educators must develop and deliver appropriate educational programmes at many levels. Environmental experts should formulate necessary actions to protect ecosystem processes and the biodiversity in terrestrial, freshwater, estuarine, marine, and aerial environments. Scientists are required to measure the impacts of remedial interventions accurately. Central players are those with expertise in waste management, engineering, recycling, repurposing, and upcycling. Collectively, planners need to guide legal experts who work with policymakers to develop enabling legal environments that will facilitate the implementation of recommended actions.

Any multidisciplinary planning required to develop the national and regional action plans should take a systemic approach (UNEP 2019) that includes life cycle assessments (UNEP 2021). Recommendations will need to be evidence-based, within the limitations of data scarcity in much of Africa, including the WIO (Jambeck and others 2015; Jambeck and others 2018, UNEP 2018). In the WIO, knowledge gaps need to be identified and research undertaken to fill those gaps. Given that research might be time-consuming and the urgency to implement the action plans, it may be necessary to adopt the precautionary principles and an adaptive management process to work with the best available data and adapt strategies as new data become available.

Different roles of the value chain in plastic pollution: points for action

Within the Life Cycle Assessment approach to the management of plastics (UNEP 2021), the plastics value chain represents the steps in the life cycle of plastics, starting from the extraction of fossil fuels from their sources and their transformation into raw materials. Subsequent stages are manufacturing and selling marketable plastic products, which consumers discard to become plastic litter and end the cycle. These different stages can be grouped into upstream, midstream and downstream sectors, with

different characteristics, costs and benefits. Each step needs to be considered when developing national and regional action plans. Here, we discuss the entire value chain. However, not all WIO countries have all the upstream components, especially the initial production of raw materials.

Upstream value chain components are concerned with producing raw plastic materials, primarily plastic pellets (nurdles), flakes and powders, or resins from fossil fuels (oil, coal, gas) and biofuels. They also include converting raw materials into manufactured plastic products and subsequent provision of the plastic products by the brand owners and packagers to the retailers who sell them. Those steps that are most directly involved in producing the plastic end products, which the retailers sell to consumers, are considered the true upstream aspects. Both retailers and consumers use and discard plastic packaging and plastic products, which initiate the downstream components that require waste management. Waste management activities represent the downstream components of the value chain. They are diverse, ranging from municipal waste management (in terms of collection and transport) to the management of landfills. The informal waste sectors are involved in sorting, collection, transportation, and upcycling. The waste is received by recyclers and those who transform plastic waste into other materials (repurpose plastics), which in turn are sold to consumers. We begin by examining the upstream and midstream components.

Characteristics of the three principal stages of the value chain: upstream Characteristics

Upstream components are run along business lines, in a competitive industry, by knowledgeable people who must provide products to the market and remain profitable. Employment opportunities are numerous, and the sector builds capacity. Economic inputs from the industry contribute to national GDPs. Plastic products are developed to meet the market demands by providing retailers. Hence, consumers, finished products that are easy and convenient to use, are lightweight, and relatively low cost (metal or glass containers would be heavier and more expensive). Plastics also contribute positively to the health sector, particularly in clinics and hospitals. Very little plastic is wasted during the manufacturing process because none of the factories can afford to lose plastics as profit margins are narrow. The industries run coordinated campaigns to reduce any loss (for example, Operation Clean Sweep, a global movement to help every plastic resin handler achieve zero loss to the environment; https://www.opceansweep.org/) and are conscious of the need to avoid criticism from governments and environmentalists.

Value is added at every step, from producing raw materials from fossil fuels to reaching a maximum value at the point of sale to the consumer. However, the moment the consumer uses and discards the product, there is an immediate loss of value.

From a purely economic and human convenience perspective, the benefits of plastics during the upstream

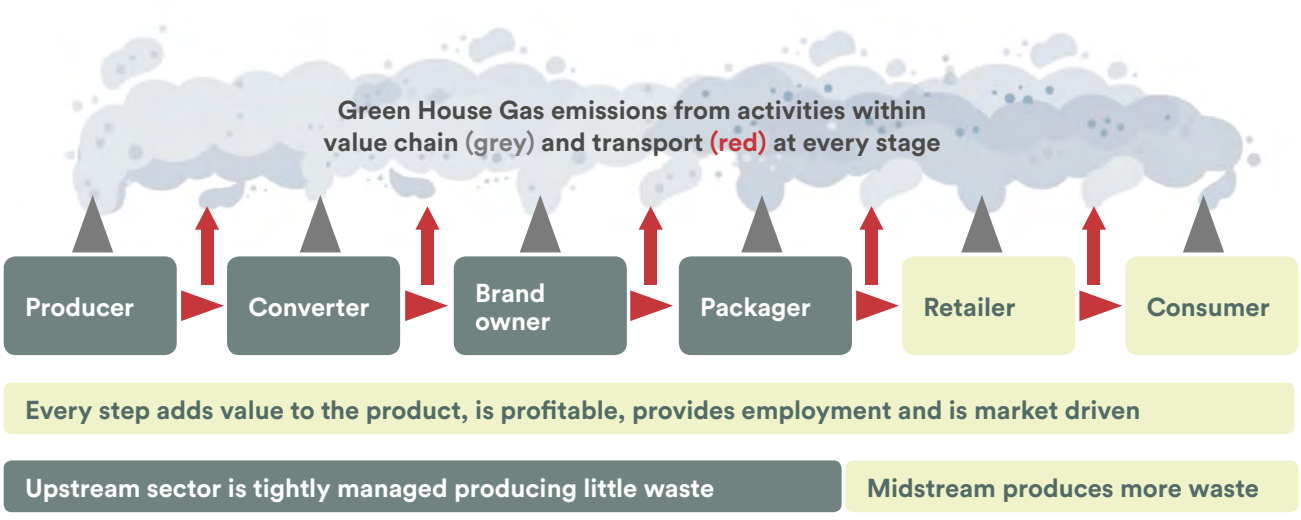

Figure 1. Every step of the value chain impacts the environment due to the operations involved and transport of materials, including contributions of Green House Gases to the atmosphere. The upstream and midstream components are driven by market objectives and are financially well managed. The upstream steps produce little plastic waste, whereas the consumers are the major contributors to the retailers' waste streams. Figure by Sustainable Seas Trust.

steps outweigh the costs. Environmentalists, however, are critical of the upstream components indicating that there are environmental costs at every step of the way, including Green House Gas (GHG) emissions (Figure 1). Some environmentalists argue that the plastics industry is entirely responsible for the downstream waste crisis and should pay for the cleaning of the environment, such as through the Extended Producer Responsibility initiatives (Dimitropoulos and others 2021). Considerable work is being undertaken to find alternatives to plastics that will offer the same benefits with no environmental costs. However, studies on plastic replacements are in their infancy, and successful results are probably decades away. In the meantime, the critical focus is on improvements to the value chains, particularly the downstream chain.

Midstream characteristics

Retailers are the crucial link between the manufacturers of plastic products, the brand owners and packagers on the one hand, and the consumers to whom they sell the final products. The role and interactions of retailers are complex, but they are involved in considerable repackaging and discarding of packaging. They sell high volumes of plastic products and plastic-wrapped materials to the consumers, most of which they discard, often after a single-use. The retailers and, particularly, consumers are primary contributors to discarded packaging and other waste materials, which are the source of downstream challenges.

Downstream characteristics

As indicated in Figure 1, at every step of the upstream and midstream of the value chain, the value increases in a market-driven sequence, from the raw material producers to the consumers. However, as soon as consumers discard the packaging or the plastic product, they drop in value or lose all value. The loss of all value occurs when there is no demand for discarded plastic waste. Consequently, the discarded, unwanted litter accumulates in all environments with many associated costs, including the burden of waste management by municipalities, which collect and transport plastic litter to landfills or dumps. As municipal waste management cannot keep pace with waste accumulation, burning is a commonly used alternative given the ease and low cost (UNEP 2018). Still, it has toxic effects on human health (UNEP 2018) and contributes considerably to GHG emissions (Beaumont and others 2019). However, developing sustainable end-markets for plastic waste can create a demand for litter to reduce waste management and human and environmental costs and accrue economic benefits. This is consistent with the philosophies that underpin the principles promoted by the circular economy publications (for example, World Economic Forum 2016). This New Plastics EEconomicreport draws attention to the potential value of punmanaged plasticsin the environment, including dumps and landfills, or are lost to the seas, for they can be worth millions of dollars if they are retained in the national economy. Building demand for discarded plastics can provide employment and clean the environment. In the WIO countries, taking steps to turn plastic waste into a valuable resource is a priority. We propose a simplified theoretical framework, although the management of plastics is complex, and circumstances may vary within and between countries. When developing Action Plans, details will need to be added to the framework outlined here.

The role of the end market

Without an end market, litter has no real value. There is no financial incentive to collect it, so the waste remains in the environment unless there are effective but costly municipal collections and transport to managed landfills. However, transforming litter into a product with a sustainable market is the first step after a market analysis to develop an enterprise that uses the volumes of available plastic waste to build and sell the products. The most apparent enterprise is to construct a recycling plant. Still, only certain plastics are recyclable and can be used in the enterprise—for example, polyethylene terephthalate, high-density polyethylene, polyvinyl chloride low-density polyethylene. As soon as the factory is operational, there is a demand for the selected recyclable plastics. This: a) gives them a value; b) leads to the collection of those plastics by the company; c) leads to the collection by the informal sectors (sometimes referred to as waste pickers or waste retrievers) who sell what they collect; and d) makes the sorting of plastics at source worthwhile. Immediate outcomes are that recyclable plastics are reduced in the environment, jobs are created in the formal enterprise and for the informal collectors, and local economy support. In addition, developing such an enterprise leads to a practical understanding of the differences between recyclable and non-recyclable plastics, the appreciation of plastics as inherently valuable material, and reduced waste management costs.

Furthermore, plastics that stay in the environment for a long time may become contaminated or weather

damaged, especially if collected from landfills or dumpsites. The enterprise will pay more for clean and fresh plastics devoid of sun damage, wind, or water exposure. This creates incentives for pre-processing at the primary source (such as sorting at home) before selling to collectors. Consequently, litter already in the environment is reduced, and the amount of new plastic litter is reduced.

As processes for recycling plastics differ from one plastic to the next, the next step is to establish which other recyclable plastics can be used to develop marketable products and then establish another enterprise. Building such recycling enterprises is a valuable step toward reducing plastic pollution but is only one relatively small step in meeting the overall challenge (The Pew Charitable Trusts and SYSTEMIQ 2020). Repurposing plastics that are not easily recycled is another valuable step in Africa. The recycling process involves mixing plastic waste with other materials, such as ground glass and crushed rubble, to produce various products. Such products include furniture, building blocks, tiles, paving stones, and fence poles. Some products are used to construct buildings, surface roads, provide paving, agricultural poles, and more. The process is to identify the market and build and expand the enterprise to satisfy and grow the market. Outcomes will be employment opportunities, growth of capacity, reduced load on the formal waste management sector, and the impact that fewer plastics pollute the environment. Additional outcomes are that humans and the environment will be healthier and local economies will grow.

Regional Outlook Promoting the municipal waste collection

As WIO countries cannot handle the current solid waste management challenges (UNEP 2018), the human, infrastructural and financial capacity must be built within municipalities to cope with the anticipated regional growth of plastics and other waste. In this regard, it would be valuable to ensure that positive working relationships between the formal and informal waste collectors are fostered to promote mutual benefits and collectively reduce national solid waste burdens.

Enabling legislation

The urgency to meet the growing waste crisis is such that it is essential that enabling policies and legislation are in place to support the development of the enterprises within municipal jurisdictions, nationally and regionally. Legislation should also govern what plastic products are permitted to enter the country. Equally, sensible guidance on which plastics should be released to the markets is required (for example, banning microbeads, plastic straws, cutlery, earbuds, and other carefully selected single-use plastics). Those in positions to guide policy and formulate legislation need to be knowledgeable and be supported by experts from different disciplines.

Developing recycling and repurposing enterprises that are profitable and large enough to reduce plastic litter significantly requires a) substantial capital investments, b) that the volumes of recyclable materials are large enough to ensure the viability of the initiative, and c) a secure, growing market. Enabling legislation can facilitate the achievement of all of these. For example, legislation, including significant tax benefits, can encourage local and foreign investment in enterprises. Legislation to promote Extended Producer Responsibility (EPR) can ensure that products are redesigned to become recyclable and the availability of funds to pay for aspects of post-consumer waste management (Dimitropoulos and others 2021). Similarly, legislation to promote the Ellen MacArthur Foundation's Plastics PACT network initiatives (Ellen MacArthur Plastic Pact 2021), which aim to stop plastic waste from packagers entering the environment, is potentially beneficial. Further, markets can be stimulated by legislation that promotes demand for recycled material and ensures that municipalities use products made from repurposed plastic waste (for example, paving, building blocks, tiles, signposts, furniture, walkways) rather than other alternative conventional products.

Regional collaboration and networking

The Nairobi Convention and WIOMSA noted that while many national initiatives deal with marine litter-related aspects within the region, there is little coordination, communication, and mutual learning among WIO countries, experts, and partners working in this field. They recognized a need for mechanisms to facilitate communication between practitioners and experts and between different programmes and funding agencies. They argued that this could help reduce duplication of work, establish partnerships, improve coordination, and provide a forum for sharing information and knowledge among experts, managers, and funding agencies, as well as joint regional planning and implementation. They pointed out that such regional efforts are of particular significance, as marine litter is transported widely by ocean currents and impacts distant localities both in the region and globally.

In response to these needs, searchable, interactive maps (to promote coordination, provide information, share knowledge, and encourage partnerships) are being developed by the African Marine Waste Network and have more than 3,000 entries. It is recommended that the African Waste Network mapping programme is further designed to best meet requirements, starting with organizations and institutions of the WIO placing their information on the maps at https://sst.org.za/maps/african-waste-network-maps/

Building of capacity, knowledge sharing, and promoting education

The Nairobi Convention and WIOMSA are concerned that the current level of knowledge about marine litter in the WIO is still insufficient to make region-wide recommendations to solve the problems related to marine litter. Although plastics have impacted people's lives since the 1950s, they have only become management, health, environmental, and economic challenges in the last few decades. Consequently, relatively few people in the WIO countries are trained in the broad spectrum of plastic-related disciplines. Most experts in the field are self-taught. Preliminary results from an ongoing survey by Sustainable Seas Trust (SST) show that only 12 out of 60 WIO universities examined thus far run courses with any plastic-related content or supervise plastic-related post-graduate studies. None of the universities covers the full spectrum of plastics-related disciplines, but rather each tends to follow the interests of the staff members who lead the courses. Despite the preliminary nature of the evaluation, it is clear that, while well-qualified experts are present within the WIO region, they are widely distributed. The need to collaborate in building regional teaching and research capacity in tertiary education institutes is apparent.

Similarly, a preliminary survey of education curricula in the countries of Africa by SST shows that the majority of the school syllabuses do not include plastic-waste issues. A coordinated, collaborative approach to education is recommended, ensuring that all countries access accurate information and valuable courses. Furthermore, capacity building in municipalities and strong promotion of understanding among public members, particularly the consumers, is required.

Nairobi Convention and WIOMSA might consider drawing together experts from within the WIO region to plot a regional strategy for education and capacity building, including the types of resources required for the different groups, how such materials should be delivered and in which languages.

National and regional action plans

The multifaceted nature of the plastics issues throughout every step in the lifecycle suggests that it is unlikely that any single institute will have the full range of expertise to develop national and regional action plans alone. Instead, a collaboration of a diversity of experts is key to ensuring that national and regional action plans are crafted to achieve desired outcomes and impacts. As the circumstances of each of the continental and island states of the Nairobi Convention are so different from the others, no single action plan can apply to every country. It is recommended, therefore, that a priority is to develop an overarching guide to what should be included within a national action plan and, in addition, have a decision-making framework that enables each country to adopt the actions to its own needs. Ideally, the overarching guide on developing national and regional action plans should be inclusively created by representatives drawn from every step in the plastics life cycle. It should have academic contributions (education, capacity building, skills development, research), government (including those directly responsible for waste management), economists and lawyers from every country. Such collaboration will ensure that the guide has a systemic approach and can be adapted to the circumstances that prevail in each country.

The purpose of the national action plans will be to provide a time-based roadmap for combating plastic waste, and in doing so, assist with the achievement of several Sustainable Development Goals. Regional action plans will promote international collaboration in achieving regional targets. They will define regional policy and open doors to transferring knowledge and harmonizing data collection methods.

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WIO Science - Policy Platform Series
(1) 2022 91-97

The Role of the Private Sector in the Management of Plastics as an Environmental Challenge

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Summary

Since their earliest days, plastics have been used to protect nature and help humans. Today, plastic is among the world's most widely-used materials. Scientifically advanced, lightweight and inexpensive, plastics suit a broad spectrum of uses. Unfortunately, this mass production and widespread use have brought the challenge of dealing with plastic products that have reached their end of life. In South Africa and around the world, far too much plastic still end up in landfills, or worse still – in the environment and, in particular, the oceans. The plastics industry is tirelessly working to raise awareness about plastics' versatility and use around the world. Moreover, it is even more important that the plastics industry and its entire value chain demonstrates its commitment to ending the contamination of the environment by plastics. As a result, manufacturers use fewer natural resources and energy, reduce CO2 emissions, create jobs, and support a variety of different industries and people. The reality is that there has been an increase in the awareness of the importance of recycling in society, the collaboration between industry, government, and NGOs, and the political will to create the infrastructure to make recycling possible and address plastic pollution. Businesses and big brand owners, retailers, and large corporates encourage recycled plastics in their packaging and products. Plastics contribute to circularity, health and safety and mitigate climate change. Businesses and big brand owners, retailers, and large companies encourage recycled plastic in their packaging and products. Plastic contributes to circularity, health and safety, and climate mitigation. In this respect, the private sector believes that plastics will play a vital role in our daily lives and our future.

Background

Plastics in the Environment

The problem caused by plastics litter in the environment has compelled governments, manufacturers and brand owners to rethink the way we produce, use and ultimately dispose of plastic. Many are now looking for innovative products that are inexpensive, non-disruptive to supply chains, and can be re-used and recycled at the end of their useful life without increasing CO_2 emissions. Lightweight plastic materials are used in many industries, helping to ensure food and water safety and reducing waste, health challenges and energy costs.

Plastic can either be synthetic or bio-based.

In South Africa, synthetic plastics are derived from coal, crude oil or natural gas, whilst bio-based plastics come from renewable products such as carbohydrates, starch, vegetable fats and oils, bacteria and other biological substances. The vast majority of plastic in use today is synthetic because of the ease of manufacturing methods involved in processing crude oil. Internationally, only a small proportion, four per cent, of the oil and gas reserves go towards the production of plastics, with the rest used for transport, electricity, heating and other applications (Plastics SA 2019).

Plastics Waste Management

On average, only 4 per cent of Africa's plastic waste is recycled (UNEP 2018). Across WIO countries, recycling rates range from nearly 45.7% in South Africa to virtually none in Comoros. Urbanisation and changing consumer behaviour are driving an increase in plastics consumption which, combined with weak municipal solid waste (MSW) collection systems, places WIO countries at risk of growing amounts of unmanaged plastics entering the Environment (UNEP 2018). Overfilled landfills are common in WIO countries and

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Figure 1. Roadside litter – Tembisa, Gauteng (credit: Douw Steyn, Plastics SA)

burden waste management services, with unmanaged plastics eventually contaminating coastal environments (Ferronato and Torretta 2019).

Current advances of plastics waste management and future directions

South African Plastics Industry

Plastics SA is a not-for-profit company that serves as an umbrella organisation for the South African plastics industry. The association is supported by membership fees derived from sales of locally manufactured plastics raw material, importers, and contributions and sponsorships from industry associations. Training activities generate the majority of the association's income. Plastics SA is a Federation of Associations. With the help of our industry associations, Plastics SA actively participates in the growth and development of the plastics industry in South Africa. The Plastics Industry Association of South Africa represents all industry sectors, including polymer manufacturers and importers, converters, fabricators, machine suppliers, and recyclers. Among Plastics SA's core

Figure 2. Learners on training at Plastics SA, Midrand, Gauteng (credit: Douw Steyn, Plastics SA)

functions are membership services, training, advocacy, research, communication, and sustainability (Plastics SA 2019).

As the largest plastics manufacturing industry in Sub-Saharan Africa, South Africa produced and imported 1 841 745 tonnes of virgin and recycled polymers in 2019. Virgin plastics in South Africa account for a very small percentage of the global market - less than half a per cent. Domestic virgin consumption is 88 per cent made up of commodity materials (polyolefins, PVC, PET and PS). Locally, recycled materials (recyclate) are converted into plastic products. Over time, many recyclates have developed unique markets that match the quality of available virgin polymers, while others complement virgin polymers well. Recyclate will replace (complement) many more virgin applications with a circular economy
(Plastics SA 2019).

Plastics Recycling in South Africa

In 2019, South Africa recycled 3 52 600 tonnes of plastics into raw materials. Of this 14 755 tons were exported to converters elsewhere, and 337 745 tonnes were converted in South Africa. The largest quantity of recyclables (approximately 70.4 per cent) came from landfills and other post-consumer sources in 2019. Post-industrial sources contributed 18 per cent. Incoming materials that have reached their end of life make up 82 per cent of the incoming recyclables. Post-industrial materials are sourced from distribution centres, shopping centres, farming communities and other waste generators. Recyclers are increasingly going directly to the waste generators to improve the quality of the incoming recyclables and reduce the costs. As a result, recyclers get cleaner materials and maintain their margins, even when fewer quantities. This is an important difference between South Africa and other developed countries. For instance, in the European Union, recyclables are retrieved as early from the waste stream as possible; in South Africa, on the other hand, recyclables are primarily obtained from landfills at a high cost (Plastics SA 2019).

Recyclable Materials

The majority of incoming materials - 57 per cent - came from the formal sector, collectors, and waste management companies - mainly baled materials and some loose materials.

Yet only three per cent of recyclables are collected directly by waste pickers and walk-ins, despite their importance to the value chain. Approximately six per cent was collected from drop-off facilities and buyback centers. Recycling companies are not geared toward buying small quantities of unsorted, unbalanced materials. Waste management companies buy recyclables from buyback centres, waste pickers and small informal collectors, compact the material before selling it to the recyclers. Only a handful of recyclers

Figure 3. An informal collector taking collected plastics to a buyer – Johannesburg (credit: Douw Steyn, Plastics SA)

have collectors and depots established over the years to complement their incoming stream of recyclables. Identifying potential sources of recyclable materials is one of the major barriers to entry for new start-ups (Plastics SA 2019).

Recycling Operations

There were 288 recycling operations recorded in South Africa at the end of 2019. Of the recyclers surveyed, 36 per cent processed post-consumer materials and granulated, wash and pelletised. Only a portion of these recyclers can successfully process landfill-sourced material. Good wash plants' high capital investment cost is feasible only for more extensive operations. Cleaner post-industrial and pre-consumer materials don't have to be washed, and the processors will only granulate and pelletise (Plastics SA 2019).

End Markets for Recyclate

Suitable end markets are critical for the sustainability of the plastics recycling industry. Markets for recyclate exist in most local market sectors. Only 4.1 per cent of the recyclate was exported as raw material to plastics converters in the SADC region and Asia. Brand owners and retailers have committed to the recycled content in packaging – 97 260 tons of recyclate were used for packaging again. Currently, only rPET is suitable for food contact. Recycled PP, PE-LD and PE-HD are used in non-food applications for personal care and domestic applications. Recycled flexible packaging was the largest market for recyclate in 2019, with 24 per cent of all recycled materials finding a local market in shopping bags, refuse bags and general, flexible packaging (Plastics SA 2019).

Industry initiatives and collaborations to deal with plastics waste

To address plastics in the environment, it is crucial to collaborate with the full plastics value chain, which includes raw material suppliers, converters, brand owners, retailers, recyclers, civil society and NGO's such as African Marine Waste Network WWF, IUCN, UNEP. Here, we focus more on the key partners of the plastics industry, such as the World Plastics Council (WPC), Global Plastics Alliance (GPA), Alliance To end Plastics Waste (AEPW) and South African initiatives. The global plastics industry supports various projects, actions, initiatives and finding best solutions to address plastics pollution:

- Plastics Waste Management Solutions
- Advocacy and Outreach
- Marine Litter Solutions
- Research
- Communication
- Education and Awareness
- Clean-up campaigns

South African initiative to end plastics waste

This initiative was started in 2019 and enjoys the support and active participation of the entire packaging value chain – including the chemicals sector, polymer and/or raw material producers, importers, packaging converters, retailers, brand owners, fast food franchises, producer responsibility organisations and

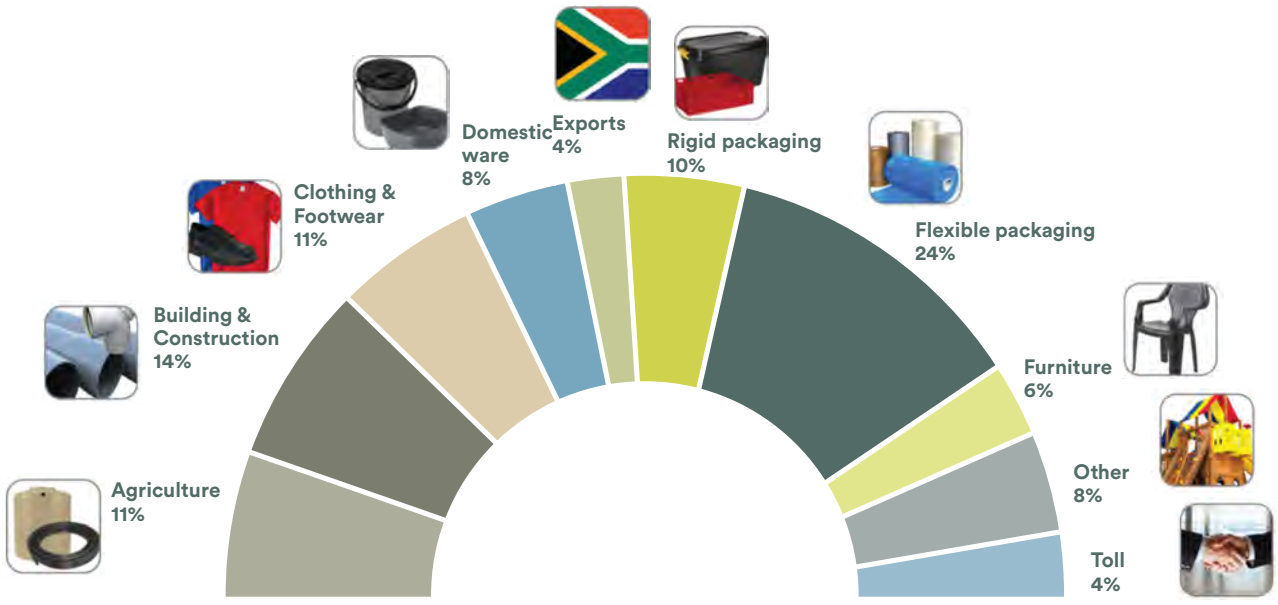

Figure 4. Domestic market applications for recycled plastics materials Plastics SA (2019)

many other stakeholders. Coordinated by the Consumer Goods Council of South Africa (CGCSA) as secretariat, six working groups were formed to look at, among other things, the role of technology, innovation and design; infrastructure; bioplastics and alternatives; and education and awareness in combatting litter, integration of the informal economy and product standards and certification. These working groups comprise industry leaders representing the entire value chain and government representatives of the forestry, fisheries and environment, trade industry and competition departments, and the UNEP.

The technology, innovation and design working group are focusing on improving the South African plastics industry's success with design for sustainability, increasing recycled content in products; securing demand for recyclate; generating energy from waste; increasing commercial and home composting facilities, developing end-markets for recycled plastic and developing refuse-derived fuels.

Improving plastics waste management, recycling infrastructure and developing reverse logistics are only some of the focus areas of the infrastructure working group. They are looking at the best ways of diverting plastic waste from landfills and the environment by considering existing infrastructure, river catchment projects and linking existing local and global networks. Their ultimate objective is to support infrastructure, create blueprint model(s) for implementation, and roll out relevant waste management projects. The bioplastics and alternatives working group developed a position paper on biodegradable and compostable packaging materials. Before introducing such packaging products, retailers and brand owners must consider various factors. One such factor is the importance of using appropriate labels and logos to ensure that they can be easily differentiated from their conventional counterparts.

The education and awareness working group's goals focus on awareness campaigns using information booklets, pamphlets, websites, mobile apps and clean-up events. They are developing a plan of action that utilises existing and new networks in the industry and government to improve awareness in schools, communities, consumers, industry and retailers, government, waste management companies, entrepreneurs and waste pickers.
The informal waste economy's integration focuses on the lack of collaboration between stakeholders – if the municipality can work with waste pickers, it will improve efficiency. Robust self-regulation and demand from retailers, manufacturers and consumers for decent quality products will go a long way in addressing product standards and certification. Participation of all key stakeholders (at all levels) is required to develop and manage plastics standards (Plastics SA, 2019).

South African Plastics Pact – The South African Plastics Pact is a collaborative initiative that brings together key stakeholders from the local plastics value chain, including businesses, the South African government, NGOs and other organisations, to tackle plastics waste and pollution at its source. The development of the SA Plastics Pact has been led by the World Wide Fund for Nature (WWF) and the South African Plastics Recyclers Organisation (SAPRO). It is supported by WRAP – the UK based global environmental NGO. Green Cape manages it with the support of WWF and WRAP. The Pact works towards the Ellen MacArthur Foundation's New Plastics Economy vision and an ambitious set of joint 2025 targets to create a circular economy for plastics in South Africa. The Pact encourages revised thought on the design, use, and re-use of plastics to achieve the targets. The SA Plastics Pact will build on the positive work started by other initiatives and help scale up and disseminate good practice. By 2025, The SA Plastics Pact will transform the country's plastic packaging sector by meeting four ambitious targets:

- Taking action on problematic or unnecessary plastic packaging through redesign, innovation or alternative (re-use) delivery models,
- 100 per cent of plastic packaging to be reusable, recyclable or compostable,
- 70 per cent of plastic packaging is effectively recycled, and
- Thirty per cent average recycled content across all plastic packaging.

By meeting these targets, the SA Plastics Pact will also stimulate job creation in the South African plastics collection and recycling sector and help create new product design opportunities and re-use business models (SA Plastics Pact 2021)

Producer Responsibility Organisations (PRO's) – A non-profit company established by producers operating in an industrial sector to support the implementation of their extended producer responsibility scheme. The PRO's plastics industry operations include PETCO, Polyco, PSA and SAVA.

PET Recycling Company (PETCO) – PETCO fulfils the PET industry's Extended Producer Responsibility (EPR) role, a voluntary industry-driven and financed environmental solution for post-consumer PET plastic. By imposing accountability over the entire life cycle of PET products and packaging, companies that manufacture, import and/or sell PET products are financially and physically responsible for such products after their useful life. PETCO raises the EPR fee directly from its members. This amount is applied to the raw material and pre-form purchases, both locally produced and imported. Those companies who purchase PET resin (both virgin and recycled) or pre-forms/sheeting pay the EPR fee to PETCO on a rand/tonne basis. A Board of Directors comprising the entire value chain of the obliged industry governs PETCO (Plastics SA 2019).

Polyolefin Recycling Company – Polyco aims to grow the collection and recycling of polyolefin plastic packaging in South Africa and promote the responsible use and re-use of polyolefins. Their mission is to reduce plastic going to landfills and end plastic waste in the environment. Polyco collaborates with various stakeholders, invests in innovation and recycling infrastructure in South Africa, and educates the industry and the consumer about recycling. Polyco was established in 2011 as a non-profit organisation by South Africa's polyolefin plastic packaging converters. Polyco members pay a voluntary levy for every ton of virgin polyolefin polymer purchased from either local or overseas raw material suppliers to ensure that Polyco will perform its extended producer responsibilities (Plastics SA 2019).

Polystyrene Association of SA – The Polystyrene Association of South Africa (POLY SA) represents their manufacturing and convertor industry members who primarily supply the food and protective packaging industries. The health and safety of products produced in South Africa is a core focus of POLY SA.

The recycling of polystyrene is a high priority. By developing end markets for the recycled material and acting as the facilitator between the recyclers/buyers and suppliers of recycled polystyrene, this Producer Responsibility Organisation (PRO) has proven the sustainable recycling of polystyrene. This recyclate is for use in the building and construction industries (lightweight concrete bricks and screeds), decor market (picture frames, cornices, curtain rods etc), arts and crafts (beads) and various charity projects (eg Bread tags for Wheelchairs, Tutu Desk and Wonderbag projects) (Plastics SA 2019).

SAVA – South African Vinyl's Association - SAVA is the representative body for the PVC industry and fulfils an active role in the sector's sustainability. With the support of its members, SAVA addresses PVC related issues. It constructively engages with stakeholders and role-players to create a positive environment for a vibrant and sustainable vinyl industry.

SAVA is dedicated to enhancing the growth and protecting the stature of the Southern African vinyl industry by expanding key markets, protecting the industry's reputation, identifying barriers to growth, and stimulating innovation. SAVA researches strategic interest and provides the industry with leadership and direction to ensure health, environmental issues and product stewardship. Through its Product Stewardship Commitment, SAVA focuses on sustainable manufacturing processes, the sustainable use of additives, closed-loop management and sustainability awareness across the entire value chain (Plastics SA 2019).

Global and Regional recommendations to address plastics in the environment

Plastic waste and plastics in the environment are unacceptable in any habitat, and this is the plastics industry's top priority at all times. Strong partnerships between an interconnected plastics value chain and all stakeholders, be they local, national or global, are needed to solve this problem and develop innovative, sustainable solutions.

Recycling is one of the most important actions currently available to reduce the impact and represents one of the most dynamic areas in the plastics industry today. Recycling provides an opportunity to minimise petrochemical usage, carbon dioxide emissions, and the amount of waste.

The industry needs to take action towards a circular economy for plastics, eliminate plastic litter in the environment, grow recycling rates and find solutions for plastics products that are not currently recyclable in the mechanical recycling value chain (Plastics SA 2019).

The vision plastics industry for a global framework includes:

- Governments commit to eliminating leakage by adopting the G20's 2050 Osaka Blue Ocean Vision.

- Establish national action plans to allow countries the flexibility to develop regionally appropriate plans to eliminate plastic waste leakage based on local circumstances and supported by enabling policies.
- Co-develop, with industry input, globally harmonised definitions and reporting metrics on plastics and plastic waste, using validated and harmonised methodologies.
- Develop global guidance, with industry input, on product design, recycled content, and resources efficiency optimisation.
- Waste management capacity building to ensure access and improved capacity for managing waste.
- Deploy technology through supporting chemical recycling technology, complementing mechanical recycling, to increase the circularity of plastics.
- Achieve climate goals by supporting life cycle analysis to evaluate impacts of plastics and alternatives

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Informing strategies to reduce marine plastic pollution in the Western Indian Ocean Region

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Summary

The plastics crisis is widely recognized, and many regional and national measures have been taken to address it. Moreover, there has been progress in developing methodological approaches that aim to fill a knowledge gap and support countries in better assessing plastic leakage and flow at the national level. Applications of these methodologies have been carried out in the Western Indian Ocean region (WIO), with promising results for guiding the consideration of relevant actions. The paper discusses some of the key challenges facing countries in the WIO region, including continental and island countries. It offers a series of recommendations for consideration at the regional and national levels for reducing plastic pollution in the marine environment. Compared to the level of investment required to upscale infrastructure for effective plastic waste management or advanced technologies for waste management and disposal, the proposed recommendations represent low-hanging fruit that is easier to implement.

Background

In recent years, the pace and scale of plastics production and use, and thus the amount of plastic entering the ocean from land-based sources, has multiplied considerably (Borrelle and others, 2020; Plastics Europe 2019; Jambeck and others, 2018). Despite its usefulness in many applications, countries across the globe struggle with its safe management and disposal at the end of its life (Jambeck and others, 2018). There has been increasing awareness of the challenges posed by plastics in the environment, particularly in the marine environment, where their presence poses dynamic problems for fisheries and wildlife. Plastics are linked to altered fisheries productivity, false satisfaction of shellfish and other wildlife, the entanglement of biota, transportation of toxic persistent organic pollutants, and human health risks from consumption of contaminated seafood. More than 99 per cent of plastics constitute hydrocarbons sourced from fossil fuels; hence their increased production results in more Greenhouse Gas Emissions (GHGs) emissions (Azoulay and others, 2019). As a result, plastic pollution in the marine environment negatively impacts coastal livelihoods and economies in the long run.

In the African continent, plastic pollution has primarily been linked to the mismanagement of solid waste (Alimi and others, 2021; Babayemi and others, 2019; Godfrey and others, 2018; Jambeck, 2017). Many factors contribute to this problem, such as under-investment in waste management infrastructure, increased use of plastics with increasing societal affluence, a lack of policies to address the plastic component of solid waste effectively, and overall low incentives for plastics recovery treatment and recycling. In many countries, municipalities or their local government equivalents are responsible for collecting and disposing of solid waste. Rather than population density, income levels are the most influential factor in accessing waste service infrastructure on the continent (Godfrey and others, 2018). High waste service provision is generally seen in high-income, affluent neighbourhoods compared to high-density, low-income areas. Solid waste management across the continent has primarily been handled through disposal in unsanitary landfills and illegal and unregulated dumpsites. The recovery of plastic waste material for recycling has been low but is slowly picking up in many countries.

http://dx.doi.org/1x.xxx/wio.13

Figure 1. Accumulated plastic litter in an open space in a low-income urban community in Cape Town, South Africa. (Photo credit: Drakenstein Municipality)

In recent years, many African countries have adopted policy and regulatory measures to address plastic pollution in the environment, whether directed at solid waste management or outright bans on products and applications. In addition, the private sector and civil society organisations are also engaged. The private sector has mobilised to address plastic waste management, mainly by developing circular economy action plans for their operations (Borrelle and others, 2020), while civil society and non-governmental organisations continue to play an important role in empowering communities to engage in sound waste

Figure 2. Local women earn a livelihood from sorting and trading plastic waste in Durban, South Africa. (Photo credit: WildOceans/IUCN)

management practices (Godfrey and others, 2018). A few countries are deploying additional mechanisms such as Extended Producer Responsibility (EPR), which shifts the burden to address the end-of-life of different products to their respective producers and brand owners. These policy and regulatory measures have resulted in increased consideration, engagement, and action planning by different sectors and actors on redesign, management and disposal of plastics. There is incineration and waste-to-energy as plastic waste treatment options. However, these have not been applied widely across the continent due to their associated high costs, mechanical and institutional challenges, and risks to human health from hazardous byproducts (Borrelle and others, 2020).

Advances in understanding the dynamics of marine plastic pollution

Parties to the Nairobi Convention, also known as the Convention for the Development, Protection, Management and Development of the Marine and Coastal Environment of the Western Indian Ocean, have taken measures to combat marine plastic pollution in the Western Indian Ocean. In their ninth Conference of Parties (COP) – the decision-making forum in which policies and strategies are agreed upon – the Parties approved Decision CP.9/3, targeted at managing marine litter and municipal wastewaters in the Western Indian Ocean. This critical decision prioritised developing a regional strategy for managing marine litter and microplastics and forming a regional technical working group on the topic. Among the other priorities was the need to implement action programs for outreach and public awareness for municipal waste and marine litter, the phase-out of microbeads in the region and the exchange of expertise and best practices.

In addition, United Nations Member States, major groups and stakeholders have recognised the challenges countries face in addressing marine plastic pollution and microplastics and have passed resolutions at past meetings of the United Nations Environmental Assembly (UNEA). The group urged governments to implement measures and action plans to reduce marine litter, improve knowledge about marine plastics and microplastics, and examine the effectiveness of appropriate governance strategies and approaches.

Accordingly, the International Union for Conservation of Nature (IUCN), in partnership with the United Nations Environment Programme (UNEP), has piloted the development and application of methodological guidance that provides countries with tools and methods to account for plastic flows and leakage at a country level, and determine appropriate interventions. The methodological guidance '*UNEP/IUCN National Guidance for Plastic Pollution Hotspotting and Shaping Action*' has been applied in a select group of countries within the WIO region, including Kenya, Tanzania, Mozambique and South Africa. These four countries have a combined coastline stretching more than 8 000 kilometres, representing nearly half of the total coastline length of all Nairobi Convention countries.

The guidance outlines a scientific approach to mapping plastic leakage and its impacts by collecting and analysing relevant plastic production, consumption, waste management, and disposal data. It enables the tracking of plastic consumption in various sectors such as healthcare, agriculture and food, logistics and transport, and households to develop corresponding solutions to reduce the adverse impacts of plastics. The modelling of these inputs results in the generation of actional hotspots that governments, in collaboration with key stakeholders, can use to identify and implement corresponding interventions and instruments to address plastic pollution. The metrics generated avail decision-makers the opportunity to set targets, agree and implement actions, and monitor progress towards success.

Such a harmonised quantification of plastic leakage and impact could benefit all countries of the Convention as it allows establishing a baseline for benchmarking and tracking the progress of interventions. From the select countries where the assessment has been implemented, there is evidence of the need for comprehensive, consistent, and credible metrics on marine plastic pollution in the WIO region. A methodology that harmonises existing data, tools and resources could support countries to achieve this objective. The assessment considers a holistic approach, covering major plastic polymers and products and their leakage and impacts along the plastics life cycle. The overall output of the plastic pollution hotspotting exercise is action-oriented and supports users with a set of options for planning and implementation.

The results from the assessment have supported and informed the development and review of relevant national action plans and strategies aimed at addressing marine plastic pollution. The results are a timely provision of metrics to influence the thinking and refinement of the implementation of objectives of

Decision CP.9/3 (2018), and the more recent Decision CP.10/10 on Water Quality and Marine litter adopted at the 10th Conference of Parties to the Convention in the year 2021.

The national assessments provide a partial basis to support a regional understanding of key plastic flows and leakage into the Western Indian Ocean as it covers the continental countries of the Convention, except for Somalia. The result provides reliable and credible baseline metrics that benefit from a quantitative and qualitative technical assessment to quantify the potential fate of plastics in the marine environment and presents a preliminary overview of strategic priority interventions and policy options for consideration by countries. The assessment outlines robust metrics of regional significance, with enough granularity for action that enables governments and regional bodies in the WIO to promote, enact and enforce legislation and other practical measures to contain and reduce marine plastic pollution.

The Indian Ocean Island nations have attempted to quantify plastic leakage to the ocean, estimated based on World Bank data on mismanaged plastic solid waste and Country Working Papers. The estimated leakage from Comoros, Madagascar, Mauritius, Seychelles has thus been provided (Kelleher 2021). Still, it will not be discussed in detail in this paper as they are not based on a comprehensive application of the '*Guidance for plastic pollution hotspotting and shaping action*'.

Measuring and forecasting plastic leakage and impacts is complex due to the multifaceted nature of leakage pathways and the general lack of data to inform leakage models. Addressing the pollution problem is even more challenging. Therefore, it requires that stakeholders from all levels and facets of society join forces to understand and benchmark the issue towards action.

Outlook for the Western Indian Ocean region

In terms of plastic leakage, the application of the hotspotting assessment across the four continental countries shows that approximately 190 000 tonnes of plastics leak into the ocean, representing 8 per cent of a total estimated 2.3 million tonnes of mismanaged plastic waste using 2018 baseline figures. Suppose estimates of the island nations in Kelleher (2021) are added to the above estimates based on country working papers. In that case, the total regional leakage to the Western Indian Ocean is about 195,528 tonnes each year, from a total of 2.41 million tonnes of mismanaged plastic waste. It is evident from this that the estimated leakage figure from the island nations does not alter the basis for discussion on plastic leakage in the region, as it represents about 3 per cent of the regional leakage component. It may be worth noting that the total regional leakage and mismanaged plastic waste could be higher if modelled on 2021 figures, during which plastic use in packaging and personal protective equipment has risen significantly due to the COVID-19 pandemic.

There are variations in per capita waste leakage across the continental countries, ranging from a low of 0.5 kg/capita/year in Tanzania to 1.4 kg/capita/year in South Africa according to IUCN-EA-QUANTIS (2020 a,b,c,d). These variations differ even more within countries when a comparison is made between rural and urban per capita leakage, with a general high figure in urban areas. The per capita waste leakage across the island nations ranges from a low of 0.12 kg/capita/year in Mauritius to a high of 2.13 kg/capita/year in Comoros. These estimates show that only Comoros and South Africa have a higher per capita waste leakage than the regional average of 1.3 kg/capita/year estimated in Jambeck and others (2015).

To better understand how the WIO countries within the assessment perform relative to one another, the per capita plastic leakage results are illustrated relative to their Human Development Index (HDI)[1] in Figure 3 below. The blue line represents the HDI score, while the orange represents their plastic leakage per capita.

The observed general trend among the continental countries Kenya, Mozambique, Tanzania, and South Africa is that plastic leakage per capita increases with HDI. South Africa, which is categorised as a 'High Human Development' country under the Human development groups of the HDI, also has a high plastic leakage per capita (1.9 kg/person/year) compared to its continental peers. Kenya, which is categorised as a 'Medium Human Development', follows in second position (0.8 kg/person/year), while Tanzania and Mozambique, categorised as 'Low Human Development', show much lower per capita leakage rates of 0.5 and 0.6 kg/person/year respectively. Different modelling methodologies also result in different outputs,

[1] Human Development Index (HDI) is a composite index that measures average achievement in three basic dimensions of human development—a long and healthy life, knowledge and a decent standard of living. See http://hdr.undp.org/sites/default/files/hdr2020_technical_notes.pdf for details on how the HDI is calculated.

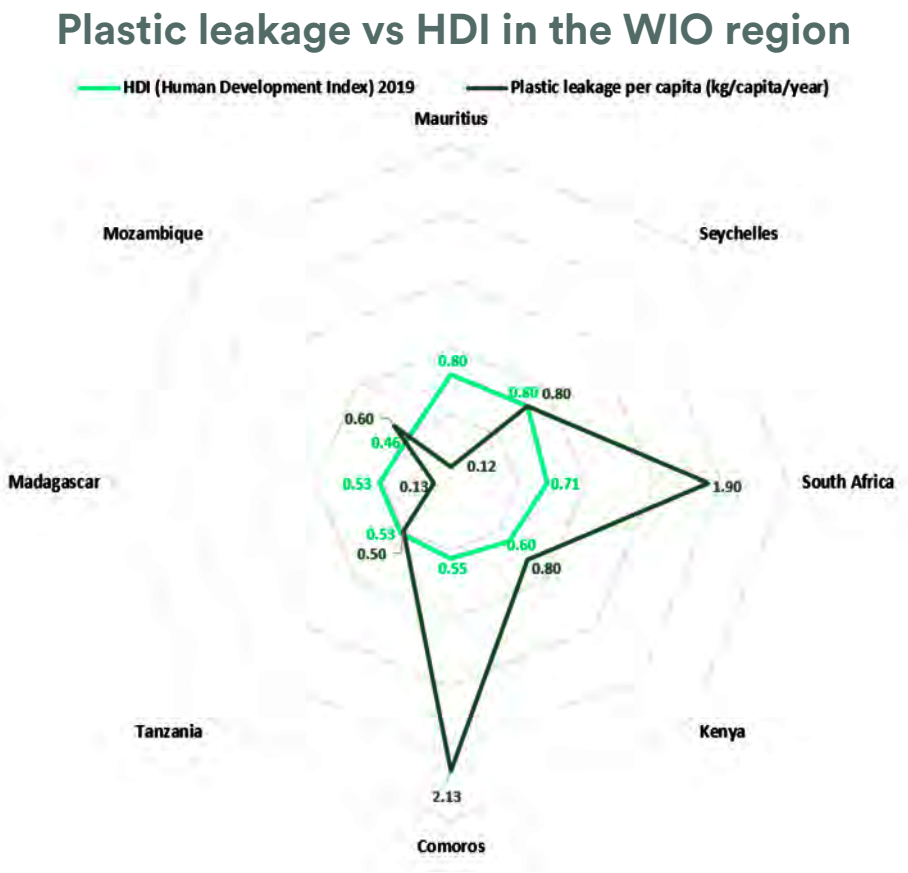

Figure 3. Relationship between plastic leakage with Human Development Index among eight countries in the WIO region (Data from IUCN-EA-QUANTIS, 2020 a,b,c,d; Kelleher 2021; UNDP 2020).

even for the same country. For example, while the leakage rate is estimated at 107 thousand tonnes per year, it is lower than that of 157 thousand tonnes estimated by Jambeck and others (2015), while for Kenya, the figure of 37 thousand tonnes is six times greater than Jambeck's estimate.

Mauritius, categorised as a 'Very High Human Development' country, has the lowest plastic per capita leakage rate (1.2 kg/person/year) among the island nations. This could be directly attributable to its high gross national income (GNI) per capita (UNDP 2020) and low poverty rate (0.2 per cent) according to a 2017 survey of poverty rate at the US$1.90-a-Day Poverty Line World Bank (2020). Seychelles, categorised as 'High Human Development', seem an outlier. It shows a higher leakage rate of 0.8 kg/person/year compared to Mauritius, despite having comparable HDI (0.8) and poverty rate (1.2 per cent, based on a 2013 survey). As the data from the island nations did emanate from applying the '*Guidance for plastic pollution hotspotting and shaping action*', it is difficult to deduce the underlying factors that could explain this disparity. Comoros, categorised as a 'Medium Human Development' country, has the highest plastic leakage rate of all the countries (2.13 kg/person/year), despite having an HDI comparable to Tanzania and Madagascar (0.55) and poverty rates of 19.1 per cent. This seems to be an outlier as there are stack disparities in yearly plastic leakage estimates between different sources, as Kelleher (2021) captured.

The WIO region has observed high quantities of plastic waste generation and leakage due to several factors, including the low levels of plastic waste collection and recovery, which range from 27 to 60 per cent and the low recycling rates, which range from 1 to 14 per cent in the four continental countries (IUCN-EA-QUANTIS, 2020 a,b,c,d). With such low collection and recycling rates, the bulk of plastics used in these countries is bound to be mismanaged and leak into the environment.

Other factors that contribute to the high levels of mismanaged waste include the dilapidation of waste management infrastructure, including the widespread use of unsanitary landfills. A landfill is considered unsanitary when waste management quality standards are not met, thus entailing a potential for leakage. Such

landfills have no regular, daily waste compaction, and neither are their bottoms designed in a way to avoid spills. There is overall low investment towards maintenance and upgrade of infrastructure, low value of most plastics after their first use, institutional and human resource deficiencies, high rates of urbanisation surpassing the capacity of existing systems. A common problem across all countries is the overuse of plastics—especially on-the-go type of plastics used in food and beverage packaging, lack of adequate waste separation at source or separate collection, leading to high contamination of most recyclables and hence their low value for recycling. Lastly, policy reform and related uncertainties, and a plastics economy stuck on the linear model of make-use-dispose hinders progress towards a circular economy.

On the positive, many countries in the region are enacting policy and regulatory measures that promote a shift towards a circular economy. Since the COVID-19 pandemic began in early 2020, the recycling sector has been quite fragile, affected by the decline in fossil fuel prices, which created a context where virgin plastics are cheaper than recycled plastic. If these factors persist, the projected increase in coastal populations across the continent could result in higher rates of plastic pollution to the ocean in the long term.

Conclusion

Based on the analysis above, it is evident that marine plastic pollution threatens the viability of coastal livelihoods and marine biodiversity and wildlife in the Western Indian Ocean. Further, it emphasises the urgent need for improving waste collection and management – the first step towards more circularity – to reduce and contain plastic inputs in the ocean. The following paragraphs provide insight and entry points for policy engagement and management intervention for countries in the WIO region and Africa to reduce overall plastic waste mismanagement and plastic leakage into the ocean.

In the WIO, a key concern is that recycling capacity remains low and is therefore not adequate to handle the increasing volume of plastic waste generated. As a result of the COVID-19 pandemic, the challenges society faces in managing waste have been brought to light. There is a growing amount of plastic waste generated in many cities due to the high production and use of single-use plastics and personal protective equipment. The pandemic has disrupted regional waste trade and logistics, especially countries with lower capacity for handling waste that must export parts of their high-value waste to countries with capacities. Thus, there is a strong case for improving local capacities and waste infrastructure to handle domestic waste in-country.

Waste collection services and management are implemented more in urban areas and cities than rural and low-income areas. As can be deduced from IUCN-EA-QUANTIS (2020 a,b,c,d), a few major cities, districts or provinces are responsible for the bulk of plastic leakage into the marine environment. In Tanzania, for example, Dar es Salaam accounts for 71 per cent of the country's leakage contribution to the Indian Ocean. Acknowledging the intricate relationship between the Human Development Index and plastic waste generation (Figure 3), the density of leakage per kilometre squared tends to be higher in urban areas and cities than in rural areas.

IUCN's partnership and collaboration with seven local, small-scale initiatives to promote circular principles towards diverting and preventing plastic waste flow into marine environments saw approximately more than 150 000 kg of plastics prevented from ending up in landfills, dumpsites and the marine environment during the period 2019 to 2021. As no single actor can independently drive full life-cycle and circular improvements, the efforts of local-level initiatives need to be acknowledged both for waste management and in enhancing livelihood options and opportunities for waste pickers, reclaimers and communities. The key lesson derived from these initiatives is the potential to build capital from waste through rethinking and redesigning sector components, minimising loss of resources, and extending the product's life. Unfortunately, despite the positive intentions in promoting a circular economy across the region, it remains weak on the social-equity dimension despite the increasing number of community and citizen-driven initiatives in the region.

Some recommendations for regional consideration

Urge governments to undertake measures to strengthen plastic recycling capacity, lessen the burden of entry and scaling for informal and formal actors, and adhere to established norms, standards, and licensing requirements as applicable.

- Encourage governments to implement measures that discourage producing and importing plastic objects that do not benefit from a recycling solution within national jurisdiction.

- Facilitate strengthening tools, capacities, and knowledge for municipalities and local government to address plastic pollution in major cities, towns, and peri-urban areas.
- Urge municipalities and local governments to scale measures to address widespread littering and open burning of plastics through increased waste collection efforts.
- In the WIO region, encourage governments and the private sector to develop and support policies to increase the value of after-use plastics, as well as redesign products and materials for End-of-Life value and circularity.
- Increase funding to local initiatives to address the socio-equity gap in the circular economy, scale-up plastic waste collection and recovery, and improve the integration of the informal sector in the waste economy.

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A Strategic Framework for Coastal and Marine Water Quality Management in the Western Indian Ocean

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Summary

Governments in the Western Indian Ocean (WIO) region, through a consultative process, have agreed on the need for a suite of national and regional actions to address major stresses on the marine environment. This is demonstrated in several initiatives, including:

- The Protocol for the Protection of the Marine and Coastal Environment of the Western Indian Ocean from Land-Based Sources and Activities (LBSA Protocol) to the Nairobi Convention
- Implementation of the Strategic Action Programme for the protection of the Western Indian Ocean from land-based sources and activities (WIOSAP)
- The Western Indian Ocean Large Marine Ecosystems Strategic Action Programme Policy Harmonisation and Institutional Reforms (WIO LME SAPPHIRE)
- Enforcing Environmental Treaties in African, Caribbean and Pacific (ACP) Countries (ACP-MEA Phase III) - funded by the European Union.

For coastal and marine water quality management (C&MWQM), improved capacity and the implementation of strategic frameworks can improve ecosystem integrity with consequent socio-economic and environmental benefits, locally, regionally and globally. Countries in the WIO region vary in their current planning and implementation in C&MWQM, and the development of a regional strategic framework will provide a basis for adoption and integration into national frameworks. This paper presents a strategic framework for C&MWQM to be considered for implementation in the region. Ultimately, achieving the strategic objective for coastal and marine water quality in the WIO region, which states '*Water quality in the WIO region meets international standards by the year 2035,*' depends on the success of the framework and on adopting the proposed implementation thereof into national policy and best practice. It also requires political commitment to assist in securing dedicated financial resources and the skilled personnel required to execute C&MWQM programmes.

Background

Protection of valuable natural resources is at the core of coastal and marine water quality management (C&MWQM), not only for conservation of biodiversity but also to safeguard and enhance socio-economic ecosystem benefits to society. Ironically, root causes in the social system are significant contributors to the deterioration of coastal and marine resources in the Western Indian Ocean (WIO). These include population growth, poverty, inequality, inadequate knowledge and awareness, inappropriate governance and lack of financial resources (UNEP and others, 2009). While these root causes typically manifest in indirect societal dynamics that contribute to the deterioration of marine ecosystems, sectors that pollute marine areas include urban development and tourism, agriculture and forestry, fisheries and aquaculture, industry, mining, marine transportation and energy production. Different types of pollution arising from these sectors have an array of environmental impacts and socio-economic consequences, including microbiological contamination, nutrient enrichment

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(eutrophication), marine litter, suspended sediment loading, and toxic pollution (UNEP and others, 2009). Not surprisingly, hotspots of marine pollution primarily coincide with the larger coastal cities and towns, where key sources of pollution are concentrated.

Reflecting on marine water quality policy and management status in the WIO region, most countries are signatories to major international conventions and agreements on combating marine pollution. At the national level, most countries have some form of legislation in place to enable the control and management of marine water quality, some more advanced than others. However, dedicated management initiatives focusing on marine water quality management are limited. Where policies and plans have been put in place, implementation remains a major challenge (eg UNEP and others, 2009; UNEP and others, 2015).

The Nairobi Convention is an important regional platform for addressing challenges facing coastal and marine ecosystems in the WIO region through catalytic interventions, dialogue and partnerships. The governments of the Contracting Parties to the Nairobi Convention have agreed, through a highly consultative process, on a suite of national and regional collective actions that are required to address major stresses on the coastal and marine environment of the region, including:

- Implementation of the Strategic Action Programme for the Protection of the Western Indian Ocean from Land-based Sources and Activities (WIOSAP) - funded by the Global Environment Facility (GEF);
- The Western Indian Ocean Large Marine Ecosystems Strategic Action Programme Policy Harmonisation and Institutional Reforms (WIO LME SAPPHIRE) - funded by the Global Environment Facility (GEF) and implemented by the United Nations Development Programme (UNDP); and
- Enforcing Environmental Treaties in African, Caribbean and Pacific Countries (ACP-MEA Phase III) - funded by The European Union.

These initiatives, amongst others, are important for the implementation of The Protocol for the Protection of the Marine and Coastal Environment of the Western Indian Ocean from Land-Based Sources and Activities (LBSA Protocol) to the Nairobi Convention.

In terms of C&MWQM, it is expected that through improved capacity and the implementation of appropriate strategic frameworks, ecosystem integrity can be improved, leading to local socio-economic and environmental benefits, in addition to global environmental benefits. Developing a regional strategic framework for C&MWQM would, therefore, provide a basis for adopting and integrating this into national coastal and marine water quality frameworks, acknowledging that countries are at different stages of development. Within this context, the Contracting Parties urged the Secretariat of the Nairobi Convention to establish such a regional framework to fast-track implementation, building on previous initiatives linked to C&MWQM in the region (eg UNEP and others, 2009; UNEP and Nairobi Convention 2009; UNEP 2010; ACSLME and others, 2014; UNEP and others, 2015). The request from the Contracting Parties is backed by various CoP Decisions, for example Decision CP.9/2.2 that encourages the Contracting Parties to harmonise legislation and strenghten institutional capacity, Decision CP.9/3 on the management of marine litter and municipal wastewater in the Western Indian Ocean, and Decision CP.9/8.4 on the reactivation of the subregional centre on combating marine pollution from oil spills and hydrocarbons, based in Madagascar, as was recommended by the Ministerial Conference on Maritime Security in the Western Indian Ocean, held in Balaclava, Mauritius in April 2018.

Advances: Proposed Strategic Framework for C&MWQM

In essence, the need for C&MWQM stems from a tension between the need to protect biodiversity, and associated socio-economic benefits, and the need for economic development in sectors which may contribute to sources of marine pollution. A Strategic Framework, as conceptualised in Figure 1, will provide direction in achieving effective C&MWQM.

C&MWQM starts with the establishment of strategic objectives and targets. The Strategic Action Programme for the Protection of the Coastal and Marine Environment of the Western Indian Ocean from Land-based Sources and Activities (UNEP and Nairobi Convention 2009) set the following Strategic Objective for water quality in the region, supported by an array of specific targets: *'Water quality in the WIO region meets international standards by the year 2035.'*

Basic principles provide broad direction within which to position implementation of C&MWQM. Five basic principles recommended for the WIO region are:

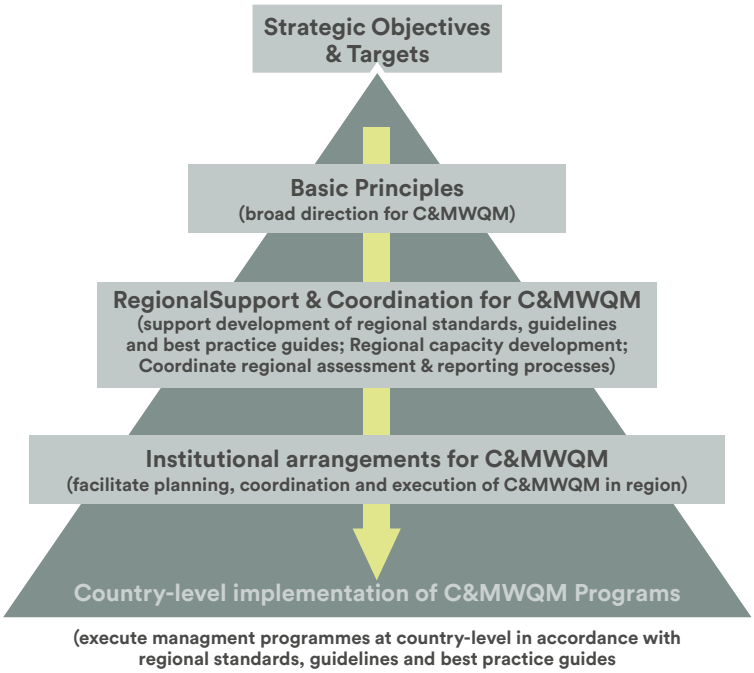

Figure 1. Conceptualisation of the strategic framework for C&MWQM in the WIO region

- Principle 1: Pollution prevention, waste minimisation and precautionary approach
- Principle 2: Receiving water quality objectives approach
- Principle 3: Integrated, adaptive assessment approach
- Principle 4: Polluter pays principle
- Principle 5: Participatory approach.

Harmonisation of C&MWQM in the WIO region requires regional support and coordination (eg through the Nairobi Convention Secretariat and partners), for example coordinating the development of regional standards, guidelines and best practice guides for developing regional capacity and regional reporting processes. Aligned with the Objectives and Targets of the Strategic Action Programmes (UNEP and Nairobi Convention 2009; ASCLME and others, 2014), many regional standards, guidelines and best practice guides relevant to C&MWQM have already been developed. These include:

- The Protocol for the Protection of the Marine and Coastal Environment of the Western Indian Ocean from Land-Based Sources and Activities (LBSA Protocol) to the Nairobi Convention;
- WIO Action Plan on Marine Litter (UN Environment 2018);
- African Marine Litter Monitoring Manual (African Marine Waste Network, Sustainable Seas Trust - Barnardo and Ribbink 2020);
- WIO Marine Highway development and Coastal and Marine Contamination Prevention Project (2020); and
- Regional oil spill preparedness in eastern Africa and WIO (UNEP and others, 2020a, 2020b).

In the case of Regional State of the Coast Reporting - derived from the requirements of the Nairobi Convention - the Western Indian Ocean Marine Sciences Association (WIOMSA) has in the past guided the technical process at the regional level together with experienced scientists, in consultation with the Contracting Parties and their National Focal Points in terms of the political agendas (UNEP and others, 2015). Ideally, in the case of future regional status reports, regional coordinators will be able to draw on national-level status reports produced as part of their C&MWQM implementation programmes.

Also key in a strategic framework, is the establishment of appropriate institutional arrangements to facilitate ongoing implementation, and alignment and coordination of effective C&MWQM in the WIO region (UNEP and GPA 2006; Taljaard and others, 2013; DEA RSA 2014) (Figure 2).

A Regional Task Force (RTF) for Water, Sediment and Biota Quality has already been established under the WIOSAP project. This provides an ideal platform for regional coordination in the future. To ensure it

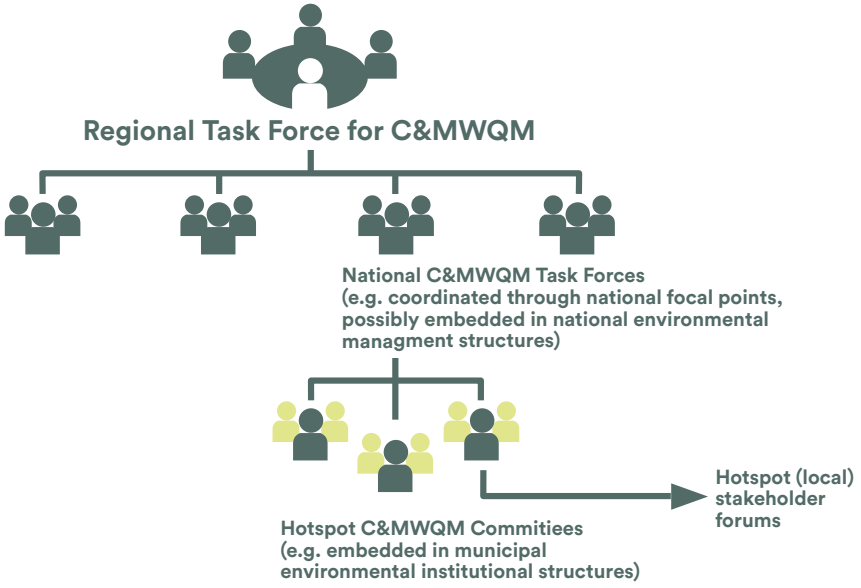

Figure 2. Proposed institutional arrangements for coordination and implementation of C&MWQM in the WIO region

has requisite political support and sustainability, it is proposed that this Task Force be formalised through a relevant CoP Decision so that it operates at the Convention level beyond the lifespan of a project. The oversight and coordination of C&MWQM within countries requires national institutional structures (eg National C&MWQM Task Forces), preferably coordinated through the National Focal Points, to facilitate coordination and alignment with the RTF. National Task Forces need to be cross-sectoral, comprising not only of environmental authorities but also those involved in activities potentially impacting on the coastal and marine environment. These may include urban development and tourism, agriculture, aquaculture and forestry, industry and mining, marine transportation, and energy production amongst others, depending on country context.

Experience in integrated coastal management (eg DEA RSA 2014) has shown that it is usually not viable for national management structures to effectively implement environmental management at the local or site-specific level, or, in this case, within identified pollution hotspots. Therefore, effective environmental planning and implementation at the local (or pollution hotspot) level necessitates local management committees. Similar to the National Task Forces, these forums can also be mainstreamed through broader local (or municipal) environmental management structures to ensure cross-sectoral representation. A dedicated local management institution actively involved in C&MWQM is also ideally positioned to test the effectiveness and applicability of legislation and policies normally developed at regional or national levels. It is, therefore, also important that higher tiers of government utilise these local institutions as a mechanism for improving legislative frameworks related to coastal management, supporting the principle of adaptive management. In the spirit of *Principle 5: Participatory approach*, stakeholder collaboration and regular consultation are essential (CSIR 2006). Towards achieving this, local stakeholder forums have proven to be effective platforms to facilitate a participatory approach to decision-making and implementation.

The implementation of C&MWQM programmes primarily happens at the country level, per adopted regional standards, guidelines, and best practice guidance. These programmes should be coordinated through the National Task Forces and Pollution Hotspot C&MWQM committees in consultation with local stakeholders. Drawing on an existing model for Integrated Coastal Management (the broader domain within which C&MEQM is nested) (Taljaard and others, 2013; DEA RSA 2014), an ecosystem-based Implementation Framework for C&MWQM has been developed for the WIO region (Figure 3) as part of the overarching Strategic Framework for C&MWQM.

To wisely allocate human and financial resources, tackling C&MWQM in a phased approach may be necessary. In this regard, identifying marine pollution *hotspots* or emerging hotspots provides a transparent mechanism to prioritise intevention in areas where coastal and marine environmental quality is most at risk of being impacted by human activities (eg Shaban

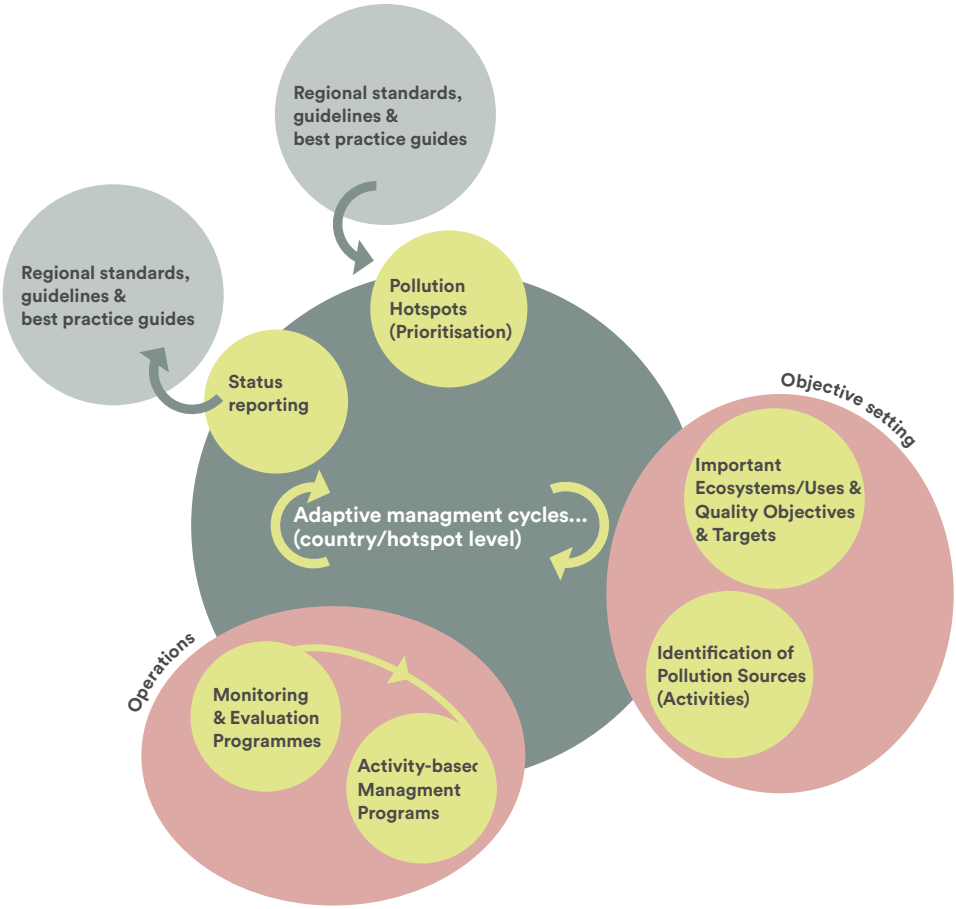

Figure 3. Ecosystem-based Implementation Framework for C&MWQM in the WIO region

2008; Lankford and Hepworth 2010). Marine pollution hotspots usually coincide with coastal urban centres (or cities) and industrial nodes in coastal and marine areas (UNEP and others, 2009). The identification and mapping of *important ecosystems, and key socio-economic beneficial uses* in a specific area, and their environmental quality objectives and associated targets are key components in a C&MWQM programme. Internationally, water and sediment quality guidelines for coastal and marine ecosystems are typically divided into four broad categories. They include the protection of aquatic ecosystems, recreational use and tourism, marine aquaculture, and industrial uses (eg Australian Government 2018; DEA RSA 2012; Health Canada 2012; US-EPA 2012).

The regional *Guidelines for Setting Water and Sediment Quality Targets for Coastal and Marine areas in the WIO*

Table 1. Summary of constituent types for which QTs are addressed in the guidelines, as well as relevance to broad categories of beneficial uses.

Type of constituent		Protection of aquatic ecosystem	Recreation	Marine aqua-culture	Industrial use
Water	Objectionable matter	•	•	Similar to Protection of Aquatic Ecosystems	Based on site-specific requirements of industries
	Physico-chemical properties	•	Refer to Drinking water guidelines		
	Nutrients	•			
	Toxicants	•			
	Microbiological indicators		•	•	
	Tainting substances			•	
Sediment	Toxicants	•		Similar to Protection of Aquatic Ecosystems	

region (UNEP and others, 2021) can be used to derive such site-specific quality targets (QTs) (Figure 3). Guided by international best-practice, selected water and sediment quality constituents and their relevance to protecting aquatic ecosystems and other beneficial uses are indicated in Table 1 (UNEP and others, 2021). Regional guidelines for setting water and sediment QTs are usually broad-based and fairly conservative to accommodate natural variability but still minimise impact risk. Therefore, such recommended QTs should be considered as a first phase in setting site-specific QTs, and depending on site-specific conditions (ecological, social and/or economic), these may need to be refined at specific national or local seascapes. As a result, the recommended QTs proposed in the regional guidelines cannot automatically become legally binding.

A participatory process (*Principle 5: Participatory approach*) is important in negotiating these objectives as they may affect local economies and the livelihoods of local communities. The aim is to negotiate and achieve a balanced, environmentally and socio-economically sustainable outcome through an integrated, consultative process (*Principle 3: Integrated assessment process*). Another key component of the objective setting phase is the identification and characterisation of potential marine pollution sources - both land-based and sea-based - that may alter water and sediment quality in a specific study area, as well as setting limits for such pollution sources. In setting limits for pollution sources, a hierarchy of decision-making should be applied as advocated by *Principle 1: Pollution prevention, waste minimisation, and the precautionary approach*. Activity-based management programmes involve the operational management of specific activities potentially contributing to marine pollution. These programmes often show a strong sectoral focus (ie activities are managed by different governing authorities through activity-specific statutory systems). However,

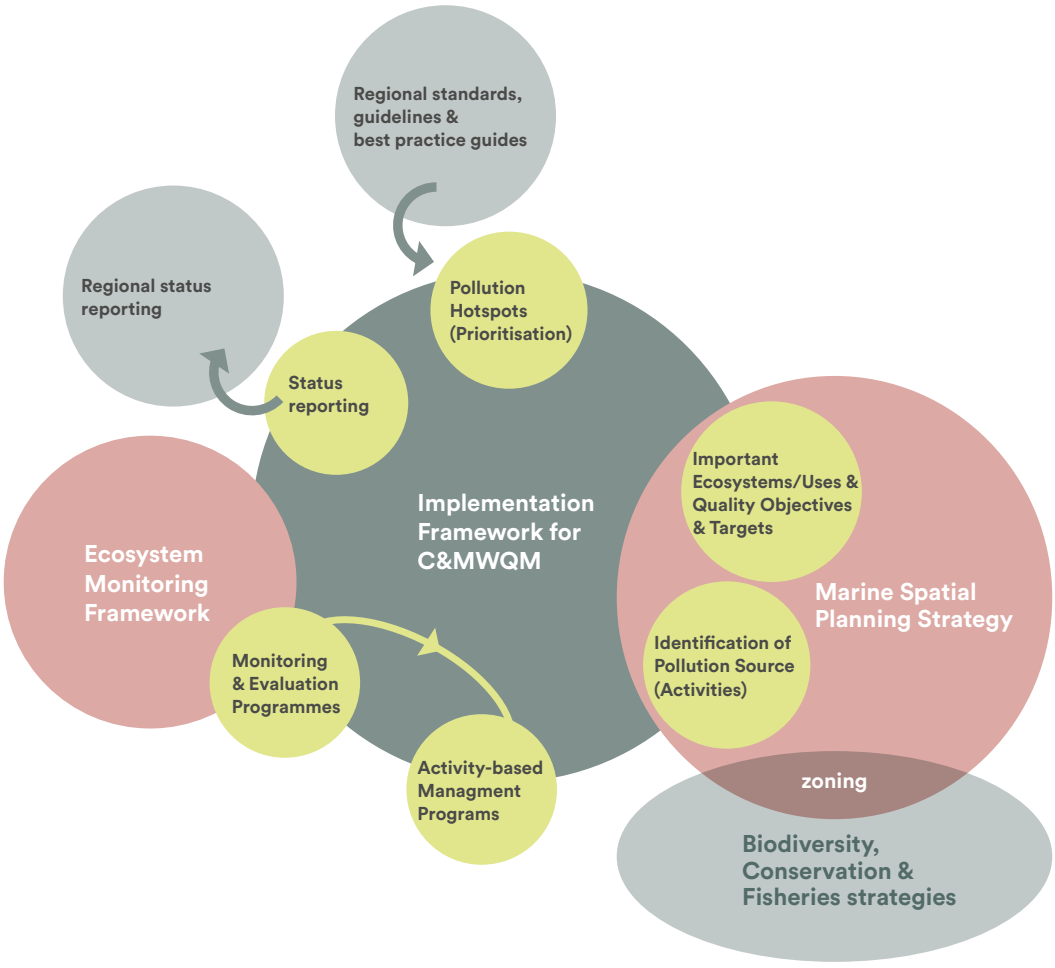

Figure 4. Alignment of elements in Implementation Framework for C&MWQM with related strategies and frameworks within the WIO region

the implementation framework places such sector- or activity-based management programmes between the overarching objective setting phase, and the monitoring and evaluation component. This implies that management programmes, even though sector-based, remain nested in an ecosystem-based approach subservient to the agreed environmental quality objectives and targets for the study area. The cost of mitigating and controlling pollution sources or activities should follow *Principle 4: Polluter pays principle*. The design and implementation of environmental quality monitoring and evaluation programmes form an integral and critical component of the operational phase in the Implementation Framework, together with activity-based mmanagement programmes. Importantly in C&MWQM, monitoring and evaluation is a means to an end, providing the data and information to inform activity-based management intervention (*Principle 3: Integrated, adaptive assessment process*), as is illustrated with the feedback loop in Figure 3. The data and information from these programmes also continuously renew understanding of the complexities of marine ecosystems and their uses and so inform management responses.

In support of a transparent, participatory process (*Principle 5: Participatory approach*), findings from monitoring and evaluation programmes also need to be communicated and shared at regular intervals with the broader society. Status reporting provides a high-level reflection on progress and ensures transparency on issues of concern that need to be addressed through a cycle of adaptive management (ie improving-by-learning, *Principle 3: Integrated, adaptive assessment process*). In turn, national-level status reports feed into the overarching regional status assessment processes, such as the WIO State-of-Coast reporting. Their production should be the responsibility of the RTF for C&MWQM. Although the Implementation Framework for C&MWQM is largely executed at the country level (eg at selected marine pollution hotspots), it reflects the overarching support and guidance provided to countries from the regional level, thus acknowledging the importance of regional coordination.

It is important to understand possible links between the implementation of C&MWQM and other initiatives within the WIO region (Figure 4). While the Implementation Framework has unique elements specifically aimed at effective implementation of C&MWQM, elements within the framework are aligned with other complementary strategies and frameworks implemented in the WIO region.

For example, the demarcation of important ecosystems, uses and location of activities contributing to marine pollution needs to be coordinated with outcomes of the marine spatial planning strategy, which should align with biodiversity, conservation and fisheries strategies in terms of zoning. In addition outputs from monitoring and evaluation programmes can contribute to the ecosystem monitoring framework initiative and vice versa. Implementation of C&MWQM should acknowledge these linkages and coordinate operations wisely to prevent unnecessary duplication of effort.

Outlook for Region and Global

Operationalisation of the proposed Strategic Framework for C&MWQM will be a major milestone in the WIO region for implementing the LBSA Protocol. Towards initiating the effective operationalisation of this framework, the following policy recommendations are proposed for consideration by the Contracting Parties:

- Contracting Parties adopt the Strategic Framework for C&MWQM for the WIO region, including the *Guidelines for Setting Water and Sediment Quality Targets for Coastal and Marine areas*.
- Where applicable, Contracting Parties develop national level C&MWQM frameworks using lessons and experiences provided in the regional Strategic Framework for C&MWQM.
- Contracting Parties formally establish a Regional Task Force (RTF) for C&MWQM (currently a project-level task force under the WIOSAP – RTF for Water, Sediment and Biota Quality).
- Contracting Parties establish national C&MWQM Task Forces to facilitate and coordinate C&MWQM, feeding into the RTF through national focal points.
- Contracting Parties adopt, as appropriate, the Strategic Framework for C&MWQM at the country-level, including *the Guidelines for Setting Water and Sediment Quality Targets for Coastal and Marine areas.*
- Established national C&MWQM Task Forces coordinate the identification of country-level pollution hotspots and establish local C&MWQM committees to oversee the execution of pollution hotspot implementation programme.
- Established national C&MWQM Task Forces coordinate the compilation of country-level status

reports that feed into overarching regional status reports - coordinated by the RTF - to inform various regional processes (eg WIO State-of-Coast reporting, Ecosystem Monitoring Strategies).

The following technical recommendation is proposed for consideration by the Contracting Parties in support of effective operationalisation of the Strategic Framework:

- The Nairobi Secretariat works with partners to support capacity building programmes supporting the effective implementation of the Strategic Framework for C&MWQM, including the *Guidelines for the setting of Water and Sediment Quality Targets.*

Ultimately, achieving the strategic goal for coastal and marine water quality in the WIO region, that '*Water quality in the WIO region meets international standards by the year 2035'* depends on countries embracing this Strategic Framework for C&MWQM and adopting the proposed implementation into national policy and best practice. A successful outcome also requires political commitment to secure dedicated financial resources and the skilled personnel required to execute C&MWQM programmes.

Acknowledgements

Financial support from the GEF (WIOSAP), GEF and UNDP (WIO LME SAPPHIRE) and the European Union (ACP-MEA Phase III) through UNEP Nairobi Convention, is acknowledged.

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Sans frontières – Ocean and Coastal Sustainability of the Western Indian Ocean

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Executive Summary

The Western Indian Ocean exemplifies the complex interconnection between a land-ocean continuum and a large social-ecological system with many smaller and equally complex nested systems. It is well understood that oceans and coastal resources in the Western Indian Ocean (WIO) are vital to the blue economy and the livelihoods of many millions of people in the region. Due to climate and environmental change and mismanagement, these resources and the human reliance on them are adversely affected. To restore and maintain a positive and nurturing relationship between the ocean, coast, and land and the uses of its resources, a societal transformation toward sustainability is necessary. Ocean, coast, and landform a complex social-ecological system. The complex system is often managed and governed in disconnected and fragmented ways. Land, coasts, and oceans urgently require management systems, governance frameworks, and scientific data, information, and tools that bridge the artificial boundaries imposed by integrated coastal management, marine spatial planning, and protected areas. Geographical and temporal scales and levels of governance are key parameters for understanding and addressing complexity. As a locus for human interest and habitation, the coast poses complex management challenges, often called "wicked problems". Furthermore, planning coastal and ocean space and resources through marine spatial planning, the maritime industry, and the blue economy remain a management challenge. Therefore, it is necessary to integrate the region's contemporary management and governance processes and align them with the global objectives of the UN Sustainable Development Goals, the Paris Agreement, and the UN Decade of Ocean Science activities. This policy discussion highlights the need for awareness, understanding, and institutional mechanisms for integrating coastal sustainability in four dimensions. These dimensions are: 1) **ocean to land,** often referred to as a catchment to coast to the ocean; 2) s**hore-to-shore** is the integration of coastal management of local places along the shoreline, but also across sub-national and national boundaries; 3) a**dministrative integration** of management interventions, planning initiatives between different levels of national to sub-national government, and "downscaling" global policy initiatives such as the SDGs to a local level; and, finally, 4) integration of different **timescales** for management, from political time frames to climate time scales. This policy discussion paper proposes a strategic approach to integrated coastal and marine resource management across the four key dimensions of sustainability, taking a pragmatic approach to the overlap and potential benefits of integrating elements of the existing coastal and marine policy instruments (as recognised in Nairobi Convention COP decision CP9/6). As a result, such commonalities are recognised and used to integrate and plan management and governance activities from ocean to land. It proposes exploring management (strategies, plans, etc.) and institutional (regional and national fora) mechanisms to explore the benefits and management of resources across the land-sea interface.

http://dx.doi.org/1x.xxx/wio.15

Background

Global change impacts all regions of the Earth, impacting livelihoods, economic development, and food security. Governments and communities must adopt adaptive strategies to build resilience in light of global climate change and local impacts, which are already noticeable today. Some are dependent less on the environmental change itself and more on the governance performance of the countries at risk. Global coastal systems and low-lying areas are particularly susceptible to these governance imbalances (including corruption (Walter and Luebke, 2013; Fredriksson and Neumayer, 2016), economic growth agenda (Davidson and others, 2003), slow energy transitioning (Hess and Renner, 2019), social inequality (Islam and Winkel, 2018) and ocean-climate drivers (Nicholls *and others*, 2007; Purvis, Bates and Hayes, 2008; Church *and others*, 2013; Liao *and others*, 2015) (including sea-level rise (Devlin *and others*, 2017; Wahl *and others*, 2017), severe storms (Haigh *and others*, 2016), winds and waves, flooding (Prahl *and others*, 2018) increased sea surface temperatures (Frölicher and Laufkötter, 2018) and ocean acidification (Kildow and McIlgorm, 2010; Ferrari *and others*, 2015), and freshwater inputs (Wong *and others*, 2014).).

The Western Indian Ocean exemplifies the complex interconnection between a land-ocean continuum and a large social-ecological system with many smaller and equally complex nested systems (UNEP-Nairobi Convention and WIOMSA, 2015). These systems are often not well-aligned with governance levels and national boundaries. Therefore, this policy proposal primarily focuses on the need to integrate contemporary management and governance processes of the region and align them with the global objectives of the UN Sustainable Development Goals, the Paris Agreement, and the UN Decade of Ocean Science activities. Important will be the downscaling and customisation of those international frameworks at the local level, taking into consideration existing local regulations and regulatory frameworks such as integrated coastal (zone) management (ICM, ICZM) or marine protected areas (MPAs).

From the situation described above, the following statements are relevant to this policy proposal:

- The resources of the ocean and coastal environment of the Western Indian Ocean (WIO) is the basis for the blue economy and the livelihoods of many millions of citizens in the region.
- These resources, and our dependence thereon, is being negatively affected by the impact of climate and environmental change and mismanagement.
- The ocean, coast and land are a complex social-ecological system.
- We deal with system complexity by using an often disconnected and fragmented management and governance approach. Geographical and temporal scales and levels of governance are key parameters for understanding and addressing complexity.
- The land, coast and ocean urgently require management systems, governance frameworks and scientific data, information and tools that span the artificial boundaries imposed by integrated coastal management, marine spatial planning and marine protected areas.
- An across-the-board transformation toward sustainability is needed to restore and maintain the positive and nurturing relationship between the ocean, coast and land, and our use of resources.
- This policy proposal presents two recommendations to establish institutional arrangements to support the sustainable development of the ocean, coast and land across the land-sea interface, along the shoreline, between levels of administration and over time.

Relationship with Nairobi Convention Decisions

ICM offers a pathway to support climate change adaptation and could act as a proxy for the management approaches needed for climate change adaptation (Ojwang *and others*, 2017; Williams *and others*, 2020). This is recognised by the Nairobi Convention COP decisions CP.9/4 & CP.9/9 (see Figure 1).

In addition to ICM, as a cornerstone for managing coastal resources and MPAs for protecting the ocean and coastal environment, marine spatial planning (MSP) (UNEP-Nairobi Convention Secretariat, WIOMSA and CSIR, 2017) has become a priority mechanism for the implementation of the Blue Economy in the WIO (Obura, 2017) (see COP decision CP.9/10).

Part of the problem, as described above and below, is that the environment of the WIO is an integrated system. As soon as we invent different 'sectoral' approaches to focus on problem areas, the sectoral approach by its nature tends not to be truly holistic. A paradigm shift to a holistic system perspective is key due to the tight interaction of the system's components, which determines the overall performance of the social-ecological system (COP decision on Ocean Governance CP.9/6).

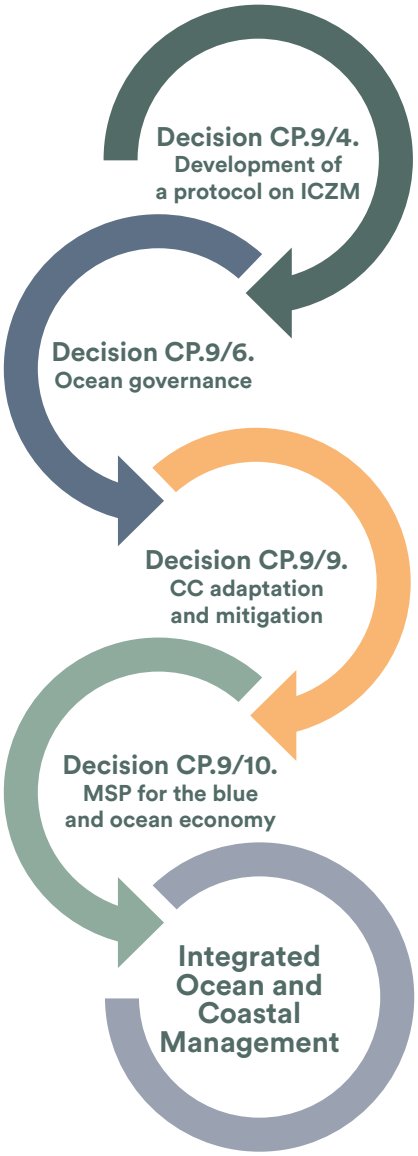

Figure 1. Decisions of the Nairobi Convention of Parties directly and indirectly supporting the development of integrated ocean and coastal management in the Western Indian Ocean.

Advances

Nowhere is this need for change more evident than on the coasts, which also attracts humans and their economic activities to live better and healthier lives. Over the next decades, coastal communities will grapple with the understanding of social-ecological resilience (Hattam *and others*, 2020), the need to adapt to climate impacts (Baills, Garcin and Bulteau, 2020), and the pressure to transform as a society (Scoones *and others*, 2020; Wilson *and others*, 2020), to sustain their activities, and the natural resource-base (Halpern, 2020) which is the cornerstone of all economy (Jouffray *and others*, 2020) and human well-being.

The complexity of the coast as a locus for human interest and habitation is well understood (coastal management challenges often referred to as "wicked problems"). However, the integration of coastal and ocean space and resources (through marine spatial planning and the maritime industry and blue economy) within the future state of the social-environment continuum in a changing climate exponentially drives a level of complexity we are ill-equipped to manage.

Within science, it is increasingly recognised that planning for sustainability requires rapid, large-scale socio-political change as a window of opportunity for transformative change of natural resources governance (Herrfahrdt-pähle *and others*, 2020). There are at least four archetypes of sustainability transformation research, with thematic structures clustered around environmental change and ecosystem services; resilience and vulnerability; knowledge production for sustainability; and governance for sustainability (Horcea-Milcu *and others*, 2020). Governing land-sea interactions requires multi-level and polycentric governance and new forms of policy integration (Schlüter *and others*, 2020).

This policy proposal promotes the creation of awareness, understanding and institutional mechanisms for integration along four dimensions of coastal sustainability (Figure 2):

- **Ocean to land** often referred to as a catchment to coast to the ocean. The actions in the three domains (ocean, land, coast) are scaled differently, and novel and integrated science and policy and governance tools are needed to connect the ocean to land;
- **Shore-to-shore** is the integration of coastal management of local places along the shoreline, but also across sub-national and national boundaries; and,
- **Administrative integration** of management interventions, planning initiatives between different levels of national to sub-national government, and "downscaling" global policy initiatives such as the SDGs to a local level.
- Integration of different **timescales** for management, from political time frames to climate time scales.

Outlook and Policy Recommendations

Main Recommendation: Integrated Coastal Zone Management is already seen as a mechanism for creating enabling conditions for planning sustainable coastal

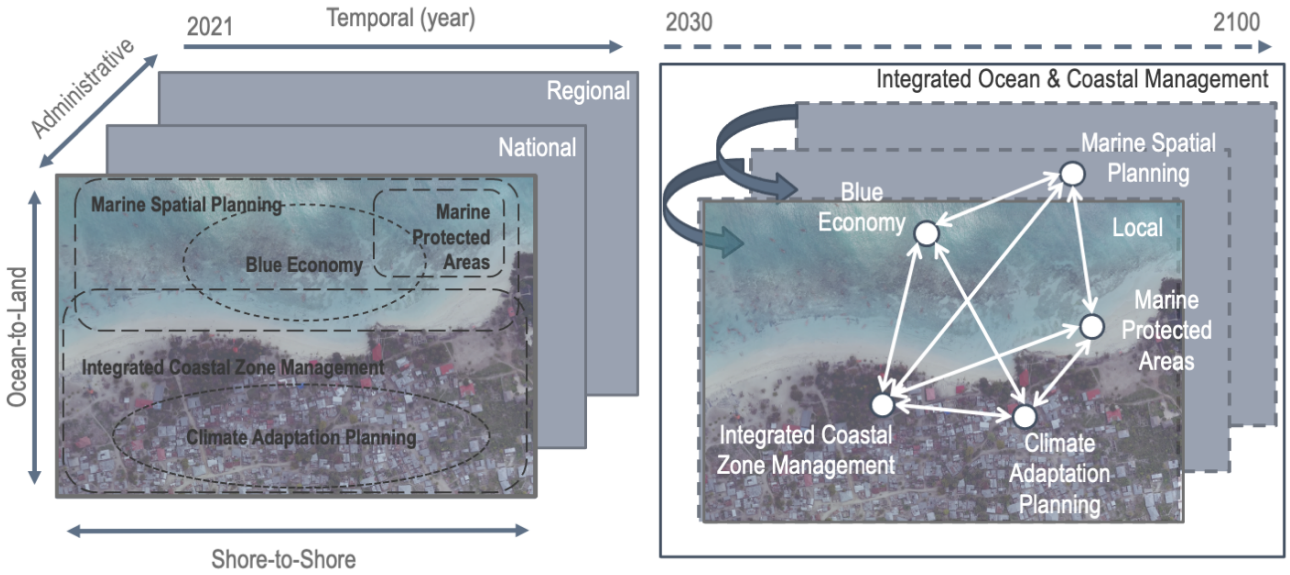

Figure 2. Four dimensions (ocean to land; shore to shore, administrative scale and temporal scale) of coastal sustainability.

resource use and management and climate change adaptation in the WIO (CP9/4 and 9/9). Furthermore, marine spatial planning is an emerging management and planning mechanism to implement the Blue Economy of the region (CP9/10). There are commonalities in the policy implementation cycles of ICM, MSP, the Blue and Green Economies and climate change adaptation. The overlap and integration between these (currently) separated domains in the WIO is the only path to achieving the SDGs and sustainability.

This policy paper proposes a purposeful integration of management across the four dimensions of sustainability and a pragmatic view on the extensive overlap and combined benefit of integrating elements of the existing policy instruments for coastal and marine resource management (in support of CP9/6). Such commonalities are recognised and actioned as a unifying and integrating mechanism to plan a range of management and governance activities from ocean to land. Pragmatically, it proposes exploring management (strategies, plans etc.) and institutional (regional and national fora) mechanisms to explore the benefit flows and management of resources across the land-sea interface. This means that all four dimensions of coastal and ocean sustainability are included in discussions on goal and objective setting, principles for decision-making, policy agreement across agencies, authority and accountability, performance indicators, lead agencies (for example, Brooks *and others*, 2020)particularly in multi-sectoral and jurisdictional systems, with coastal management of New South Wales (NSW as it relates to coastal and marine resource management.

Practical actions and deliverables arising from this policy recommendation may include:

- Developing a white paper for Integrated Ocean and Coastal Management in the WIO.
- Developing a high-level integrated ocean and coastal management strategy for the WIO, incorporating the principles of both ICM and MSP and the targets of the SDGs.
- Including a chapter on the four dimensions of sustainable coastal and ocean management in the WIO Regional State of the Coast.
- Developing a set of indicators to monitor the state of the coastal-ocean systems across contemporary concepts of boundaries
- Convening a workgroup to consider a more comprehensive understanding of the flow of benefits from the Blue Economy, especially between ocean resources (planned at the national level) and local communities and coastal urban administration. Such a working group needs to pay more attention to economic development synergies between coastal and inland areas in the context of the Blue Economy.

Supporting Recommendation: The role of transdisciplinary research to integrate disciplines, sectors and activities such as economic planning, local governance, national climate adaptation, natural sciences, and studies in humanities is recognised and encouraged. The four dimensions of sustainable coastal and ocean management require a different response from the scientific community and greater openness in supporting transdisciplinary approaches and interdisciplinary

research in the WIO. The scaling differences along the four dimensions require the involvement of a vastly increased number of stakeholders. At the same time, the quality of scientific evidence must be improved, but so must the representation of stakeholder engagement within a co-design framework of solutions to resource management issues.

For the supporting recommendation, the practical actions and deliverables may include:

- Developing a protocol for engagement of stakeholders across the four dimensions of coastal and ocean sustainability. This should address the involvement of local stakeholders (citizens, communities, urban settlements, cities) in the planning process and sustainable utilisation of marine resources.

Conclusion

The Nairobi Convention is ideally placed to advance the above recommendations, considering the need for concerted regional action and national specificities and progress in implementing coastal and marine management. This is best achieved by establishing a dedicated working group tasked with supporting planning across the land-sea interface, monitoring progress in implementation, identifying and contributing to addressing capacity development needs, and promoting the exchange of knowledge and experiences with nations in the region.

Acknowledgement

This policy proposal was supported by the outputs of the WIOMSA MASMA EKLA and CICLICO projects (Grant Nos. MASMA/OP/2013/01 and Cities&Coasts/OP/2018/02) as well as the I2B Programme of the Helmholtz-Zentrum Hereon, Germany.

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Marine protected areas

Addressing shifting governance contexts and development objectives in the Quirimbas National Park, Mozambique

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Summary

This paper presents critical lessons from the Quirimbas National Park (QNP) review process and policy recommendations for implementing spatial management efforts in the Western Indian Ocean (WIO). This case study provides insights into how Mozambique's development trajectories have influenced governance of the QNP, and consequently, the proposed downgrading of regulations and expansion of protected area boundaries. Shifting the most populated areas to sustainable use management will relax park regulations and allow the government to accommodate and engage local communities in various sustainable use activities. This will also enable the creation of additional sources of income for the conservation area and contribute to its financial sustainability. Whereas keeping the ecologically essential areas under total protection management will help prevent future degradation of these areas. Lessons learned from terrestrial parks that went through downgrading, downsizing, and degazettement (PADDD) show the importance of increasing the governance capacity of various government levels and stakeholders involved in protected area management.

Background and rationale

Marine protected areas (MPAs) are among the most commonly applied spatial management tools for biodiversity conservation. Considering their history, MPA planning and management have evolved to address multiple objectives and evaluate different approaches to ensure their success and sustainability (Hough 1988; McCook and others, 2009; Pressey and Bottrill 2009). In terms of planning, MPA objectives have included ecological processes and various threats to ensure persistence of biodiversity, and different social, economic, and political considerations to reduce conflict between protected area management and stakeholders, and increase compliance (Ban and Klein 2009; Green and others, 2009; Pressey and Bottrill 2009). Management has also evolved to become more adaptive to increase MPA effectiveness (Hockings and others, 2000; Salafsky and others, 2001). Despite the considerable strides, MPA planning and management have yet to learn to be more dynamic to keep up with shifting governance contexts and development objectives to ensure their success and sustainability (Pressey and others, 2013).

Currently, there are 154 MPAs in the Western Indian Ocean (WIO), and these were established with different objectives and are managed using different approaches (Levin and others, 2018). In addition to government-led MPAs, Kenya, Tanzania, Mozambique, and Madagascar have locally-managed marine areas (LMMAs) established by communities with support from various bridging organisations (Rocliffe and others, 2014). Whilst the WIO have come closer to achieving biodiversity targets set by various international agreements. East African nations still struggle to maintain the effort needed to implement their MPAs effectively (Gill and others, 2017; McClanahan and Muthiga 2017; Levin and others, 2018). The majority of the MPAs and LMMAs in the WIO have limited management performance due to

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changes in governance structure, insufficient finances, weak enforcement, and lack of human resources and technical capacity (Rocliffe and others, 2014; Gill and others, 2017). Hence, it is important to understand the history and limitations of existing management approaches and the shifts in governance priorities to make meaningful recommendations to adapt to the changing MPA contexts.

Using the Quirimbas National Park (QNP) in Mozambique as a case study, we describe the lessons learned from the protected area review process. The lessons presented in this paper are envisioned to provide insights into how the development trajectories of Mozambique have influenced governance of the QNP, and consequently, the proposed downgrading of regulations and expansion of protected area boundaries.

Expansion of the Quirimbas National Park

The QNP is located in Cabo Delgado province in Northern Mozambique. It has a total area of 9 130 km^2, including 7 945 km^2 of terrestrial and 1 185 km^2 of marine components (Figure 1A). It is also surrounded by a buffer area that has a total area of 5 730 km^2. The QNP was established in 2002 by the national government with support from the World Wide Fund for Nature (WWF-Mozambique) and other stakeholders (Mozambique government - Ministry of Tourism 2004; Baghai and others, 2018). Unlike most of the protected areas in Africa, one of the main reasons for the QNP's establishment was to conserve biodiversity and support rural development for local communities in Cabo Delgado (Chevallier 2018; Mucova and others, 2018). More specifically, the QNP was also established to support the needs of communities residing in the park, which included: i) addressing human and wildlife conflict; ii) supporting the economic and infrastructure development within the park and Cabo Delgado; and iii) diversifying livelihood opportunities to benefit communities (Mozambique government - Ministry of Tourism 2004; Baghai and others, 2018).

Since its establishment, the QNP has gone through two different management models (Baghai and others, 2018), shifting from technical-financial support partnership to government management model. From 2005 to 2010, the park was managed under a partnership between the government and WWF-Mozambique with funds from the French Agency for Development (AFD), where the government remained the official authority for the park and WWF-Mozambique played an active role providing technical and financial support to build management capacity (Baghai and others, 2018). From 2011 to 2016, the WWF-Mozambique started phasing out the partnership, shifting to an advisory support role. The view of the donors and WWF was that their role as partners should be short-term, and the Mozambican government should start taking on the leadership role to increase their management capacity. Since 2017, when the partnership ended, the park has been under the government management model, while WWF remained engaged in some community projects but no longer directly involved in park management (Baghai and others, 2018). Since the shift in governance structure, management of the QNP has weakened, and recent assessments have shown declines in forest vegetation, wildlife populations, and coral reef condition inside the park due to various human activities and encroachment of mining operations (McClanahan and Muthiga 2017; Baghai and others, 2018; Mucova and others, 2018).

With the enactment of the Conservation Law in 2017 and its corresponding regulation in 2018, the government started reviewing conservation areas' status, objectives, and governance and their alignment with the new management categories defined by the law. The review of the QNP was undertaken between 2019 and 2020 and engaged various stakeholders from the QNP management, government officials and staff from Cabo Delgado, and representatives from other institutions that have been involved in planning and management of the park in multiple stakeholder workshops. Initially, the review's focus was to identify, under the new conservation law. This management category could allow better management of protected areas, and for the case of the QNP, with an increasing resident population highly dependent on natural resources for livelihood. The objectives of the review then shifted to re-thinking and redesigning the protected area management zones and restrictions.

The stakeholder engagement process adopted a top-down approach, where spatial design scenarios were prepared using biodiversity conservation and socioeconomic objectives. These design scenarios were then presented to stakeholders for review and discussion. During the participatory review process, stakeholders suggested expanding the QNP to extend regulatory and management frameworks for unmanaged areas of Cabo Delgado with high importance for conservation. However, the high level of restrictions in national parks (ie, total protection areas) would not

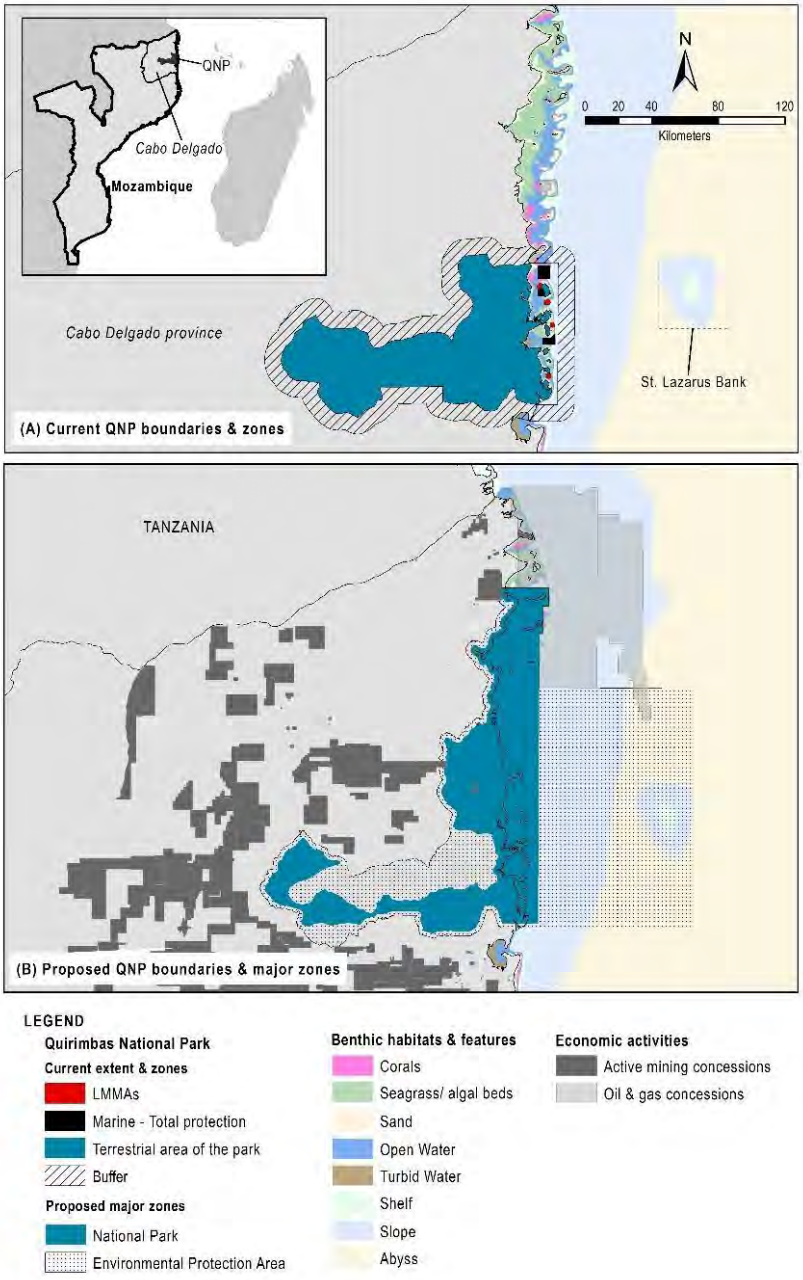

Figure 1. Current (A) and proposed (B) QNP boundaries and major zone categories. Note that the terrestrial zones in the current zoning scheme are not presented.

allow resident communities to use natural resources in the area, increasing conflicts related to access to natural resources and exacerbating poverty in the region. Because the conservation law defines new conservation area categories, it was concluded that the most populated areas of the QNP should be downgraded to the category of Environmental Protection Area (EPA) (ie, sustainable use conservation area) to allow sustainable use activities and promotion of the inclusive conservation approach, where local communities can effectively contribute to the conservation of biodiversity and benefit from it.

The EPA is also the only conservation area category that allows creating other conservation areas inside its boundaries. Therefore, zoning can be done in two ways: (1) considering the zoning categories defined by the law, and (2) for areas inside the EPA that would need dedicated management or a higher level of protection, it could be considered the creation of other conservation areas inside the EPA. Thus, to provide a higher protection status to areas with high value for conservation (ie habitats and ecosystems relevant for conserving biodiversity), stakeholders opted to keep some areas categorised as national parks inside the EPA. If ratified,

this will increase the total area managed in Cabo Delgado and ensure sustainable use of ecosystem goods and services in the province (Figure 1B).

The proposed EPA has a total area of 27 520 km², which could potentially conserve and manage 10 022 km² of terrestrial and 17 497 km² marine ecosystems and habitats (Figure 1B). Whereas the proposed national park area (QNP inside the EPA area) could potentially protect an area of 9 827 Km², of which about 4 262 Km² is marine. The proposed expansion's two major zones (ie, QNP and EPA zones) will be zoned further based on different objectives. For the marine component, the QNP and EPA are envisioned to protect coastal and marine ecosystems, including the northern islands up to Vamizi Island, about 700 Km² of mangrove forest, and the offshore area of St. Lazarus Bank (about 100 km from the coast).

Lessons learned from the QNP expansion

The proposed expansion of the QNP was also a result of efforts by the Mozambican government to update the category of several conservation areas in the country to align the status of these areas to the terms of the new conservation law and improve management of these conservation areas. Shifting the most populated areas to sustainable use management will relax park regulations and allow the government to accommodate and engage local communities in various sustainable use and economic activities within EPA boundaries. This will also enable the creation of additional sources of income to the conservation area and contribute to its financial sustainability. Keeping the ecologically important areas under total protection management as a national park will help prevent future degradation of these areas.

The shift from total protection to sustainable use management of the most populated areas of the QNP is a form of protected area downgrading, downsizing, and degazettement (PADDD). The potential increase of the total area conserved occurred in the backdrop of human encroachment settlements and other activities inside the strict protection zones of the QNP. Although the increase in the total area of protection may be seen as a win for biodiversity conservation, establishing and managing it might become more challenging. Protecting such a large area will require appropriately crafted policies to support park regulations, strict enforcement of management zones, and high governance capacity. Moreover, managing a much larger size would require more human and financial resources, which the government have already found challenging to provide. Therefore sources for financing the conservation area must be identified and promoted. Lastly, downgrading the entire scope of the QNP to a sustainable use area could still potentially negatively impact the conservation area management and contribute to changes in park boundaries and regulations. Studies have shown that the probability of an enacted PADDD event increases with the protected area's size (total area). This is likely to occur with increasing local population densities and economic growth (Symes and others, 2016). Thus, the increase in the total area could put it at higher risk of being amended again in the future. Still, the review in zoning may help define strategies to manage the growing population and promote improved inclusion of these communities in conservation initiatives.

Although there are a lot of potential negative implications of downgrading part of the QNP to a sustainable use management area, communities and other stakeholders in Cabo Delgado have been greatly encouraged by the review process. The review process also facilitated several different discussions about including participatory processes in decision-making and management to sustain the QNP. The renewed interest and commitment of various stakeholders in the QNP will hopefully contribute to improved governance of this area.

Policy recommendations for implementing spatial management efforts in the WIO

Frequently, MPAs are considered permanent spatial closures. However, governments worldwide enact PADDD when human activities encroach protected area boundaries or when development is prioritised over conservation objectives. PADDD is not unique to Mozambique, and it has been recorded globally, including some of the WIO countries. Some of the terrestrial protected areas in Kenya, Madagascar, Tanzania and South Africa were downgraded, downsized, or degazetted because of encroachment of pastoralist communities, land titling, logging concessions, timber licensing, and government corruption (Mascia and Pailler 2011).

Lessons from these terrestrial parks point out the importance of increasing the governance capacity of various government levels and stakeholders involved in protected area management. This also holds for MPAs and other spatial management tools that can be

used to regulate coastal and marine areas in the WIO. Increasing the governance capacity of WIO nations is very important because it can ensure that MPA and other management zones and relevant laws and regulations are strictly enforced and that sufficient resources are allocated. Increasing the governance capacity of relevant stakeholders will require improving their awareness and education of the importance of maintaining ecosystem function to sustain the benefits provided by various coastal and marine ecosystems. Hopefully, this will help government and non-government stakeholders explicitly discuss trade-offs between conservation and development objectives to make informed and better decisions.

From this experience, we recommend that the WIO states consider the following recommendations to limit PADDD in both MPA and terrestrial protected areas:

Technical recommendations

- Ensure management effectiveness assessments are included in MPA management plans and are conducted regularly as part of the adaptive management cycle;
- Support and develop research on PADDD to understand its implications on the achievement of conservation, social, and economic objectives.

Policy recommendations

- Promote a more inclusive approach to MPA management by considering access, use rights, and cultural and historical values of local communities to reduce PADDD;
- Identify complementary financing sources (eg, sustainable tourism, nature-based solutions, biodiversity offsets) and encourage broader stakeholder engagement to sustain MPA management; and,
- Formulate criteria and guidelines as part of the regional MSP implementation process to accommodate current and future transformations caused by social, economic, political and climate change events to minimise the negative impacts of PADDD.

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WIO Science - Policy Platform Series
(1) 2022 131-138

Strengthening the WIO MPA System (WIOMPAS): Institutionalising performance tracking and expansion of conservation areas through multi-level cooperation

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Summary

The advocacy for establishing a global network of marine protected areas (MPA) has led to the scaling up of local efforts and attempts to develop and strengthen national to regional initiatives. This support for MPA networks continues to rise due to the increasing number of studies on the ecological benefits that networks provide, including enhanced ecosystem recovery and fisheries sustainability. However, significant advances in MPA network development is urgently needed to address the continuous threats from fisheries exploitation, pollution from oil and gas concessions, shipping and land-based threats, and the impacts of climate change. Moreover, a larger proportion of the world's oceans are still unprotected, including the Western Indian Ocean (WIO). In July 2021, the United Nations Environment Programme (UNEP) Nairobi Convention and the Western Indian Ocean Marine Science Association (WIOMSA) launched the MPA Outlook. This report written by representatives from each of the Contracting Parties to the Nairobi Convention is the first review of MPAs in the WIO. The Outlook report presented and described the Contracting Parties' progress in achieving Aichi Target 11 and Sustainable Development Goal 14 set by the Convention of Biological Diversity (CBD) and the U.N., respectively. Considerable effort has been undertaken by the governments, non-government and academic institutions, and communities to establish and manage the 143 MPAs and 173 locally-managed marine areas in the WIO. These national and local MPA efforts had led to the protection of 7 per cent of the combined exclusive economic zone in the region. Whilst the WIO countries have made great strides in marine conservation in the last decade, there is still a lot to be done to expand protection and improve the management effectiveness of existing MPAs. Additionally, an assessment of how existing MPAs can contribute to the achievement of other Aichi Targets (eg Target 6 – fish, invertebrates and aquatic plants are managed and harvested sustainably) is also needed to ensure that management initiatives in the region can support broader conservation and sustainability goals. These assessments could also identify data and information gaps to help monitor and evaluate MPAs and coastal and resource governance assessments. Furthermore, a strategic roadmap is needed to help WIO governments prepare to implement the post-2020 biodiversity policy. To contribute to these initiatives, a systematic framework to strengthen the WIO MPA System (WIOMPAS) is recommended to institutionalise the performance tracking of individual MPAs and expedite the expansion of existing conservation efforts. The Contracting Parties to the UNEP Nairobi Convention can facilitate top-down and bottom-up governance schemes in-country and bilateral cooperation between neighbouring countries to implement the systematic framework to be developed. The WIOMPAS framework will serve as the basis for developing MPA networks at the country-level, including a system of MPAs through national- and community-led initiatives and transboundary arrangements. Moreover, the role of other effective conservation measures (OECMs) in the WIO and their social, economic, ecological and legal context and general guidelines for their implementation will be articulated. The framework will also serve as a guide to support the institutionalisation of MPA monitoring and evaluation to improve management efforts and ensure the sustainability of conservation efforts. It is also important that this framework be prioritised and integrated within broader regional and national marine spatial and land-sea planning initiatives to help increase the effectiveness of MPAs by minimising threats from land-based, coastal and maritime activities.

http://dx.doi.org/1x.xxx/wio.17

Background and rationale

Establishing a global network of MPAs is key to sustaining marine biodiversity and fisheries and to ensuring the persistence of biodiversity in the face of climate change (IUCN-WCPA, 2008; Klein and others, 2015; Walton and others, 2014). As part of the global commitments to meet biodiversity targets, governments are scaling up their conservation efforts to establish MPA networks at the national level. Consequently, research on ecological and social processes that occur at multiple spatial scales are undertaken by different organisations and institutions to support the establishment and implementation of MPA networks at various spatial scales (Harrison and others, 2012; Horigue and others, 2012; Kool and others, 2011; Levin and others, 2018). Currently, research and development on MPA networks are primarily undertaken at local to sub-national scales (ie lower government levels or finer scale ecological units, such as bays, gulfs) due to the limitations placed by government jurisdictions and pragmatic management and policy concerns (Abesamis and others, 2017; Harrison and others, 2012; Horigue and others, 2012). Creating more localised MPA networks is a good first step, but it is necessary to step up efforts at national, regional, and even global levels to increase the protection of shared resources and coastal areas, resolve boundary disputes, and improve conservation efficiency by considering both land-based and maritime activities (Chua 2006; Horigue and others, 2012; Levin and others, 2018; Maina and others, 2020; Walton and others, 2014). A regional MPA network design can also be used as a framework to facilitate the establishment of national MPA networks that can incorporate different MPA types and management arrangements and strategies (Levin and others, 2018; Maina and others, 2020; Walton and others, 2014). The establishment of regional MPA networks could also facilitate the use and implementation of other spatial management tools to improve the management of shared seas and oceans and provide better safeguards to the increasing threat of climate change (Levin and others, 2018).

Scientific advances

Recent developments in conservation science show that increased protection of ecological processes in MPA designs (ie size, spacing, and location) can ensure the persistence of biodiversity and support fisheries sustainability (Bode and others, 2016; Green and others, 2015; Krueck and others, 2017; Magris and others, 2014). However, adequate representation of ecological processes within MPAs can be challenging because these processes often span larger (ie >1000s of kilometres) and multiple spatial scales (ie local to global) that may also transcend national boundaries (Cumming and others, 2006; Mills and others, 2010; Fidelman and others, 2012). To address these challenges, government cooperation, collaboration, and coordination is recommended to establish MPA networks that can transcend jurisdictions and be nested within the different levels of the government organisation (ie local government, national government, regional associations) (Chua, 2006; Horigue and others, 2012; Levin and others, 2018).

Table 1. Summary of COP Decisions that can be considered in the development of the WIOMPAS

COP and Decision Number	Focus	Relevance to the WIOMPAS
CP7/4 (1): recognition or designation of important bird areas	Important bird areas	Prioritise and ensure protection in national MPA networks
CP7/7: identification and description of ecologically or biologically significant marine areas (EBSAs)	Ecologically or biologically significant marine areas	Prioritise and protect national MPA networks
CP8/6 1 (a) & CP9/7(a): establishment of a transboundary MPA between Kenya and the United Republic of Tanzania	Transboundary MPAs	Conservation of marine corridors and transboundary areas Institutional arrangements for transboundary governance
CP8/6 2 & CP.9/7 (2): develop and implement new transboundary initiatives for management of shared resources	Transboundary management	Sustainable management of shared resources Institutional arrangements for transboundary governance
CP8/10 (4), CP8/13, & CP 9/10: developing area-based management tools such as marine spatial planning	Area-based management	Application of spatial planning tools and management
CP9/10 (4): establishment of MPAs in areas beyond national jurisdiction	Areas beyond national jurisdiction	Protection and sustainable management of shared resources Institutional arrangements for collaborative governance

Establishing MPA networks require significant resources, technical expertise, and social capital among different stakeholders, especially government institutions (Fernandes and others, 2009; IUCN-WCPA 2008; Weeks and others, 2014). Therefore, scaling up to form a regional MPA network would require countries to formulate concrete plans to develop national MPA networks (Horigue and others, 2012; Walton and others, 2014). Moreover, national governments should coordinate with neighbouring states to create synergies, address boundary disputes, and align development priorities with increasing the regional network's effectiveness (UNEP-WCMC 2008; Walton and others, 2014).

Regional governance context

The WIO is in a position to establish a regional MPA network because the UNEP Nairobi Convention provides the institutional arrangements that can help facilitate and guide the development of national networks and coordinate efforts to strengthen regional initiatives. Moreover, the governments of the WIO region have made many decisions that are relevant to regional MPA network establishment (Table 1).

These decisions motivate establishing different MPAs that address multiple objectives and require other governance arrangements without creating an MPA network. Moreover, these decisions may serve as an impetus for establishing different MPA types in the WIO. Still, a systematic approach for developing a regional MPA network will facilitate regional coordination and assist in organising initiatives to support decisions on identifying marine EBSAs, establishing transboundary MPAs, and implementing spatial management initiatives through marine spatial planning.

Additionally, a regional MPA Network for the WIO was recommended in the MPA Outlook to help expedite the expansion of marine conservation areas and coordinate efforts and share knowledge and resources to improve the management effectiveness of existing

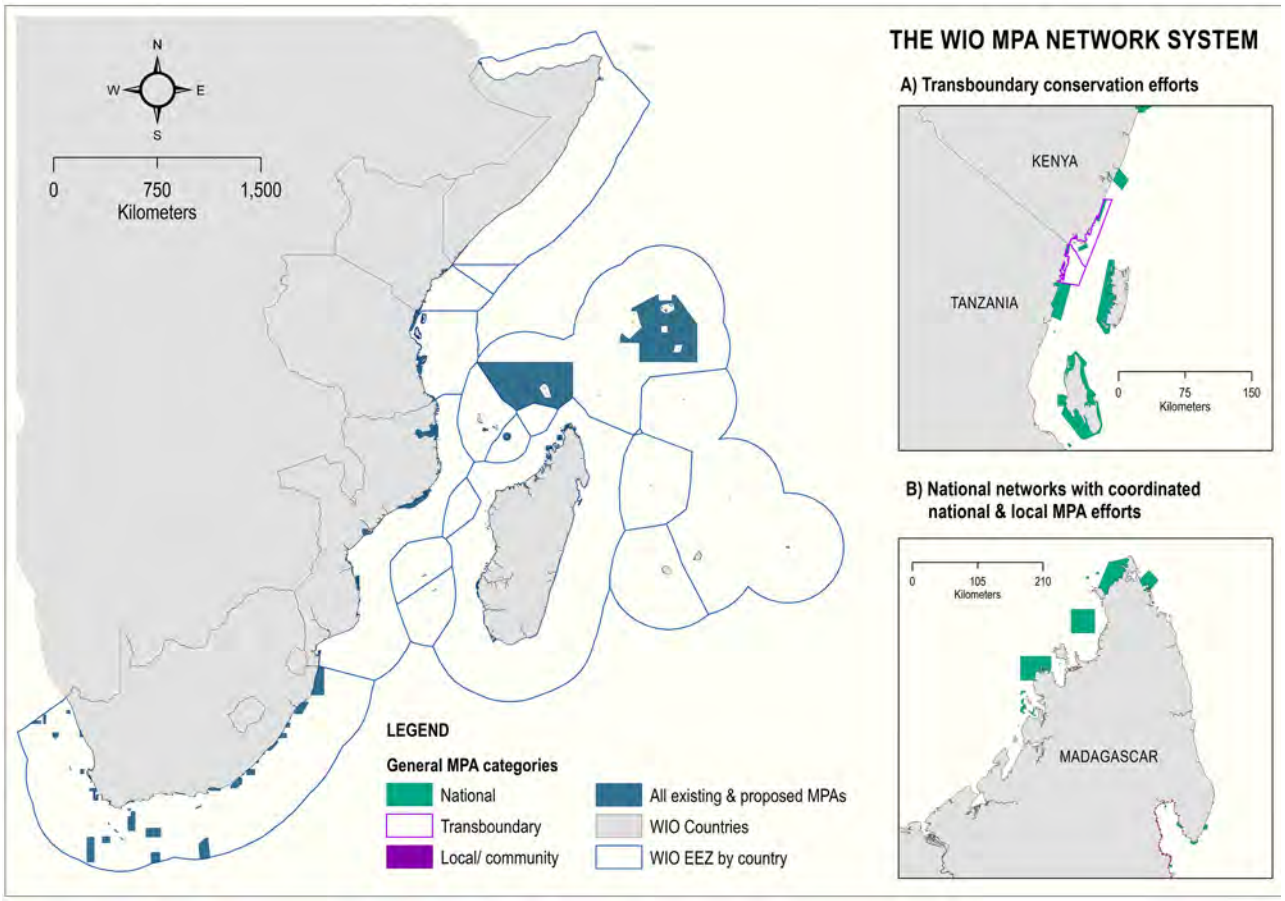

Figure 1. Existing and proposed MPAs in the WIO. The insets present (A) transboundary conservation, and (B) coordination of national and local MPA efforts that could be included in national MPA network plans. This multi-level and multi-scalar planning and governance approach will helpfully establish and strengthen the WIO MPA network. Note: MPAs presented in this figure does not include the Prince Edward Island MPA in South Africa, which was also excluded in Part V of the Outlook Report. Data sources: UNEP Nairobi Convention and WIOMSA. WIO MPA Database from the MPA Outlook Report

MPAs (Richmond and others, 2021). The MPA Outlook was initiated by the UNEP Nairobi Convention in partnership with the WIO Marine Science Association (WIOMSA) to review the progress made towards the achievement of the CBD Aichi Target 11 and United Nations Sustainable Development Goals (ie SDG 14). The development of the MPA Outlook required working closely with representatives from the Contracting Parties to develop the WIO MPA database, and evaluate MPA management performance using the Management Effectiveness Tracking Tool (Hockings and others, 2000; Stolton and Dudley 2016; UNEP and WIOMSA 2021).

Launched in July 2021, the Outlook report recorded 143 established MPAs in the region, which covers a total area of *555* 437km^2 or 7 per cent of the combined EEZ of the WIO nations (Figure 1) (Richmond and others, 2021). This demonstrates substantial progress for marine conservation made by the region over the last decade. The MPAs established are crucial to protecting endemic WIO species, including the WIO coelacanth (*Latimeria chalumnae*), fish eagle (*Haliaeetus vociferoides*), big-headed turtle (*Erymnochelys madagascariensis*), and Madagascar teal (*Anas bernieri*); endangered species such as dugongs, leatherback and hawksbill turtles; and key bird nesting sites. The majority of these MPAs were established nearshore and covered coral reefs, mangroves and seagrass habitats, which translates to the protection of 17 per cent of the combined East African coastline (Chadwick and others, 2021; Richmond and others, 2021).

Despite the progress made towards achieving the Aichi Target 11, most offshore features (eg banks, seamounts) within the EEZ of WIO nations remain unprotected (Chadwick and others, 2021; Richmond and others, 2021). Furthermore, recent studies have found that MPAs are not connected, with significant gaps in connectivity conservation as envisaged in biodiversity conservation policies. Hence, more effort is required to protect these important habitats and processes. In addition to the area expansion, WIO governments need to exert more effort to improve the management performance of their existing MPAs (Chadwick and others, 2021; Richmond and others, 2021). An evaluation of 101 established MPAs showed that most MPAs were not effectively managed. Most of the MPAs assessed do not have sufficient financial, technical and human resource capacity and infrastructure to support operations. This lack of capacity have led to weak enforcement and continued illegal activities in most MPAs in the region (Chadwick and others, 2021; Richmond and others, 2021).

The MPA Outlook development not only showed progress towards achieving international targets. It also described the strengths of WIO governments in MPA establishment and management and the opportunities for improvement. This includes having strong legal bases for establishing and managing MPAs, and institutional support through regional cooperation and other governance arrangements across different WIO governments and academic and non-government institutions (Tuda and others, 2019, 2021; Richmond and others, 2021). The WIO states are already sharing experiences through various regional fora organised by the UNEP Nairobi Convention Secretariat and WIOMSA. The governments could still enhance their efforts further by aiming to establish a regional MPA network (Richmond and others, 2021). The regional MPA network in the WIO can include transboundary arrangements between governments and national MPA networks (Figure 1A and B). Currently, the proposed marine transboundary conservation area between the shared border of Kenya and Tanzania is being championed as the model for co-developing shared MPAs (KWS and MPRU 2015; Tuda and others, 2019). In terms of developing national MPA networks, Madagascar has organised a network of locally-managed marine areas (LMMAs) through MIHARI in addition to its government efforts (Mayol 2013). This is an important development, particularly since LMMAs can be considered as OECMs and contribute to achieving biodiversity goals. Since these OECMs involve communities and indigenous groups in management, they can be an effective and sustainable conservation measure because they tend to be more socially acceptable (Gurney and others, 2021; Mayol 2013; Rocliffe and others, 2014).

Regional and global outlook

To establish a regional MPA System in the WIO or the WIOMPAS, it is important to consider the feedback relationship between individual MPAs and MPA networks (Figure 2). A functional network depends on effectively and sustainably managed individual MPAs; however, individual MPAs can benefit from being part of functional networks since networks contribute to enhanced recovery and improved management due to synergistic effects across connected ecosystems and coordinated governance (Horigue and others, 2012; Horigue and others, 2014). More specifically, the ecological component of MPA

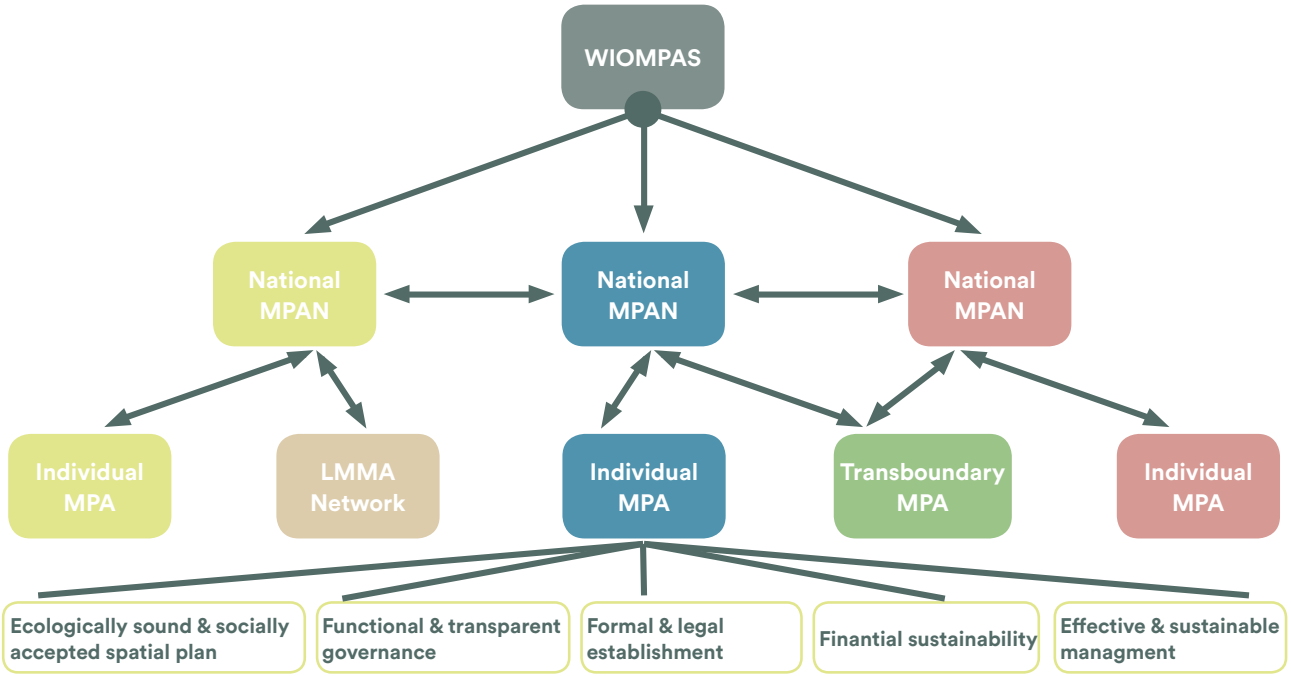

Figure 2. A systematic framework for strengthening and formally establishing the WIOMPAS through the coordinated establishment of national MPA networks that include different MPA types and governance arrangements.

networks is a system of individual MPAs that work synergistically to increase protection and ensure persistence of biodiversity inside and outside of MPAs (Abesamis and others, 2017; Grorud-Colvert and others, 2014). The social component of MPA networks helps increase the management effectiveness of individual MPAs due to the collaborative actions of individual MPA management and governance units (Lowry and others, 2009; Horigue and others, 2014). The ecological networks also depend on the effective and sustainable implementation of individual MPAs and coordination across different governance actors. The success and functionality of networks require an effectively designed system of individual MPAs implemented at various spatial scales and sustained implementation of individual MPAs (Lowry and others, 2009; Weeks and others, 2014; Horigue and others, 2015). The sustainability of individual MPAs relies on (1) functional and transparent governance; (2) formal and legal establishment; (3) availability of sufficient financial resources; and (4) continuous and adaptive management activities. (Horigue and others, 2012; Horigue and others, 2014). Hence, achieving sustainable management of the WIOMPAS will require concerted efforts from MPA managers, enforcers, governments, communities and other institutions to create networks at the national and sub-regional levels.

A systematic framework is necessary to strengthen the WIOMPAS. This framework will be used as the roadmap to describe the ecological and social components needed to develop and sustain national MPANs in the region (Figure 2). The ecological component of the WIOMPAS will include recommendations on the placement of MPAs that will be based on a systematic conservation planning process. Systematic conservation planning is a regional planning process that helps design efficient and socially acceptable conservation areas (Margules and Pressey 2000; Pressey and Bottrill 2009). It is adaptable to different contexts, including situations that have data limitations (Ban and others, 2009; Weeks and others, 2010). Using the systematic conservation planning process can also help ensure that the proposed design for the WIOMPAS adheres to ecological design principles and will be sensitive to the needs and other social and economic objectives in the region (Horigue and others, 2015; Weeks and others, 2015). The proposed MPAs in the network could include government-led conservation areas, OECMs, and transboundary conservation areas managed by the governments and communities.

The social component of the WIOMPAS, on the other hand, will form the institutional arrangements to support effective implementation and sustained

good governance of MPAs and national networks. Developing these institutional arrangements will require a series of government and stakeholder meetings and bilateral agreements to coordinate the establishment and management of different MPA types. Elements of the social MPAN already exist in the region. These include the network of MPA managers and conservation scholars, leaders, and advocates organised by WIOMSA and the structures set by the UNEP Nairobi Convention. The Contracting Parties and the network members are already organising themselves and supporting different MPA initiatives (Richmond and others, 2021). However, there is still a need for improving coordination and reporting mechanisms to support the development of national MPANs and the WIOMPAS.

The WIOMPAS roadmap will also include guidelines to institutionalise monitoring and evaluation and regular reporting of the status of individual MPAs. Using the MPA Outlook as a baseline, the Contracting Parties could regularly monitor management performance, MPA staff competency, and MPA outcomes to gauge the effectiveness of conservation efforts in the region. Regular monitoring and evaluation, and reporting are important because it helps complete the adaptive management cycle. Consistent monitoring and reporting can also document and share best practices, identify gaps in management and knowledge, and increase transparency and accountability in governance.

Lastly, the WIOMPAS must be integrated into broader planning and management frameworks such as integrated coastal zone management and marine spatial planning (MSP) to ensure that ecosystems that underpin human well-being are protected and reduce conflict with other coastal maritime activities. Creating the WIOMPAS aligns with the proposed WIO MSP Strategy developed by Nelson Mandela University with support from the UNEP Nairobi Convention (Lombard and others, 2021) (See CP 8/10(4) and CP 9/10). The proposed regional MSP Strategy suggests developing and integrating MPA networks at the national level within governments' MSP processes and spatial management plans. Embedding the WIOMPAS in MSP will aid in reducing the coastal and marine threats to MPAs. However, threats to coastal and marine ecosystems should be treated holistically and include the threats coming from land-based activities. Hence, the WIOMPAS must also be integrated with land-sea planning processes apart from integrated coastal zone management plans to consider the impacts of land-based activities, particularly in the face of global climate change and rapid urbanisation.

To strengthen the WIOMPAS, the Contracting Parties of the Nairobi Convention may need to consider the following:

- Develop and adopt a systematic framework to strengthen and formally establish the regional MPA System in the WIO (WIOMPAS) and ensure that the regional network adheres to ecological principles of MPA design and is sensitive to the social, economic, and cultural values in the region.
- Evaluate and identify other potential conservation areas in the WIO, which can be managed through different management schemes (ie individual governments or co-management schemes with communities, non-government organisations, and transboundary arrangements).
- At the national level, spatial planning processes must prioritise conservation areas and integrate them in broader land-sea and marine spatial planning processes to minimise threats to MPAs and ensure the persistence of biodiversity that WIO communities depend on.
- Institutional arrangements will be developed and adopted to ensure effective management of individual MPAs in the region, including mechanisms to regularly conduct and report results of monitoring and evaluation of MPAs established, management performance and competency of MPA staff, and have MPA representation in MSP stakeholder processes.
- Support capacity building initiatives and regular fora to help develop the knowledge and skills of different MPA leaders and personnel and align activities with the MSP Technical Working Group.

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WIO Science - Policy Platform Series
(1) 2022 139-144

A regional Marine Spatial Planning strategy for the Western Indian Ocean

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Summary

The need for a regional marine spatial planning (MSP) strategy was emphasised by the Parties to the Nairobi Convention (NC) and partners at a meeting to discuss MSP in the Western Indian Ocean (WIO) held in Dar es Salaam in March 2019. Here, the NC Secretariat was requested to work with partners to develop a strategy. From June 2020 to March 2021, a stakeholder process was undertaken to develop the principles and components of this regional strategy. The intention was to inform regional MSP processes and provide a framework for member countries to use as they develop their national strategy. Stakeholders identified the following vision for the regional strategy: "A WIO with inclusive and sustainable management of ocean and coastal ecosystem services for human wellbeing." The goal was defined as: "An inclusive and holistic MSP process that produces a regional marine spatial plan to support the sustainable management of ocean and coastal ecosystems for all." Based on an ecosystem-based approach to MSP, 11 objectives, nine strategic priorities and ten enabling mechanisms for implementing a regional MSP process were defined. The strategy adds a new dimension to global MSP practices by adopting a systems thinking approach (similarly proposed by the United Nations in 2014 for green economy policymaking). The strategy provides five strategic and four technical recommendations for member countries to consider. The strategy will be presented to the Tenth Conference of Parties to the Nairobi Convention (COP10) in November 2021 for consideration as an appropriate guidance document for the region. A complete draft of the strategy and its Appendices will be available from the Nairobi Convention Secretariat thereafter.

Background and rationale

Three years ago, Obura and others (2017) estimated the annual "gross marine product" (equivalent to a country's annual gross domestic product) of the Western Indian Ocean (WIO) region to be at least USD20.8 billion. The total "ocean asset base" of the region was estimated to be at least US$333.8 billion. Realising the value and importance of the ocean's natural capital, the WIO countries are undergoing rapid economic diversification and transformation with blue economy plans to further utilise their vast coastal and marine ecosystem goods and services. While agriculture, tourism and fisheries continue to be the mainstay in WIO economies, new sectors such as oil and gas, coal, mineral, and sand mining concessions are increasing in the region (ASCLME/SWIOFP 2012).

Developing a blue economy in Africa aligns closely with the African Union (AU) 2050 African Integrated Maritime Strategy (AIMS 2050) and the African Union Agenda 2063 – The Africa we want. In particular, Goal 6 of the agenda specifies that "Africa's Blue/ocean economy shall be a major contributor to continental growth and transformation through (1) Sustainable exploitation of marine resources and energy and (2) Streamlining of port operations and aquatic transport. Furthermore, Goal 7 of the strategy recommends sustainable use of resources through natural resource management and biodiversity conservation. The African Union also recognises the challenges (eg illegal fishing, pollution and piracy) that its member states face in realising the full potential of the blue economy. Therefore, the Africa Blue Economic

http://dx.doi.org/1x.xxx/wio.18

Strategy established a clear vision for the continent towards developing an inclusive and sustainable economy (AU-IBAR 2019). To achieve this vision and goals for the region, marine spatial planning (MSP) is one of many tools that can be used to build an inclusive blue economy that prioritises sustainability.

MSP, as defined by the Intergovernmental Oceanographic Commission (IOC) of UNESCO, is "a process of analysing and allocating parts of three-dimensional marine spaces (or ecosystems) to specific uses or objectives, to achieve ecological, economic, and social objectives that are usually specified through a political process". MSP is a process that is: ecosystem-based (balancing ecological, economic, and social goals and objectives toward sustainable development); integrated across economic sectors and among governmental agencies; place-based or area-based; adaptive (capable of learning from experience); strategic and anticipatory (focused on the long-term); and participatory, with stakeholders actively participating in the process" (http://msp.ioc-unesco.org/about/msp-facts/).

Various decisions and agreements were established at the previous Conference of the Parties (COP) to the Nairobi Convention[1]. MSP was identified as a tool for sustainable blue economic growth, capacity building, conservation and area-based management. Developing MSP in the region is also one of the priority areas of the Nairobi Convention Work Programme 2018-2022. Furthermore, the Nairobi Convention expressed the need to strengthen ocean governance in the WIO and apply MSP to achieve the Aichi Biodiversity Targets and the SDGs at a regional capacity building workshop held in Kenya in 2018. It was acknowledged that "MSP shows great promise if built on a foundation of reliable information, coupled with appropriately (multi-) scaled governance and institutions. MSP is useful to mitigate multi-sectoral stakeholder conflict, at multiple levels of coastal and ocean governance" (Nairobi Convention, 2018). Lastly, the need for a regional MSP strategy was emphasised by the Parties to the Nairobi Convention and partners at a meeting to discuss MSP in the WIO held in Dar es Salaam in March 2019. Here, the Nairobi Convention Secretariat was requested to work with partners to develop a regional strategy.

Although some of the WIO countries have developed spatial management plans and started implementing MSP, different coastal and marine economic sectors are still being managed individually, resulting in a lack of coordination in decisions and actions that negatively impact coastal and marine ecosystems goods and services. It is essential to apply a harmonised approach in developing coastal areas and utilising coastal and marine resources and space among all the competing needs and associated stakeholders. To achieve this, a regional approach to MSP can have added benefits by applying a broader perspective to some of the challenges associated with marine and coastal governance. A regional context provides an opportunity for joint learning, improved cooperation, and capacity building to support MSP implementation across the WIO region consistently. A regional strategy will aim to harmonise policy and legislative structures towards common goals and objectives of an ecosystem-based approach to ocean management, as endorsed by decisions at CoP 8 and CoP 9. A regional approach will provide a coordinated structure for knowledge and data sharing, incorporate broad stakeholder engagement and increase communication and collaboration with relevant organisations in the region. The regional MSP strategy will provide guidelines to achieve these overarching goals; however, successful implementation of sustainable development and planning will still rely on each country's ability to implement MSP in its national context.

Linkage to regional and global processes

The use of MSP as a tool to achieve global and regional objectives is emphasised by existing initiatives such as The IOC-UNESCO MSP programme, MSPglobal (international guidelines, pilot projects, roadmaps, expert panel), GEF LME: Learn platform with an MSP Toolkit and the European Union (EU)-MSP platform, among others. Numerous MSP projects linked to these platforms and initiatives emphasise the importance and value of conducting MSP to address challenges associated with conservation, area-based planning and management, sustainable growth and the cross- and transboundary issues associated with planning in the marine and coastal environment.

At a regional level, the development of MSP initiatives in the WIO is a key deliverable and output of ongoing regional projects such as the Strategic Action Programme for the protection of the Western Indian Ocean from land-based sources and activities (WIOSAP) and Western Indian Ocean Strategic Action Programme Policy Harmonization and Institutional Reforms (SAPPHIRE) funded by the Global Environment Facility (GEF) (Nairobi Convention, 2020). A regional MSP strategy will also build on the extensive

work that has been conducted in areas beyond national jurisdiction (ABNJ) (Wright and others, 2019), including understanding connectivity in the WIO (Maina and others, 2020, Popova and others, 2019), area-based planning (Macmillan-Lawler and others, 2018, Rochette and Wright 2015, UNEP-WCMC 2019a) and other research linked to the ABNJ Deep seas project. A framework for MSP in ABNJ has also been developed (UNEP-WCMC 2019b). These documents and reports will help guide the development of a regional MSP strategy. Collaboration among these research groups will establish valuable networks and capacity for MSP implementation at a regional scale. Furthermore, at a regional level, an MSP strategy for the WIO will build on and use valuable data and outputs from previous projects in the region, such as the detailed transboundary diagnostic analysis (TDA) linked to UNDP- supported GEF-financed Agulhas and Somali Current Large Marine Ecosystems (ASCLME) Project and the World Bank-supported GEF-financed South West Indian Ocean Fisheries Project (SWIOFP).

The Western Indian Ocean Regional Marine Spatial Planning Strategy

This paper presents the main aim and objectives of the MSP strategy and the process towards its development to date, including key concepts and strategic priorities to be included in the document. The overall purpose of the strategy is to support the WIO with principles and guidelines for national MSP initiatives that will address transboundary and cross-sectoral challenges. One of the main priorities of this project was to be as inclusive and transparent as possible, to develop a strategy that addresses the main needs and challenges in the WIO. A preliminary situational assessment included a stakeholder mapping exercise to identify the high-level institutions associated with MSP in the region and the key stakeholders that are either currently involved in MSP in the WIO or are likely to be key role players in the future MSP initiatives. Furthermore, at the WIO Regional MSP workshop held in Dar es Salaam, Tanzania, in March 2019, the Focal Points of the Nairobi Convention, and those who participated in the workshop recommended the development of a regional MSP Strategy be led by a Technical Working Group (TWG) hosted by the Nairobi Convention Secretariat. The TWG (two representatives from each country) were consulted to provide information and MSP updates for each of the respective member states.

The situational assessment was conducted to (1) broadly review regional and national policies, legislation and governance structures for MSP implementation; (2) identify current MSP practices and initiatives in the WIO; (3) identify capacity, gaps and opportunities for MSP; and (4) determine the status of MSP in the region or MSP "readiness" for planned MSP initiatives. The assessment aimed to apply this information to the development of the MSP strategy, identify opportunities for cross-border MSP across different governance structures, and provide broad guidelines and recommendations for MSP implementation at a national level in the region. Building on two preliminary reports, data and information for the situational assessment were gathered through a detailed literature review incorporating online grey literature and published reports but also published scientific articles. Additional national-level information was obtained through broader stakeholder engagement.

In an attempt to apply a bottom-up approach to developing the MSP strategy, a series of discussion questions were posed to the TWG and relevant stakeholders to identify the key issues in the region and challenges for MSP implementation, the main objectives and strategic priorities that should be included in a regional MSP strategy, and to identify the potential uptake and feasibility of MSP at a national level. Responses (n=19) were used to develop an online questionnaire, to which there were 28 responses, to develop the strategy further. Input from the TWG and stakeholders was used to determine the main challenges (governance issues and threatening processes) that need to be addressed in the WIO, the overall vision and goals for the MSP strategy, and a set of strategic priorities for MSP implementation, along with enabling mechanisms for implementation. Based on a series of foundational principles, this information was synthesised into a structural framework to guide MSP at a regional scale in the WIO (Figure 1).

A Systems Thinking Approach to Marine Spatial Planning

The regional strategy introduces and supports a systems thinking approach (see Figure 1: "Systemic perspective of strategic priorities"), previously articulated by the United Nations for green economy policymaking (UNEP 2014). Systems thinking and modelling encompasses a broad set of skills, tools, approaches, and processes well suited to complex, interconnected problems. The holistic nature of a systems perspective encourages the breaking down of the mentality of remaining in separate 'silos' (ie disciplines, departments, organisations). It requires that we overcome

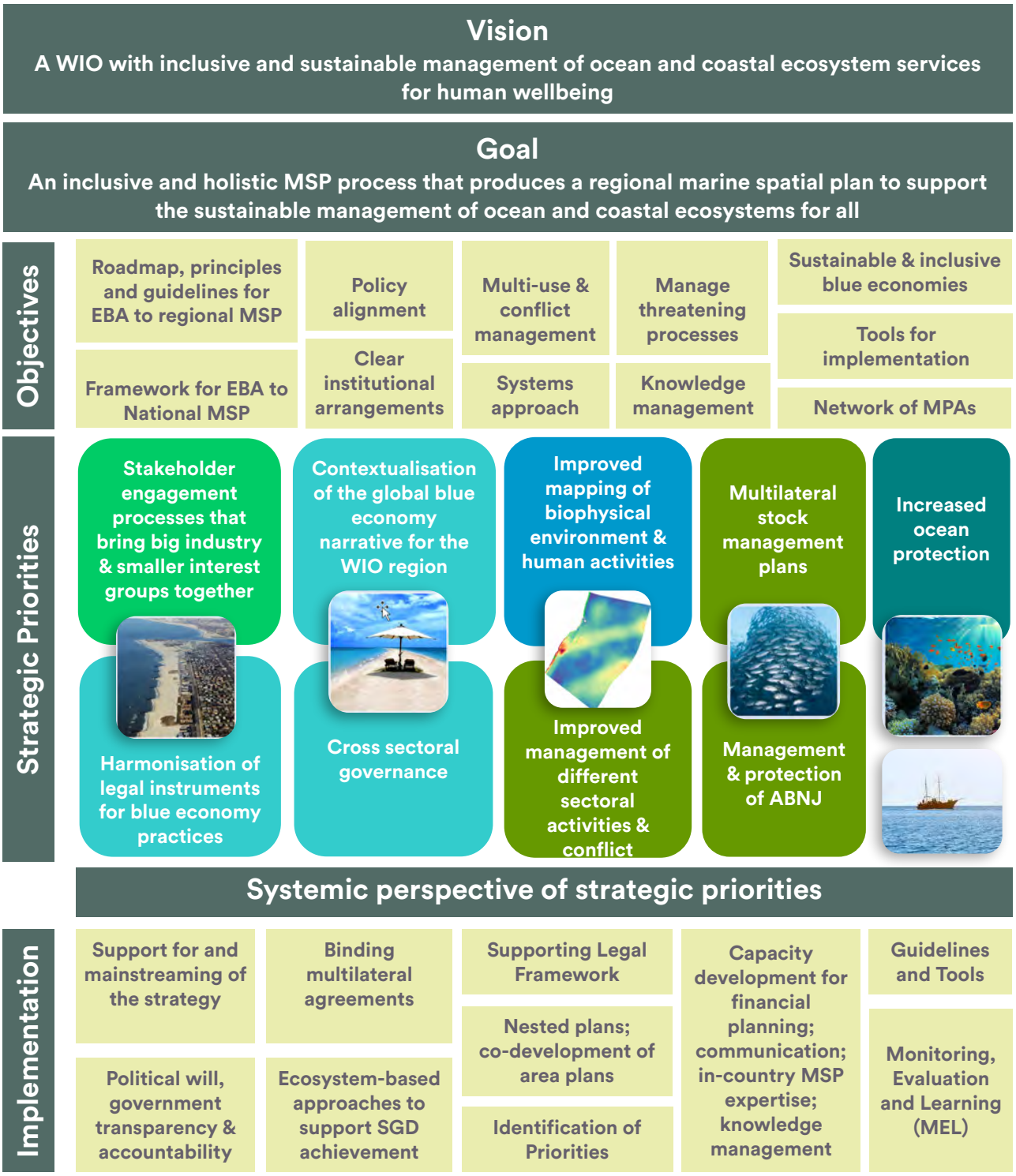

Figure 1. A structural view of the regional Marine Spatial Planning strategy for the Western Indian Ocean, based on questionnaire responses from the Technical Working Group members of member states of the Nairobi Convention and civil society stakeholders.

short-term and short-sighted decision-making while seeking a balance between a high-level (ie strategic) and more detailed (ie operational) perspective, helping to "see the forest for the trees" (https://learningforsustainability.net/systems-thinking/). Using systems theory as an approach involves making explicit the trade-offs between various options and actions and becoming clearer on the assumptions underpinning policies and actions. It also seeks to minimise the unintended negative consequences of policies and actions. Systems thinking in practice requires helping problem holders to see the world through the eyes of

others and mediating between conflicting ideologies, values, and ways of working.

Furthermore, it involves developing testing policies in a simulation environment, for example, by building simulation models (currently being developed at Nelson Mandela University as part of the Algoa Bay Project (https://algoabayproject.com/)). Another benefit of using the systems thinking approach is that it can consider the roles and impacts of time, area and scale on decision-making. Decisions made for a given area at a given time will have impacts (positive or negative) across space and times in the future. Therefore, novel systems thinking approaches will help identify these complexities and demonstrate their relationships, which is key to adopting MSP in the WIO region. The regional MSP strategy will not focus on providing solutions. Still, it will demonstrate how stakeholders can articulate desired scenarios for their country and the region and then understand how a regional MSP strategy can assist them in achieving their desired scenarios for effective management of their marine and coastal resources. The MSP strategy will serve as a guiding document to assist regional and national implementation of ocean governance systems and mechanisms. Achieving regional and international goals and overall ocean sustainability will depend on the effective implementation of the MSP strategy (among others) and activities in the region.

Recommendations

Recognising that countries of the WIO are at different stages and have different priorities with regards to MSP, both strategic and technical recommendations are provided as follows:

Strategic Recommendations (Actions for the parties to the Nairobi Convention)

Contracting parties are encouraged to:

- Support and mainstream this marine spatial planning strategy to achieve improved governance of the WIO.
- Harmonise in-country MSP development to support regional marine ocean use and planning without compromising national MSP processes.
- Adopt an ecosystems-based approach to MSP, according to the "Malawi Principles" and the IOI-UNESCO steps.
- Secure funding and develop capacity for regional and in-country MSP.
- Develop regional partnerships with regional economic communities (eg SADC), regional fisheries management organisations and other regional bodies and commissions (eg the IOC).

Technical Recommendations (Actions for the MSP Technical Working Group).

The technical working group is encouraged to:

- Provide a platform for shared learning and promote regional best practices.
- Promote an enabling policy environment for the development of in-country MSP legislation.
- Assist with establishing in-country cross-sectoral forums/committees/working groups to integrate sectoral policies and assist with the MSP process.
- Develop in-country knowledge management systems that contribute to, and benefit from, a regional knowledge management system.
- Develop a communication and stakeholder engagement plan to ensure co-development and support for regional and national area plans.
- Support capacity development within and between countries to support strategy implementation

In conclusion, this strategy will be presented to the Tenth Conference of Parties to the Nairobi Convention (COP10) in November 2021 for consideration as an appropriate guidance document for the region. A complete draft of the strategy and its Appendices will be available from the Nairobi Convention Secretariat thereafter.

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Fish and Fisheries

Illegal, unreported, and unregulated fishing in small-scale fisheries and impacts on ocean conservation and blue economy in the Western Indian Ocean

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Summary

The African Coastal waters harbour some of the most ecologically rich marine resources globally, supporting livelihoods, food security and other ecosystem services and serving as a substantial revenue stream for coastal communities. Yet increasing pressure from Illegal, Unreported and Unregulated (IUU) fishing threatens the vitality of the oceans and the communities that depend on them. IUU fishing activities in the Western Indian Ocean (WIO) region are particularly alarming, constituted by the destructive fishing practices of artisanal fleets and illegal industrial foreign-driven fishing. Taken together, IUU fishing practices cause overfishing and loss of habitat, loss of opportunities for income generation, physical injuries and loss of lives. The aggregate of IUU in the WIO and coastal regions worldwide costs as much as 80 billion USD per year in lost economic opportunity, impeding nations' ability to meet Sustainable Development Goals (SDGs) and Aichi Target 6 of the Convention on Biological Diversity. The Southern African Development Community (SADC) 16 member states, South-West Indian Ocean Fisheries Commission (SWIOFC), Nairobi Convention and other key institutions and partnerships demonstrate promise in supporting efforts to stop IUU Fishing and provide technical IUU Fishing Solutions. However, to date, many of the strategies being employed to halt IUU fishing and support sustainable fisheries management in the WIO focus on industrial offshore fishing, largely overlooking artisanal/small-scale fisheries. Artisanal/small-scale fisheries remain severely under-serviced and poorly regulated due to data scarcity, inconsistent policies, laws and regulations, and lack of consensus to counter IUU fishing and track the impact of anti-IUU fishing measures. There is an urgent need for information, analysis of data, sharing of data and collaboration to improve monitoring of small-scale fleets and small-scale fishing practices. Without substantial intervention, IUU fishing will continue to face the eradication of key artisanal fishery stocks, along with immense negative consequences to the larger marine ecosystem, coastal communities, and nations within the WIO and beyond. Both policy and technical solutions will be needed to curb IUU fishing in the WIO, including agreement by the Parties to the Nairobi Convention around IUU fishing as an environmental, social, and economic issue, the development of a WIO regional plan of action, completion of a WIO regional threat assessment, and the establishment of a regional inter-sectoral IUU fishing expert panel.

Background

African coastal waters contain some of the richest fisheries in the world and increasingly contribute to Africa's food security, foreign exchange, employment, and livelihood support services (Obiero and others, 2019). African fisheries provide an estimated economic value of more than US$24 billion, accounting for 1.26 per cent of the gross domestic product (GDP) of all African countries and have nearly doubled fish production over the last 20 years (de Graaf and Garibaldi 2014; FAO 2020). The African Union Development Agency estimates that 10.4 million tonnes of total fishery production in the region feed more than 30 per cent of the continent's population, or roughly

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200 million people (Obiero and others, 2019). As of 2018, the Food and Agriculture Organization (FAO) estimates that more than five million people in Africa work in the fisheries and aquaculture sector (FAO 2020). However, African fisheries and associated livelihoods are being threatened by illegal activities, requiring a coordinated regional approach involving cooperation across borders.

The Challenge of Illegal, Unreported and Unregulated fishing

IUU fishing is among the most significant global threats to securing sustainable fisheries for both present and future generations. In broad terms, IUU fishing refers to fishing activities that do not comply with regional, national, or international fisheries conservation or management measures.[1] IUU fishing encompasses a range of illicit activities, including fishing without permission or out of season; harvesting prohibited species; using outlawed types of fishing gear; disregarding catch quotas, or non-reporting or underreporting catch weights. In addition, fishing vessels of various flags have taken advantage of the absence of strong enforcement mechanisms in coastal countries (FAO 2007). Often connected to transnational crimes, including human rights abuses, piracy, and drug, arms, and human trafficking, IUU fishing poses a significant threat to global fisheries and the health and conservation of the ocean (Widjaja and others., 2019). Legal fishing activity and associated livelihoods are constantly being undermined by illegal activity. The use of illegal gear leads to species loss and diminishes biodiversity, which threatens food and economic security. In addition, unreported fishing creates inaccuracies in scientific data, resulting in challenges for implementing sustainable fisheries management practices (Widjaja and others, 2019). Illicit marine resource trade in Africa, including IUU fishing, is estimated to cost the continent between US$7.6 and US$13.9 billion and US$1.8 and US$3.3 billion in losses annually in economic and income impacts, respectively (Sumaila and others, 2020). Within African nations' Exclusive Economic Zones (EEZ), a substantial portion of the illegal catch is made by domestic artisanal fleets and industrial fleets encroaching into nearshore exclusive artisanal zones and/or small-scale fisheries (AU-IBAR, 2016).

IUU Fishing in artisanal fisheries in the WIO

IUU fishing activities conducted in artisanal/small-scale fisheries within the Western Indian Ocean (WIO) region are increasing at an alarming rate, resulting in negative biological, economic and environmental consequences that may undermine the future of sustainable fisheries (Drammeh 2007; Stop Illegal Fishing 2017). IUU fishing practices in small-scale fisheries, also commonly referred to as "overfishing" and "destructive fishing" practices, including the use of explosives and poisons to kill fish; the use of fine mesh fishing nets and other destructive gears and techniques; the use of traps and weirs; the destruction of mangroves and coral reefs; and the catch of juvenile and immature fish and invertebrates, among others (Widjaja and others, 2019).[2] In addition to destructive fishing activities conducted by artisanal fleets, industrial foreign-driven IUU fishing vessels often illegally encroach nearshore areas, commonly used by small-scale fishers. The encroachment may result in conflicts over spatial use of marine zones and food insecurity due to overfishing and damage to boats and gear (AU-IBAR 2016). Unreported fish catch consequences are substantial and affect coastal communities disproportionately, especially when considering that artisanal fisheries account for 50 per cent of the world catch and employ 90 per cent of all fishers (Fluet-Chouinard and others, 2018). For example, with more than a dozen countries fishing illegally in its waters, Somalia has lost millions of tonnes of fish, reportedly more than 80 per cent than officially reported. Consequently, it impacts the socio-economic fabric of its coastal communities and its ability to effectively and sustainably manage its fisheries (Makoni 2017). While artisanal/small-scale fisheries are critical for supplying employment and income, most research and strategies to combat IUU fishing are specific to offshore larger-scale industrial fisheries.

Advances

IUU fishing and governance within artisanal/small-scale fisheries remain severely under-serviced and poorly regulated due to several factors, including

[1] The FAO's International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU) provides the following definition of IUU fishing: Activities are classified as illegal fishing takes place when vessels or harvesters operate in violation of the laws of a fishery. Unreported fishing is fishing that has been unreported or misreported to the relevant national authority or regional fisheries management organization (RFMO), in contravention of applicable laws and regulations. Unregulated fishing generally, refers to fishing by vessels without nationality, vessels flying the flag of a country not party to the RFMO governing that fishing area or species on the high seas, or harvesting in unregulated areas. (FAO 2001)

[2] IUU fishing within small-scale fisheries is also commonly referred to as "illegal fishing," "overfishing" or "destructive fishing." In many cases, small-scale, artisanal catches are simply not reported because there is no official or legal mandate to record and report such catches, or even if there notionally is such a requirement, no data collection system or resources are in place to record and report all artisanal catches in many coastal communities.

inadequate research and support, insufficient human resources, and limited investments into sustainable fishery practices (Breuil and Yvergniaux 2014). The lack of sufficient data on the extent and impacts of IUU fishing performed by industrial fishing vessels and small-scale fishers within artisanal/small-scale fisheries restricts the ability to address the problem and measure the impact of any mitigating strategies. Furthermore, the inconsistent implementation of policies, laws, and regulations to counter IUU fishing and the general lack of cohesiveness and consensus amongst countries and their respective agencies weakens the impact of anti-IUU fishing interventions in the region. The lack of transparency and/or access to electronic data-gathering systems, insufficient information sharing between agencies and countries, general inability to accurately distinguish legal from illegal fish, and lack of capacity and resources hamper the ability to react to known IUU fishing threats.

Despite a growing IUU fishing problem impacting artisanal/small-scale fisheries in the WIO region, few actors have a comprehensive understanding of the scope and broader impacts of the problem. Economic incentives, weak governance, and barriers to enforcement remain primary drivers for IUU fishing, substantially undermining the potential for blue growth across the region (Widjaja and others., 2019).[3] A concerted regional effort is critical to addressing the key drivers of IUU in artisanal/small-scale fisheries. Given that most governments in the WIO region have limited capability or capacity to manage small-scale fisheries on a sustainable basis, local fisheries' administrations/local communities cannot combat IUU fishing activities alone.

Unregulated IUU fishing in the nearshore environment by industrial foreign-driven and artisanal fishing fleets may damage the marine environment, deplete fish stocks, decrease the value of fisheries, increase food security risks, and disrupt the social cohesion of coastal communities' (Widjaja and others, 2019). IUU will continue to be one of the leading barriers to effective marine conservation efforts, limiting positive impacts for communities, thwarting management effectiveness and impeding the potential expansion of spatial protections such as marine protected areas (MPAs) and Locally Managed Marine Areas (LMMAs).

[3] Blue growth, or environmentally sustainable economic growth based on the oceans, is a strategy of sustaining economic growth and job creation necessary to reduce poverty in the face of worsening resource constraints and climate crisis.

Along with lost social and environmental conservation opportunities, continued IUU fishing results in substantial net losses to countries' economies. Eliminating IUU could add US$30 to $45 billion to the GDP of coastal states in Africa, increase job opportunities, support livelihoods, increase social protection and reduce food insecurity and poverty in many of Africa's poorest countries (AU-IBAR 2016).

Efforts to Combat IUU

Globally, IUU fishing costs roughly US$80 billion annually in foregone economic benefits. Consequently, economic growth and food production, and the ability of coastal states to meet several of the 2030 Sustainable Development Goals (SDGs) and Convention on Biological Diversity's Aichi Target 6 are undermined (The World Bank 2017).[4] A failure to curb IUU fishing will result in a widespread inability to meet the SDGs, including SDG 1: No Poverty; SDG 2: No Hunger; SDG 3: Good health and well-being; SDG 8: Decent works and economic growth; SDG 11: Sustainable cities and communities; SDG 14: Life below water; SDG 16: Fostering peace and justice and strong institutions; and SDG 17: Partnerships for the goals. By agreeing to SDG targets 14.4 and 14.6, countries aim to "end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices," and "prohibit certain forms of fisheries subsidies that contribute to overcapacity and overfishing and eliminate subsidies that contribute to IUU fishing [by 2020]" (UN General Assembly 2015).

SADC

The Southern African Development Community (SADC) 16 member states have estimated an annual loss of US$200 million from IUU fishing, with impacts being felt at community levels (Stop Illegal Fishing 2017).[5] SADC has initiated capacity-building efforts and policies, including the *2008 SADC Statement of Commitment to combat illegal, unreported and unregulated (IUU) fishing* (Stop Illegal Fishing 2017). In collaboration with several countries within the WIO region, SADC is establishing a Regional Fisheries Monitoring Surveillance Coordination Centre (MCSCC) in

4 Target 6: By 2020, all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem-based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.

5 Comprises 16 Member States: Angola, Botswana, Comoros, Democratic Republic of Congo, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Tanzania, Zambia and Zimbabwe.

Mozambique to implement the regional MCS strategy for promoting regional cooperation on MCS. FISH-i Africa is a regional Task Force of MCS officers that is being incorporated into the SADC MCSCC. This Task Force has enhanced regional cooperation, coupled with dedicated intelligence, analysis and technical expertise inhibiting illegal catch from getting to market and preventing illegal operators from pursuing their lucrative business. Although some countries within the WIO region have acknowledged the importance of combatting IUU fishing, many will fall short of this goal without an immediate, forceful, and unified effort.

SWIOFC

The South-West Indian Ocean Fisheries Commission (SWIOFC) is a regional fishery body established by the FAO Council to promote the sustainable development, conservation and management of shared resources in its region and serves as a critical platform in its region for any fisheries management issues. Ten out of twelve SWIOFC members are parties to the FAO Port-State Measures Agreement (PSMA), the first binding international agreement to target IUU fishing by preventing vessels engaged in IUU fishing from using ports and landing their catches. The effective implementation of the PSMA in the SWIO region contributes to the long-term conservation and sustainable use of living marine resources and marine ecosystems. Inspired by the PSMA, the Indian Ocean Tuna Commission (IOTC) adopted a resolution on Port State Measures Resolution (IOTC Resolution 10/11, superseded by Resolution 16/11 to Prevent, Deter, and Eliminate IUU Fishing).

The Nairobi Convention

The Nairobi Convention provides the regional framework and platform for the protection and sustainable use of the coastal and marine environment, building capacity, sharing of information and commitment by parties to advance the region's blue economy (United Nations Environment Programme / Nairobi Convention 2020). Regionally, the Nairobi Convention member states have endorsed the FAO Code of Conduct for Responsible Fisheries and have implemented various action plans, including developing national strategies to counter IUU fishing. The Convention offers a solid administrative framework for addressing IUU fishing in artisanal/small-scale fisheries in the WIO due to the existing political mandate for regional marine conservation and fisheries policies and governance.

There are many other foundations and partners supporting efforts to stop IUU at the global and regional levels (Table 1)

Outlook for Regional and Global

The need for data and technical solutions to address IUU fishing in WIO artisanal/ small-scale fisheries

Artisanal/small-scale fisheries are an important source of employment and income, supporting an estimated quarter of a million fishers throughout the WIO region (Obura 2017). However, most strategies to overcome the IUU catches focus on large stocks and larger ships in the offshore environment (Widjaja and others., 2019). The Indian Ocean Commission Regional Fisheries and Aquaculture Strategy (2015-2025) states that technical assistance and investments into building coastal fisheries management capacity have been made. However, it acknowledges that addressing IUU fishing and governance within artisanal/small-scale fisheries remains severely under-serviced and poorly regulated due to several factors. These include limited understanding and support, insufficient human resources, and limited investments into sustainable fishery practices (Breuil and Yvergniaux 2014). The lack of conclusive data surrounding the extent and impacts of IUU fishing performed by industrial fishing vessels and small-scale fishers within artisanal/ small-scale fisheries restricts the ability to address the problem being faced and measure the effectiveness of any anti-IUU fishing actions. Furthermore, the inconsistent implementation of policies, laws, and regulations to counter IUU fishing in the region and the general lack of cohesiveness and consensus amongst the countries and their respective agencies weakens the impact of anti-IUU fishing interventions. The lack of transparency and/or access to electronic data-gathering systems, insufficient information sharing between agencies and countries, general inability to accurately distinguish legal from illegal fish and lack of capacity and resources hamper the ability to react to known IUU fishing threats.

There is an urgent need for information, data analysis and sharing, and collaboration resulting in improved monitoring of small-scale fleets and small-scale fishing behaviour (Anderson 2011). Technology is increasingly being used to track and identify vessels suspected of conducting IUU fishing activities offshore, allowing for targeted enforcement operations against the suspected vessels and the owners of the businesses. Satellite tracking and other cost-effective technologies and

Table 1 Foundations/ Partners Supporting Efforts to Stop IUU Fishing

Foundations/ Partnerships Supporting Efforts to Stop IUU Fishing	
Moore Foundation	The Moore Foundation Environmental Conservation Program balances long-term conservation with sustainable use. They establish models for collaboration that can be replicated and expanded around the globe. And we seek to create lasting change in how land, freshwater and coastal marine ecosystems are managed.
Oceans *5* Alliance	Oceans *5* is an international funders' collaborative comprised of new and experienced philanthropists dedicated to protecting the world's five oceans. They focus their investments on projects and campaigns to establish marine reserves and constrain overfishing.
Oak Foundation	Oak Foundation commits its resources to address global, social, and environmental concern issues, particularly those that have a major impact on the lives of the disadvantaged.
Kingfisher Foundation	The Kingfisher Foundation is a family foundation founded in 1998. Their goal is to restore and preserve the health and resilience of marine fish populations by reducing or eliminating illegal, destructive and economically unviable fishing practices. Kingfisher invests in and promotes innovative ideas and practices to align economic incentives and public policies with sound fishery management and effective conservation.
Blue Nature Alliance	The Blue Nature Alliance is an ambitious global partnership that collaborates with governments, NGOs, Indigenous peoples, and scientists to advance effective large-scale ocean conservation. The Alliance aims to catalyse the conservation of 18 million square kilometres of the ocean over five years.
NGOs Supporting Anti-IUU Initiatives in the WIO	
Wild Oceans	Wild Oceans is working in the WIO region to combat illegal fishing and unsustainable fishing practices. Wild Oceans is well-placed to play a key role in a regional effort bringing strong technical, networking and research skills to the table.
Stop Illegal Fishing	An African-based Not for Profit organisation works closely with governments, civil society, NGOs, intergovernmental with the SADC, supports FISH-i Africa, and coordinates the technical team.
WWF	WWF has facilitated the organisation of local fishing communities and helped build their capacity to combat illegal fishing, create alternative sources of income, and implement environmental education programs.
RARE	RARE addresses coastal overfishing by working directly with community fishers to establish clear rights, strong governance, local leadership, and participatory management to ensure local communities capture benefits from conservation and fisheries management activities.
The Nature Conservancy	TNC works with national governments, regional bodies and the fishing industry in the WIO to address IUU fishing, improve transparency at sea and codify best practices into fisheries management policies.
Technical Companies with IUU Fishing Solutions	
Global Fishing Watch	Has proven success in advancing ocean sustainability and stewardship by using technology to visualise, track and share data about global fishing activity in near real-time at no cost.
Trygg Matt Tracking	Trygg Matt Tracking is a Fish-i Africa technical team member by providing its fisheries intelligence analysis and vessel tracking to national authorities and relevant international institutions supporting anti-IUU fishing operations.
Sea Shepherd	Has assisted in countering IUU fishing in most oceans of the world. They have recently partnered with African governments, including Gabon, to effectively address IUU fishing within African waters.
Allen Institute for AI (AI2)	With the Skylight Alerting platform, AI2 has focused its anti-IUU efforts offshore. Combining Skylight with their EarthRanger protected area platform, AI2 will have the ability to track and monitor industrial foreign-driven vessels both near- and offshore. This will enable MPA/ LMMA managers and fisheries officers to make informed decisions on artisanal vessel activities by combining and analysing real-time data from remote imaging, through sensors and from information from observations.

tools exist through Global Fishing Watch, OceanMind, Trygg Matt Tracking, and Skylight. In parallel, there has been experimentation with onboard cameras and other remote observation tools by fisheries inspectors and enforcement officers that have increased the success of operations. The use of technology for nearshore artisanal fishing has seen limited success since many vessels don't possess Automatic Identification System (AIS) and Vessel Monitoring System (VMS) technology. Port inspections, stronger regulations, awareness workshops, technical advancements and, to some extent, satellite imagery are being used in an attempt to address this.

This paper calls for a regional plan of action to better understand and address IUU fishing by both small-scale fishers and industrial fishing vessels occurring within artisanal/small-scale fisheries of the WIO region, with a particular emphasis on programs to improve information, raise awareness, and devise strategies to curb those illegal activities. There is an urgent need for collective regional effort (in the form of long-term support to national Governments) prioritising research, information sharing, capacity building, and strengthening Monitoring Control & Surveillance (MCS) systems. An integrated and participatory approach to sustainable development and management of small-scale fisheries involving all stakeholders (resource users, academia, civil society, and Governments) is recommended.

Policy Recommendations for member states of the Nairobi Convention

- Achieve recognition and agreement by the Parties to the Nairobi Convention that IUU fishing conducted by both industrial fishing vessels and small-scale fishers within artisanal/small-scale fisheries is a pervasive threat. The threat goes beyond sustainable management of ocean and coastal resources and poses a significant risk to the region's economic development and social welfare.
- Achieve recognition and agreement by the Parties to the Nairobi Convention that IUU fishing risks the achievement of SDGs and blue economy initiatives at both a country and regional level, endangering food security, sustainable livelihoods, and social protections.
- Develop a WIO regional plan of action by the Parties to the Nairobi Convention to address IUU fishing performed by industrial fishing vessels and small-scale fishers within artisanal/small-scale fisheries and unlock the full potential of the blue economy in alignment with and in support of other regional efforts.

  The plan will include:

  1. assistance and support to national Governments to elaborate legislation and regulations for small-scale fisheries;
  2. improving research and information gathering to create awareness and sensitisation of fishing community and policymakers on biodiversity and the sustainability of resources; and
  3. strengthening local fisheries organisations and institutions for community-based and/or participatory management, co-management, and improving MCS in small-scale fisheries.

Technical Recommendations

- Conduct a WIO regional threat assessment focusing on IUU fishing practices by both industrial fishing vessels and small-scale fishers within artisanal/small-scale fisheries. Without first understanding the extent of the threat in the region, IUU fishing will continue to impact the ability to deliver on blue economy initiatives and achievement of the SDGs by countries within the WIO and the region at large. The threat assessment will include:

  4. the full scope of IUU fishing conducted by both industrial fishing vessels and small-scale fishers within artisanal/small-scale fisheries;
  5. the extent of the threat of IUU fishing to coastal resources and the broader impacts on the blue economy, which links to SDGs, food security, poverty, etc;
  6. how IUU fishing impacts the ability of LMMAs and MPAs to function effectively both from a conservation and blue economies perspective; and
  7. opportunities where technology can enhance collection, dissemination, and analysis of information to promote active management, real-time situational awareness, and improved business information systems to inform management decision-making.
- Mobilise actors' networks and establish a regional inter-sectoral IUU fishing expert panel. The political will to address IUU fishing is still constrained by limited knowledge and consensus mechanisms in the region. There is a need to establish a regional inter-sectoral expert panel on IUU fishing threats and solutions to facilitate sustainable ocean-based economic, social, and environmental benefits and share strategies that

are part of or aligned to the SADC efforts. The panel may include academia, government, policymakers, industry and traditional and indigenous knowledge holders.

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Cities and Blue Economy

Building the Blue Economy of the Coastal Cities of the Western Indian Ocean (WIO)

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Summary

Cities are critical and vital nodes for human settlements and essential in nurturing the systems' value and maintaining life. Along with coastal cities, urbanization is active in using the city space and the generation of new public and private spaces. The coastal city nexus offers settlements, services and a variety of challenges. In addition, the nexus brings in several concepts, the most important of which is The Blue Economy (BE) concept. It is a key component of coastal economic empowerment, sustainable development, and ecosystem management. Cities and local governments play a critical role in developing coastal space and coastal landscape. Municipal and local governments must play a key role in facilitating land-sea planning and providing more space for coastal investment prioritization. Proper and strategic positioning will result in an increase in income for low income and informal settlements that depend on coastal ecosystems for their daily sustenance. In the WIO region, the blue economy must be viewed not only as a method of extracting resources but also as a method for integrating the cityscape and the seascape protectively and productively. For the two systems to co-exist for futuristic development, the economy is critical in enhancing the livability of the coastal communities and a manageable force in driving urbanization. BE and coastal cities nexus can only be realized through a robust governance system that allows adjustments. Enhanced programs and plans for the coastal communities, enhanced financial support and increased fiscal energy invested in the municipality will increase the capacity of the municipality to achieve BE. Several blue economy sectors can benefit the cities, such as fisheries, waterfront development, maritime transportation, port infrastructures, coastal tourism, and bioprospecting. WIO cities are at different levels of fiscal capacity, governance levels, city planning, and infrastructure development that supports the blue economy. Several points of departure and weaknesses in enhancing BE in the WIO region include different Municipal Governance systems and their low fiscal capabilities and cooperation within the region. To enhance a strategic WIO regional BE outlook, the country based enhanced operational environment can facilitate shared experiences with cities in other countries. Again, integrated governance systems can assist the less developed blue economy sectors and countries, enhancing synergies and economic strength and research on BE. The development of a blue economy and strengthening coastal cities in the WIO region relies on measures that enhance multilevel urban risk and blue economy management, alignment of policies and incentives for proper use of the land-sea management, strengthening of the local government and community capacity to participate and enhance the blue economy agenda as well as synergies with the private sector, appropriate financing and plans to manage the blue economy sector and the institutional capacity development of blue economy in education and consistent research.

Background and Regional outlook

At the Ninth Meeting of the Conference of Parties to the Nairobi Convention (COP 9) held in Mombasa, Kenya in August 2018, Contracting Parties to the convention recognised for the first time the need to partner with UN-Habitat to address the environmental challenges and opportunities posed by rapid urbanisation, especially of coastal cities in the WIO region as articulated in the SDG 11 and the New Urban Agenda (NUA). Further, COP 9 urged Contracting Parties to consider undertaking climate change vulnerability assessments of their urban coastal areas, including urban spatial planning processes and integrating marine natural capital (UNEP 2018, UNEP/NC/COP/9/9). In addition, the Convention Secretariat was requested to collaborate with UN-Habitat and

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other partners to develop a regional action plan and roadmap to assist the Contracting Parties in integrating the NUA into coastal cities of the WIO region for the protection of the marine and coastal environment (UNEP 2018, UNEP/NC/COP/9/13).

Blue economy policy and strategy are still in their infancy at national and local levels in several WIO countries. However, the concepts of the blue economy are taking shape in the region, with some Contracting Parties having developed and implemented blue economy actions and strategies at national levels. For example, South Africa's Operation Phakisa (Findlay 2018) is an integrated tool and platform to enhance the blue economy nationally. Mauritius and Seychelles have also progressed in integrated coastal systems management of the land-sea interface while improving national blue economy sectors. Kenya hosted a high-level blue economy conference in 2018 with over18 000 participants worldwide, initiating meaningful dialogue on the blue economy.

The linkages between environment, society, and economy in coastal cities are essential in fostering and enhancing a sustainable blue economy in the WIO region. Therefore, there is a need to better understand their interdependencies and the associated constraints for sustainable development. If appropriately managed, coastal cities can offer better socio-economic conditions and quality of life to residents and the broader context in which they are situated. Therefore, the integrated adaptive management and sustainable development of coastal cities and their marine environment are essential.

It is against this background, and in response to the COP 9 decisions, WIOMSA, in collaboration with UN-Habitat, commissioned a series of studies on the status of the blue economy in four cities in three WIO nations.

- The case studies for four cities based on primary research include Mombasa and Kilifi (Kenya), Dar es Salaam (Tanzania) and Port Louis (Mauritius). These in-depth city case studies are provided as separate reports, informing both the roadmap and this Status Report.
- The status report is essential to identifying areas and institutions that need to be enhanced or created within the region to improve coastal communities and urban-ocean sustainability. Apart from fostering regional initiatives as part of the Nairobi Convention, the report's outcomes will also address critical global initiatives that include SDG 11 on sustainable cities and communities. SDG 14 protects marine resources, improves food security and economic status, and creates partnerships to enhance WIO cities' livability while guarding against climate change hazards.
- The Status Report sets the scene for a final document, the *'Roadmap for the development of the blue economy in coastal cities*". The study is informed by secondary research across the region and primary research in 4 cities – Mombasa, Kenya; Kilifi, Kenya; Dar es Salaam, Tanzania; and Port Louis, Mauritius. The Status Report is a knowledge resource for city and national government stakeholders, WIOMSA, UN-Habitat and other partners. The report highlights the importance of cities to the blue economy, interdependencies across its sectors, social, economic and environmental and impacts and broader urban systems, and the value of coordinated planning.
- The *'Roadmap for the development of the blue economy in coastal cities*' (WIOMSA and UN-Habitat,

2021a)- responds to challenges and opportunities identified in more comprehensive research and provides specific blue economy recommendations for WIO cities and their stakeholders, including but not limited to city and national government stakeholders, WIOMSA, UN-Habitat, donors, private and civil society organisations. The roadmap report focuses on specific policy and operational, blue economy actions for cities, rather than theoretical or conceptual approaches on how cities relate to the blue economy.

Production of the reports

The six reports blend secondary research across cities of the WIO region and primary findings from the city case study research. Based on learning from the desktop phase, Dar es Salaam, Port Louis, Mombasa and Kilifi Town were selected as case study cities. Specific factors which influenced choice are as follows: a desire to choose at least one mainland and one island city; selection of cities which allowed exploration of key blue economy themes that emerged in the desktop research phase (a port city, a tourism hotspot, a city with solid fishing sector connection and a rapidly growing smaller city); and logistics related to travel and availability of interviewees.

Key informant interviews and focus group discussions were the primary means of field investigation, engaging key stakeholders across blue economy sectors and stakeholder types (government, academia, private and civil society). Researchers consulted 85 stakeholders across the four cities. Field research obtained and analysed data for major blue-economy industries' economic, social, and environmental dimensions using the strengths, weaknesses, opportunities, and threats (SWOT) analytical framework to gain an in-depth, balanced understanding of the city-blue economy relationship. Semi-structured interviews were used to elicit stakeholders' thoughts on overarching city blue economy strengths, weaknesses, opportunities, and threats before exploring specific blue economy sectors with which the stakeholder was involved (e.g., fishing, tourism, and maritime transport and shipping). The final chapters of this Status Report summarise key blue economy issues for WIO cities and highlight some critical recommendations detailed in full in the roadmap. Proposals responded to the city challenges and opportunities uncovered during the primary and secondary research. The roadmap uses a modified Delphi methodology to prioritise a long list of blue economy recommendations (WIOMSA and UN Habitat, 2021b)

This research was carried out between January 2020 and early March 2021 before and after the COVID-19 outbreak. Findings reflect that, although the impacts of COVID-19 were largely acknowledged, before-after perceptions differed. Generally, the long term economic, social and environmental impacts of the pandemic and the blue economy are yet to be fully established.

Summary of the main findings

Importance of cities to the blue economy

Coastal cities are gateways of trade and transport for countries in the WIO region and essential blue economy activity and infrastructure sites, including ports, airports, hotels and fish markets, and the workforce that supports key blue economy sectors. These sectors do not necessarily exist in harmony and must manage competing demands. Coastal cities are also sites of significant urban population growth, which is unplanned and vulnerable to climate-induced hazards, including sea-level rise and coastal flooding. Urban growth challenges are not limited to major coastal cities but are also experienced in rapidly growing smaller secondary cities. The smaller cities are often unplanned and lack corresponding infrastructural development. These challenges play out at the city level and should be recognised in blue economy policy and operational action.

Blue economy governance and varying city influence

The influence of local authorities on the blue economy differs considerably across WIO countries, linked to decentralisation and fiscal autonomy. Mainland cities with a more advanced devolution process (eg Durban, Mombasa and Dar es Salaam) have significant responsibility and budgetary independence. In Mozambique, cities have devolved responsibilities but have lower fiscal and administrative capacity. In Comoros and Madagascar, local authorities offer a more stable government. Still, they are undermined by low budgetary capacity. In Seychelles and Mauritius, city authorities typically have much lower responsibility than their mainland counterparts and little blue economy planning and implementation. Nationally driven blue economy projects and FDI play a crucial role across WIO cities.

Even cities with limited blue economy responsibility provide essential municipal services supporting or undermining blue economy sectors (WIOMSA and UN Habitat, 2021b). It is, therefore, crucial that all

local authorities are engaged in blue economy planning where aspirations of urban planning are merged with the marine sector. WIO countries are at different blue economy strategy formulation stages and Marine Spatial Planning (MSP). Seychelles, Mauritius, South Africa and Kenya have made the most progress. In Kenya, MSP is carried out at the national and local levels. The blue economy strategy development and MSP are part of a complex ocean governance network. Integrated coastal zone planning is important in enhancing the urbanscape and protection of the urban form and ocean waters' protection and sustainable use. Locally Managed Marine Areas (LMMAs), classified as Other Effective Area-Based Conservation Measures (OECMs), complement the Marine Protected Areas (MPAs) and engage local communities in marine conservation. Designated coastal waters protection ultimately ensures the future sustainability of ocean resources and future sources of food and livelihood for urban residents while mitigating some of the more comprehensive environmental damage of urbanisation processes.

Sector-specific challenges and opportunities

Ports are crucial to nations economic development, commonly measured as GDP, and the overall cities' socio-economic performance. This is illustrated by the port of Durban, which employs 53 000 people directly and another 50 000 indirectly. Ports are typically national assets and are operated at the national level, with local authorities' little or no involvement in port operations. Ports are therefore subject to decisions made at the national level, which may conflict with city aspirations. Nationally, there is a need to ensure that ports are supported by sufficient economic infrastructures such as road and rail. While authorities may want to have greater input in city port operations at the local level, they must ensure that the city economy is sufficiently diverse to limit reliance on ports, often outside their control. In addition, ports in the WIO pose significant challenges to local waters through shipping processes, including fuel and ballast water and land reclamation. Future port investment in WIO cities needs to adopt a green port approach and certifications to minimise environmental and cascading impacts on the environment and other blue economy sectors such as fishing and tourism.

Coastal areas and coastal cities are vital to the tourism sector in many WIO countries. For example, Durban accounted for 24 per cent of South Africa's tourism earnings in 2015, and coastal tourism provides around 60 per cent of overall tourism earnings in Kenya. For coastal cities, challenges include protecting the tourism sector from external shocks (such as terrorism and pandemics). These shocks can dramatically affect visitor numbers and ensure that tourist spending in cities filters down to local communities rather than remaining foreign-owned, all-inclusive hotels. Cities facing such challenges have been exploring ways to better cater to domestic visitors and conference guests, who are less susceptible than international tourists to external shocks and are more likely to visit and spend money in local communities. In Port Louis, Mauritius and for cities on other WIO small island states, one key challenge is how to attract visitors who typically bypass the city and head straight for more remote beach resorts. Evidence of community community-led ecotourism that can sustain both marine biodiversity and local livelihoods is highlighted across cities.

Fishing provides a vital livelihood source to fishers in waters off the coast from WIO cities and those engaged in fish processing and value addition. Fishing is also a crucial source of protein for city residents. Inadequate equipment, including vessels and ancillary equipment, reduces the fishing sector's potential for local fishers across several WIO countries and cities. Local fishers are limited to nearby waters, which are overfished. Limited processing and storage facilities in WIO cities is another prohibitive factor meaning that much fish stock is wasted or has little value-added. For the fishing potential to be realised in WIO cities, these are two key investment areas. Local community groups exist in most WIO cities, known as Beach Management Units (BMUs), fishing associations or similar. Supporting these community groups can increase local livelihood potential and contribute to more sustainable management of coastal waters.

Waterfront Development projects, if delivered effectively, as well-designed mixed-use development, can provide valuable public space for community activity and trade. They can generate sustainable economic benefits from natural coastal assets while respecting and protecting natural coastal and marine habitats. However, not all waterfront developments in WIO cities balance these factors, so strong development control and environmental impact assessment are essential to ensure that development is carried out responsibly (Bolleter, 2014; WIOMSA and UN Habitat, 2021a, 2021b). Population and infrastructure in WIO cities are particularly vulnerable to the future impacts

of climate change. For the blue economy to flourish in coastal cities, service provision challenges must be addressed alongside or as part of specific blue economy investments, holistic programming, integrated with more comprehensive resilient urban planning and climate adaptation (Chang and Huang 2011).

Operational environment

The operational environment is the backbone of sustainable blue economy strategies in coastal cities. Since Coastal cities are an interface between the landscape and the seascape, innovative waste management strategies are essential to make this environment work and deliver effective solutions. The operational environment also includes transportation planning, education and resilient anticipatory planning. Most cities in the WIO region have a firm policy concerning waste management. However, more effort is needed in helping these cities deal with transportation planning due to port and related infrastructure, resilient and anticipatory planning of these cities in light of the challenges that they face example, sea-level rise and inundation. Realigning the cities form through strengthened planning is key in integrating the city planning needs and the operational environment for the overall blue economy strategy.

Technical recommendations for regional implementation of cities and blue economy in the WIO region

The region has potential for future growth of other blue economy sectors such as marine biotechnology, renewable energy, and resource extraction. Still, the recommendations are intentionally focused on blue economy sectors and the most prominent themes identified across WIO coastal cities.

- Support the blue economic governance and planning by formalising local Marine Spatial Planning (MSP) legislation. Specific spatial planning considerations may include adopting land-sea planning to include spatial uses within 5km offshore and establishing coordinated city structures for blue economy planning.
- Promote ports and maritime trade by identifying additional supply chain opportunities (processing, other value addition activities) spatially proximate to existing port activities.
- Enhance tourism by developing and promoting the city's tourism strategies, supporting local assets and communities, connecting cities and beach resorts, and coordinating regional tourist locations.
- Support the local fishing industry by incentivising bulk buying of local seafood products and focusing on local produce.
- Promote green waterfront developments through public-private partnership (PPP) initiatives, including multiple area market analysis, land use assessment, financing, and/or operations.
- Enhance operational environment by mapping circular economy opportunities in cities, including livelihood opportunities for local communities, transportation planning and infrastructure, innovative plastic waste solutions, resilient and anticipatory planning, and systematic interventions concerning recycling infrastructure and processes. In addition, develop a city circular economy strategy.
- Disseminate research findings using online learning platforms to cities and their respective blue economy stakeholders and encourage them to consider the local context when applying report recommendations and the follow-up steps. This could be achieved through a series of interactive, online modules for a municipality to undertake at their convenience. It may involve a simple overarching module or a series of modules focusing on a specific blue economy theme (eg tourism) or cities of a similar typology (eg higher/lower capacity).
- Provide technical assistance to cities for blue economy planning and recommendations. This would involve tailoring the guidance and learning into local blue economy action plans. The scale of this activity could range from working with a few cities to working with multiple cities across the region, developing city blue economy strategies and connecting coastal cities.
- Intensify research on the blue economy to address specific knowledge gaps, such as multiple objectives for blue economy, sub-national, regional tourism strategies, city circular economy plans, and COVID-19 impact on the blue economy in WIO cities.

Policy recommendations based on the 2018 COP for coastal cities and blue economy.

In achieving the conventions strategies for the sustainable and workable blue economy and integrating the new urban agenda, including urban spatial planning processes, it is important to consider integrating marine natural capital**,** which also includes:

- Helping the parties enhance their operational environment to maximise gains in the blue economy in WIO cities

- WIOMSA, the Nairobi Convention Secretariat and other regional partners strengthen and integrate blue economy \ governance and planning in waterfront development, ports and maritime trade for the WIO region.
- Technical assistance on the blue economy should be offered by the Contracting Parties to local authority and county governments in the region and involve coastal cities in developing the blue economy.

Conclusions

The blue economy is a rapidly evolving concept. Hence there is a need to merge the aspirations of the people living in the coastal cities benefiting from the marine environment in the WIO region. The opportunities and challenges are intertwined between the marine and terrestrial crucial coastal ecosystems, the coastal cities and communities that can benefit from in the spirit and letter of SGD 11. However, challenges exist that include the policy environment, some untapped gaps and potential that require further research. The WIO region already has a starting point in enhancing tourism, water sports development, waterfront development, among others, in facilitating the merging of these concepts along with the land and the sea in a productive way. However, more effort needs to be made in assisting contracting parties in learning lessons from their peers and enhancing the positive development of the blue economy in the cities of the WIO region.

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(1) 2022 163-166

Private sector engagement for a sustainable blue economy in the Western Indian Ocean Region

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Summary

There is growing recognition that the private sector has a key role in achieving the Agenda 2030 Sustainable Development Goals (SDGs), including SDG 14, which focuses on 'Life Below Water'. Private sector involvement is also pivotal in regional and global blue economy initiatives and policy frameworks. Examples of private-sector contributions to more sustainable oceans include adopting environmentally sustainable practices within business operations to address overfishing, plastics pollution, habitat destruction and other harmful impacts. In addition to improved business practices, the private sector can directly contribute to ocean protection and governance initiatives through sharing skills, data, technical support, communications support, financing and a range of services and assets. Based on a recently developed strategic framework for private sector engagement in the Western Indian Ocean Region by the Nairobi Convention, we present insights from the Western Indian Ocean (WIO) region.

Background

The Nairobi Convention countries derive approximately US$ 25 billion per year from the coastal and marine resources of the WIO region, mainly from tourism, fisheries, coastal agriculture, mining, mariculture, and ports and coastal transport sectors (UNEP 2009). The private sector plays a vital role in these economic activities and is an important engine of economic growth, job creation and poverty alleviation, especially in coastal areas. In addition, the private sector is an important source of investment capital for unlocking ocean assets in the region, valued at US$ 333.8 billion (Obura and others, 2017), thereby contributing to the development of the region's blue economy.

The private sector's economic activities in marine and coastal sectors rely heavily on marine and coastal ecosystems for goods and services as business inputs and indirectly through business value chains (TEEB 2010). At the same time, the activities of businesses, both large and small across a wide range of sectors, have significant and often detrimental impacts on coastal and ocean environments. In order to manage our oceans sustainably, private sector engagement in ocean governance and protection is crucial, as is ensuring an inclusive and sustainable blue economy for the region.

Advances

The private sector community relying on the ocean and coasts can be broadly categorised as direct ocean users, ocean user support industries, and providers of infrastructure for the ocean economy (Holthus 2018). Direct ocean users are industries that depend directly on the ocean to extract or produce goods such as fish, oil and gas, renewable energy, seabed minerals, and ocean space for shipping, coastal, marine and cruise tourism, and submarine cables marine uses. Further, ocean user support industries are the ecosystem of sectors that depend on the direct ocean users for their existence, such as shipping, shipbuilders, marine fuels, maritime electronics, logistics, crew training, and those that drive the need for economic activities in ocean industry. These include the primary industries, manufacturers or retailers that transport commodities, materials or products by sea. Additionally, the ocean economy infrastructure providers include the financial,

http://dx.doi.org/1x.xxx/wio.21

insurance, legal, and other service sectors that enable ocean industries to develop and operate.

At the 2018 Nairobi Convention Conference of Parties (COP9), Contracting Parties adopted Decision CP9/13/5. It encourages communication and collaboration between Contracting Parties and the civil society, private sector, non-governmental organisations, local governments, and municipal authorities in implementing the work programme of the Nairobi Convention. Harnessing synergies and collaboration, it aims to promote impact and commitment. A work programme was created by Nairobi Convention in response to this decision, aiming to engage stakeholders in public and private sectors in the greening of operations and management practices to support innovative ocean governance (UNEP 2018). In this regard, the Western Indian Ocean Large Marine Ecosystems Strategic Action Programme Policy Harmonisation and Institutional Reforms (WIO LME SAPPHIRE) project acknowledges the private sector involvement of ocean-related businesses. These include the tourism industry, large-scale fisheries, shipping companies, mining, water transport, etc. are important components of effective ocean governance and management.

To date, two studies have been completed and reports generated under the SAPPHIRE project related to improved private sector partnerships for ocean governance: i) an assessment report for private sector engagement in the Western Indian Ocean region, and ii) a strategic framework for private sector engagement in the Western Indian Ocean region. The assessment report outlines key maritime sectors of the region, including fisheries, tourism, shipping and ports, shipbuilding and repair, oil and gas, renewable energy, mining, desalination and undersea cabling. It summarises each sector's key stakeholders and environmental impacts and reviews existing private sector involvement in partnerships aimed at coastal and marine conservation and protection from the WIO and elsewhere. The strategic framework builds on the assessment report to propose a series of implementation measures for engagement of the private sector. For example, it proposes the establishment of a WIO Blue Economy Platform (WIO-BEP) as a regional platform for facilitating private sector engagement across sectors and for promoting partnerships between the private sector, governance authorities (regional and national) and civil society. It also proposes partnerships in research and monitoring and many sector-specific partnerships.

In the assessment report, it was noted that efforts to involve the private sector in ocean governance have been piecemeal and have often failed to achieve the expected results. If private sector partnerships are effective, the mutual benefit must be derived from the partners involved (UNEP and others, 2021). For example, for the private sector, sustainable ocean business practices would provide an opportunity for long-term profitability as they can lower costs, physical, regulatory and social risks and enable more efficient operations (Bhattacharya and Managi, 2013). The involvement of the private sector also has a direct relationship with strengthening regional cooperation

Table 1. Collaboration among environmental stakeholders and private businesses has co-benefits.

Potential benefits for the environmental sector	Potential benefits for the private sector
Reduction of stress on the WIO LMEs	Improved understanding of the risks and opportunities related to the environment, climate and sustainability
Contribution to SDGs, sustainability, Nairobi Convention work programme	Improved understanding of environmental impacts and how to decrease risks and secure more robust supply chains
Identification and implementation of innovative solutions to environmental problems	Assistance in meeting statutory requirements
Mainstreaming of environmentally friendly practices into private sector operations	Access to funding through, for example, the Green Climate Fund, Blue Action Fund, etc
Access to private sector knowledge, technology and innovations	Cost-savings through more efficient resource use and improved sustainability
Facilitation of information-sharing, including best practices	Access to stakeholders and technical assistance
Acceleration of the transition to a blue economy	Insight into current and future policy environments
Improved policy-making (responsive to private sector needs)	Access to stakeholders and technical assistance
Improved governance	

and ocean governance in the WIO region. Numerous benefits would accrue from a regional approach, as shown in the figure below (UNEP and others, 2021):

Outlook for the region and Recommendations

As highlighted in the assessment report on private sector engagement, there is great diversity among private sector actors in the WIO region in terms of the nature of their activities (economic sector) and scale of activities – from micro-enterprises to multinational corporations. Consequently, there is a wide range of potential collaboration opportunities that may be designed around one or more of the following objectives:

- Advocacy and awareness-raising
- Information sharing (including identification and sharing of best practices)
- Joint research and ecosystem monitoring
- Promoting the adoption of joint standards (including through certification, branding, industry charters, etc.)
- Training and skills development
- Incentives to support behavioural change
- The implementation of demonstration projects

Various potential modalities can be utilised as mechanisms for engagement with the private sector, including information dissemination; public events, training and campaigns; open networks and policy discussions; multi-stakeholder fora; partnerships and alliances; and transactions (UNEP 2019). Strategic engagement with the private sector will thus require prioritising interventions and partners from these opportunities. The assessment report proposes the prioritisation of four economic sectors, namely: a) Fisheries (including capture fisheries, mariculture, and seafood processing); b) Extractive industries (oil & gas, coastal and offshore mining); c) Tourism and recreation; and d) Shipping and ports (including shipbuilding and repair).

The Strategic Framework also proposes many partnerships to increase engagement with the private sector as follows:

a. *The WIO-Blue Economy Platform (*WIO-BEP)
   The WIO-BEP is proposed to serve as a regional platform to facilitate private sector engagement across sectors and promote partnerships between the private sector, governance authorities (regional and national) and civil society. The membership of WIO-BEP is proposed to include, among others, private sector stakeholders together with organisations that form part of the Western Indian Ocean Sustainable Ecosystem Alliance (WIOSEA). For resource mobilisation purposes, a WIO-BEP fund could be established, through which voluntary contributions from the private sector and contributions from donors could be made.
b. *Research and Monitoring*
   Engaging and including research and monitoring organisations that were members of the WIOSEA during the Agulhas and Somali Current Large Marine Ecosystem (ASCLME) and South-West Indian Ocean Fisheries (SWIOF) Projects are proposed as a priority. This would facilitate monitoring ecosystem-related indicators and ocean-climate observations in the WIO.
c. *Sectoral Partnerships*
   The strategic framework also outlines many preliminary concepts for partnerships for priority sectors to be assessed in the consultation process and developed into full partnership proposals in consultation with the relevant partners and other potential partnerships. These include:
   - A regional capacity-building partnership for applying ocean accounting frameworks in ocean governance processes.
   - A WIO Alliance for Sustainable Octopus Utilization
   - A regional partnership on ICT for Fisheries
   - The establishment of a Regional Sustainable Tourism Council
   - The establishment of a Regional Marine Pollution Response Centre

Contracting Parties are urged to strengthen collaboration with the private sector and other stakeholders for the conservation and sustainable utilisation of coastal and marine resources in the context of a sustainable blue economy in the WIO. Specifically, Contracting Parties are encouraged to:

- Adopt the report on the strategic framework for the engagement of the private sector in the Western Indian Ocean and the recommendations therein, including developing an implementation plan and a framework for reporting on progress in implementing the Strategic Framework for Private Sector Engagement; assessing the feasibility of WIO-BEP to support more effective private sector partnerships in the region, and establishing focus groups to assess and drive forward the proposed partnerships in the Strategic Framework for Private Sector Engagement
- Develop a multi-stakeholder advocacy strategy in coastal and ocean stewardship that enables

companies to contribute resources and influence through individual actions and multi-stakeholder partnerships. This will help to accelerate the transformation to a sustainable and inclusive blue economy.

Despite growing awareness of unsustainable practices related to humanity's relationship with the oceans, anthropogenic pressures compromising ocean health continue to mount. Achieving SDG14 requires concerted action at global, regional and local levels. The WIO region has completed the assessment of the current contribution of the private sector to ocean protection and governance and identified numerous opportunities to strengthen its role in this regard. The region has also developed a strategic framework for fostering more effective partnerships between civil society, government and the private sector. Necessary steps remain to be taken, and implementing the strategic framework for private sector engagement should be at the centre of these efforts going forward.

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Climate change impacts and adaptation

WIO Science - Policy Platform Series
(1) 2022 169-173

Ocean Acidification: A hidden risk to sustainable development in the Western Indian Ocean

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Summary

Ocean acidification (OA) is a profound change in ocean chemistry due to anthropogenic carbon dioxide (CO_2) emissions. The ocean represents 72 per cent of the Earth's surface and contains about 99 per cent of the available surface water. In response to the accumulation of CO_2 in the atmosphere, the ocean is currently absorbing about one-third of anthropogenic emissions (Gruber and others, 2019). This absorption rate is increasing as more CO_2 is emitted to the atmosphere via natural and anthropogenic pathways. The chemical dissolution of CO_2 in seawater is changing the carbonate chemistry of the ocean's surface, a phenomenon known as ocean acidification (OA). The ocean's average acidity has already increased by 30 per cent. Biogeochemical models based on the IPCC's business-as-usual CO_2 emissions scenario project a further decrease of average open ocean pH, leading to the acidity of up to 150 per cent higher than today (Doney and others, 2009). This rate of change is nearly ten times faster than anything observed within the past 50 million years, thus outpacing the ocean's capacity to restore oceanic pH and carbonate chemistry in the near future. Without rapid science-based action, the consequences of OA on marine species, ecosystems, associated services and peoples depending on them will be dramatic. A large body of evidence, based on paleo, laboratory and field observations, clearly demonstrates that OA will have strong negative impacts on many marine species and ecosystems. For example, up to 50 per cent of all tested marine animals, including many seafood species, are negatively impacted when exposed to near-future OA conditions (Wittmann and Pörtner 2013). OA already has a negative impact on some marine-related industries. For example, OA had a negative impact on the US Pacific Northwest oyster industry with an estimated US$110 000 000 cost, along with associated socio-economic impacts, direct or indirect, on 3 200 employees in the sector (Ekstrom and others, 2015). Addressing and minimising the negative impacts of OA requires urgent actions, combining mitigation (reduction of CO_2 emissions) and adaptation (Gattuso and others, 2015) which require local and regional data to efficiently inform the development and implementation of locally adapted solutions and the policy process.

http://dx.doi.org/1x.xxx/wio.22

Background

OA will have consequences for the WIO region. Although OA is a global problem, it has cascading implications for regional and local ecological and socio-economic systems and, potentially, human health. Most marine species and ecosystems are likely to be impacted by the chemical changes associated with OA as more CO_2 is available for photosynthesis. Under low pH, organisms have to increase their energy investment to maintain pH homeostasis in their body and cells. This cost is particularly high in calcifying organisms that need to create high pH environments to precipitate calcium carbonate for their shells and skeletons. As a direct consequence, calcifying organisms facing OA are at risk, including reef corals (high biodiversity hotspots prized by tourists and essential to artisanal fisheries), deep corals (an essential resource for biodiversity and a potential biochemical reservoir for the pharmaceutical industry), and most benthic species of commercial interest and shellfisheries. These habitats and species are also key features of some of the Ecologically and Biologically Significant Marine Areas (EBSAs) of the Southern Indian Ocean (Secretariat of the Convention on Biological Diversity, 2016). Consequently, a series of appropriate priority actions were identified during the OA workshop in Zanzibar in 2019 to be included in an Action Plan for the region for consideration by the Nairobi Convention (Laffoley and others, 2020).

OA is now recognised as a major threat by the international community and is linked to various global initiatives such as the Paris Agreement on climate change and the CBD post-2020 Global Biodiversity Framework discussions. OA is also one of the targets of the Sustainable Development Goals (SDG 14.3, which calls for nations to minimise and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels). Furthermore, the Global Ocean Acidification Observing Network (GOA-ON), a network of 750 scientists and resource managers from 100 countries, sets guidelines for monitoring and assessing OA and provides a data portal for viewing where data is collected around the world. GOA-ON is supported by multiple organisations such as the IOC-UNESCO, IAEA-OA-ICC, NOAA OAP, and IOCCP. GOA-ON has already started establishing the technical and human capacity for OA measurement, including in the WIO.

Advances in the WIO

Local and regional data are needed to develop and implement adaptation solutions. Research over the last fifteen years has led to a better understanding of OA's chemical and biological aspects and, in turn, the potential socio-economic effects on the global scale (Hall-Spencer and Harvey 2019). This research also demonstrated that biological response is highly dependent on local conditions (Vargas and others, 2017). The ocean's chemistry varies tremendously between regions and over time (days, seasons, etc.). This is particularly true in the coastal zones where other processes such as currents, biology or pollution play a key role. Understanding and forecasting the future impacts of OA requires understanding the local chemical conditions (monitoring) and consequences of changing carbonate chemistry on local species and ecosystems (biological experimentations and field observations). It is not possible to simply extrapolate data from one region to another.

The house is on fire- OA research should be prioritised toward short-term solutions. There is an urgency in developing and implementing mitigation and adaptation solutions to address OA, which strongly rely on the evaluation of the regional societal needs (eg key ocean services and industries threatened by OA), identification and collection of the needed data (eg monitoring at the relevant Spatio-temporal scale and understanding of biological impacts and their complexity regarding ecological interactions, multiple stressors, evolution). This co-design approach aligns with the UN Decade for the Ocean call to develop the "science we need for the ocean we want". The framework for building multi-national ocean governance exists in the WIO region and is facilitated by the UN SDGs, the UNEP Regional Seas Framework, and the Work Programme of the Nairobi Convention (2018-2022; main activity 39l, "Building capacities and partnerships to address the impacts of ocean acidification, including scientific cooperation at the national and regional levels." under the Assessments and Capacity Development section, but also activities 39a and j).

Ocean acidification research in the WIO is in its infancy. The monitoring of OA in the Indian Ocean lags far behind other oceans if data coverage of CO_2 partial pressure (pCO_2) in surface waters is used to indicate the intensity of the scientific effort (Figure 1). These gaps in data collection have led to serious underestimation and high variability of the contribution of the Indian Ocean to the global sink of anthropogenic CO_2 (ie 21±10%; Gruber and others 2019). Better data would allow characterisation of OA' hot spots' where more research and protection efforts could be directed.

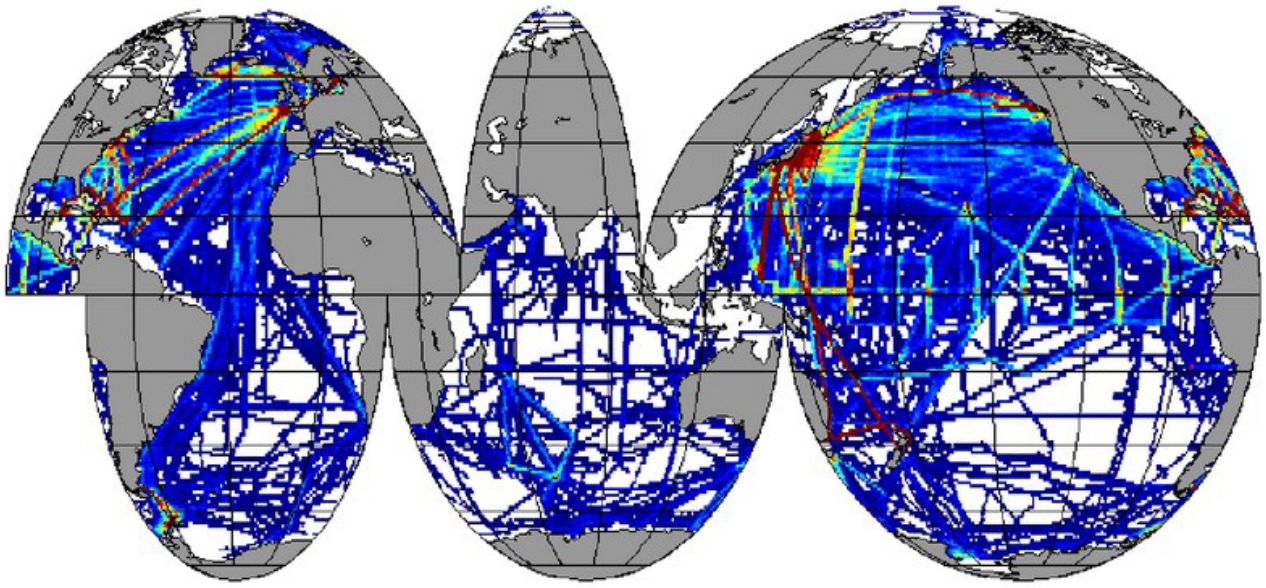

Figure 1. Historical inventory of global surface pCO_2 data used to illustrate the scientific effort towards monitoring OA. A large proportion of the central and western Indian Ocean (centre) has not been surveyed (Bakker and others, 2016).

Small-scale regional projects are already documenting the impacts of OA

For example, in the Mascarene region, at the eastern boundary of the WIO, surface pCO_2 was found in equilibrium with the atmosphere and surface pH in the expected range, around 8.1 (Harlay unpublished data; DFN2018406 EAF-Nansen cruise report). However, in vertical profiles of dissolved carbonate concentration, the 1 per cent aragonite saturation horizon (Ω_{Ara}=1), the chemical boundary below which seawater becomes corrosive to calcium carbonate used by many marine organisms to build their shells and skeletons, was at 750 m depth, 250 m above the previous observations, 23 years previously (ie the nine *R/V Knorr* expeditions in 1994-96). It is believed that this process will occur at an even faster rate in the future as CO_2 continues to increase in the atmosphere, leading to unfavourable environments for many key species as early as 2050. Investigations and experiments on OA's biological and ecological impacts are also being undertaken to focus on coastal ecosystems. For example, the juveniles of the fish *Argyrosomus japonicus* Dusky kob from South Africa were shown to be highly sensitive to near-future OA (Edworthy 2017). A critical reef-building coral (*Acropora austera*) in South Africa was also shown to exhibit a much slower growth in near-future OA conditions.

Regional and Global Outlook

The Nairobi Convention can critically assist with a highly needed strategic focus on OA in the WIO region. This paper is a new response to past COP decisions, CP.9/9 (Climate change adaptation and mitigation), to urge Contracting Parties to address the impact of OA, including through capacity development and the enhancement of scientific cooperation in partnership with research and academic institutions, regional monitoring and adaptation activities. Recently, WIOMSA, in partnership with IOC-UNESCO, IAEA-OA-ICC, and GOA-ON, supported six projects along the Eastern African Coast (Kenya, Mauritius, Mozambique, Seychelles, South Africa and Tanzania) to support OA observation systems in the field and the implementation of the SDG 14.3.1 indicator methodology. Further, the investigation of biological response to OA using laboratory-based experiments or a combination of both is being investigated as described in the East Africa OA White Paper (Ramessur and others, 2020).

The objectives of the Nairobi Convention can further support OA initiatives by:

- Supporting the development of a regional strategy for East Africa through regional workshops in the WIO region, bringing together scientists, policymakers and ocean users.
- Prioritising solution-oriented OA research to help countries achieve SDG target 14.3, which minimises OA's impacts.
- Creating a community of practice in the WIO focused on OA and other stressors of the marine environment.

- Developing and implementing mitigation and adaptation solutions to address and minimise the impacts of OA.

Conclusions and recommendations on ocean acidification in the WIO.

Take-home message – Ocean Acidification (OA) is a quantifiable and ongoing global process resulting from CO_2 emissions. Our understanding of the regional ecological and socio-economic consequences of OA in the WIO is limited. This knowledge is needed for the development and implementation of solutions. It will be enhanced by investigating and linking ocean and coastal carbonate chemistry with biological responses and the consequences for marine ecosystem services. This requires local and regional data and prioritisation of science towards solutions. WIO scientists are not currently empowered to address the issue of OA. We ask policymakers to recognise the threat posed by OA and for political support for further development, expansion, and enhancement of this area of research in the region, for example, through international research programmes, grants, and researchers' mobility frameworks.

Promoting a national and regional solution-oriented research strategy – The only way to fully address OA is to reduce global CO_2 emissions (mitigation). However, as OA effects are already visible today on marine ecosystems and services, it is critical to implement adaptation strategies to avoid dramatic effects within the timeframe required for mitigation (Gattuso and others, 2015). Adaptation strategies include protection of ecosystems (eg, marine protected areas, reduction of other environmental stressors), repair of damaged ecosystems (eg, restoration programmes) as well as adaptation (eg, change in aquaculture practices). Identification of local priorities should be based on local needs, availability of solutions and ease of implementation. This approach, involving scientists and ocean users, would prioritise data gaps and research needs.

Communication and Mitigation – Outreach and educational programmes must involve a concerted effort to communicate OA and its threat to the public. Special attention should be given to training and capacity development at the political-decision making level, to people with influence, national administrations and NGOs. The United Nations Policy Brief on OA as a platform can be used so that National Action Plans can be formulated, regional and local policies developed, and general awareness of OA promoted. There must be a regional commitment to climate change mitigation, via the Paris Agreement, with a view for national implementation of emission reduction strategies and adaptation plans relevant to the WIO marine environment.

Research and Adaptation – The development and implementation of efficient adaptation strategies to minimise the impact of OA directly depend on scientific understanding and many knowledge gaps remain in the WIO region. OA research can be expensive and remains inaccessible to most coastal communities worldwide and in the WIO. Thus, there is an immediate need for funding research, knowledge sharing and transfer, and capacity development. Depending on the local needs and gaps in data, research will include: (i) short-term high-resolution chemical monitoring aimed at capturing the present natural variability experienced by key marine ecosystems (*weather*); (ii) long-term chemical monitoring to feed regional and international databases and help modellers refine their carbonate budgets and OA projections at the regional scale in the WIO; (iii) biological monitoring as well as laboratory and field experiments aimed at understanding the mechanisms behind how key marine species and ecosystems respond to OA and other key environmental drivers. This is particularly important considering that many habitats and organisms that form the base of the food chain in the region and support large fisheries are biogenic accretors particularly vulnerable to OA. The economic impact of OA on fisheries and tourism is likely to be substantial and may include loss of profits and employment and may even lead to loss of coastal infrastructure due to decreased storm protection facilitated by reefs because of OA. The impact of OA needs to be considered in planning socio-economic activities that form part of the regional ocean economy as it poses a hidden risk for sustainable development.

Technical recommendations

The Secretariat working with WIOMSA and other partners support the development of a regional strategy for capacity building bringing together scientists, policymakers and ocean users. The Secretariat working with partners must establish a community of practice in the WIO focused on OA.

Policy recommendations

We call upon the Contracting Parties to develop and implement mitigation and adaptation solutions to address and minimise the impacts of OA as part of their broader climate-change intervention strategies.

Our recommendation should also include prioritising solution-oriented OA research to help their countries achieve SDG target 14.3, which aims at minimising the impacts of OA.

Acknowledgements.

Thanks to UNESCO-IOC-WIOMSA for providing funds under MASMA/OA/2019 (March 2019-December 2021) and GOA-ON for networking opportunities.

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WIO Science - Policy Platform Series
(1) 2022 175-180

COVID-19 and the future of Ocean Sustainability: supporting adaptation to post-COVID changes in the Western Indian Ocean

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Summary

The COVID-19 pandemic is generating significant changes for the future of the ocean. Here, we summarise the findings of a participatory process that brought together 25 diverse stakeholders from across the globe, including WIO participants, to understand those changes and identify their strategic implications.We focussed on the short term and long-term impacts of COVID-19 on seven areas that are key to ocean sustainability: healthy, sustainable ecosystems; community resilience and sustainable livelihoods; inclusive, sustainable economies; equality and equity; effective governance; climate change adaptation and mitigation; and awareness and understanding. It identifies how, in the short term, the medical response and associated lockdowns are impacting these seven key areas. The report also looks at how three priority long term impacts areas, including widespread economic recessions; increasing digitalization; and changes to data and research, might impact ocean sustainability. It also reveals that these impacts may be positive or negative depending on different alleviating and exacerbating factors.From these impacts, alleviators and exacerbators, we identified six areas for strategic action to shift the balance of impacts, particularly in the long term, towards positive outcomes and away from negative ones. These six areas emphasize the opportunity COVID provides: to select inclusive, equitable and sustainable options over inequitable and unsustainable options in all actions; to leverage the inevitable digitalization towards positive outcomes; to embrace interconnectivity and complexity; to leverage the unique global event to support shifts in mindsets towards long term solutions; to reduce compounding ecosystem pressures and threats particularly that affect the most vulnerable people, and to build resilience at all levels – across social and ecological domains.

Pathways to a more sustainable future will involve transitioning responses to short term impacts into long term actions and responses, promoting factors that alleviate impacts and transforming factors that exacerbate impacts. Recommendations for implementation in the WIO include:

- Incorporate scenario or 'future thinking' approaches into project development and adapting to COVID-19 to strengthen and take advantage of alleviators and avoid or reduce the influence of exacerbators;
- Identify how one or more of the strategic interventions can be mainstreamed into COVID-recovery and other projects and processes;
- Support dialogues and consultations at relevant levels (local, national, regional) for WIO participants to explore and define their experience of COVID-19 and its implications for their lives and work.

http://dx.doi.org/1x.xxx/wio.23

Background

The COVID-19 pandemic has transformed human activity from the scale of the globe down to individuals, including across Western Indian Ocean (WIO) countries. While prior pandemics have had higher mortality figures, and events such as wars and natural disasters have transformed the policies and actions of countries across the planet, no other pandemic, nor any other pressure, has changed peoples' behaviour so foundationally across all these scales.

People stopped travelling, with perhaps the greatest impact on a core sector for WIO countries - the tourism and travel industry. At the same time, fisheries were affected by labour shortages, broken value chains, and collapsed processing industries. Maritime transport has faced a severe disruption, with 40 per cent of ports having seen a 25 per cent decline in throughputs. Many seafarers were unable to resume their merchant shipping services. Offshore energy, including renewable operations, representing vital contributions to the

Figure 1. A) As the COVID lockdown extended in June-August 2020, support programmes were put in place by many NGOs and civil society groups, donating basic provisions to fishing and other coastal communities. B) Returning to fieldwork and community engagement required adhering to guidelines such as wearing masks and limited participants in more open spaces (Credit: D Obura)

Two Global Cohorts of Participants

Figure 2. Representation of participants in the COVID-19 lab process by gender (inner, black), ethnicity (yellow), country (orange) and profession (grey).

global economy and supply chains, faced challenges to conducting personnel changeovers and could not get specialized personnel on offshore platforms to undergo routine safety inspections and maintenance checks. Vast amounts of data and research on ocean energy exploration have also been disrupted.

The impact of COVID-19 in individual sectors of human activity are multiple, and studies are emerging documenting how it has affected coastal societies and communities, such as small-scale fishing (Bennett and others, 2020) and coastal cities (Kithiia and others, 2020).

The uncertainties of a pandemic on this scale make it almost impossible for entities from countries to sub-national governments to businesses, communities, and even families to plan for their future. Will people be able to travel in one month, or three months, or one year? Travel restrictions persisted for 18 months, coming and going with new infection waves. Will schools reopen, then close again? Will jobs be available once people can go back to work? How can people interact as they are used to – shaking hands, meeting across a table or in a traditional ceremony, in sports and cultural events, in politics and religious gatherings?

Post COVID-19 resilience and recovery measures are needed across the planet (Büscher and others, 2021). For regions such as the WIO, recovery will depend on our ability to engage sustainable approaches towards local, national, regional and multilateral development cooperation. So building back better in terms of blue recovery will depend on our resolve to revitalize tourism and travel, fisheries, maritime transport, ocean renewable energy sectors. This should incorporate strategies that cut across multiple sectors and countries of the region in a holistic, "source to sea" approach. Governments, NGOs, businesses and other stakeholders all need to do their part to reduce marine pollution at source while protecting and restoring coastal and marine ecosystems and to create alternative livelihoods and business opportunities derived from the ocean spaces; develop or modernize port and coastal infrastructure; engage sustainable fisheries, aquaculture, tourism and maritime industry;

Table 1. Ocean sustainability areas and the alleviators (factors that reduce impacts) and exacerbators (factors that intensify impacts) that affect them, identified by lab participants.

Ocean sustainability areas	Alleviators	Exacerbators
• Healthy, sustainable ecosystems • Community resilience and sustainable livelihoods • Inclusive, sustainable economies • Equality and equity • Effective governance • Climate Change Adaptation and Mitigation • Awareness and understanding	• Cooperation • Effective governance • Empowered and supported local communities • Strategic use of the disruption • Funding • Inspired youth leaders • Improving equity • Increasing equality	• Tendency towards business as usual • Unsupportive political environments • Siloed thinking and action • Climate change impacts • Reduced focus on climate change and environment • Degraded quality of international negotiations and other governance dialogues • Poor capacity in key actors

enhance ocean-related energy sources, and integrate waste management

The United Nations has adopted ocean governance and sustainable development processes as part of its Sustainable Development Goals (SDGs). In particular, SDG 14 commits to "Conserve and sustainably use the oceans, seas, and marine resources for sustainable development". The COVID-19 pandemic, affecting SDG 3 on "good health and wellbeing", impacted all other domains of the SDGs, raising calls for a "One Health" approach to resolving it (Häsler and others, 2020; Ruckert and others, 2020) and applicable to understanding its impacts on achieving SDG 14.

To facilitate this multi-sectoral and multi-stakeholder engagement, we need fora to meet to consider all these challenges and identify pathways to move forward in their context. Further, there is a need for joint action at the regional level in the WIO to align coastal and marine responses to the COVID-19 pandemic and harmonize approaches to tackle shared challenges.

This Sustainable Oceans Lab event was convened as a first step to bring together 25 diverse stakeholders from across the globe (figure 2) in a rapid online process to engage together to develop a systems-level analysis of the short and long-term implications of the COVID-19 crisis (CORDIO and Reos Partners, 2020). Learning from these findings, we may identify mechanisms for regionally-focused events to do the same, to support better from COVID-19 concerning Western Indian Ocean sustainability.

Advances

The lab looked at the short-term impacts of COVID-19 – both the medical response and the lockdowns – on seven key areas of ocean sustainability (Table 1). A surprise to participants was that impacts may have both a positive face and a negative face, and which of

Table 2. Long term sustainability areas identified by lab participants and how they may evolve through positive and negative scenarios into the future.

	Positive scenario	Negative scenario
Economic recession	**Regrow and Adapt** – the hardships of the COVID-19 response inspire people to look beyond economic growth to focus on a more holistic view of wellbeing and equity among people.	**Withdraw and Protect** – the hardships of the COVID-19 response lock-in tendencies towards 'business as usual', siloed thinking, and narrow political approaches.
Increasing digitalization	**Connecting Worlds** – many months spent online to give people greater hunger for an emotional and physical connection with nature and with one another.	**Digital Divide** – as people lose contact with nature and each other, their links erode misinformation increases, and decision-making disconnects from reality.
Changes to data and research	**Discovery** – this "real-world experiment" teaches people surprising connections and opportunities, unlocking new approaches, inspiration, learning and cooperation to "build forward better".	**Closing Down** – the stoppages in research, monitoring and data collection lead to data gaps and difficulty restarting them after lockdowns. Research and new thinking are blocked, and people close down into their comfort zones, impeding progress.

these dominates could depend on a range of 'alleviators' (emphasizing the positive) and 'exacerbators' (emphasizing the negative).

In the long term, participants emphasized how three key responses - widespread economic recession, increasing digitalization, and changes to data and research, might affect the ocean sustainability areas (Table 2). Scenarios highlighting positive versus negative pathways in each of these domains illustrate this:

COVID-19 has changed the landscape of strategic interventions that can help to advance ocean sustainability and achieve SDG 14. Further, actions to achieve sustainability and SDG14 can play a key role in supporting recovery and rebuilding from COVID-19. The lab identified six major areas for strategic action (figure 3) that would help actors on the ground, including communities, governments, businesses, NGOs, researchers, and others. Particularly when working together across their diverse perspectives, backgrounds and interests, identify how to turn negatives into positives – to avoid and transform the 'bad' scenarios' and create 'good' scenarios and pathways in the specific context they may be in.

Outlook to regional and global processes

In the WIO region context, ocean governance is linked to all relevant national, regional and international regulatory frameworks (Momanyi, 2015). These include, but are not limited, to the UN Convention on the Law of the Sea; the Convention on Biological Diversity; the International Convention for the Prevention of Marine Pollution from Ships (MARPOL); The United Nations Fish Stocks Agreement; The Food and Agriculture Organisation (FAO) Code of Conduct of Responsible Fisheries; the South-West Indian Ocean Fisheries Commission (SWIOFC); the Agreement of the Indian Ocean Tuna Commission (IOTC); and the Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported, and Unregulated Fishing.

The Nairobi Convention aims to address and mitigate environmental degradation activities that harm marine life, undermine coastal communities, and negatively affect human health in the western Indian Ocean region. These threats make it more important than ever for governments in the region to work together to strengthen the protection of the ocean through policy interactions, technical cooperation, science and research – and hence the core importance of the Nairobi Convention for post-COVID recovery in the WIO. Western Indian Ocean countries, through the support of the Nairobi Convention, made a variety of commitments under SDG 14 in the UN Oceans Conference in 2017 and are likely to play a prominent role in the second Oceans Conference to be co-hosted by Kenya and Portugal in June 2022.

Relevance to the Nairobi Convention and its Work programme

Applying these strategic approaches will support achieving SDG 14 and SDG 3 to improve resilience to the ongoing and future impacts of COVID-19 and broader health and other diverse threats experienced in the future. The threat from COVID-19 was not anticipated except in specialized health sectors before December 2019. As a result, the Nairobi Convention's Work Programme for 2018-2022 does not explicitly reference health aspects relative to the pandemic. However, general areas of building capacity and resilience to cope with multiple and diverse threats, including climate change, are relevant and a core part of the Work Programme:

- Paragraph 31 (b) To support countries in their commitment to the attainment of the 2030

Figure 3. Strategic interventions to 'build forward better' from Covid-19 for ocean sustainability (adapted from CORDIO and Reos Partners, 2020).

Agenda and the Sustainable Development Goals, in particular through Goal 14, to conserve and sustainably use the oceans, seas and marine resources for sustainable development.

- Paragraph 24 on building partnerships by implementing catalytic activities under programmes and projects supported by members of the Consortium for the Conservation of Coastal and Marine Ecosystems in the Western Indian Ocean and other non-governmental organizations.
- Under Information and awareness, paragraph 45 (k) Convening science-policy dialogues for scientists, policymakers, and decision-makers civil society and the private sector, in collaboration with partners, to provide knowledge and generate approaches to tackling current and emerging threats.

Recommendations

Recommendations from the 'COVID-19 and the future of Ocean Sustainability' process provide tangible guidance to 'build back better' from the challenges of the pandemic and across other major threats and challenges. This is a particular challenge when projects may already have predetermined actions and log frames that may not be able to address new realities post-COVID. The following approaches or actions can be adopted to alleviate this, which we call technical recommendations because of their practical application in project and discussion processes.

Technical recommendations

- Incorporate scenario or 'future thinking' approaches into project development to adapt to COVID-19. To do this, consider how to **take advantage of and strengthen alleviators** – which help generate positive actions and outcomes, such as cooperation, empowered communities, inspired youth leaders – while **avoiding and reducing the influence of exacerbators** – which reinforce and worsen negative actions and outcomes, such as unsupportive political environments, siloed thinking and tendency towards business as usual – to create positive outcomes to help deliver favourable outcomes.
- Identify how one or more of the **strategic interventions can be mainstreamed** into COVID-recovery and other projects and processes:
  - Ensure inclusive, blue, sustainable approaches
  - Build resilience of people and ecosystems to withstand future shocks
  - Embrace interconnectivity and complexity
  - Leverage digitalization to enhance activities, outputs and outcomes
  - Reduce ecosystem pressures and threats
  - Support shifts in mindsets to promote positive and reduce negative scenarios.
- **Support dialogues and consultations** at relevant levels (local, national, regional) for WIO participants to explore and define their experience of COVID-19 and its implications for their lives and work. This may occur through ongoing or new projects, joining the Sustainable Oceans Lab (www.sustainableoceanslab.org) or initiating similar processes in the region. Other examples of scenario processes to foster more effective and contextualized actions include the WIO Futures Scenarios (www.wiofutures.org).

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