Integration of ocean-based adaptation and mitigation actions into regional and national climate policies in Africa

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Executive summary

Introduction

Climate change is one of the significant challenges we have to face together with biodiversity loss. Recent Intergovernmental Panel on Climate Change (IPCC) and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) global reports underline the broad and diverse range of climate change impacts expected on our societies and ecosystems and the magnitude of the earth's sixth mass extinction, indicating that climate and biodiversity are linked. Over 80% of ecological processes are impacted by climate change, while nearly 40% of the mitigation needed to meet the 2°C Paris goal can be provided by nature-based solutions. All these would have consequential effects on Africa, including its ocean domain and the people who rely on the resources therein for survival.

Ocean-based solutions to mitigate and adapt to climate change are actions to protect, sustainably manage and restore ecosystems to address societal challenges and biodiversity conservation. They are flexible and adaptable, they are cost-effective and they bring multiple benefits. Besides being used in academic literature, several of these actions have been proposed in many high-level documents, including the IPCC AR6, the High Level Panel for a Sustainable Ocean Economy, the Because the Ocean Initiative, etc. Central to ocean-based actions to mitigate and adapt to climate change are ecological restoration, ecological engineering, ecosystem-based adaptation, ecosystem-based mitigation and ecosystem-based disaster risk reduction.

This publication highlights the impact of climate change on Africa's oceans and coasts, including technical issues and process-related considerations/opportunities. Informed by the analysis of ocean-based actions in the Nationally Determined Contributions (NDCs) from 15 African countries, an assessment of climate-related commitment and agreement by the African countries, an overview of existing indigenous knowledge essential for climate mitigation and adaptation, and a stocktake of frameworks and metrics to track progress, this document aims to walk Africa Climate Negotiators through the options to concentrate on during negotiations at the United Nations Framework Convention for Climate Change (UNFCCC) Conference of Parties (COP), laid out following the existing areas within the UNFCCC process and ongoing negotiations: Mitigation, Adaptation, Loss and Damage, Indigenous People's Knowledge and Engagement, Finance, Science, Technology Mechanism, Capacity Building, and Transparency and the Global Stocktake.

The first chapter of this report provides a conceptual background on the importance of the ocean in climate change adaptation and mitigation measures and the implications of current and future climate change projections on the oceans and coasts of Africa. Climate change is expected to compound existing vulnerabilities and exacerbate direct and indirect impacts on the ocean ecosystem and coastal communities. The direct impact of climate change on Africa's ocean domain will be felt principally through: Sea-level rise, coastal storm surges, ocean warming and acidification, and broader alterations in the hydrological cycle. This chapter highlights that the interactions between socio-economic development, coastal ecosystems and climate risks pose complex challenges such as insecurity in coastal and maritime areas, increased rural-urban migration towards coastal urban centres, urbanising coastline, increases in illegal fishing due to pressures over fish resources overlaps, propensity for illegal maritime migration, etc.

The second chapter of this report initially discusses the place of climate mitigation and adaptation in the ocean context, identifying that ocean-based climate actions are becoming mainstream in today's climate policy discourse. The second part of this chapter forms the main focus of analysis for the entire report. As a primer

to understanding the shift toward a more bottom-up approach to climate action, recent studies highlighting various ocean-based climate action areas that can help fight against and adapt to climate change are presented, including the 2019 study by the High-Level Panel for Sustainable Ocean Economy (HLP) on ocean and climate change. This chapter also provides a brief overview of how ocean-based actions have been advocated and operationalised in different ocean domains with examples from the Mediterranean. It further analyses and discusses how African countries have included ocean-based actions in their NDCs while identifying key challenges and recommendations. It considers different ocean-based climate actions (herein called 'variables') across multiple intervention areas (e.g. ocean-based renewable energy, decarbonising ocean-based transport, marine and coastal ecosystems protection and restoration, improved fishery management) to provide a comparative, comprehensive and standardised evaluation of the integration of ocean-based adaptation/mitigation actions in 15 NDCs, three each from the five African regions (West Africa – Nigeria, Benin, Cape Verde; Central Africa – Cameroon, Democratic Republic of Congo, Equatorial Guinea; East Africa – Kenya, Seychelles, Tanzania; North Africa – Morocco, Egypt, Algeria; Southern Africa – Mozambique, Namibia, Madagascar). Some results from this evaluation show that:

1. Climate mitigation and adaptation is still not considered extensively using Ocean Renewable Energy (ORE). Regardless, there is a clear indication that NDCs are advancing towards increased integration of adaptation and mitigation under the "Increase ocean-based renewable energy" intervention area in Cape Verde, Seychelles, and Namibia, which are also countries where the Blue Economy strategy and MSP process are developing.
2. There is zero consideration for seabed carbon storage as an option to mitigate and adapt to climate change in evaluating NDCs across West, Central, North, Southern and East Africa.
3. Options for solar radiation management and other ocean-based geoengineering (e.g. cloud brightening, albedo enhancement) are not considered for climate mitigation and adaption in any NDCs evaluated
4. Out of the 15 countries evaluated in West, Central, North, Southern, and East Africa, only seven countries (Tanzania, Seychelles, Madagascar, Equatorial Guinea, Egypt, Cape Verde, and Benin) have included actions to decarbonize ocean-based transport in their NDCs to mitigate climate change in the sector. These eight countries mainly focus on adopting policies to reduce emissions of other greenhouse gases and developing and implementing hybrid power systems -winds, waves, current, and sun.
5. Across the regions, interventions to protect and restore key marine and coastal ecosystems and support species have greatly benefited NDCs assessed. About 27% (West Africa), 36% (North Africa), 40% (Central Africa), (33%) Southern Africa (33%), and 27% (East Africa) of NDCs include ocean-based actions aimed at protecting and restoring key marine and coastal ecosystems and supporting species towards climate mitigation and adaptation.
6. In West Africa, 8% of actions to mitigate climate change are focused on fisheries management, 4% in North Africa, 6% in Central Africa, 8% in Southern Africa, and 2% in East Africa
7. Most NDCs are early integrators of ocean-based actions for climate integration across many intervention areas, including ocean-based renewable energy, ocean-based transport, coastal and marine ecosystems fisheries and other cross-cutting areas.

The third chapter focuses on the various international processes that African countries have agreed on and committed to, identifying how these processes relate to sustainable ocean development, the climate issues that come up within their implementation, and opportunities for climate actions possible within their mandate. It adapts the generic synergy from identified agreements and commitments to their specific mainstreaming context for climate change and ocean governance in Africa. This chapter takes a comprehensive review and comparative analysis of these essential documents to reveal gaps and potential entry points for mainstreaming ocean and climate change concerns. Some agreements already include climate-responsive language and actions – and can be referenced as good practice, e.g., Convention on Biological Diversity and the Global Compact for Safe, Orderly and Regular Migration. The review also provides an overview that explains how these agreements and commitments can be aligned to strengthen Africa's position at COP27. Interestingly, the chapter reveals areas of synergy for climate change action consideration in Africa and with emphasis that:

1. Accelerating the implementation of Agenda 2030 is critical for more effective ocean-climate action in Africa. For instance, ocean renewable energy is one option for energy transitions envisaged in SDG7 on sustainable energy.
2. Simultaneously addressing climate change, sustainable ocean development presents challenges that demand a decentralised multi-level approach, recognizing the critical role of subnational and local governments, local communities, indigenous peoples, and the marginalised.
3. Governments at the national level need to work with other government levels to ensure coherence, vertical integration and alignment of climate and ocean policies while mainstreaming relevant action into all public policy sectors to avoid silos.
4. Climate change impacts are already, directly and indirectly, affecting a broad range of human rights of coastal communities and human resources in the maritime sector. Therefore, obligations to humans, indigenous peoples, and local communities, gender equality, women empowerment, and intergenerational equity must be paramount.
5. A more robust ocean science-technology-policy interface for synergistic ocean-climate actions is needed, including instruments like the Global Sustainable Development Report and the Technology Facilitation Mechanism.
6. Actions needed to mitigate climate change in Africa and globally have a transformative impact on the world of work and jobs, particularly for the Island States whose primary GDP earnings depend on the ocean and communities who rely on the ocean to sustain their livelihoods. The transformation would not be underestimated.
7. Concessional finance from bilateral donors remains Africa's most critical component of climate finance, given the many fiscal constraints and the urgent need for adaptation.

The fourth chapter of this report provides a comprehensive overview of existing indigenous knowledge in Africa that is important for climate mitigation and adaptation. First, the background to understanding the many interpretations of Indigenous and local knowledge (ILK) is presented from local natural resource management, historical and contemporary experiences, social norms, socio-cultural governance structures and spiritual beliefs perspectives. A look at the role of indigenous knowledge in climate change adaptation globally reveals the significance of ILK in supporting efforts to build the adaptive capacity to climate change. Yet researchers, policymakers, and service providers often undervalue these knowledge systems. For instance, several indigenous communities use ILK, traditional

weather and climate forecasting globally as a guiding framework for adapting to extreme climate events and conditions. The chapter presents case studies of how indigenous communities and people in Africa have survival strategies and variations in their ability to adapt to and mitigate against a range of climate change hazards such as floods and droughts in both terrestrial and marine domains. For instance, local communities in some parts of Africa have developed and practice adaptation strategies/actions for flood prevention (e.g. water resources management (e.g. the indigenous rural communities in the basin of the River Affin, Indigenous farmers of Ouémé, Benin Republic, and farmers in Lake Victoria Basin), food security (e.g. local communities within the Zambezi Basin, Zimbabwe, and male fishers of Ngazidja, Comoros), Drought Risk Reduction (e.g. communal farmers in the O.R. Tambo district in the Eastern Cape province of South Africa), and social and human capital development (e.g. coastal communities of Ayetoro, Awoye, Orioke, Araromi, Abereke and Obefela in Ondo state and Burutu, Gbekebor and Ogulaha in Delta State, Nigeria). Some indigenous communities in Africa have also used their local and traditional knowledge for climate change monitoring and surveillance. This includes the smallholder farmers of Semiarid Palapye, Eastern Botswana, local artisanal fishers in Cape Verde, the Afar Pastoralists in Northeastern Ethiopia and the local farmers in the Eastern Cape province of South Africa. This chapter concludes by highlighting several knowledge gaps about the appreciation and utility of ILK for climate adaptation and mitigation in Africa. This includes (i) the under research and documentation of climate change adaptation knowledge systems and practices by local and indigenous people in different African communities, (ii) constraints for the integration of indigenous knowledge as part of an evidence-based needed for climate change adaptation policy formulation and implementation occasioned by low investment in climate change adaptation research, (iii) inadequate platforms for inter-linkages and exchange among Indigenous and local people across coastal communities in Africa, (iv) the integration of Indigenous and local knowledge with scientific knowledge for practical climate change adaptation efforts, (v) the need to consider the gender dimension of climate change adaptation and cultural differences that may limit adaptation uptake, (vi) further research on how to identify the tipping points in time and space where communities can no longer adapt using ILK.

The fifth chapter of this report gives an overview of widely agreed metrics and frameworks to inform a methodological proposal for African countries to measure and track their climate adaptation and mitigation progress. First, approaches for measuring, aggregating and comparing adaptation results, including their strengths and limitations, are presented. This includes approaches to:

- measure adaptation progress and effectiveness concerning reduced negative climate change impact (outcome evaluation approaches), assess various stages and aspects of adaptation (systematic approaches),
- assess and track the adaptation process at the development and implementation phase while working towards a desired objective and outcome (process-based approaches).
- Monitoring government policies and programs and complementing outcome-based tracking approaches (Analysing policies and programmes approaches)
- identify many vulnerable locations of climate risk, future vulnerabilities prediction and informed adaptation planning and predict successful adaptation in contrast to outcome-based approaches that focus on the direct manifestations of reduced risk following adaptation (examining measures of changing vulnerability approach).

The chapter identifies and reviews existing tools and metrics used to assess and track ocean-based adaptation and mitigation actions. This chapter presents the characteristics and utilities of various existing methodologies in terms of scale, sectors, systems, application domain, and actors. This includes the Monitoring and Evaluation Framework for Adaptation to Climate Change (MEFACC), AdaptME toolkit, Climate change adaptation monitoring and assessment tool (AMAT), Tracking adaptation and measuring development (TAMD), saved health, saved wealth, Participatory monitoring, evaluation, reflection and learning (PMERL) framework, and the Vulnerability Reduction Assessment (VRA) Framework. Some of these tools have been directly applied for local adaptation planning in Africa. This includes the integration of TAMD framework into Local Adaptation Plans (LAP) in Mozambique and Tanzania to support local stakeholders in monitoring and evaluating their efforts. (MRV) + has also been used for national and sub-national adaptation tracking in Kenya. In conclusion, this chapter posits that countries need to develop or adopt suitable frameworks for tracking their adaptation strategies as contained in their NDC's as most of the updated NDC's by African countries do not have frameworks for climate change adaptation monitoring, evaluation and tracking.

In the sixth chapter of this report, recommendations on how to better integrate ocean-based climate actions into NDCs and related policies towards climate mitigation and adaptation in Africa are presented based on gaps and outcomes identified in chapters 1 – 5. These recommendations include input and output actions necessary to encourage operational measures for climate change adaptation, adopting policies for adaptation and mitigation planning, and taking advantage of the ocean as a solution to the climate crises in Africa and beyond. Cross-referencing these recommendations with the different UNFCCC's mechanisms on mitigation, adaptation, Loss and damage, Indigenous Knowledge, Finance, and Science allows the proposal of possible options to inform an African position during the upcoming COP27.

Abbreviations and acronyms

IPCC	Intergovernmental Panel on Climate Change
SROCC	Special Report on the Ocean and Cryosphere
GHG	Greenhouse Gas
GDP	Gross Domestic Product
GCRI	Global Climate Risk Index
LECZ	Low Elevation Coastal Zone
WHO	World Health Organisation
AR6	IPCC Sixth Assessment Report
NAPs	National Adaptation Plans
NAPA	National Adaptation Programme of Action
NAMAs	Nationally Appropriate Mitigation Actions
NDCs	Nationally Determined Contributions
LTSs	Long-Term Strategies
SBSTA	Subsidiary Body for Scientific and Technological Advice
IUCN	International Union of Conservation of Nature
HLP	High-Level Panel for Sustainable Ocean Economy
MSP	Marine Spatial Planning
ICZM	Integrated Coastal Zone Management
MPAs	Marine Protected Areas
ORE	Ocean Renewable Energy
CO_2	Carbon Dioxide
COP	Conference of Parties
SDGs	Sustainable Development Goals
ILO	International Labour Organization
ISA	International Seabed Authority
MLC	Maritime Labour Convention
IMO	International Maritime Organization
NUA	New Urban Agenda
CBD	Convention on Biological Diversity
LMOs	Living Modified Organisms
BBNJ	Biodiversity of Areas Beyond National Jurisdiction
UNCLOS	United Nations Convention on the Law of the Sea
MGRs	Marine Genetic Resources
ABMTs	Area-Based Management Tools
EIAs	Environmental Impact Assessments
ABNJ	Area Beyond National Jurisdiction
GCM	Global Compact for Migration
SFDRR	Sendai Framework for Disaster Risk Reduction
HFA	Hyogo Framework for Action
ILK	Indigenous and Local Knowledge
TEK	Traditional Ecological Knowledge
EbA	Ecosystem-based Adaptation
MRE	Measuring, Reporting and Evaluating
ND-GAIN	Notre Dame Global Adaptation Index
ESI	Environmental Sustainability Index
GCRI	Global Climate Risk Index
UNDP	United Nations Development Programme
GEF	Global Environment Facility
DRM	Disaster Risk Management
NRM	Natural Resource Management
LDCF	Least Developed Countries Fund
M&E	Monitoring and Evaluation
MEFACC	Monitoring and Evaluation Framework for Adaptation to Climate Change
UKCIP	United Kingdom Climate Impact Programme
AMAT	Climate Change Adaptation Monitoring and Assessment Tool
CCA	Climate Change Adaptation
TAMD	Tracking Adaptation and Measuring Development
CRM	Climate Risk Management
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
SW	Saved Wealth
SH	Saved Health

PMERL	Participatory Monitoring, Evaluation, Reflection and Learning
ERL	Evaluate, Reflect On and Learn
DRR	Disaster Risk Reduction
VRA	Vulnerability Reduction Assessment
LAPs	Local Adaptation Plans
NWP	Nairobi Work Programme
AC	Adaptation Committee
LEG	Least Developed Countries Expert Group
WIM	Warsaw International Mechanism for Loss and Damage
LCIPP FWG	Facilitative Working Group of the Local Communitie and Indigenous Peoples Platform
SCF	Standing Committee on Finance
GCF	Green Climate Fund
GEF	Global Environment Facility
AF	Adaptation Fund
GST	Global Stocktake
EEDI	Energy Efficiency Design Index
HCFCs	Hydrofluorocarbons
FAO	Food and Agricultural Organization of UNESCO
IAMs	Integrated Impact Assessment Models
ISO	International Organization for Standardization
IWSM	Integrated Watershed Management
CBDR–RC	Common but Differentiated Responsibilities and Respective Capabilities
MEPC	Marine Environment Protection Committee
ARC	African Risk Capacity
FDI	Foreign Direct Investment
CPPAs	Corporate Power Purchase Agreements
VAT	Value-Added Tax
ETM	Energy Transition Mechanism
FIPs	Fishery Improvement Projects
SSF	Small-Scale Fisheries
AfDB	Africa Development Bank
AAAP	Africa Adaptation Acceleration Programme

Chapter 1

Setting the stage

Credit: Gaby Barathieu / Ocean Image Bank

This chapter provides background and conceptual elements underpinning the current state of the oceans and climate change to help set the stage for the later chapters (namely, chapters 2 to 6).

The ocean and climate change

Covering 71% of the earth's surface, the ocean plays a significant role in sustaining the earth's system, hosts incredible biodiversity and contributes to global socio-economic development. Recent findings from the IPCC[1] and the IPBES[2] reinforce the vital role of the ocean and adjoining coastal environment in protecting livelihoods, regulating climate and sustaining biodiversity.

The role of the ocean in mitigating climate change is significant. The ocean stores a substantial level of CO_2 and an overwhelming portion of excess heat 1. Besides absorbing 90% of the excess heat from anthropogenic sources, the ocean efficiently sinks 23% of human-caused CO_2 emissions 2. The ocean contributes to climate mitigation and adaptation in many exciting ways. Coastal ecosystems, including mangroves, tidal marshes and seagrass meadows, sequester and store carbon ten times greater per unit area than mature tropical forests, and five times more per equivalent area than tropical forests 3. Likewise, these ecosystems act as a natural defence for coastal communities against extreme weather conditions and other effects of climate change. They also support biodiversity and help strengthen the ability of coastal communities to cope with the attendant impacts of climate change.

However, the ability of the ocean to continue playing a mitigation and adaptation role against climate change is decreasing, as ocean health is declining due to natural and anthropogenic stressors. The 2019 IPCC SROCC indicated the reasons for this, i.e., anthropogenic GHG impact the ocean and coastal areas, and, coupled with other human activities (fisheries, agriculture, resource extraction, tourism and shipping), have exerted enormous pressure on the ocean. This is exacerbated by population growth concentrated along the coast. This has led to changes in water temperature, ocean chemistry changes in oceanic circulation, rising sea levels, increased storm intensity, and changes in the diversity and abundance of marine species. Interestingly, ocean and coastal actions may help to avoid, reduce and reverse ocean health degradation, and can provide over one-third of the climate mitigation needed to keep global warming below two or even 1.5 degrees Celsius and help humanity adapt to the consequences of climate change 4. Therefore, the implication of all this is that a low carbon emissions trajectory is imperative to preserving the ocean's health and continuing to provide the ecosystem services that people depend on.

> "The role of the ocean in mitigating climate change is significant."

The ocean and climate change in Africa

Africa is a region shaped by the ocean, as only 16 of the 55[3] sovereign countries in Africa are landlocked states. The countries have approximately 26,000 km of coastlines, 6.5 million square kilometres of the continental shelf, and about 13 million square kilometres of exclusive economic zones. More than 90% of Africa's trade is conducted by sea 5, and the number of people living by the

1 https://report.ipcc.ch/ar6wg2/pdf/IPCC_AR6_WGII_FinalDraft_FullReport.pdf

2 https://zenodo.org/record/6417333/files/202206_IPBES%20GLOBAL%20REPORT_FULL_DIGITAL_MARCH%202022.pdf?download=1

3 According to the African Union, there are 55 countries in Africa. https://au.int/en/member_states/countryprofiles2

coast is expected to increase significantly throughout this century, as population growth and urbanisation in the coastal zone are on the rise [6].

Fisheries in Africa are estimated at USD21 billion in total gross value added. In 2018, approximately 14.5 million people in the region worked in fishing or aquaculture, contributing significantly to countries' GDP [7]. Coastal tourism provided an additional USD80 billion in 2018 alone, and the contribution to employment in 2018 was estimated at 24 million jobs [7]. But, increasingly, Africa's ocean domain is under pressure. Unsustainable fishing and fishing practices, increased coastal degradation, poor wastewater treatment, farmland run-off, chemical and hydrocarbon pollution, and population growth threaten essential ecosystems [8]. Despite Africa contributing minimally to greenhouse gas emissions, it has experienced some of the most severe impacts of climate change, e.g., drought, famine, outbreaks of pests and disease, water scarcity, irregular rainfall patterns, etc. Chapter 9 of the IPCC WGII report focused solely on Africa and presented evidence of the loss and damages experienced. African biodiversity loss is projected to be widespread and escalating with every 0.5°C increase above present-day global warming (high confidence). Above 1.5°C, half of the assessed species are projected to lose over 30% of their population or area of suitable habitat. At 2°C, 7-18% of species assessed are at risk of extinction, and over 90% of East African coral reefs are projected to be severely degraded by bleaching.

Growing climate risk in the African ocean domain: What are the issues?

The health of the ocean and its ecosystems influences the social and economic values that could be accrued from it. However, the extent and health of Africa's ocean and coastal ecosystems have been deteriorating due to several anthropogenic stressors, including overfishing, pollution, the intensive use of coastal zones, and the harmful impacts of upstream human activities [9] [10]. While anthropogenic stressors are increasingly posing threats to Africa's ocean domain and the livelihood of coastal communities that depend on it, the impacts of climate change have compounded and accelerated these threats. Indeed, different ocean sectors and coastal communities are already feeling the brunt of climate variability and climate extremes and are expected to be more exposed relative to future climate change projections [10].

The direct impact of climate change on Africa's ocean domain

The African region is inherently exposed to climate-related risks. Changes in the region's temperature have been higher on average than in other regions, and weather patterns have become more variable and extreme [11]. According to the recent Global Climate Risk Index, which analysed the extent to which countries have been adversely affected by the impacts of weather-related events (cyclones, storms, floods, heatwaves, droughts, etc.), Mozambique, Zimbabwe, Malawi, South Sudan and Niger are listed among the ten most vulnerable to climate-related disasters, while Mozambique is listed among the top ten most affected countries from 2000 to 2019 in terms of the Long-Term Climate Index annual averages [12]. The region is further projected to face a wide range of climate change-related impacts, including warming, food insecurity, increased monsoon activity, rainfall variability, and more frequent and more intense cyclones and droughts in the coming decades [11] [13].

Low Elevation Coastal Zones (LECZ) in the region are more vulnerable and exposed to climate change, with coastlines shaped by climate variability [15]. Climate change adds to the stress factors directly generated by human activity on the coast and inland, compounding existing risks and exacerbating their impacts on coastal communities. More so, extreme weather events are also taking a toll

> "The African region is inherently exposed to climate-related risks."

on African cities[4] – which are multiplying – and are a threat to the livelihoods of millions of people across the continent [6] [14]. Also, along with important social, economic and political factors, changes in the regional climate are impacting the availability of natural resources essential to livelihoods and food security, resulting in migration, conflict or a combination of the two, particularly in the horn of Africa [15] [16].

Considering the combination of hazards, exposures and vulnerabilities that characterise Africa's ocean and coastal domain, the following subsections offer an overview of the past and projected risks posed by climate variability and extreme climate events and their particular knock-on effects on ecosystems and coastal communities. The discussion is structured around the significant climate-related risks to the ocean and coasts: sea-level rise, storm surges, increased seawater temperature, ocean acidification and alterations in the hydrological cycle.

Sea-level rise (SLR)

The most critical and discussed consequence of climate change for Low Elevation Coastal Zones (LECZs) and island states is the rise in global mean sea level (**Figure 1**). Sea levels have risen by between 0.18 to 0.2 m (180–200 mm) since 1900, with the rate of SLR accelerating in recent decades [17]. With medium confidence, the Sixth Assessment Report (AR6) of the IPCC reports that early impacts of accelerating sea-level rise have been detected in coastal areas, resulting in an increased incidence of flooding, water table salinisation, erosion, etc. [18]. The report also warns that coastal risks will increase by at least one order of magnitude over the century due to sea-level rise, with significant consequences for ecosystems, people, livelihoods, infrastructure, food security, cultural and natural heritage, and climate change mitigation at the coast [19]. These risks are already being felt in cities and settlements by the sea, including those in Africa, and will accelerate beyond 2050 and beyond 2100, even if warming stops [18]. According to Chapter 9 of the IPCC AR6 report, which focuses on Africa, exposure of people and assets to climate hazards is increasing in Africa and is compounded by urbanisation, infrastructure deficit and growing populations in informal settlements (high confidence). High population growth and urbanisation in low elevation coastal zones will be significant drivers of exposure to sea-level rise in the next 50 years (high confidence). By 2030, 108-116 million people will be exposed to sea-level rise in Africa (compared with 54 million in 2000), increasing to 190-245 million by 2060.

Under relatively low population growth scenarios, the sensitive populations (people under five or above 64 years old) exposed to heatwaves of at least 15 days above 42°C in African cities are projected to increase from around 27 million in 2010 to 360 million by 2100 for 1.8°C global warming, and 440 million for >4C global warming [21]. Given its low-lying position next to the Atlantic Ocean, Lagos, Africa's most populous city, is susceptible to sea-level rise's negative impacts. Coastal inundation has increased flooding problems (**Figure 2**), heightening already prevalent social conflict and significantly affecting the health, safety and livelihoods of an estimated 21 million inhabitants [14] [20].

Similarly, many coastal cities – including Abidjan, Durban, Cape Town and Dar es Salaam – are projected to experience increasing flood and erosion damage [14]. Over the years, SLR-induced coastal floods have generated significant losses in many coastal African countries. For example, in 2017 alone, they caused an estimated $3.8 billion, or 5.3% of GDP, in losses and damages in coastal areas of Benin, Côte d'Ivoire, Senegal and Togo [21]. African heritage sites

> "The most critical and discussed consequence of climate change for Low Elevation Coastal Zones (LECZs) and island states is the rise in global mean sea level."

4 Most of the biggest cities in Africa are coastal and host more than half of the urban population; these include Lagos, Luanda, Mogadishu, Abidjan, Alexandria, Dar es Salaam, Casablanca, Accra and Durban.

are reported to be threatened by coastal flooding and erosion as SLR accelerates, with at least 151 natural and 40 cultural sites in Africa from 2050[5], including coastal heritage sites in Cameroon, the Republic of the Congo, Djibouti, Western Sahara, Libya, Mozambique, Mauritania and Namibia exposed by the end of the century [22]. Small island heritage sites are especially at risk. For example, Aldabra Atoll, the world's second-largest coral atoll, and Kunta Kinteh Island (the Gambia) could see significant amounts of their extent at risk by 2100 under high emissions, raising questions about their survivability under climate change [22].

5 Under the worst-case scenario, this is also true for Côte d'Ivoire, Cape Verde, Sudan and Tanzania.

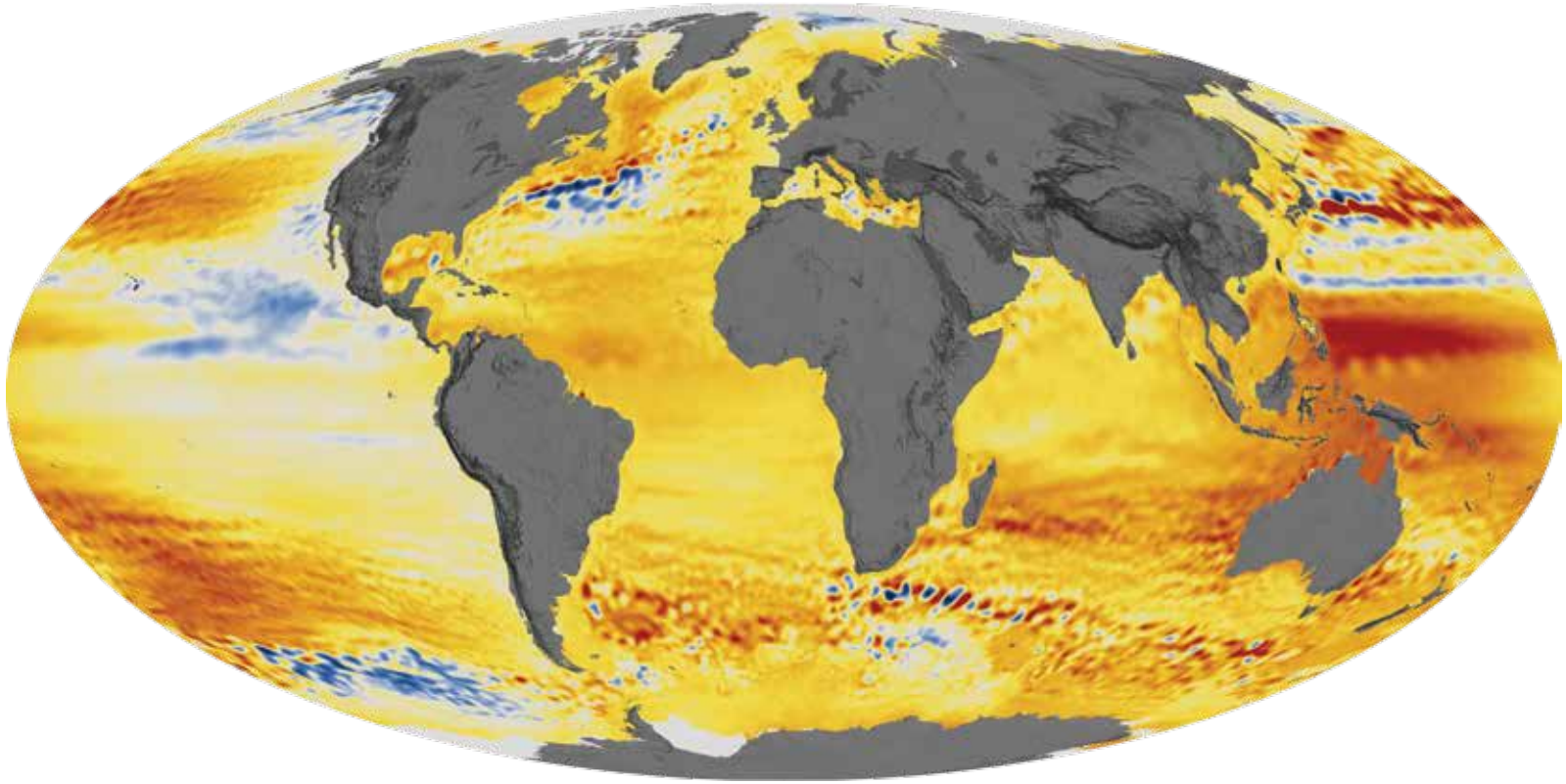


FIGURE 1 Global mean sea level from 1992 to 2014, based on data collected from the TOPEX/Poseidon, Jason-1 and Jason-2 satellite altimeters. Figure legend colours indicate a 22-year sea surface change (cm) ranging from -7cm (blue) to +7cm (red). (Figure Source: https://earthobservatory.nasa.gov/images/91746/sea-level-rise-is-accelerating)

SLR also exacerbates the problem of saltwater intrusion in surface water and groundwater in Africa. For example, studies have revealed the problem of seawater intrusion (SWI) into the coastal aquifers of Eastern Africa (Somalia, Eritrea, Tanzania, Sudan, Kenya and Djibouti) and Northern Africa (Algeria, Tunisia and Libya) as a result of climate change [23] [24]. In Tanzania, the Pangani residents depend on the 500-kilometre Pangani River (FIGURE 3) and underground aquifers as the primary drinking water sources. However, the rising ocean has been leaking salt water into aquifers and wells over the last few decades. Sample records show that the total soluble salt levels downstream of the Pangani River are far beyond the World Health Organization's (WHO) acceptable standards at 2,000 milligrams per litre [25].

It is clear from the recent IPCC Sixth Assessment Report that an increase in sea level (90 cm by 2100) would increase flooding, with devastating effects on critical infrastructure and livelihoods in Africa's coastal communities. According to a UNESCO report on coastal vulnerability in the Central Africa Region, 38 of the 72 villages in Cameroon listed in the single-mode Coastal Agro-ecological Zone are identified with the potential to be permanently flooded, which could cause the demolition of fishers' houses, the migration of approximately 5,900 fishermen and their families, and the loss of 33,000 ha of mangroves (30% of the total area of mangrove forests in Cameroon) [26]. In Angola, floods affect, on average, about 100,000 people every year, more or less 0.4% of the total population and mainly in large urban cities, including Luanda, Benguela, Cabinda and Namibe (FIGURE 4), which are located in areas susceptible to the risks of the effects of climate change [27].

FIGURE 2 Image of a potential future Lagos skyline illustrating what such inundation could look like (Credit: Patrick Keys & Mathew Keys)

FIGURE 3 River Pangani, a major coastal river in north-eastern Tanzania, currently faced with saltwater intrusion (Credit: Aslak Raanes, Creative Commons license 2.0 Generic)

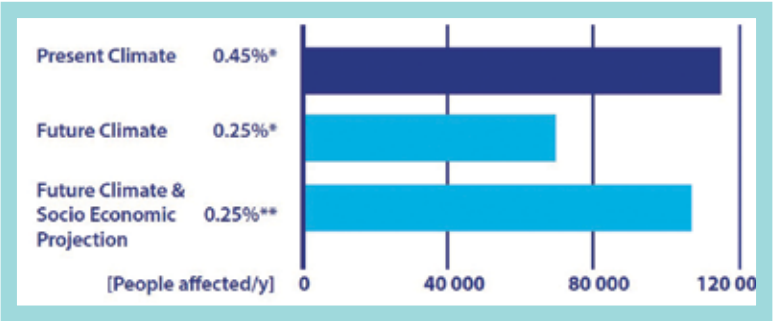


FIGURE 4 The affected people are geographically concentrated in the most urbanised provinces. 26

Coastal storm surges

An increase in temperature and altered precipitation, wave and wind patterns can make storms more intense and storm surges more likely to hit the coast 28. Intensifying storm surges are making extreme sea-level events more frequent in Africa, exposing LECZ areas to periodic coastal flooding and accelerating coastal erosion and saltwater intrusion into freshwater aquifers 20 25 29 30. People, infrastructure and businesses are increasingly exposed to the threats posed by storm surges, especially in coastal areas of West Africa (FIGURE 5). For example, about 56% of the Benin, Côte d'Ivoire, Senegal and Togo coastlines is subject to an average erosion of 1.8 metres per year, leading to losses of high-value urban land, losses of assets (houses, infrastructure) and damage to critical ecosystems (mangroves, marine habitat), with the highest cost – estimated at $0.5 billion per year – in Senegal 31. Also, the coastlines of Mozambique, Egypt, Nigeria, Tanzania, South Africa and Kenya are projected to become increasingly vulnerable to storms due to their growing coastal populations 14 30 32.

Coastal storms have also proved fatal, having killed over 200,000 people globally since 2000 33. Cyclone Idai and Kenneth, two of the most intense storms ever to have hit the shores of Africa, killed almost 1,000 people in Mozambique in 2020 and left 1,641 injured 34. Coastal storms induce flooding, and erosion also causes significant economic losses, destroying or damaging Africa's buildings and infrastructure, such as roads, bridges and harbours. According to the reports, the proportions of land on the DRC's shoreline exposed to erosion due to coastal storms will eventually be doubled (200 metres to Nsiamfumu [FIGURE 6] by 2100, and 100 metres between Moanda and Banana) 35.

FIGURE 5 Coastal erosion is eating up coastal properties in Senegal (Credit: Djiby Sambou, Saint Louis, Senegal: Creative commons 3.0)

In 2019, Cyclone Idai hit Mozambique and neighbouring countries (Zimbabwe and Malawi), wreaking havoc of catastrophic proportions and causing a humanitarian crisis, becoming the deadliest and costliest tropical cyclone in the South-West Indian Ocean [12]. In Mozambique alone, Cyclone Idai caused about USD1.4 billion in total damage, affecting about 2.5 million people [34]. By damaging infrastructure, coastal storms are also likely to affect water quality and disrupt the delivery of public services like transport, education, the health system and emergency response in Africa.

Ocean warming and acidification

According to the IPCC AR6[6], "The Physical Science Basis", global surface temperature in the first two decades of the 21st century (2001-2020) was 0.99 [0.84 to 1.10] °C higher than 1850-1900, with ocean warming accounting for 91% of the heating in the climate system [37]. In Africa, climate change will likely increase the likelihood and intensity of marine heatwaves [38]. Under relatively low population growth scenarios, the sensitive population (people under five or above 64 years old) exposed to heatwaves of at least 15 days above 42°C in African cities is projected to increase from around 27 million in 2010 to 360 million by 2100 for 1.8°C global warming, and 440 million for >4°C global warming [19]. Off the coast of Nigeria, 591 ocean heatwaves occurred between April 1988 and November 2017, with the longest lasting for 25 days in 2016 [38]. The IPCC AR6 on Impacts, Adaptation and Vulnerability reveals that increasing global surface temperature has doubled the probability of marine heatwaves around most of Africa. Warmer temperatures can lead to increased ocean stratification, increasing algal blooms, reducing oxygen levels in seawater, accelerating coastal eutrophication and increasing the development, extent and duration of coastal dead zones. In 2008, a World Resources Institute's study identified 20 eutrophic coastal zones in Africa, out of which eight have documented hypoxia and 12 are areas of concern (FIGURE 7). A warming ocean surrounding Africa is already altering the health, size and distribution of coastal fish populations and is particularly detrimental to coral reefs [39]. Coral reefs along the east coast of Africa have been badly hit due to ocean warming and acidification, with consequences for sources of livelihood, particularly tourism and shellfish fisheries. During the most extensive coral bleaching event – from 2014 to 2017 – which affected reefs worldwide, African coral reefs in Seychelles, Madagascar,

FIGURE 6 Coastal land loss in Moanda, DRC, exacerbated by shore erosion. Credit: UNDP

6 https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf

Mauritius, Kenya, Tanzania (FIGURE 7) and Comoros were hit 40. This took a toll on the African scuba diving industry, with estimated losses amounting to $2.2million and $15.09 million in Zanzibar and Mombasa, respectively 41. Annual shellfish production in Egypt is above 7,000 tons per year 42; the sector is, however, currently being confronted by threats such as climate change impact 43. In the long term, shellfish are at risk from sea-level rises and ocean acidification 36. Oysters are likely to be influenced by increasing ocean acidity and temperature and may consequently reduce in overall abundance and/or distribution 45.

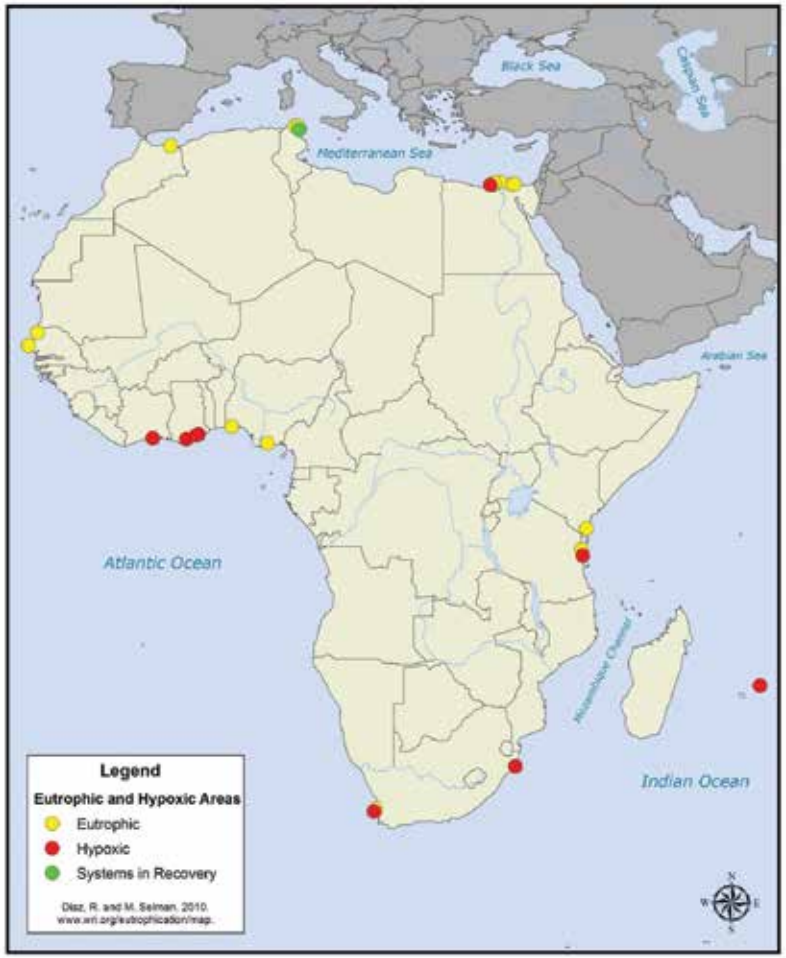


FIGURE 7 Eutrophic and hypoxic coastal zones in Africa. (Credit: World Resources Institute)

In West Africa, the unprecedented recent invasion of *Sargassum spp.* seaweed on coastal shores is attributed to factors that include the warming of the ocean due to global climate change [46] (FIGURE 9).

Broader alterations in the hydrological cycle

The primary driver of freshwater input for the coast is the frequency and intensity of precipitation, which is also being altered by climate change [32], thereby exacerbating other impacts. The IPCC AR6 report posits that future warming would negatively affect the hydrological cycle in Africa, causing extreme drought and inducing water stress. Predominantly in the countries of Eastern Africa and along the coasts of Western Africa and Southern Africa, an estimated 19 million hectares of land is affected by salinity occasioned (directly or indirectly) by climate change-induced drought. This has had a devastating impact on livestock production profit margins for farmers and put food security at risk [47] [48]. Following the impacts of drought in the Western, Eastern and Northern Cape in 2021, drought was declared a national disaster and linked to the reduced well-being of children and young people across South Africa [49]. Recent water scarcity in the KwaZulu-Natal province of South Africa has been attributed to the country's climate profile and has been a driver of regional conflicts [50]. The hyper-arid systems and dune stabilisation expansion are becoming more prevalent on the African coasts, for instance, in southern Angola [26], where a major "classic" desertification issue (the movement and perceived expansion of the desert to typically marginally suitable agricultural production areas) has emerged (FIGURE 10).

FIGURE 8. Coral reefs along the east coast of Africa and the islands of Zanzibar, Seychelles and Madagascar provide jobs for thousands in diving and other allied industries (Credit: Magnus Manske, Chumbe Island, Zanzibar: Creative Commons License 2.0)

FIGURE 9. West African coastal shores have seen an unprecedented recent invasion of ***Sargassum***, a free-floating brown seaweed, negatively impacting aquatic resources, fisheries and waterways (Credit: Jonathan Wilkins, 'Sargasso Seaweed with waves and sandy beach', Creative Commons Attribution-Share Alike 3.0 Unported)

Indirect impact of climate change on Africa's coastal and ocean domain

Climate change, socioeconomic systems and maritime insecurity

The recent IPCC Sixth Assessment Report acknowledges that climate change has already contributed to changes in terrestrial and freshwater ecosystems [51]. By impacting availability of and access to natural resources, the effects of climate change can disproportionately affect communities depending on natural resources for their livelihoods, such as farmers, herders and fishers, leading to decreased economic output and growth as well as increased food insecurity, poverty and inequality rates, which are often at the heart of conflicts and socio-political insecurity.

The impact of climate change on inland terrestrial ecosystems could also contribute to insecurity in coastal and maritime areas through different mechanisms. For instance, some analyses highlight that increases in piracy in Somalia were indirectly influenced by the impact of climate change. According to the International Expert Group on Piracy off the Coast of Somalia, convened by the Special Representative of the UN to Somalia, increases in piracy were rooted in high levels of insecurity and political instability as well as poverty, unemployment and reduced availability of natural resources – partly influenced by recurrent droughts – which strongly affected pastoralist communities inland [52].

Africa's food systems are among the most vulnerable in the world due to their strong reliance on rainfed agriculture, the increasing number and intensity of extreme weather events, and the limited coping capacity because of high poverty rates [53]. There is growing evidence that climate change has contributed to migration and human mobility flows [53] [54]. The interaction between climatic and non-climatic factors has increased rural-urban migration, often towards big urban centres located on the coast. Generally, Africa's rapidly growing

FIGURE 10. Desertification in Angola. (Credit: https://landportal.org/pt/news/2017/03/governo-cria-órgãonacional-para-combater-desertificação-e-efeitos-da-seca-angola)

cities are unplanned and associated with the increase of poverty and informal settlements, which are often home to migrants and displaced populations [53] [55]. In these contexts, tensions between migrant and host communities can increase when combined with "othering" discourses that instrumentalise ethnic and national identities and perceptions of increased competition for jobs, natural and economic resources, and public services.

Africa's rapidly urbanising coastline overlaps with traditional livelihood zones, including small-scale fishing. In the urbanised fringes of Lagos, Nigeria, between the lagoon and the wider Atlantic Ocean, communities engaged in small-scale fisheries find their traditional livelihoods, local economy and food security threatened by coastal gentrification and development efforts due to the rapid urbanisation of the megacity [56] [57]. Small-scale fisheries in the Lagos Lagoon have historically shaped and supported the settlement of people in this area. Climate-related risks such as sea-level rise and rainfall variability, together with environmental degradation and deterioration in water quality, have resulted in the depletion of the local fish supply [58].

Further, the unregulated growth of the sand mining industry, propelled by land reclamation and infrastructural development along the shoreline, has contributed to risks of flooding and groundwater

contamination, in addition to undermining the viability of fishing as a major livelihood [57]. Waterfront communities dependent on small-scale fisheries are disproportionately affected, facing critical human security risks, including livelihood erosion, food insecurity and health-related risks, compounded by lack of access to essential services and land tenure insecurity in the slums they inhabit. Many in the informal waterfront settlements are migrants from inland Nigeria, driven to the coast by the effects of drought and ethnic conflict [59]. They further face the risk of removal through forced evictions, resulting in secondary displacements [60] [61].

Addressing intersectoral conflicts such as that between small-scale fisheries and the sand mining industry, along with land tenure and governance challenges, is therefore crucial for policy discussions around Blue Economy and Blue Justice [7]. This is especially relevant for Africa's urbanising coastal systems facing conflicting scenarios around planning desirable futures.

Moreover, the climate crisis will compound existing socio-economic and ecological stresses present in coastal zones in Africa. Projected increases in the frequency, severity and duration of extreme weather events will endanger marine and coastal ecosystems, undermining biodiversity and ecosystem services while also putting at risk cities, settlements and infrastructure along coastlines, where more than a quarter of the population in Africa lives [51] [53]. The IPCC Fifth Assessment Report highlighted the increasing concern over the impact of climate change on maritime security through changes in marine and coastal ecosystems [53]. This concern was influenced by maritime security issues such as humanitarian assistance in climate-related disasters as well as territorial disputes due to changing coastlines and resource access. For instance, climate change may also compound pressures on resources used to maintain maritime security, such as fighting criminal activity, allowing freedom of navigation and developing disaster relief operations [53]. Hence, climate impacts could undermine the capacity of states to control their maritime and coastal territory and population, paving the way for the increasing presence of criminality and curtailing the capacity to prevent conflicts[7] [62] [63].

The interaction between climatic and non-climatic impacts on coastal resources potentially aggravates existing socio-economic vulnerabilities, which, in turn, may lead to increased maritime criminal activities, such as piracy, illegal fishing and human, drug and arms trafficking [53] [62]. One of the most explicit links in this nexus is the impact of climate change on fisheries and aquaculture, which are particularly important for human welfare in coastal developing countries [64] [65]. Fish accounts for more than one-third of animal protein intake in Africa, making it a crucial source of food security on the continent [53]. However, African oceans are particularly vulnerable to climate change, with two-thirds of the world's most vulnerable fishing sectors [66]. The climate crisis is exacerbating existing pressures on ocean resources led by overfishing and pollution, undermining marine ecosystems and threatening the ability of the oceans to continue providing livelihoods, food and ecosystem services [53] [67].

Ongoing changes in climate, such as the warming and acidification of the ocean, will particularly affect food production and productivity by impacting shellfish aquaculture, marine animal biomass and fisheries in most tropical developing countries, including many African communities [51]. In these contexts of increased socio-economic vulnerabilities, the affected population is more likely to engage in different types of maritime criminality. Poverty and food insecurity decrease the opportunity cost of joining these criminal activities, which may be regarded as an alternative for generating income and coping with the adverse effects of both climatic and non-climatic

> "Waterfront communities dependent on small-scale fisheries are disproportionately affected, facing critical human security risks, including livelihood erosion, food insecurity and health-related risks"

7 It must be noted that African countries have limited resources invested in maritime security, whether funding, human capacity (coastal law enforcement, coast guards, navy) or infrastructure (small coastal vessels, naval ships, command centres for tracking vessels and maintaining maritime domain awareness).

phenomena [68] [69]. Fishermen are comparatively more vulnerable to being recruited by organisations involved in maritime criminality, since most of these criminal activities need similar skills and expertise to those held by fishermen [69].

This phenomenon is particularly worrisome considering that some parts of Africa, such as West Africa, will see one of the greatest climate impacts on the availability of resources, and also because of the strong presence of fish in their diet [70]. Likewise, some estimations for West Africa project that 50% of the jobs related to the fishing industry will be lost by 2050 due to climate change, impacting livelihoods, purchasing power and food security in the region [71] [72]. At the same time, some countries in this region are particularly affected by different maritime criminal activities, such as piracy (in Nigeria, Benin, Guinea, Togo and Cameroon), drug trafficking (in Guinea-Bissau, Nigeria, Ghana and Senegal), human trafficking (in Nigeria and Senegal), arms trafficking (in Nigeria) and illegal fishing (in Mauritania, Senegal, the Gambia and Sierra Leone).

Increasing pressures on fish resources has sometimes led to increases in illegal fishing when fishermen try to cope with the hardship by fishing in the maritime zones of neighbouring countries [62]. For example, reduced availability of resources in northern Senegalese waters have pushed some fishermen to move northwards and fish in Mauritanian waters, creating a maritime security issue to which Mauritanian authorities have responded with numerous arrests [73] [74]. Tensions escalated in 2019 following the killing of a Senegalese fisherman by a Mauritanian coast guard, which ignited attacks on Mauritanian-owned businesses in the border city of Saint Louis. In these types of scenarios, the impact of climate change on maritime ecosystems could exacerbate these trends and increase maritime insecurity by increasing disputes between governments and communities.

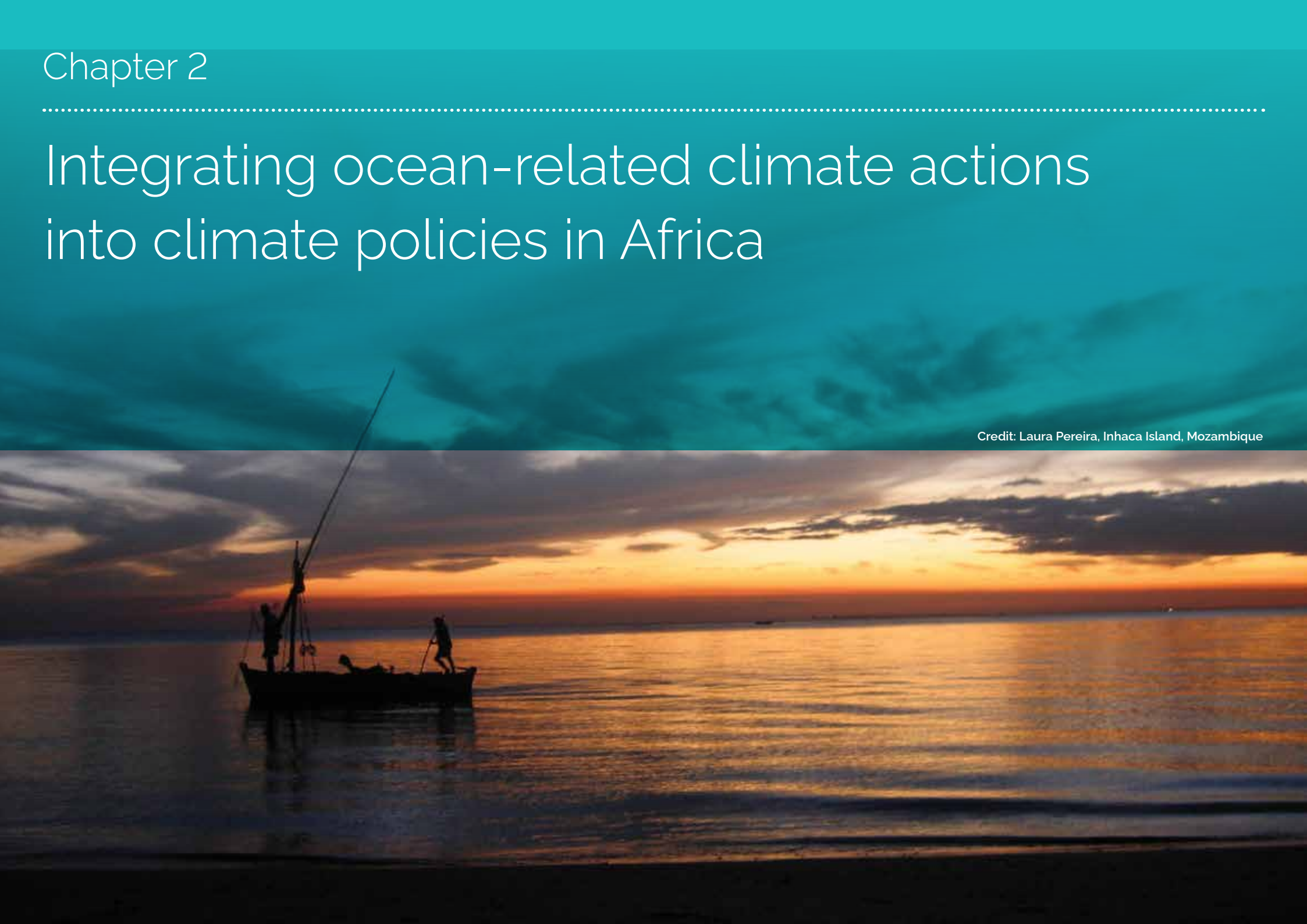
Piracy is present mainly on Somali and West African coasts and has its roots in persistent poverty, the lack of law enforcement and the opportunities [for piracy] in the considerable international maritime trade in the area. The lack of capacity of governments to provide welfare and security for their citizens increases the likelihood of attacks on international vessels as well as off-shore oil and gas installations [75] [69] [62]. In these scenarios, negative climate impacts on the capacity of states to control their maritime and coastal territory and population, as well as the effect on livelihoods, may contribute to piracy and maritime insecurity via these indirect mechanisms [62].

The climate crisis may intensify current socio-economic and environmental vulnerabilities and risks that are considered drivers of both irregular migration and human trafficking [63] [76]. As the impact of climate change on human security increases, criminal actors could utilise the propensity to migrate abroad for their own benefit. In contexts of disorder and fragility following extreme weather events, the increase of vulnerability of individuals and communities is something the traffickers can benefit from [63]. In Senegal, where the fishing industry employs around 17% of the workforce and accounts for 1.8% of the GDP, increases in water temperatures and water salinity are already contributing to the reduction of fish stocks [77]. The effect of climate on ocean resources may, in turn, impact livelihoods and employment opportunities in coastal areas and reinforce irregular migration of young people towards Europe or elsewhere in West Africa [78]. In the case of Senegal, the role of pirogues – traditional small fishing boats widely used in Senegal for artisanal fishing – in clandestine migration to Europe has been widely documented [79] [80] [81]. While migration has been recognised as an effective adaptation strategy, irregular migrants are exposed to insecurity and extreme suffering and often die before reaching their destination [79] [82].

> “some estimations for West Africa project that 50% of the jobs related to the fishing industry will be lost by 2050 due to climate change, impacting livelihoods, purchasing power and food security in the region [71, 72]”

Chapter 2

Integrating ocean-related climate actions into climate policies in Africa



Credit: Laura Pereira, Inhaca Island, Mozambique

Overview of national climate policies

The global climate governance architecture shapes the development of Africa's national and regional climate governance frameworks. Following the dictates of the UNFCCC, several African governments have produced climate policy frameworks such as the National Adaptation Plans (NAPs), National Adaptation Programme of Action (NAPA), Nationally Appropriate Mitigation Actions (NAMAs), Nationally Determined Contributions (NDCs), Long-Term Strategies (LTSs), etc. Several other climate policies are emerging at national level that are not mandated by the UNFCCC process but are still influenced by it. These documents are often developed in response to national priorities and development trajectories. However, the degree to which ocean-related actions in these policies have been integrated has not been documented. In this section, a general overview of the NDC is carried out, followed by an overview of how two essential concepts to reduce the impact and risk of the climate change crisis (mitigation and adaptation) are contextualised in the ocean sphere and how ocean-based actions feature in the climate discourse towards mitigation and adaptation. Finally, 15 regionally representative NDCs in Africa are evaluated to reveal how ocean-based climate actions are integrated within them.

Nationally Determined Contributions (NDCs)

NDCs, sometimes referred to as Intended Nationally Determined Contributions, are developed to meet the long-term goals of the Paris Agreement (see **Figure 11** for explanation). Countries (Parties) are required by Article 4, Paragraph 2 of this agreement to prepare, communicate and maintain successive NDCs, a series of post-2020 climate actions that they intend to carry out post-2020 to reduce national emissions and adapt to the impacts of climate change. Only 25 African coastal countries have submitted an updated version of the first round of their NDCs (these are Angola, Benin, Cape Verde, Cameroon, Comoros, Congo, Congo Democratic Republic, Ghana, Guinea, Guinea-Bissau, Liberia, Mauritania, Mauritius, Mozambique, Namibia, Nigeria, Sao Tome and Principe, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Togo, Tunisia and Tanzania). Côte d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Gabon, Madagascar, Morocco and Senegal are yet to update their NDCs. At the same time, the Gambia is the only country on the continent to have submitted its Second NDCs. NDCs are submitted by countries every five years to the UNFCCC Secretariat. To enhance the ambitions over time, the Paris Agreement provides that successive NDCs will represent a progression compared with the previous NDC and reflect its highest possible ambition.

Intended: The term "intended" reflects the fact that the legal status of the contributions and their final form under the 2015 agreement are yet to be decided. Contributions might also be subject to adjustment, for example, if future rules change the assumptions (for example, concerning land sector accounting) that Parties made when preparing their INDCs.

Nationally determined: The language "nationally determined" underscores that contributions will be developed by countries in accordance with their national circumstances rather than determined collectively.

Contribution: INDCs were defined at COP19 as contributions "towards achieving the objective of the Convention as set out in its Article 2." That objective is "to achieve the stabilization of greenhouse gas (GhG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner" (UNFCCC 1992). INDCs may also contribute to numerous domestic objectives associated with the shift to a low-carbon economy, including gains in energy efficiency, reduced deforestation, and improved air quality, among others, as further described below. The term "contribution" is used without prejudice to the legal nature of the contribution or type of contribution.

Figure 11. Intended National Contribution explained [83]

Climate mitigation and adaptation in the ocean context

Several ocean sectors contribute to global greenhouse gas (GHG) emissions due to the concentration of ocean activities offshore and on the coast. The coastal population and assets are also highly vulnerable to climate change impacts such as heatwaves, floods, severe storms and droughts [84]. Coastal communities and cities are at the forefront of climate policies [19], and the need for technocrats, policy makers and scientists to respond to climate change is crucial for integrated climate governance. Responses to climate change in the ocean consist of designing and implementing policies and practices to reduce anthropogenic GHG emissions, known as *mitigation measures*, and answers to climate-related impacts and risks, known as *adaptation measures*. In planning for mitigation, the primary goal is to reduce current and future direct and indirect GHG emissions, mainly from energy production, maritime transport, fisheries, land use, waste, industry and ports. The primary goal of adaptation is to adjust the ocean, social and ecological environments to minimise the dire impacts of both slow-onset and extreme events caused by climate change. Chapters in IPCC AR6 (Working Group II and III) covering the relationships between climate adaptation and mitigation raised the need to examine possibilities for integrating adaptation and mitigation policies and foundations for decision-making for the ocean, and addressed ocean and coastal issues – both directly, through chapters on adaptation in the ocean and mitigation in human settlements, infrastructure and spatial planning, and indirectly, through the subjects of integrated risk and uncertainty assessment of climate policies – and included a chapter focusing on Africa. Including the ocean in mitigation and adaptation options has led to a search for ocean-based actions across scales. The importance of bottom-up action is recognised along with increasing acceptance of the critical role of the ocean, coasts and associated ecosystems. Experts, researchers and decision-makers worldwide have been driven to find ways to mitigate GHG emissions and seek innovative strategies to adapt to climate change using ocean-based solutions (**Table 1** and **Figure 12**).

Ensuring that the impacts of climate change on the ocean are reduced to the barest minimum will require immediate and effective action to mitigate greenhouse gas emissions and other stressors [85]. Historical and ongoing emissions, and the long timescales over which these emissions and stressors affect the earth's systems, will require mitigation and adaptation actions to manage the risks of committed climate change [37]. Interestingly, ocean-based climate actions are becoming mainstream in today's climate policy discourse.

Several studies and processes have presented convincing arguments, proving that the ocean is not only a victim of climate change but also a solution for it [4] [86] - [90]. The ocean and its associated ecosystems have emerged as leading climate change adaptation and mitigation actors, reflecting both a shift toward a more bottom-up approach to climate action (as seen in the Paris Agreement) and the unique capacities of policy makers to implement climate policies at national, regional and global levels. For example, in 2021, the Subsidiary Body for Scientific and Technological Advice (SBSTA), in their ocean and climate change dialogue informal summary report [8], highlighted the interest of governments in strengthening understanding of action on ocean and climate change adaptation and mitigation. While recognising that silos must be addressed in both process and practice, the dialogue offers several vital options and opportunities for strengthening ocean-based actions under processes such as the UNFCCC at the national level, and across finance and other cross-cutting areas. Likewise, mitigation and adaptation efforts using ocean-based measures are increasing globally. In 2019, the

> "Ensuring that the impacts of climate change on the ocean are reduced to the barest minimum will require immediate and effective action to mitigate greenhouse gas emissions and other stressors [85]."

8 https://unfccc.int/sites/default/files/resource/SBSTA_Ocean_Dialogue_SummaryReport.pdf

International Union of Conservation of Nature (IUCN) compiled a list of case studies showing how ocean-based actions have been applied to mitigation and adaptation efforts in the marine and coastal ecosystems in the Mediterranean (including Algeria and Morocco) (**Table 1**).

Table 1. Case studies of ocean-based actions for climate mitigation and adaptation in the Mediterranean [91]

Marine and coastal ecosystems		
Case study Life Blue Natura Andalucía (life 14/ccm/es/000957) *Posidonia Oceanica* as a carbon sink	**Case study** Sustainable management of Morocco's marine resources	**Case study** Rehabilitation of the coastal dune ecosystem of the commune of Corso
Approach used: ■ Ecosystem-based mitigation ■ Area-based conservation	Approach used: ■ Ecosystem-based adaptation ■ Ecosystem-based management	Approach used: ■ Ecological restoration
Location: ■ Andalusia (spain)	Location: ■ Marine protected area for the purposes of fishing of Alborán ■ Mar Chica lagoon ■ Al Hoceima National Park (Morocco)	Location: ■ Commune of Corso (W. Boumerdes) (Algeria)
Ecosystem type: ■ Seagrass meadows (*Posidonia oceanica*)	Ecosystem type: ■ Sea, estuary, seagrass beds, cliffs	Ecosystem type: ■ Sand dunes
Challenges: ■ Establishment of valid scientific methodologies to measure carbon fixation in the *Posidonia* seagrass meadows ■ Inclusion of the *Posidonia* seagrass meadows in CO_2 ■ Emissions offset projects	Challenges: ■ Destruction of the marine biotope ■ Decline of the local osprey population ■ Decline of the demersal stock	Challenges: ■ Protection of and prevention of the degradation of the dune ecosystems
Delta		
Case study: Adaptation and mitigation measures for climate change in the Ebro delta	**Case study:** Agro-ecological project of Petit Saint-Jean	**Case study:** Adaptation of the original camargue salt marshes to climate change
Approach used: ■ Ecosystem-based adaptation ■ Ecosystem-based mitigation ■ Ecosystem-based management	Approach used: ■ Ecosystem-based management	Approach used: ■ Ecosystem-based adaptation ■ Ecosystem-based disaster risk reduction

Delta (continued)		
Location: ■ Ebro Delta, Catalonia (spain)	**Location:** ■ Petit Saint-Jean Farm, Saint-Laurent D'aigouze, La Camargue (France)	**Location:** ■ Camargue, Bouches-Du-Rhône (France)
Ecosystem type: ■ Wetlands, rice fields, coastal sand dunes and beaches	**Ecosystem type:** ■ Agricultural fields	**Ecosystem type:** ■ Lagoons and other coastal habitats
Challenges: ■ Responding to several mitigation and adaptation needs linked to climate change in a delta area: ■ Avoiding coastal erosion in delta areas with subsidence ■ Improving water quality of water that undergoes strong use by agriculture before returning it to nature ■ Reducing greenhouse gas emissions using appropriate agriculture practices in rice fields	**Challenges:** ■ Creating a showcase of agro-ecology locally and in the whole of the French Mediterranean area, in order to transfer the agronomic achievements to a wide variety of actors	**Challenges:** ■ Depolderisation of 4,000 ha and abandonment of the coastline defence works ■ Restoration of coastal ecosystems

However, recent studies have identified various ocean-based climate action areas that could help fight against and adapt to climate change. In 2021, the Because the Ocean report [86] identified necessary ocean-based action for climate change mitigation as needing to include: (1) encouraging natural carbon sequestration by coastal ecosystems; (2) developing a range of sustainable ocean-based renewable energy solutions; (3) promoting adaptation and resilience solutions for vulnerable populations, ecosystems and ecosystem services threatened by climate change; and (4) implementing hybrid solutions supporting both adaptation and mitigation. In 2019, the High-Level Panel for Sustainable Ocean Economy (HLP) released a critical report highlighting the importance of the ocean as a solution to climate change, itemising five areas of opportunity with corresponding short- and medium-term priorities (**Figure 12**). According to the report, these areas of opportunity present themselves in areas such as ocean-based renewable energy; ocean-based transportation; coastal and marine ecosystems; fisheries, aquaculture and dietary shifts; and carbon storage in the seabed (see **Table 2** below for examples of proposed actions under each identified opportunity area).

By implementing these ocean-based actions across all identified areas in TABLE 2, the report concludes that emissions gaps by 2030 and 2050 could be reduced by upward of 4 billion tons of CO_2e per annum and 11 billion tons of COe per annum, respectively [93].

Key ocean-based adaptation actions have been identified in reports and studies as those that: protect critical ecosystems and support species adaptation; improve fishery management, cultural shifts and low-carbon diets; and strengthen international cooperation [19] [85]. Therefore, just as ocean-based actions are critical for climate change mitigation, they are equally crucial for adaptation, and integrating these two dimensions into climate policy may provide far-reaching benefits [85]. The latter could lead to more effectiveness in reducing climate change impacts, exposure and sensitivity to impact drivers, and/or building adaptive capacity, particularly in coastal communities whose livelihoods depend on the ocean [90] [92]. Ocean-based adaptation interventions have also been promoted to achieve cost-efficient outcomes and avoid maladaptation (the problem of increasing risks from adaptation) as well as malmitigation (i.e., increasing risks from mitigation) [84]. However, it is worth emphasising that although ocean-based mitigation and adaptation actions may overlap in some intervention areas, they aim to address different issues, and the characteristics of the adaptation and mitigation actions on the ground differ significantly (as synthesised in TABLE 1). However, with CO_2 concentrations in the atmosphere rising to irreversible levels that may not be stabilised at safe limits with current mitigation targets, both types of measures need to be implemented simultaneously to ensure that we address climate change systematically and effectively.

Nonetheless, realising these benefits requires a better understanding of countries' progress in integrating ocean actions into their climate policies.

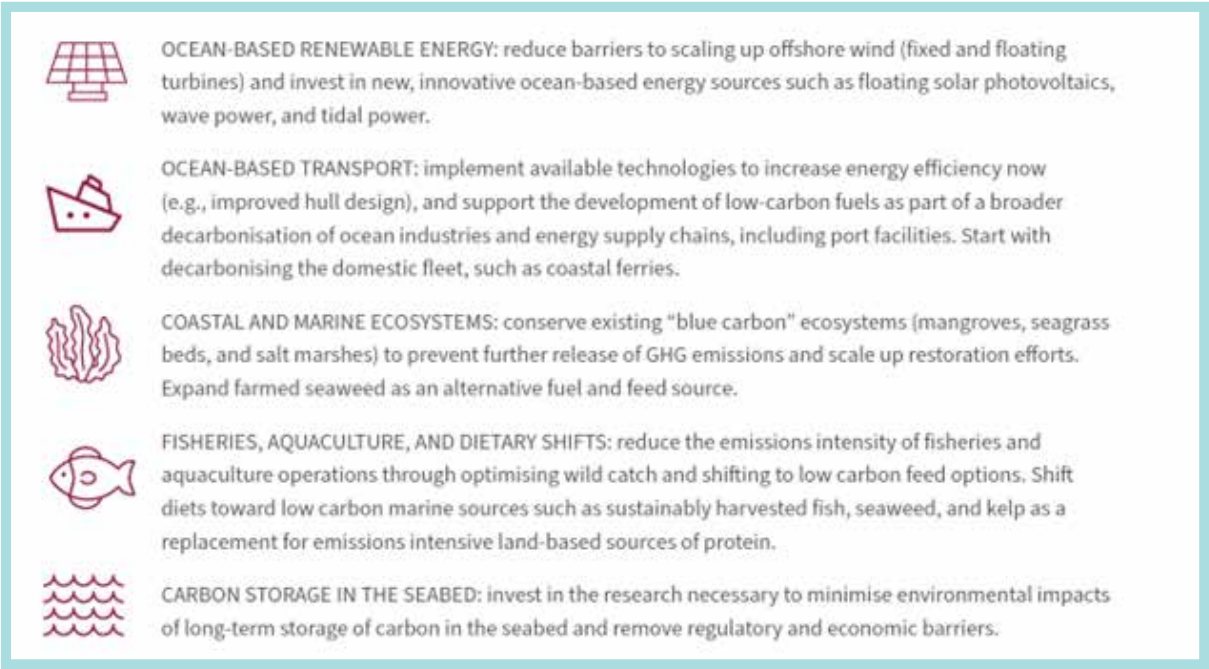


FIGURE 12. Five ocean-based climate action areas that could help in the fight against climate change [93]

AREAS OF OCEAN-BASED CLIMATE ACTION	2030 MITIGATION POTENTIAL ($GTCO_2E$/YEAR)	2050 MITIGATION POTENTIAL ($GTCO_2E$/YEAR)
1. Ocean-based renewable energy	0.18-0.25	0.76-5.40
2. Ocean-based transport	0.24–0.47	0.9 – 1.80
3. Coastaland marine ecosystems	0.32-0.89	0.50-1.38
4. Fisheries, aquaculture, and dietary shifts	0.34-0.94	0.48-1.24
5. Carbon storage in the seabed (Action in this Area Requires Further Research Prior to Implementation at Scale)	0.25-1.0	0.50–2.0
Total	1.32-3.54	3.14-11.82
Total percentage contribution to closing emissions gap (1.SOC pathway)	**4-12%**	**6-21%**
Total percentage contribution to closing emissions gap (2°C pathway)	**7-19%**	**7-25%**

TABLE 2. Each intervention area's total mitigation potential (expressed as a range) [93]

	MITIGATION ACTION	ADAPTATION ACTION
Sectoral focus	All sectors that can reduce GHG emissions	Selected at-risk sectors
Geographical scale of effect: Global, local, regional	Global	Local, regional
Temporal scale of effect	Long term	Short, medium and long term
Effectiveness	Reduction in global temperature rise commitment	Increases in climate resilience
Ancillary benefits (or co-benefits)	Multiple	Improved response to extreme events in current climate
Actor benefits	Through ancillary benefits	Almost fully through reduction of climate impact and ancillary benefits
Payment by polluter	Yes	Not necessarily
Monitoring	Relatively easy (measuring the reduction of greenhouse gas emissions)	More difficult (measuring the reduction of climate risk)

TABLE 3. Main differences between mitigation and adaptation [94]

Progress in integrating ocean actions into African states' climate policies

This section reviews and evaluates how ocean-based actions are integrated into climate change policies in Africa to address this knowledge gap. For this analysis, policies with complementary processes, mandates and elements of countries' responses to climate change were initially considered in line with the Paris Agreement. They include the Nationally Determined Contributions (NDCs), Long-Term Strategies (LTSs), National Adaptation Programme of Action (NAPA) and National Action Plan (NAP). However, the NDCs were selected, as they focus on actions at the country level to cut emissions and adapt to climate impacts. NDCs are comprehensive national-level documents addressing climate change issues and mandatory documents under the Paris Agreement. Fifteen NDCs, three each from five African regions, were reviewed by a team of selected researchers fluent in English and French and having a working knowledge of Spanish. Data from the NDCs were extracted using content analysis from the perspective of integrating ocean-based adaptation and mitigation actions. Recognising that policy making does not take place in distinct stages and often overlaps in the real world [95], our evaluation follows two essential parts that are peculiar to the NDC document: (i) the envisioning and planning part and (ii) the implementation, management and monitoring part.

The **envisioning and planning** part of the NDC documents covers the aspects where goals and targets are set based on the policy objectives for adaptation and mitigation. Often, countries set long-term emission reduction targets on a short-term (up to 2030), medium-term (up to 2050) and long-term (up to 2100) basis, following the IPCC projections of the future climate change format. It also contains different adaptation and mitigation measures (or combinations of measures) considered as pathways for meeting countries' climate-resilient and low-carbon development objectives and their relationship with one another. The **management and monitoring** of the NDC documents speak more to actions necessary for effective implementation, including budgeting and financial commitments, monitoring and evaluation. For instance, implementing different climate change actions (particularly the structural ones) can be costly; therefore, it is imperative for a clear and transparent budget allocation and financial commitment for financing climate action. It also covers essential actions for the joint implementation of ocean adaptation and mitigation measures, regulatory frameworks and institutional coordination. For example, institutional and jurisdictional divergences between adaptation and mitigation measures can become obstacles to an integrated climate policy approach. Monitoring and evaluation systems can track and evaluate results before, during and after implementation, enabling improvements and modifications through feedback processes.

Considering this report's scope and time limitation, only 15 NDCs were included in the evaluation to demonstrate how African countries have integrated ocean-based actions into their climate change policies. Out of the 15 NDCs analysed, 13 were in English and two were in French.

Based on a desktop study, the policy documents were reviewed, and their content was analysed and evaluated by applying the analytical framework developed for this section. Variables for this analysis were gathered from various works of literature that have identified different ocean-based actions across multiple intervention areas to provide a comparative, comprehensive and standardised evaluation of the integration of ocean-based Adaptation/Mitigation actions. Indicators have been developed for the two policy document parts, "Envisioning and Planning" and "Implementation and Monitoring", with their respective scores for the variables, as shown in **Table 4**

> "institutional and jurisdictional divergences between adaptation and mitigation measures can become obstacles to an integrated climate policy approach"

below. The different colour coding shows the relation of each variable to mitigation (blue), adaptation (gold) and hybrid (purple). Indicators were specified to gauge whether the selected variables were considered in 11 different ocean intervention areas, assessing the level of integration of ocean-based climate adaptation and mitigation actions in the various policies. Most variables (36) were based upon a scoring scale of 0-2 – if an indicator did not return with a score, or if there was no evidence of the indicator being mentioned or suggested, the policy received a 0. If an indicator was fulfilled for either mitigation or adaptation, the policy was given a score of 1. If an indicator was fulfilled for both mitigation and adaptation, the policy was given a score of 2.

Score explanations and guidelines were developed to ensure that all researchers conducted the policy reviews with the same analysis. Annex I illustrates the scoring systems and how the variables across the intervention areas were scored.

To ensure consistency, the lead author conducted the reviews of six NDCs and guided the evaluation, and all scoring decisions were justified using qualitative information from the climate policy documents. In cases where any discrepancies became apparent during the review analysis, the wider research team discussed the findings to resolve these issues.

Part of policy document	Intervention area	Variables	Variable code	References	Scores
Envisioning	**Increasing ocean-based renewable energy**	Application of marine spatial planning, Marine Protected Areas (MPAs)	ORE1	[85]	0-2
		Design regulatory frameworks for renewable energy	ORE2	"	0-2
		Advance storage capacity and design	ORE3	"	0-2
		Improve performance of energy systems	ORE4	"	0-2
		Enhance marine biomass-fuelled energy with carbon capture on land, marine biochar, etc.	ORE5	[90]	0-2
	Seabed carbon storage	Explore potential environmental impacts	SCS1	[85]	0-2
		Map marine geophysical potential	SCS2	"	0-1
		Explore the integrity of long-term storage technologies	SCS3	"	0-1

TABLE 4. List of ocean-based climate adaptation and mitigation actions (variables), associated intervention areas in the climate change policies and their associated scoring scales

Part of policy document	Intervention area	Variables	Variable code	References	Scores
		Develop regulatory frameworks	SCS4	"	0-1
		Scale up technologies	SCS5	"	0-1
		Invest in the research necessary to minimise environmental impacts of long-term storage of carbon in the seabed	SCS6	[93]	0-1
	Solar radiation management	Integrate cloud brightening	SRM1	[90]	0-1
		Albedo enhancement	SRM2	"	0-1
	Decarbonising ocean-based transport	Redesign the Energy Efficiency Design Index (EEDI) formula	DOC1	[85]	1-2
		Adopt policies to reduce emissions of other greenhouse gases	DOC2	"	0-1
		Improve ship designs	DOC3	"	0-2
		Develop and implement hybrid power systems – wind, waves, currents and sun	DOC4	"	0-2
	Protecting and restoring key marine and coastal ecosystems and support species	Enhance protection measures for mangroves, kelp seagrass, salt marsh and seaweed beds to prevent further losses	PRES1	[85]	0-2
		Map blue carbon ecosystems	PRES2	"	0-1
		Advance biorefining techniques	PRES3	[90] [93]	0-2
		Apply Marine Spatial Planning (MSP), Integrated Coastal Zone Management (ICZM), Marine Protected Areas (MPAs), etc.	PRES4	[85]	0-2

Part of policy document	Intervention area	Variables	Variable code	References	Scores
		Expand farmed seaweed as an alternative fuel and feed source	PRES5	"	0-2
		Restore and enhance degraded habitats and ecosystems and create new ones	PRES6	"	0-2
		Assisted evolution and genetic modification	PRES7	[90]	0-1
		Maintain and restore coastal hydrology regimes	PRES8		0-2
		Reduce pollution from all sources, including land and rivers	PRES9		0-2
		Enhance open-ocean productivity by adding nutrients (fertilisation)	PRES10	[90]	0-2
		Addition of natural or man-made alkalinity to enhance CO_2 carbon storage	PRES11	"	0-1
	Improving fishery management	Eliminate harmful fisheries' subsidies	IFM1	[90]	0-2
		Reduce discards	IFM2	"	0-2
		Reduce HCFCs in refrigerants	IFM3	"	0-1
		Create incentives for lower trophic level aquaculture	IFM4	"	0-2
		Optimise wild catch and shift to low-carbon feed options	IFM5	[19] [93]	0-2
		Extend surveillance technologies for tracking fishing	IFM6	[90]	0-2

Part of policy document	Intervention area	Variables	Variable code	References	Scores
		Shifting to low-carbon feed options for cultured fish	IFM7	[19] [93]	0-1
	Cultural shift, low-carbon diet	Create incentives to shift diets to low-carbon protein (e.g., fish, seaweed) diets	CSLCD1	[19] [93] [90]	0-2
		Explore carbon tax on red meat other carbon-intensive foods	CSLCD2	[90]	0-1
	Enhancing human and economic sectors and social systems (defend, co-exist or retreat)	Relocate communities, structures and/or assets from areas that are impacted / likely to be significantly affected	EHESS1	[92]	0-1
		Implement strategies to protect assets from the impacts of flooding (involve the construction of seawalls and the reforestation of riparian areas)	EHESS2	"	0-1
		Encourage coping with the new conditions	EHESS3	"	0-1
Management and monitoring	**Improving ocean climate finance**	Common funding arrangement or budget using innovative blue/green financing, including blue bonds, debt-for-nature swaps, resilience credits, nature insurance, etc.	IOCF1	[89] [86]	0-2
		Financial commitments/budget by governments, private sector, etc.	IOCF2		0-2

Part of policy document	Intervention area	Variables	Variable code	References	Scores
	People-centred response to multiple ocean and coastal threats	Ocean literacy and public awareness	PRMT1	[21] [89] [86]	0-2
		Include indigenous perspectives	PRMT2	[21] [89] [86]	0-2
		Coastal community participation	PRMT3	"	0-2
		Integration between different government levels	PRMT4	"	0-2
		Provide materials and financial incentives for coastal communities	PRMT5	[4] [92]	0-1
		Development of labour and professional skills enhancement	PRMT6	[89]	0-1
		Development of MSP, MPA, etc. and ocean legislation	PRMT7	[21] [89] [86]	0-2
	Monitoring	Implement a system of monitoring and evaluation (e.g., reef check surveys, etc.) of productivity of coastal and marine ecosystems	MON1		0-2
		Measuring and transparently reporting climate change impacts on ocean ecosystem resilience and disaster risk reduction	MON2		0-2
		Improve methods for monitoring mitigation benefits to the ocean	MON3		0-2

To ensure that the policies were reviewed in the same manner, minimising the subjectivity of scoring, detailed guidelines were developed for reviewing and evaluating the policies (Annex I). The guidelines also include indicator descriptions, score explanations, related keywords and scoring examples (Annex II).

Individual and overall scores for each country across all variables were aggregated in percentages; An overall score of 0-49% is considered an "early-stage" integrator; a score of 50-69% is a "moderate" integrator; while an "advanced" integrator has a score of 70% or more. "Early-stage" integrator countries incorporate a few ocean-based actions into their NDC, primarily aiming to address mitigation or adaptation. "Moderate" integrators incorporate more ocean-based actions into their policies than the "early-stage" integrators, while adopting a more balanced approach to addressing mitigation and adaptation. "Advanced" integrator countries incorporate several hybrid ocean-based actions into their NDCs across several intervention areas, while adopting a well-balanced approach to mitigation and adaptation. Out of the 36 variables, 11 (highlighted yellow in Annex II) did not receive any score for adaptation or mitigation.

West Africa

Figure 13a-c summarises the score components for West African countries across various variables and the integration level across individual and overall variables. The plots are separated into three bar charts to reflect the imbalance between the number of variables considered (sample size) for evaluation in the different intervention areas (a-c). In the ocean-based renewable intervention area, for example, **Figure 13a** shows that Benin, Cape Verde and Nigeria did not mention in their NDCs the application of MSP, MPAs and other areas-based management tools (ORE1) in the quest to develop ocean renewable energy (ORE). However, the three countries recorded a score of 1 each concerning the variable "Design regulatory frameworks for renewable energy" (ORE2). Benin and Cape Verde have indicated in their NDCs an interest in advancing storage capacity and design (ORE3) for climate mitigation, scoring one point each, while the three countries scored one point each for mentioning improving the performance of energy systems (ORE4) for climate mitigation. Benin's and Cape Verde's NDCs indicate interest in marine biomass-fuelled energy with carbon capture on land, marine biochar, etc. (ORE5).

Variables (SCS 1-6) to access the integration of ocean-based action under the "Seabed carbon storage" intervention area did not return any value for the NDCs of the three West African countries. This intervention is still not well understood in the sub-region, and more research on how this could be operational is needed.

Just like with the seabed carbon storage intervention, countries in West Africa have not integrated ocean-based actions such as cloud brightening (SRM1) and albedo enhancement (SRM2) to mitigate climate change in the intervention area of "Solar radiation management". This also might result from uncertainty about the methods and technology required for this type of intervention and the limited scientific knowledge of their usage.

Integration of actions such as redesigning the Energy Efficiency Design Index (EEDI) formula (DOC1) and improving ship designs (DOC3) into the NDC "Decarbonising ocean-based transport" was not done in any of the three West African countries evaluated. However, only Cape Verde has proposed measures focusing on adopting policies to reduce emissions of other greenhouse gases (DOC2) in the maritime transportation sector. Benin is the only country of the three West African countries considered that has included actions to develop and implement hybrid power systems – wind, waves, currents and sun (DOC4) into its NDC.

Under the intervention area "Protecting and restoring key marine and coastal ecosystems and support species" (**Figure 13b**), actions

to enhance protection measures for mangroves, kelp seagrass, salt marsh and seaweed beds to prevent further losses (PRES1) featured prominently in Benin's, Cape Verde's and Nigeria's NDCs, with the countries scoring two points each. This can be attributed to these countries' importance for blue carbon ecosystems, owing mainly to the supporting of livelihoods. However, only Cape Verde's NDC has the action to map the blue carbon ecosystems (PRES2) proposed, and ditto with advancing the effort to advance biorefining techniques (PRES3). However, Cape Verde's and Nigeria's NDCs score two points each on applying MSP, ICZM, MPA, etc. (PRES4) as actions in their NDCs to mitigate and adapt to climate change, while Benin scores one, as it proposed this action only for climate adaptation. Surprisingly, ocean-based actions such as expanding farmed seaweed as an alternative fuel and feed source (PRES5), restoring and enhancing degraded habitats and ecosystems and creating new ones (PRES6), assisted evolution and genetic modification (PRES7), improving open-ocean productivity by adding nutrients (fertilisation) (PRES7) and addition of natural or man-made alkalinity to enhance CO_2 carbon storage (PRES8) were not suggested in any of the countries' NDCs, and therefore did not return any scores. Nonetheless, Benin and Cape Verde suggested actions to maintain and restore coastal hydrology regimes (PRES8) in their NDCs, scoring one point each in the evaluation. Reducing pollution from all sources, including land and rivers (PRES9), was suggested in Benin's NDC as an action to adapt to climate change, and therefore scored one point in the evaluation, while Cape Verde and Nigeria scored two points each, as they have suggested this action in their NDCs to mitigate and adapt to climate change.

Meanwhile, in the fishery management intervention area **(Figure 13b)**, only Cape Verde out of the three West African countries has set out actions to eliminate harmful fisheries' subsidies (IFM1), reduce discards (IFM2), optimise wild catch and shift to low-carbon feed options (IFM5), extend surveillance technologies for tracking fishing (IFM6) and shift to low-carbon feed options for cultured fish (IFM7), therefore scoring 100% in the evaluation. However, out of the three countries, only Nigeria has set out actions to reduce HCFCs in refrigerants (IFM3) in its NDC to mitigate climate change. **Figure 13b** also shows that only Cape Verde and Nigeria have suggested creating incentives for lower trophic level aquaculture (IFM4) in their NDCs for climate adaptation and mitigation, respectively.

In the intervention area of "Cultural shift, low-carbon diet", **Figure 13c** shows that none of the West African countries evaluated have included actions to create incentives to shift diets to low-carbon protein (e.g., fish, seaweed) diets (CSLCD1).

Figure 13c also shows how the three West African countries have integrated actions to enhance human and economic sectors and social systems (defend, co-exist or retreat) into their NDCs. None of these countries suggests relocating communities, structures and/or assets from areas that are impacted / likely to be significantly affected (EHESS1) or encouraging coping with the new conditions (EHESS3) in their NDCs as an action to adapt to climate change. Meanwhile, action to implement strategies to protect assets from the impacts of flooding (involving the construction of seawalls and reforestation of riparian areas) (EHESS2) was suggested only in Cape Verde's NDC, with one point.

Regarding the intervention area of "Improve ocean climate finance", **Figure 13c** shows that out of the NDCs evaluated for West Africa, only that in Cape Verde proposed having a common funding arrangement or budget using innovative blue/green financing, including blue bonds, debt-for-nature swaps, resilience credits, nature insurance, etc., for climate mitigation and adaptation (IOCF1). Being an island state with the potential to leverage its natural and produced ocean access to negotiate innovative finance might be the reason. Similarly, Benin indicated financial commitments/budgets by governments, private sector, etc. (IOCF2) in its NDC.

FIGURE 13C also shows that under the "People-centred response to multiple oceanic and coastal threats" intervention area, only Benin and Cape Verde suggest actions on ocean literacy and public awareness (PRMT1) to mitigate and adapt to climate change, therefore having one point each. Meanwhile, including indigenous perspectives as climate mitigation and adaptation action (PRMT2) is considered only in Benin's NDC for climate mitigation and adaptation, scoring one point, compared with Cape Verde and Nigeria. The Nigeria NDC did not suggest coastal community participation (PRMT3) action, while Benin's NDC included this for both mitigation and adaptation (two points), and Cape Verde had it for adaptation (one point). Intention to integrate between different government levels (PRMT4) was considered as a mitigation and adaptation action in Benin's NDC, therefore scoring two points in the evaluation, while this action was suggested for either mitigation or adaptation in Cape Verde's and Nigeria's NDCs, earning them a score of 1 each. The provision of materials and financial incentives for coastal communities (PRMT5) is suggested only in Benin's and Cape Verde's NDCs (one point each), but not in Nigeria's for climate adaptation. Also, the development of labour and professional skills enhancement (PRMT6) is not suggested in Benin's or Nigeria's NDCs as an adaptation action, but only in Cape Verde's NDC, therefore scoring a point on the evaluation chart. Development of MSP, MPA, etc. and ocean legislation (PRMT7) has been suggested in Benin's and Cape Verde's NDCs to respond to multiple ocean and coastal threats.

Under the "Monitoring" intervention area, FIGURE 13C shows that Benin and Cape Verde have included a system of monitoring and evaluation (e.g., reef check surveys, etc.) of productivity of coastal and marine ecosystems (MON1) in their NDCs for both mitigation and adaptation (two points), while Nigeria included this action for mitigation (one point). Benin and Cape Verde have proposed actions to measure and transparently report climate change impacts on ocean ecosystem resilience and disaster risk reduction (MON2), ditto proposing improved methods for monitoring mitigation benefits to the ocean (MON3) in their NDCs for both mitigation and adaptation.

FIGURE 13D indicates that the protection and restoration of key marine and coastal ecosystems and support species (27% total), provision of a people-centred response to multiple ocean and coastal threats (25% total) and monitoring (15% total) are the topmost intervention areas in evaluated NDCs in West Africa. It also shows that the most integrated ocean-based climate mitigation and adaptation actions are those focused on enhancing measures to protect blue carbon ecosystems (8%), restoring and enhancing degraded habitats and ecosystems and creating new ones (7%) and implementing a system of monitoring and evaluation of the productivity of coastal and marine ecosystems (7%). However, FIGURE 13E shows that NDCs in West Africa are early integrators of ocean-based climate actions, with the NDC from Cape Verde being the best integrator of these actions (47%), compared with Nigeria (16%) and Benin (37%).

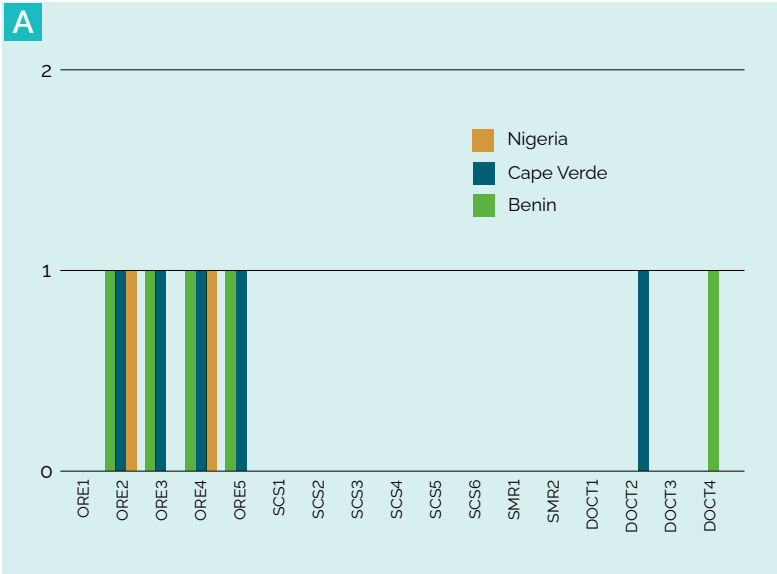
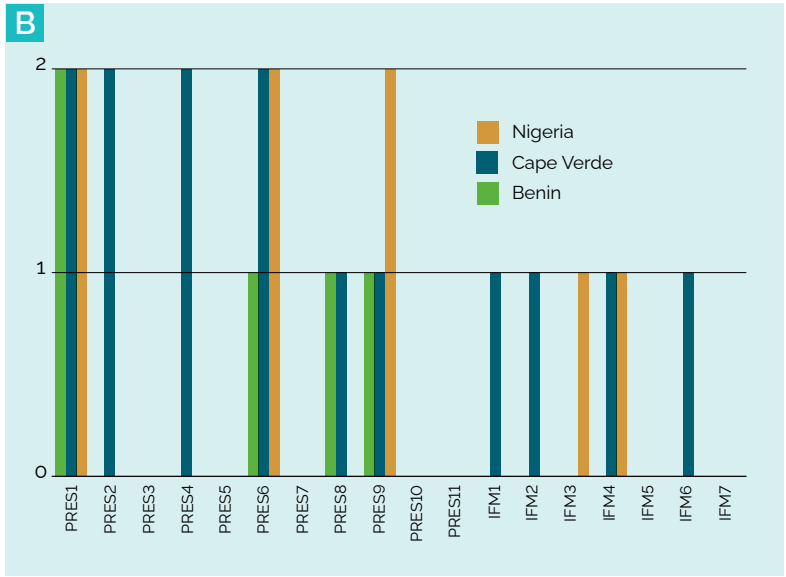
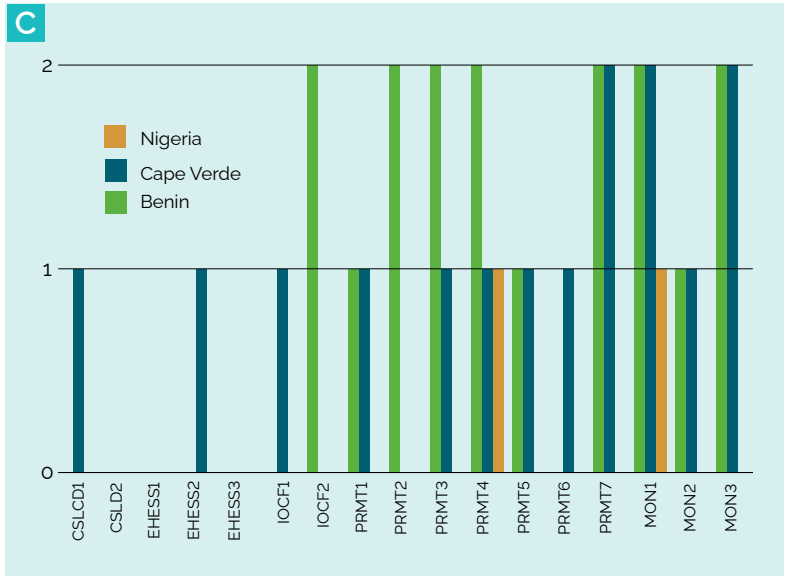
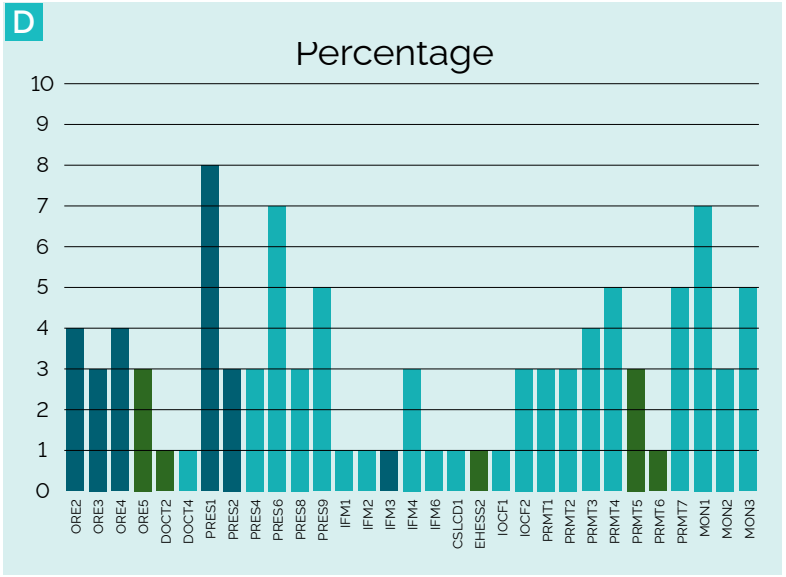


FIGURE 13A-C. Identification of the level of ocean-based actions integration into NDCs for climate adaptation and mitigation by selected West African countries across various intervention areas (based on the comprehensive assessment)







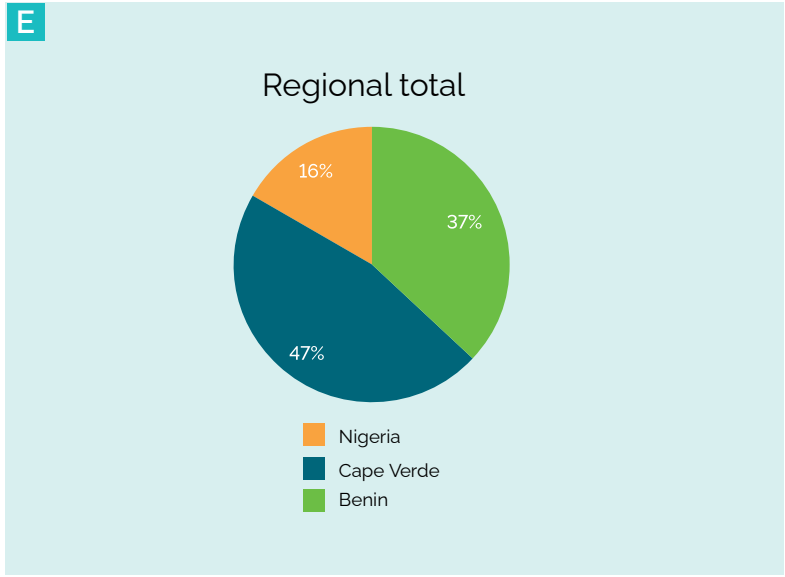


FIGURE 13D. Percentages of ocean-based actions integrated into combined NDCs in selected West African countries

FIGURE 13E. The overall integration of ocean-based climate actions into selected NDCs in West Africa

Central Africa

Figure 14a-c summarises the score components for Central African countries across various variables and the integration level across individual and overall variables. The plots are separated into three bar charts (following the rationale of **Figure 13** above) to reflect the imbalance between the number of variables considered (sample size) for evaluation in the different intervention areas (a-c). For example, in the ocean-based renewable intervention area, **Figure 14a** shows that MSP, MPAs and other area-based tools (ORE1) for ORE management were not considered in Cameroon, Congo DR or Equatorial Guinea's NDCs. However, with a score of 2, designing regulatory frameworks for renewable energy (ORE2) was fully integrated into Cameroon's NDC for climate mitigation and adaptation, while Congo DR and Equatorial Guinea scored one point each, as they have integrated the variable into their NDC for either adaptation or mitigation. None of the Central African countries evaluated indicated interest in advancing storage capacity and design (ORE3) for either climate mitigation or climate adaptation. Among the three countries (scoring one point respectively), only Congo DR's NDC mentioned improving the performance of energy systems (ORE4) and interest in marine biomass-fuelled energy with carbon capture on land, marine biochar, etc. (ORE5) for climate mitigation.

Figure 14a also shows that an evaluation of Cameroon's, Congo DR's and Equatorial Guinea's NDCs to access the integration of ocean-based action under the "Seabed carbon storage" intervention area did not return any value (0), indicating that the consideration for such intervention is still not considered as potential action for climate mitigation, perhaps because of the inadequate scientific evidence of its operation and also the uncertainty surrounding the short- and long-term impact of carbon storage in the seabed.

Likewise, **Figure 14a** indicates that ocean-based actions based on "Solar radiation management", such as cloud brightening (SRM1) and albedo enhancement (SRM2), were not integrated into Cameroon's, Congo DR's or Equatorial Guinea's NDCs to mitigate climate change, as the three countries scored zero points on the evaluation table. The technology, science and evidence for applying these geoengineering options to mitigate and adapt to climate change are uncertain, which explains the zero level of their integration into NDCs in the countries evaluated.

How Cameroon, Congo DR and Equatorial Guinea have integrated ocean-based actions under the "Decarbonising ocean-based transport" intervention area is shown in **Figure 15a**. The three countries did not consider redesigning the Energy Efficiency Design Index (EEDI) formula (DOCT1), improving ship designs (DOCT3) or developing and implementing hybrid power systems – wind, waves, currents and sun (DOCT4) for either mitigation or adaptation action in their NDCs. Meanwhile, among the three countries, only Equatorial Guinea considered adopting policies to reduce emissions of other greenhouse gases (DOCT2) in its NDC for climate mitigation, with a score of 1.

Only Congo DR, out of the three countries, considered enhancing protection measures for mangroves, kelp seagrass, salt marsh and seaweed beds to prevent further losses (PRES1) for climate mitigation and adaptation, with a score of 2. The commitment of the country and international development partners to protect the Congo basin may have contributed to the integration of this variable. However, only Equatorial Guinea's NDC has considered the mapping of blue carbon ecosystems (PRES2) and the application of MSP, ICZM, MPA, etc. (PRES4) as an action to mitigate and adapt to climate change, while the variables to advance biorefining techniques (PRES3) and expand farmed seaweed as an alternative fuel and feed source (PRES5) did not return any value in our evaluation. Restoring and enhancing degraded

habitats and ecosystems and creating new ones (PRES6) did receive two points each for the three countries, indicating that this action is fully integrated into the NDCs, while assisted evolution and genetic modification (PRES7) and maintaining and restoring coastal hydrology regimes (PRES8) were not suggested in any of the countries' NDCs, and therefore did not return any score. Nonetheless, various levels of integration of action to reduce pollution from all sources, including land and rivers (PRES9) for mitigation and adaptation in the Cameroon, Congo DR and Equatorial Guinea NDCs, vary (see **Figure 14b**). Congo DR's NDC scored 2, as it suggested this action, while Cameroon and Equatorial Guinea scored one point each, as their NDCs considered this variable only for climate adaptation. Perhaps for the same reason as SRM1 and SRM2, none of the three countries has considered enhancing open-ocean productivity by adding nutrients (fertilisation) (PRES10) and adding natural or man-made alkalinity to enhance CO_2 carbon storage (PRES11) as actions to mitigate climate change in their NDCs.

Several ocean-based actions are necessary for climate mitigation under the "Improving fishery management" intervention area (**Figure 14b**). Some, such as eliminating harmful fisheries' subsidies (IFM1), reducing discards (IFM2), optimising wild catch and shifting to low-carbon feed options (IFM5), extending surveillance technologies for tracking fishing (IFM6) and shifting to low-carbon feed options for cultured fish (IFM7) were not considered in Cameroon's, Congo DR's or Equatorial Guinea's updated NDCs. Actions to reduce HCFCs in refrigerants (IFM3) and create incentives for lower trophic level aquaculture (IFM4) were suggested only in the Congo DR's updated NDC for climate adaptation.

Figure 14c summarises how ocean-based actions to mitigate and adapt to climate change under the "Cultural shift, low-carbon diet" intervention area have been integrated into updated NDCs in Cameroon, Congo DR and Equatorial Guinea. Actions such as creating incentives to shift diets to low-carbon protein (e.g., fish, seaweed) diets (CSLCD1) and exploring carbon tax on red meat and other carbon-intensive foods (CSLCD2) are not included in Cameroon's, Congo DR's or Equatorial Guinea's updated NDCs.

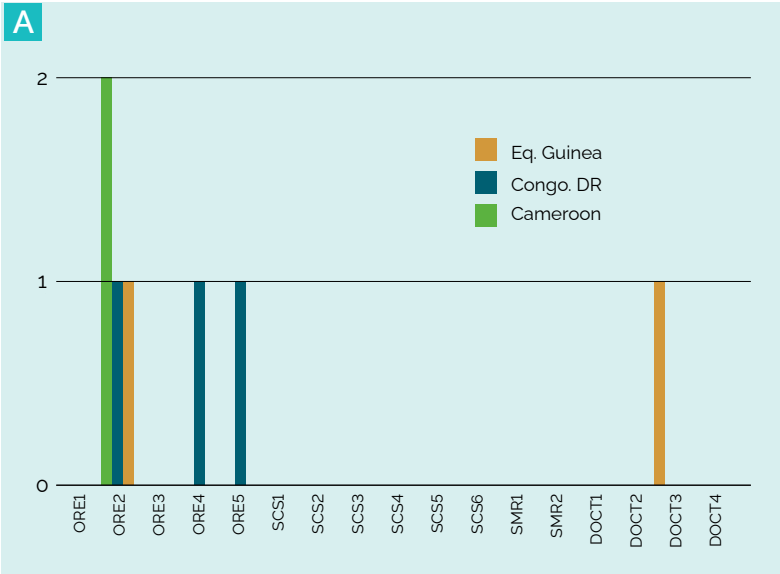
Also, **Figure 14c** shows that among the updated NDCs evaluated in Central Africa, only Equatorial Guinea's NDC suggests action to implement strategies to protect assets from the impacts of flooding (involving the construction of seawalls and reforestation of riparian areas) (EHESS2) under the "Enhancing human and economic sectors and social systems (defend, co-exist or retreat)" intervention area. Actions such as relocating communities, structures and/or assets from areas that are impacted / likely to be significantly affected (EHESS1) and encouraging coping with the new conditions (EHESS3) were not included in Cameroon's, Congo DR's or Equatorial Guinea's updated NDCs.

Regarding the intervention area of "Improving ocean climate finance", **Figure 14c** shows that none of the Central African states evaluated have included common funding arrangements or budgets using innovative blue/green financing, including blue bonds, debt-for-nature swaps, resilience credits, nature insurance, etc. (IOCF1) or financial commitments/budget by governments, private sector, etc. (IOCF2), as required actions to mitigate and adapt to climate change. Meanwhile, in the "People-centred response to multiple ocean and coastal threats" intervention area, none of the NDCs considered ocean literacy and public awareness (PRMT1), including indigenous perspectives (PRMT2), coastal community participation (PRMT3), providing materials and financial incentives for coastal communities (PRMT5) or development of labour and professional skills enhancement (PRMT6) as actions to mitigate and adapt to climate change. However, with a score of 1 each, Congo DR's and Equatorial Guinea's NDCs consider integrating between different government levels (PRMT4) for climate adaptation. At the same time, only Equatorial Guinea's NDC

suggests developing MSP, MPA, etc. and ocean legislation (PRMT7) as actions that can enhance climate adaptation.

An evaluation of Equatorial Guinea's NDC (scoring two points) shows that it includes actions to implement a system of monitoring and evaluation (e.g., reef check surveys, etc.) of productivity of coastal and marine ecosystems (M1), compared with Cameroon's and Congo DR's NDCs, which score one point each, as they have included the action for climate mitigation only. Among the three NDCs, only Equatorial Guinea proposed actions to measure and transparently report climate change impacts on ocean ecosystem resilience and disaster risk reduction (M2) for climate adaptation. None of the NDCs considered improving methods for monitoring mitigation benefits to the ocean (M3), which implies that progress on the state of the ocean concerning mitigation efforts may not be well captured for onward review and improvement of actions.

Figure 14d indicates that enhancing the protection and prevention of further loss to blue carbon ecosystems (44% total) and monitoring (16% total) are the topmost intervention areas in evaluated NDCs in Central Africa. It also shows that the most integrated ocean-based climate mitigation and adaptation actions are those focused on the restoration and enhancement of degraded habitats and ecosystems and the creation of new ones (19%), the design of regulatory frameworks for renewable energy (13%), the reduction of pollution from all sources (13%) and the implementation of a system of monitoring and evaluation of the productivity of coastal and marine ecosystems (13%). However, **Figure 14e** shows that NDCs in Central Africa are early integrators of ocean-based climate actions, with the NDC from Equatorial Guinea being the best integrator of these actions (41%), compared with Congo DR (40%) and Cameroon (19%).



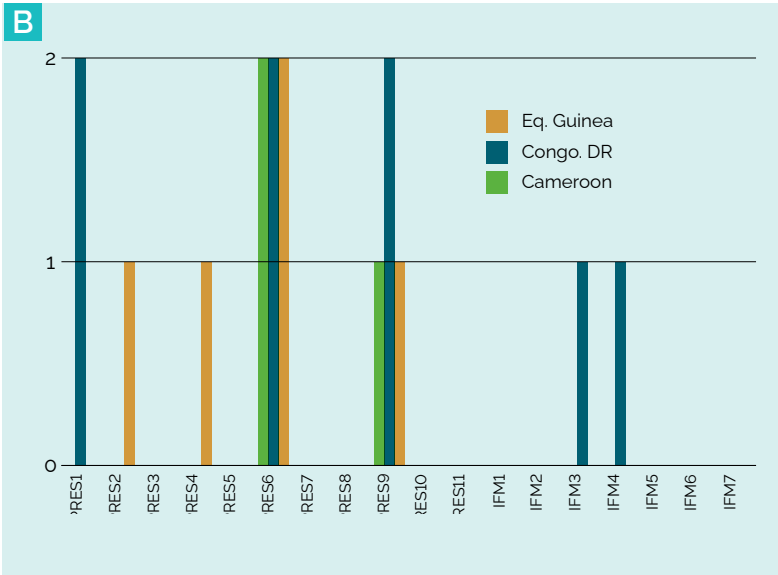
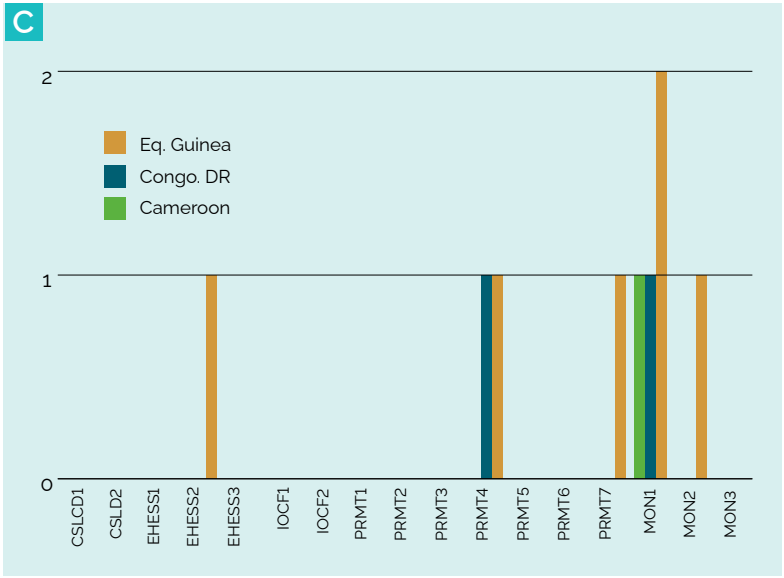


Figure 14a-c. Identification of the level of ocean-based action integration in NDCs for climate adaptation and mitigation by selected Central African countries across various intervention areas (based on the comprehensive assessment)



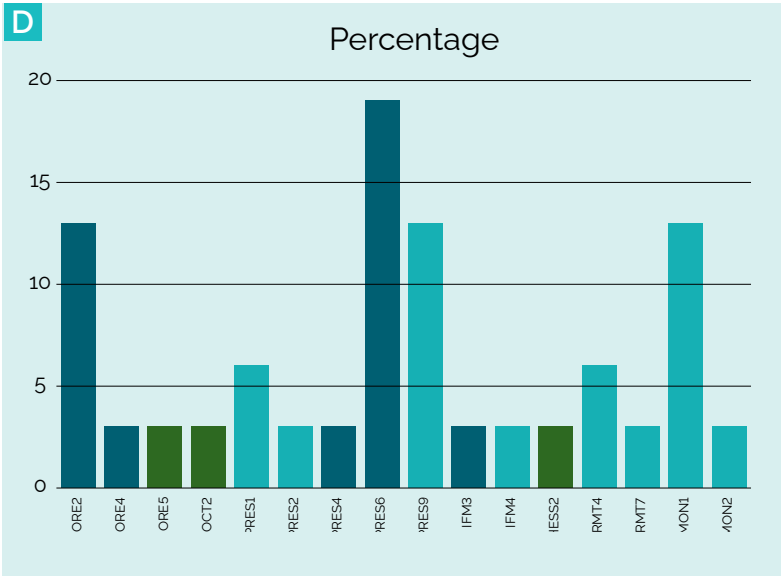


FIGURE 14D. Percentages of ocean-based actions integrated into combined NDCs in Central Africa

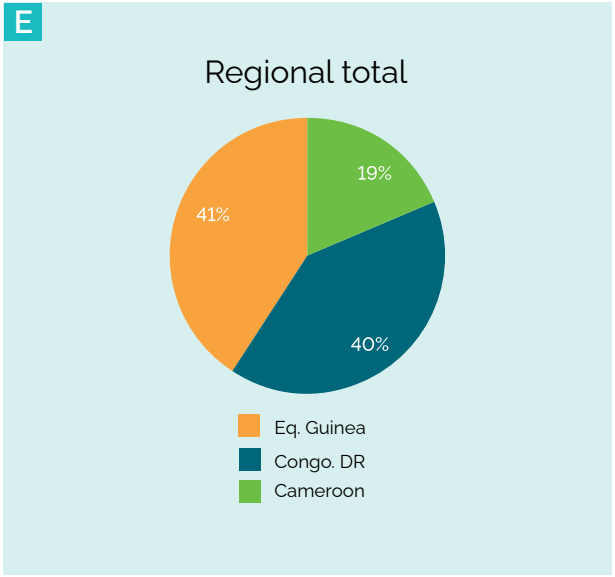


FIGURE 14E. The overall integration of ocean-based climate actions in selected NDCs in Central African countries

North Africa

Figure 15a illustrates the components of the "Ocean renewable energy", "Seabed carbon storage", "Solar radiation management" and "Decarbonising ocean-based transport" intervention areas in selected North African updated NDCs. The plots are separated into three bar charts (following the rationale of **Figure 14** above) to reflect the imbalance between the number of variables considered (sample size) for evaluation in the different intervention areas (a-c). It shows that updated NDCs in Algeria, Morocco and Egypt do not consider the application of marine spatial planning, MPAs, etc. (ORE1) to support the management and implementation of ORE. However, the updated Moroccan NDC considers (with a score of 1) designing regulatory frameworks for renewable energy (ORE2) to mitigate the effects of climate change. Advancing storage capacity and design (ORE3) as an action to mitigate and adapt to climate change was not mentioned in any of the three selected NDCs from North Africa. In contrast, improving the performance of energy systems (ORE4) is considered for both climate mitigation and climate adaptation actions in Algeria's updated NDC (two points), while the NDC in Morocco has considered this action only for climate mitigation purposes. Additionally, **Figure 15a** shows that the three countries scored 0 when evaluated for consideration of marine biomass-fuelled energy with carbon capture on land, marine biochar, etc. (ORE5) in their NDCs.

The level of integration of actions in the "Seabed carbon storage" intervention area by the evaluated North African countries is illustrated in **Figure 15a**. None of the NDCs considers this action, particularly for climate mitigation, which reveals the limitation of countries in operationalising this seabed carbon storage as an option for mitigating climate change. The situation is also the same for the "Solar radiation management" intervention area, as actions such as cloud brightening (SRM1) and albedo enhancement (SRM2) are not considered in the updated Algerian, Moroccan and Egyptian NDCs. Regarding the "Decarbonising ocean-based transport" intervention area, **Figure 15a** also indicates that none of the three countries has considered actions such as redesigning the Energy Efficiency Design Index (EEDI) formula (DOCT1) or improving ship designs (DOCT3) in their NDCs. In contrast, only Algeria (with a score of 1) presents the adoption of policies to reduce emissions of other greenhouse gases (DOCT2) and the implementation of hybrid power systems – wind, waves, currents and sun (DOCT4) in its NDC concerning climate adaptation.

The level of integration of NDCs from Algeria, Morocco and Egypt under the "Protecting and restoring key marine and coastal ecosystems and support species" intervention area is shown in **Figure 15b**. With a score of 2 each, the Algerian and Moroccan NDCs fully consider enhancing protection measures for mangroves, kelp seagrass, salt marsh and seaweed beds to prevent further losses (PRES1) for climate mitigation and adaptation, while the updated Egyptian NDC (having scored 1) has considered this action only for climate adaptation. Mapping blue carbon ecosystems (PRES2) towards climate mitigation and adaptation has received less integration in the three NDCs evaluated, with only Morocco (having scored 1) considering this action for adaptation purposes. Meanwhile, none of the North African countries has considered advancing biorefining techniques (PRES3) as an action for climate mitigation and adaptation. Scoring one point each, Algeria, Morocco and Egypt consider the application of MSP, ICZM, MPAs, etc. (PRES4) in their NDCs for climate adaptation. Consideration of the expansion of farmed seaweed as an alternative fuel and feed source (PRES5) is not on the table in the three countries as an action for either mitigation or adaptation, as the NDCs in the three countries recorded a score of 0. **Figure 16b** also shows that, with each scoring two points, Algeria and Morocco have integrated actions towards restoring and enhancing degraded habitats and ecosystems and creating new ones (PRES6) in their NDCs, compared with a 0 score

recorded by the Egyptian NDC. Although the option of an assisted evolution and genetic modification (PRES7) was not considered in the updated NDCs for the selected North African countries, the NDCs in Morocco and Egypt scored a point each in their integration of actions to maintain and restore coastal hydrology regimes (PRES8) and reduce pollution from all sources, including land and rivers (PRES9). It can also be seen from **Figure 16b** that the NDCs in the three countries recorded no value concerning the integration of actions to enhance open-ocean productivity by adding nutrients (fertilisation) (PRES10) or adding natural or man-made alkalinity to enhance CO_2 carbon storage (PRES11), signifying that these geoengineering options are not yet understood, or that evidence for their large-scale application is still relatively insufficient.

Figure 15b shows that none of the North African countries evaluated considers the integration of five (IFM1, IFM2, IFM3, IFM4 and IFM7) out of seven climate-based actions for climate mitigation and adaptation in the "Improving fishery management" intervention area (see **Figure 15b**). Among the three countries, only Morocco has proposed optimising wild catch and shifting to a low-carbon feed option (IFM5), and extending surveillance technologies for tracking fishing (IFM6) as actions to mitigate climate change.

Figure 15c illustrates that actions that encourage cultural shift and low-carbon diets, such as creating incentives to shift diets to low-carbon protein (e.g., fish, seaweed) diets (CSLCD1) and exploring carbon tax on red meat and other carbon-intensive foods (CSLCD2) are not mentioned in the updated Algerian, Moroccan and Egyptian NDCs as a means of adapting and mitigating climate change. Morocco and Egypt recorded a 0 value as they did not include any actions under the "Enhancing human and economic sectors and social systems (defend, co-exist or retreat)" intervention area in their NDCs. However, from the three actions presented for evaluation, Algeria scored a point, as its NDC suggests implementing strategies to protect assets from the impacts of flooding (involving the construction of seawalls and the reforestation of riparian areas) (EHESS2).

How Algeria, Morocco and Egypt have fared in "Improving ocean climate finance" intervention toward climate mitigation and adaptation is shown in **Figure 15c**. None of the three countries considers a common funding arrangement or budget using innovative blue/green financing, including blue bonds, debt-for-nature swaps, resilience credits, nature insurance, etc. (IOCF1), in their NDCs to enhance the capacity to mitigate and adapt. However, with a score of two points, Morocco has fully integrated actions on financial commitments/budget by governments, private sector, etc. (IOCF2) into its NDC.

Figure 15c also shows how NDCs in the selected North African countries integrate actions in the "People-centred response to multiple ocean and coastal threats" intervention area. Ocean literacy and public awareness (PRMT) as an action to mitigate and adapt to climate change received varying levels of consideration in the evaluated NDCs. Morocco has the highest score of 2 points, considering that it includes this action for mitigation and adaptation. In contrast, Algeria and Egypt scored a point each for including ocean literacy and public awareness (PRMT) as an action to adapt to climate change. Under this intervention area, NDCs in the three countries, having recorded zero points each, did not consider including indigenous perspectives (PRMT2) as essential for mitigation or adaptation. However, Algeria and Egypt consider coastal community participation (PRMT3) in their NDCs; Algeria's NDC considers this for mitigation and adaptation (scoring two points), while Egypt (scoring a point) considers this action in its NDC only for climate adaptation. Also, only Algeria, having scored two points among the three countries, considers an integration between different government levels (PRMT4) for climate mitigation and adaptation. For climate adaptation only, Morocco and Egypt, having scored a point each, consider providing materials and financial incentives for coastal communities (PRMT5) as a climate adaptation action in their

updated NDCs. Meanwhile, regarding the development of labour and professional skills enhancement (PRMT6), none of the evaluated updated NDCs in North Africa has proposed this significant action as necessary for climate adaptation. Among the North African countries evaluated, only Algeria has included developing MSP, MPA, etc. and ocean legislation (PRMT7) as a climate adaptation action.

FIGURE 15C shows how, to a varying extent, selected countries in North Africa have included ocean-based climate actions under the "Monitoring" intervention area. For example, the updated Moroccan NDC, having scored two points in this evaluation, considers implementing a system of monitoring and evaluation (e.g., reef check surveys, etc.) of the productivity of coastal and marine ecosystems (MON1) for both climate adaptation and climate mitigation. On the other hand, the updated Algerian and Egyptian NDCs scored a point each, indicating that the actions have been considered for climate adaptation. The Moroccan and Egyptian NDCs consider measuring and transparently reporting climate change impacts on ocean ecosystem resilience and disaster risk reduction (MON2) for climate mitigation. Among the three countries, only Egypt has mentioned improving methods for monitoring mitigation benefits to the ocean (MON3) in their NDC for climate adaptation.

FIGURE 15D indicates that enhancing the protection and prevention of further loss to blue carbon ecosystems (36% total), responding to multiple ocean and coastal threats (25% total) and monitoring (15% total) are the topmost intervention areas in evaluated NDCs in North Africa. It also shows that the most integrated ocean-based climate mitigation and adaptation actions are those focused on protection measures for mangroves, kelp seagrass, salt marsh and seaweed beds to prevent further habitat losses (11%), restoring and enhancing degraded habitats and ecosystems and creating new ones (9%), ocean literacy and public awareness (9%) and implementing a system of monitoring and evaluation of the productivity of coastal and marine ecosystems (9%). However, FIGURE 15E shows that NDCs in North Africa are early integrators of ocean-based climate actions, with the NDC from Morocco (43%) being the best integrator of these actions, compared with Algeria (32%) and Egypt (25%).

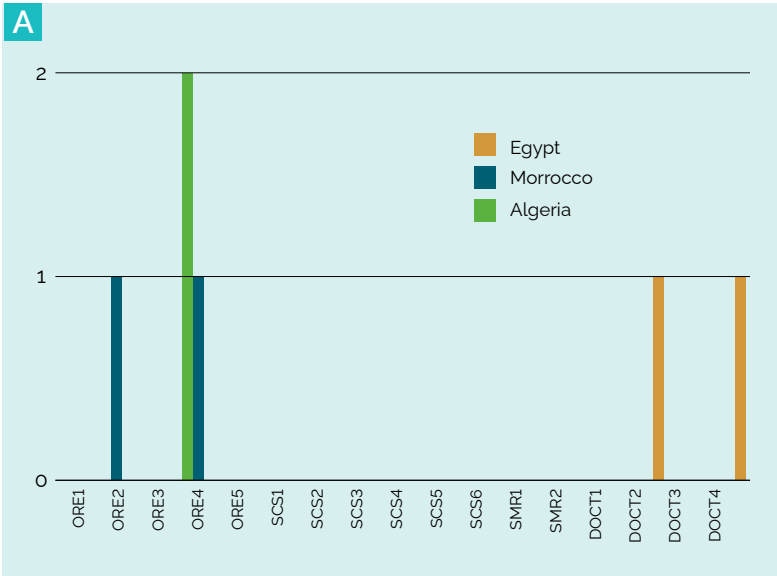


FIGURE 15A-C. Identification of the level of ocean-based actions integration in NDCs for climate adaptation and mitigation by Selected North African countries across various intervention areas (based on the comprehensive assessment)

FIGURE 15E. The overall integration of ocean-based climate actions in selected NDCs in North African countries

Southern Africa

Figure 16a-c summarises the score components for the various intervention areas for ocean-based climate actions in selected updated Southern African NDCs. The plots are separated into three bar charts (following the rationale of **Figure 15** above) to reflect the imbalance between the number of variables considered (sample size) for evaluation in the different intervention areas (a-c). **Figure 16a** shows the score components for the "Ocean renewable energy", "Seabed carbon storage", "Solar radiation management" and "Decarbonising ocean-based transport" intervention areas in selected updated Southern African NDCs. Regarding the "Ocean renewable energy" intervention area, there is no consideration for the application of marine spatial planning, MPAs, etc. (ORE1) as an action to guide the implementation of ORE in the evaluated Southern African NDCs. However, Mozambique, Namibia and Madagascar, scoring a point each in the evaluating of their NDCs, did consider designing regulatory frameworks for renewable energy (ORE2) to mitigate the effects of climate change. However, only Namibia's and Madagascar's updated NDCs (having scored a point each) considered advancing storage capacity and design (ORE3) as an action to mitigate climate change. **Figure 16a** also shows that among the evaluated NDCs from Southern Africa, only Madagascar (scoring a point) considers improving the performance of energy systems (ORE4) for climate mitigation. Namibia's NDC (with a score of two points) is the only NDC in the evaluated Southern African countries to consider marine biomass-fuelled energy with carbon capture on land, marine biochar, etc. (ORE5) in its NDC for climate mitigation and adaptation.

Meanwhile, an evaluation of how NDCs in the evaluated Southern African countries have considered actions regarding seabed carbon storage and solar radiation management as interventions for climate mitigation and adaptation did not return any results, indicating that these interventions have not gained any support from the sub-region. **Figure 16a** shows that out of the four ocean-based actions set out to evaluate Southern African countries' NDCs concerning the "Decarbonising ocean-based transport" intervention, only Namibia's NDC returned a score, as it considers the adoption of policies to reduce emissions of other greenhouse gases (DOCT2) for climate mitigation.

Figure 16b illustrates the integration of ocean-based actions in Mozambique's, Madagascar's and Namibia's NDCs under the "Protecting and restoring key marine and coastal ecosystems and support species" intervention area. With Namibia scoring two points, actions related to enhancing protection measures for mangroves, kelp seagrass, salt marsh and seaweed beds to prevent further losses (PRES1) are considered in Namibia's updated NDC for both climate mitigation and climate adaptation. In contrast, Mozambique and Madagascar have only one point each, as their NDCs consider these actions only for climate mitigation. Likewise, actions towards mapping blue carbon ecosystems (PRES2) are included in both Mozambique's and Namibia's update NDCs, with the former geared toward climate adaptation (scoring a point) and the latter toward both mitigation and adaptation (scoring two points). Meanwhile, actions to advance biorefining techniques (PRES3) are not considered for climate mitigation or adaptation in any evaluated NDC from the Southern African countries. Scoring one point each, Mozambique and Madagascar consider the application of MSP, ICZM, MPAs, etc. (PRES4) in their NDCs as needed action for climate adaptation, while actions related to PRES4 are considered in Namibia's NDC for both mitigation and adaptation, with Namibia scoring two points. Out of the NDCs evaluated in Southern Africa, only Mozambique considers action aimed at expanding farmed seaweed as an alternative fuel and feed source (PRES5) for climate adaptation, scoring a point, while the others recorded a score of 0.

Figure 16b also shows that the three countries score one point each, indicating their consideration for actions towards restoring and enhancing degraded habitats and ecosystems and creating new ones (PRES6) in their NDCs to mitigate or adapt to climate change. While actions for assisted evolution and genetic modification (PRES7) are not considered in any NDCs, Namibia considers the integration of actions to maintain and restore coastal hydrology regimes (PRES8). As illustrated in Figure 16b, all the evaluated NDCs consider reducing pollution from all sources, including land and rivers (PRES9), for climate mitigation, indicating the role of excess pollution in accelerating global warming. Meanwhile, actions such as enhancing open-ocean productivity by adding nutrients (fertilisation) (PRES10) and the addition of natural or man-made alkalinity to enhance CO_2 carbon storage (PRES11) did not return any value for the countries in our evaluation.

In the "Improving fishery management" intervention area, Figure 16b shows that none of the NDCs evaluated in Southern Africa consider actions to eliminate harmful fisheries' subsidies (IFM1), reduce discards (IFM2) or optimise wild catch and shift to low-carbon feed options (IFM5). However, to adapt to and mitigate climate change, Namibia's NDC includes actions to reduce HCFCs in refrigerants (IFM3), extend surveillance technologies for tracking fishing (IFM6) and shift to low-carbon feed options for cultured fish (IFM7), as the fisheries sector is critical to the country's socio-economic development. Of the three countries evaluated, only Mozambique considers actions to incentivise lower trophic level aquaculture (IFM4) towards climate mitigation.

Figure 16c illustrates that the evaluated countries in Southern Africa have not incorporated actions under the "Cultural shift, low-carbon diet" intervention area in their updated NDCs to mitigate and adapt to climate change, including creating incentives to shift diets to low-carbon protein (e.g., fish, seaweed) diets (CSLCD1) and exploring carbon tax on red meat and other carbon-intensive foods (CSLCD2). Under the "Enhancing human and economic sectors and social systems (defend, co-exist or retreat)" intervention area, only the Namibian NDC proposed the relocation of communities, structures and/or assets from areas that are impacted / likely to be significantly affected (EHESS1) for climate adaptation. However, actions regarding implementing strategies to protect assets from the impacts of flooding (EHESS2) have been considered in Mozambique's, Namibia's and Madagascar's NDCs for climate adaptation. Mozambique's and Namibia's NDCs consider actions that encourage coping with the new conditions (EHESS3) for climate adaptation.

Concerning the "Improving ocean climate finance" intervention area, Figure 16c also shows that only Mozambique and Namibia have included a common funding arrangement or budget using innovative blue/green financing, including blue bonds, debt-for-nature swaps, resilience credits, nature insurance, etc. (IOCF1), in their updated NDCs, both for climate adaptation. Also, having recorded one and two points respectively, as shown in Figure 16c, both Namibia's and Madagascar's updated NDCs include actions for financial commitments/budget by governments, private sector, etc. (IOCF2), with the former aimed at climate adaptation and the latter at both adaptation and mitigation.

As shown in Figure 16c, an evaluation of ocean-based actions in various NDCs in Southern Africa reveals a varying level of consideration by Mozambique, Namibia and Madagascar concerning the "People-centred response to multiple ocean and coastal threats" intervention area. For example, having scored two points, Mozambique considers ocean literacy and public awareness actions (PRMT1) in its NDC for both climate mitigation and climate adaptation. In contrast, Namibia and Madagascar scored a point each, revealing that their updated NDCs consider actions related to ocean literacy and public awareness as (PRMT1) for only climate adaptation. However, none of the three countries evaluated has considered including the indigenous perspective (PRMT2) for either climate adaptation or climate mitigation. Actions aligned with coastal community participation (PRMT3),

integration between different government levels (PRMT4) and providing materials and financial incentives for coastal communities (PRMT5) are considered only in Mozambique's and Namibia's updated NDCs towards climate adaptation. Mozambique, Namibia and Madagascar did not consider developing actions concerning labour and professional skills enhancement (PRMT6) for climate change in their updated NDCs, but did consider developing MSP, MPA, etc. and ocean legislation (PRMT7) for either mitigation or adaptation, or both.

Concerning the "Monitoring" intervention area, **Figure 16c** also shows that Mozambique scored two points and considers the implementation of a system of monitoring and evaluation (e.g., reef check surveys, etc.) of productivity of coastal and marine ecosystems (MON1) as an action of both climate mitigation and climate adaptation, while Namibia and Madagascar score a point each, indicating consideration for only climate mitigation. Actions concerning measuring and transparently reporting climate change impacts on ocean ecosystem resilience and disaster risk reduction (MON2) are proposed in Mozambique's, Namibia's and Madagascar's updated NDCs for either climate mitigation or climate adaptation. Mozambique's and Namibia's updated NDCs indicate considerations for improving methods for monitoring mitigation benefits to the ocean (MON3). The former considers it for climate mitigation and adaptation, the latter only for climate adaptation.

Figure 16d indicates that enhancing the protection and prevention of further loss to blue carbon ecosystems (31% total), responding to multiple ocean and coastal threats (20% total) and monitoring (16% total) are the topmost intervention areas in the evaluated NDCs in Southern Africa. It also shows that the most integrated ocean-based climate mitigation and adaptation actions are those focused on the restoration and enhancement of degraded habitats and ecosystems and the creation of new ones (6%), applying MSP, ICZM, MPAs, etc. (6%), ocean literacy and public awareness (6%) and implementing a system of monitoring and evaluation of the productivity of coastal and marine ecosystems (6%). However, **Figure 16e** shows that NDCs in Southern Africa are early integrators of ocean-based climate actions, with the NDC from Namibia (46%) being the best integrator of these actions, compared with Mozambique (33%) and Madagascar (21%).

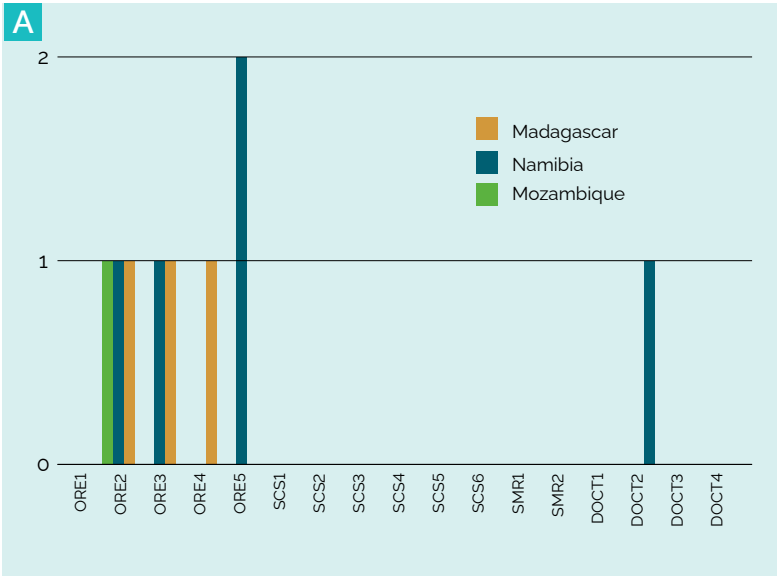
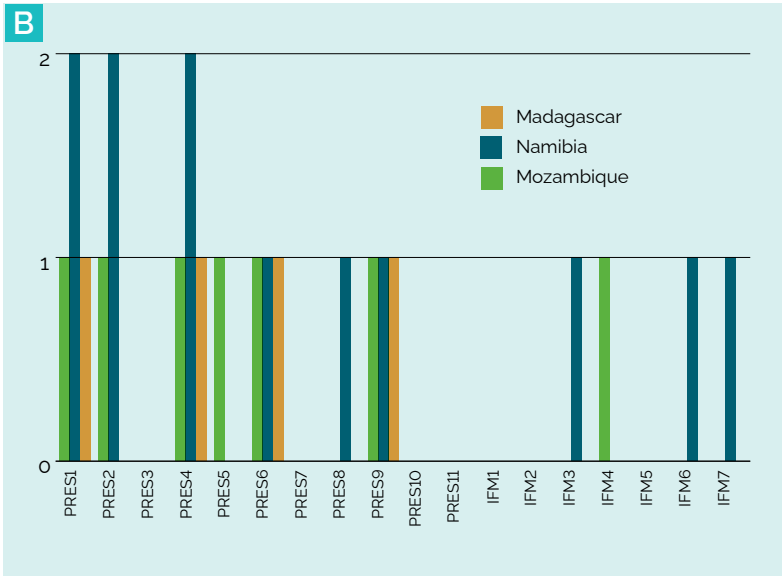


Figure 16a-c. Identification of the level of ocean-based actions integration into NDCs for climate adaptation and mitigation by selected Southern African countries across various intervention areas (based on the comprehensive assessment)



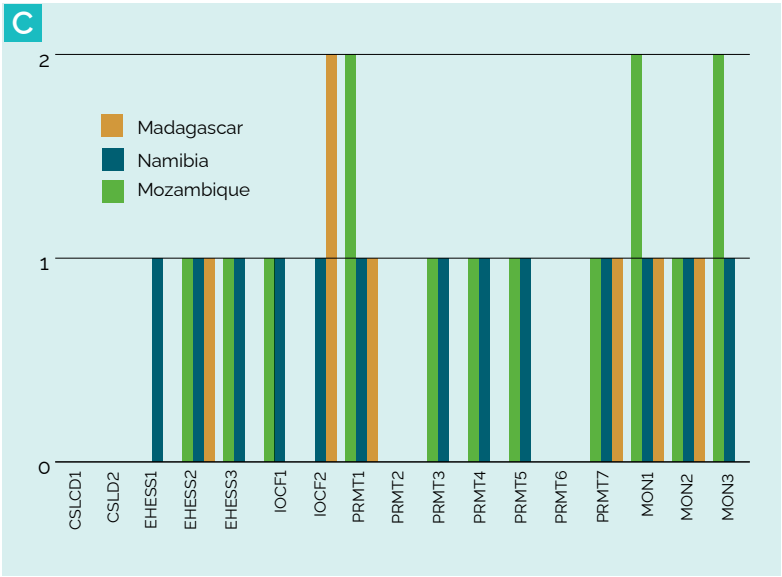
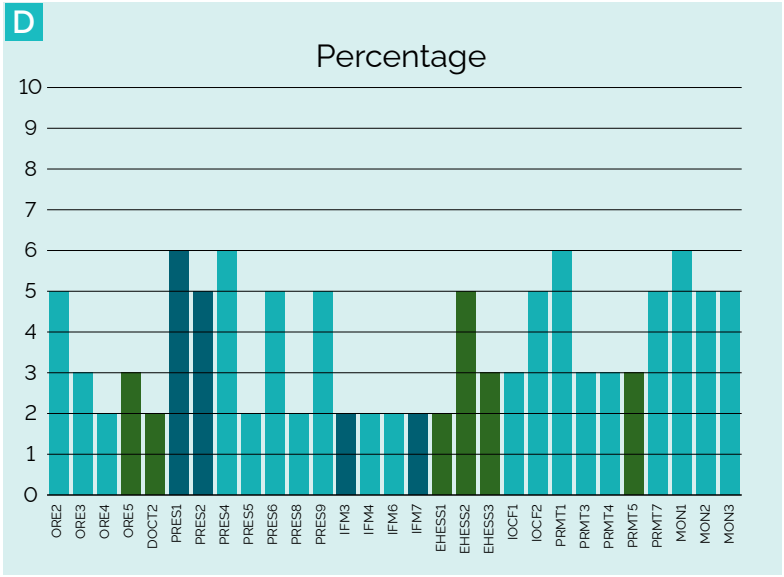


FIGURE 16D. Percentages of ocean-based actions integrated into combined NDCs in Southern Africa



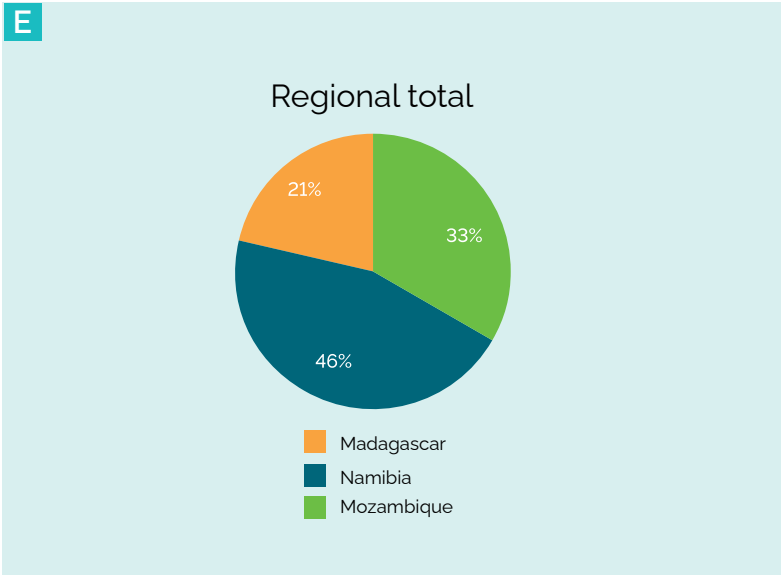


FIGURE 16E. The overall integration of ocean-based climate actions in selected NDCs in Southern African countries

East Africa

Figure 17a-c summarises the score components for the various intervention areas for ocean-based climate actions in selected updated East African NDCs. The plots are separated into three bar charts (following the rationale of **Figure 16** above) to reflect the imbalance between the number of variables considered (sample size) for evaluation in the different intervention areas (a-c). **Figure 17a** shows the score components for the "Ocean renewable energy", "Seabed carbon storage", "Solar radiation management" and "Decarbonising ocean-based transport" intervention areas in selected updated East African NDCs. Regarding the "Ocean renewable energy" intervention area, it is shown that none of the evaluated NDCs in East Africa considers the application of marine spatial planning, MPAs, etc. (ORE1) to implement ORE. However, Tanzania's updated NDC considers designing regulatory frameworks for renewable energy (ORE2) to mitigate and adapt to climate change, having scored two points in the evaluation system. Seychelles and Kenya have also considered implementing MSP, MPA, etc. (ORE1) in their updated NDCs to advance their ORE, but only for climate mitigation (having scored a point each in the evaluation). Among the NDCs evaluated in East Africa, only the Seychelles considers advancing storage capacity and design (ORE3), improving the performance of energy systems (ORE4) and developing marine biomass-fuelled energy with carbon capture on land, marine biochar, etc. (ORE5) in their NDC for mitigation, having scored a point on each of the variables.

Similar to outcomes from West, Central, North and Southern Africa, **Figure 17a** shows that no updated NDCs in the selected East African countries consider any climate mitigation or adaptation variables under the "Seabed carbon storage" or "Solar radiation management" intervention areas. However, an evaluation of the NDCs against several ocean-based actions in the "Decarbonising ocean-based transport" intervention area shows that Tanzania (having scored a point) and Seychelles (having scored two points) consider the adoption of policies to reduce emissions of other greenhouse gases (DOCT2), with the former aiming at climate mitigation and the latter aiming for both mitigation and adaptation. In addition, among the East African NDCs evaluated, Tanzania considers developing and implementing hybrid power systems – wind, waves, currents and sun (DOCT4) to mitigate climate change in the transport sector.

Figure 17b shows that under the "Protect and restore key marine and coastal ecosystems and support species" intervention area, all three countries include actions to enhance protection measures for mangroves, kelp seagrass, salt marsh and seaweed beds to prevent further losses (PRES1) in their updated NDCs. Having scored two points each on the evaluation system, Seychelles and Kenya consider this action both for climate mitigation and climate adaptation, while Tanzania considers it only for climate mitigation. While Tanzania did not score any points in its consideration of mapping blue carbon ecosystems (PRES2) in its NDC, Seychelles considered actions to map blue carbon ecosystems in its NDC for both climate mitigation and climate adaptation, and Kenya considers these actions for climate adaptation, having scored a point in the evaluation system. Actions to advance biorefining techniques (PRES3) to mitigate or adapt to climate change are not considered in any evaluated NDCs in East Africa (see **Figure 17b**). However, the application of MSP, ICZM, MPAs, etc. (PRES4) is pronounced in the Tanzanian, Seychellois and Kenyan NDCs to protect and restore key marine and coastal ecosystems for climate mitigation and adaptation. Consideration for the application of MSP, ICZM, MPAs, etc. in Seychelles's and Kenya's NDCs aims at climate mitigation and adaptation, with the countries having each scored two points in the evaluation system, while Tanzania aims at climate adaptation, having scored a point. Actions aimed at expanding farmed seaweed as an alternative fuel and feed source (PRES5),

assisted evolution and genetic modification (PRES7), enhancing open-ocean productivity by adding nutrients (fertilisation) (PRES10) and adding natural or man-made alkalinity to enhance CO_2 carbon storage (PRES11) did not receive consideration in any of the NDCs evaluated in East Africa. Contrarily, Tanzania, Seychelles and Kenya have considered actions to restore and enhance degraded habitats and ecosystems and create new ones (PRES6) in their NDCs. These actions are proposed for climate mitigation for Tanzania and Seychelles, but both mitigation and adaptation in Kenya. Having scored a point in the evaluation system, among the three countries, only Tanzania's NDC considers maintaining and restoring hydrological regimes (PRES8) for climate adaptation. But Seychelles's NDC proposes actions to reduce pollution from all sources, including land and rivers (PRES9), for climate mitigation and adaptation, while consideration in Tanzania's and Kenya's NDCs is mainly for climate adaptation.

Considerations for ocean-based actions under the "Improving fishery management" intervention in the evaluated NDCs in the East Africa area unexpectedly include the thriving fisheries sector in the region (**Figure 17b**). Out of the three countries, only the NDC from Seychelles considers actions to reduce HCFCs in refrigerants (IFM3), and Tanzania is the only country to consider extending surveillance technologies for tracking fishing (IFM6).

Figure 17c shows that ocean-based actions to mitigate and adapt to climate change focusing on the "Cultural shift, low-carbon diet" intervention area are not considered in the evaluated NDCs in East Africa, including creating incentives to shift diets to low-carbon protein (e.g., fish, seaweed) diets (CSLCD1) and exploring carbon tax on red meat and other carbon-intensive foods (CSLCD2). However, proposals to relocate communities, structures and/or assets from areas that are impacted / likely to be significantly affected (EHESS1) and encourage coping with the new conditions (EHESS3) are not included in any of the evaluated NDCs under "Enhance human and economic sectors and social systems (defend, co-exist or retreat)". Implementing strategies to protect assets from the impacts of flooding (EHESS2) have been considered in all three NDCs for climate adaptation.

Figure 17c also illustrates that East African countries emphasise actions to "Improve ocean climate finance" in their NDCs. All three countries scored two points each in the evaluation system, implying their incorporation of a common funding arrangement or budget using innovative blue/green financing, including blue bonds, debt-for-nature swaps, resilience credits, nature insurance, etc. (IOCF1) to mitigate and adapt to climate change. Also, Tanzania and Seychelles include financial commitments/budgets by governments, private sector, etc. (IOCF2) to enable climate adaptation and mitigation, while Kenya's NDC considers this action for climate adaptation only.

As shown in **Figure 17c**, an evaluation of ocean-based actions in various NDCs in East Africa reveals a varying level of consideration for "People-centred response to multiple ocean and coastal threats" intervention to mitigate and adapt to climate change. For example, having scored two points, Seychelles considers ocean literacy and public awareness actions (PRMT1) in its NDC for climate mitigation and adaptation. In contrast, Tanzania and Kenya consider actions related to ocean literacy and public awareness (PRMT1) for climate adaptation only, having scored a point each in the evaluation system. Seychelles considers including the indigenous perspective (PRMT2) for either climate adaptation or mitigation, while Tanzania considers the indigenous perspective only for climate adaptation. **Figure 17c** also shows that coastal community participation (PRMT3) is considered in Seychelles's NDC for climate adaptation and mitigation, while in Tanzania's and Kenya's NDCs, coastal community participation is considered for climate adaptation only.

Meanwhile, Tanzania and Seychelles consider actions to integrate between different government levels (PRMT4) for climate mitigation and adaptation in their updated NDCs, with the former focusing on

adaptation while the latter focuses on both mitigation and adaptation. Providing materials and financial incentives for coastal communities (PRMT5) as an action for climate adaptation is proposed in Tanzania's, Seychelles's and Kenya's NDCs. However, while Seychelles considers developing actions concerning labour and professional skills enhancement (PRMT6) to adapt to and mitigate climate change in its updated NDC (having scored two points in the evaluation system), Tanzania considers this action only for climate adaptation. Developing MSP, MPA, etc. and ocean legislation (PRMT7) to implement a people-centred response to multiple ocean threats is considered only in Tanzania's and Seychelles's NDCs for climate adaptation.

Concerning the "Monitoring" intervention area, **Figure 17c** illustrates that Tanzania and Kenya scored a point each in the evaluation system, indicating that the former considers the implementation of a system of monitoring and evaluation of the productivity of coastal and marine ecosystems (MON1) as an action of both climate mitigation and climate adaptation, while the latter considers it for climate adaptation. In contrast, Seychelles, having a score of two points on the evaluation system, adequately considers these actions both for climate mitigation and for climate adaptation. Tanzania's and Seychelles's NDCs scored two points each for measuring and transparently reporting climate change impacts on ocean ecosystem resilience and disaster risk reduction (MON2) to mitigate and adapt to climate change, while Kenya's NDC proposed related actions only for climate mitigation. Tanzania's and Seychelles's updated NDCs indicate considerations for improving methods for monitoring mitigation benefits to the ocean (MON3). The former considers it for climate mitigation and adaptation, the latter only for climate adaptation.

Figure 17d indicates that a people-centred response to multiple ocean and coastal threats (28% total), enhancing the protection and prevention of further loss to blue carbon ecosystems (26% total) and monitoring (15% total) are the topmost intervention areas in the evaluated NDCs in East Africa. It also shows that the most integrated ocean-based climate mitigation and adaptation actions are those focused on common funding arrangements or budgets using innovative blue/green financing (7%), the restoration and enhancement of degraded habitats and ecosystems and the creation of new ones (6%), applying MSP, ICZM, MPAs, etc. (6%), financial commitments/budget by governments, private sector, etc. (6%) and measuring and transparently reporting climate change impacts on ocean ecosystem resilience and disaster risk reduction (6%). However, **Figure 17e** shows that NDCs in East Africa are early integrators of ocean-based climate actions, with the NDC from Seychelles (46%) being the best integrator of these actions, compared with Tanzania (32%) and Kenya (22%).

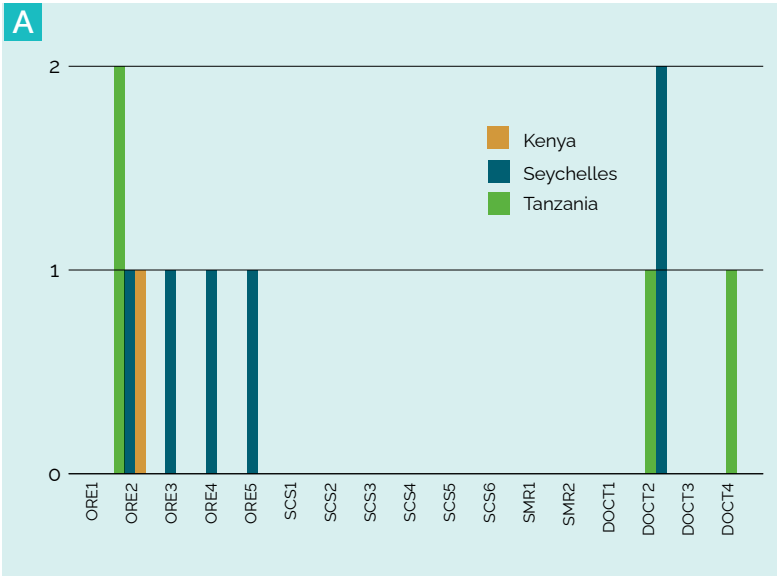
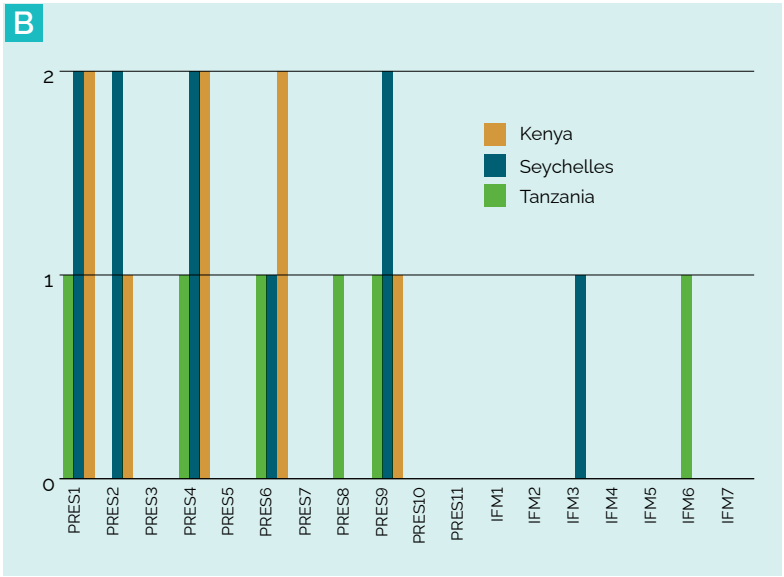
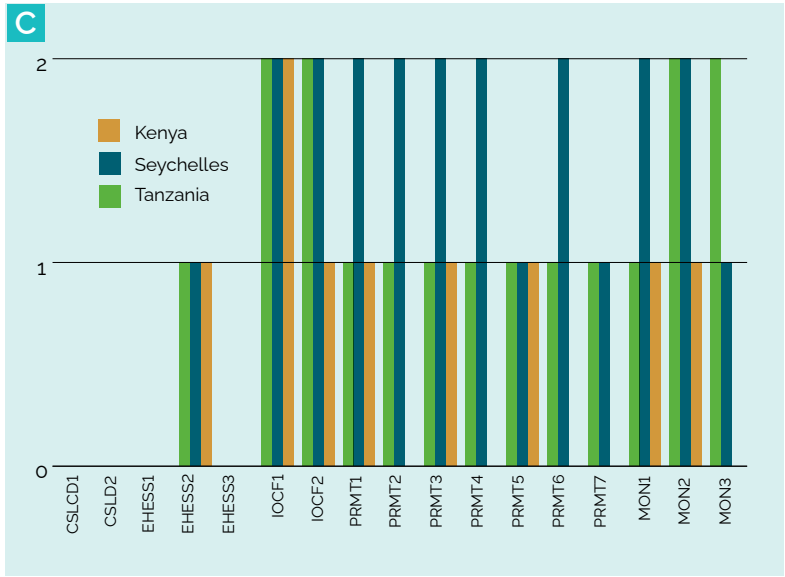
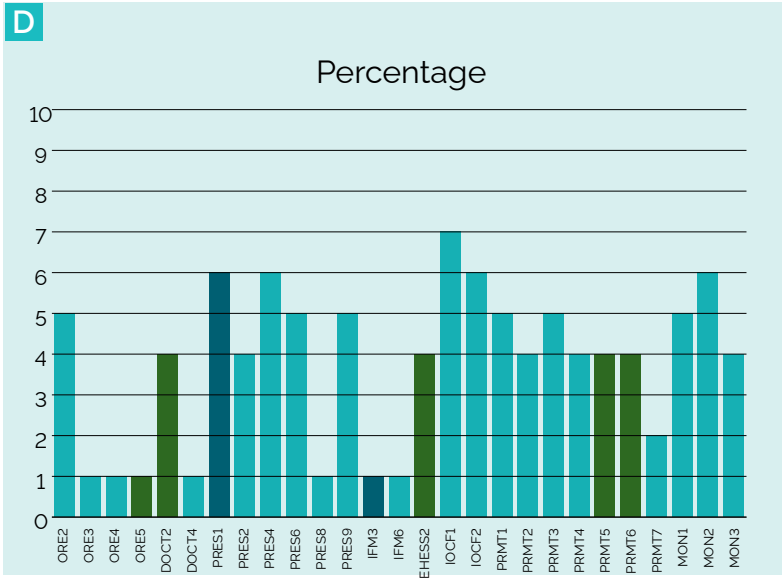


Figure 17a-c. Identification of the level of ocean-based actions integration in NDCs for climate adaptation and mitigation by selected East African countries across various intervention areas (based on the comprehensive assessment)







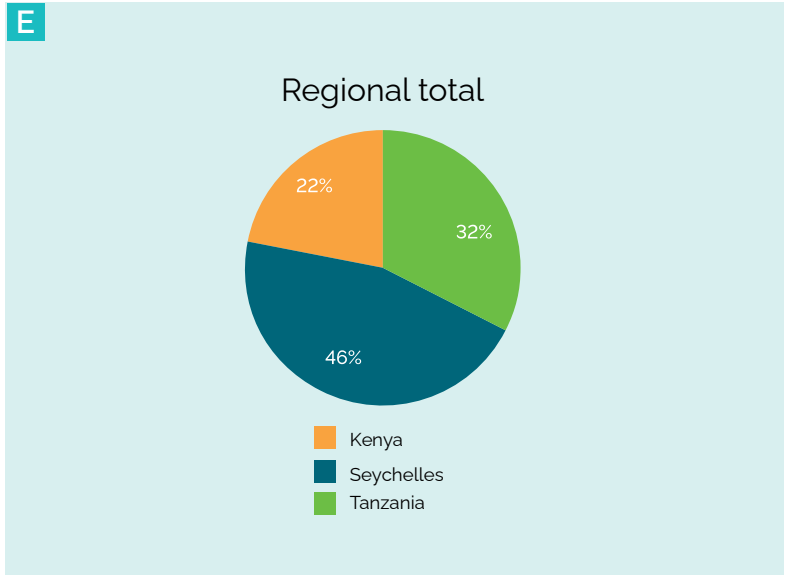


FIGURE 17D. Percentages of ocean-based actions integrated into combined NDCs in East Africa

FIGURE 17E. The overall integration of ocean-based climate actions in selected NDCs in East African countries

What are the results saying?

Increase ocean-based renewable energy

The ocean hosts a wealth of climate change mitigation solutions, including ocean-based renewable energy, and area-based planning frameworks such as MSP, MPA and ICZM have been central to this. For example, climate-smart MSP is a process with the potential to reconcile clean energy's role in delivering decarbonisation with biodiversity considerations, broader Sustainable Development Goals, and ambitions of other marine users, including fisheries, shipping and coastal tourism. However, the application of MSP, MPAs, etc. to guide the implementation of ORE has not been central to Africa's coastal countries' quest to exploit the potential of ORE for climate change adaptation and implementation. This can be explained by the fact that, for example, MSP and other area-based management tools are still developing in Africa. Secondly, even where MSP processes are in place in Africa, such as Namibia, Angola, Seychelles, Tanzania, South Africa, etc., the focus is mostly on critical areas such as nature-based solutions, fisheries and aquaculture, shipping and transportation, etc. Also, most African coastal countries and island states have not started exploring the potential of climate mitigation and adaptation from ORE in their plans, compared with the emphasis on renewable energy on land. The assessment shows that the regulatory framework for renewable energy is essential for African coastal and island states. About 28.5% of countries' combined NDCs address the design of regulatory frameworks for renewable energy to enhance climate adaptation and mitigation. However, where more technical actions are needed (i.e., advancing storage capacity and design, improving the performance of energy systems, and enhancing marine biomass-fuelled energy with carbon capture on land, marine biochar, etc.), only 14% (ORE3), 12% (ORE4) and 12% (ORE5) of combined NDCs in evaluated countries have considered these actions, suggesting that climate mitigation and adaptation are still not considered extensively using ORE. Regardless, there is a clear indication that NDCs are advancing towards increased integration of adaptation and mitigation under the "Increase ocean-based renewable energy" intervention area in Cape Verde, Seychelles and Namibia, which are also countries where the Blue Economy strategy and MSP process are developing. This suggests that the island states and countries with clear policy guidance from the national government can better develop NDCs with stronger consideration for ORE actions to adapt to and mitigate climate change.

Seabed carbon storage

The long-term storage of CO_2 in seabed sediments has been proposed as an option for climate mitigation, particularly taking advantage of stranded assets[9]. However, this assessment has shown zero consideration for seabed carbon storage as an option to mitigate and adapt to climate change in evaluating NDCs across West, Central, North, Southern and East Africa. Although this option has been debated to be of potential benefit for African countries to mitigate and adapt to climate change, considering the advantage provided by current offshore hydrocarbon infrastructure, the feasibility of its adoption would have to be scrutinised. Because of the uncertainties, it is crucial to study the multiphysics process of injection, the postinjection fate of CO_2 and the ability of subsea disposal under different geological and operational conditions. However, several African countries are Parties to

> "The assessment shows that the regulatory framework for renewable energy is essential for African coastal and island states."

9 In simple terms, stranded assets are those that turn out to be worth less than expected as a result of changes associated with the energy transition, for example, drilling rigs / seismic vessels, pipelines, empty oil wells, etc.

the London Convention[10] and Protocol[11], two international instruments under the International Maritime Organization (IMO) that have taken ground-breaking steps to address carbon capture and sequestration in the seabed. With this, countries can develop regulatory frameworks for the potential adoption of seabed carbon storage for climate mitigation.

Solar radiation management

Globally, solar radiation management intervention for climate mitigation has never been implemented on the full scale, raising uncertainty about these strategies' price, efficiency and unforeseen impacts. The technologies required for cloud brightening, albedo enhancement and other geoengineering interventions may also risk adverse impacts on the ozone layer, regional precipitation patterns, marine ecosystems and coastal agriculture [96]. Still, African countries need to invest in research into these technologies. Also, due to the nature of these technologies, there may be challenges associated with international governance and the risk of international conflict. Still, suppose the cost of implementation were low and the efficacy of mitigation were high. In that case, ocean-based solar radiation and other ocean-based geoengineering options may be vital to a climate change risk management portfolio for climate mitigation in Africa.

Decarbonising ocean-based transport

Out of the 15 countries evaluated in West, Central, North, Southern and East Africa, only seven countries (Tanzania, Seychelles, Madagascar, Equatorial Guinea, Egypt, Cape Verde and Benin) have included actions to decarbonise ocean-based transport in their NDCs to mitigate climate change in the sector. These countries focus their actions mainly on adopting policies to reduce emissions of other greenhouse gases and developing and implementing hybrid power systems – wind, waves, currents and sun – which account for 2%, 4%, 3%, 2% and 5% of ocean-based climate actions in the combined NDCs in West, North, Central, Southern and East African countries respectively. This low integration can be attributed partly to the fact that international shipping was not explicitly mentioned in the 2015 Paris Climate Agreement. Efforts to make ocean-based transport cleaner and greener have progressed over the years, and countries included in this assessment are aware of the goals set out by the IMO's MEPC.304(72) Resolution, 13 April 2018[12], to "reduce carbon compound (i.e., oxides and dioxides) emissions from new ships through the implementation of successive phases of the Energy Efficiency Design Index (EEDI)". It is worrisome that the evaluated countries have not included actions related to EEDI and improving ship designs in their NDCs in compliance with Appendix VI to the MARPOL Convention, requiring countries to reduce ocean transport-derived CO_2 emissions by switching to alternative fuels. However, as this is not necessarily a simple task for port and maritime administrators, additional support should be provided either from the AU or from sub-regional organisations via peer-to-peer learning or partnering with other actors such as IMO knowledge-based institutes.

> "… ocean-based solar radiation and other ocean-based geoengineering options may be vital to a climate change risk management portfolio for climate mitigation in Africa."

10 In 2006, the London Protocol Contracting Parties adopted amendments to Annex I of the Protocol to regulate carbon capture and sequestration in subsea geological formations (CCS-SSGF).

11 In 2009, the Parties amended LP Article 6 concerning the export of wastes for dumping purposes, aimed at enabling Parties to share transboundary sub-seabed geological formations for sequestration projects, on the condition that the protection standards of the LP are fully met.

12 In 2018, the IMO adopted an initial strategy for reducing GHG emissions, aimed at cutting shipping GHG emissions by at least 50% by 2050, compared with 2008 levels.

Protect and restore key marine and coastal ecosystems and support species

Across the regions, interventions to protect and restore key marine and coastal ecosystems and support species have received significant consideration in NDCs assessed. About 27% (West Africa), 36% (North Africa), 40% (Central Africa), (33%) Southern Africa (33%) and 27% (East Africa) of NDCs include ocean-based actions aimed at protecting and restoring key marine and coastal ecosystems and supporting species towards climate mitigation and adaptation. Overall, the highest consideration comes from the island states (Seychelles and Cape Verde) and countries with existing or ongoing processes for integrated ocean management (Namibia, Kenya and Equatorial Guinea). Enhancing protection measures for and mapping blue carbon ecosystems (mangroves, kelp seagrass, salt marsh and seaweed beds) and restoring and enhancing degraded habitats and ecosystems are significantly focused on under this intervention area, particularly for climate mitigation, and the reasons are not far-fetched. African countries generally initially started addressing related climate mitigation actions in their national environmental policies in the 1970s, following the Convention on Wetlands of International Importance[13], through the 1992 Rio Conference and Earth Summit, which led to the UNFCCC and was sealed by the 2002 World Summit on Sustainable Development in South Africa. Also, the focus on actions to reduce pollution from all sources, including land and rivers, can be attributed to the fact that Africa has many rivers and tributaries, and countries have been Parties to the 1974 Convention for the prevention of marine pollution from land-based sources[14]. It is only recently that policy efforts have started to address adaptation issues, either as stand-alone plans or in combined action plans such as the NDC. The lack of integration of geoengineering actions, including assisted evolution, genetic modification, ocean fertilisation and artificial alkalinity addition, into the NDCs is understandable – there are scientific and unique regulatory concerns.

Improve fishery management

Despite the alteration of the productivity and distribution of marine fisheries by climate change, improved and climate-adaptive fishery management is essential to mitigate and adapt to many of the negative impacts on human society, including conflict, food insecurity and poor economic productivity [97] [98]. West Africa considers more ocean-based actions to mitigate and adapt to the effects of climate change in their NDCs, compared with other regions assessed in this study, with Cape Verde being the only country ticking most boxes on actions, including eliminating harmful fisheries' subsidies, reducing discard, reducing HCFCs in refrigerants, creating incentives for lower trophic level aquaculture, and extending surveillance technologies for tracking fishing (Figures 13b, 14b, 15b, 16b and 17b). It is, however, not certain whether the sustainable fisheries partnership agreement[15] between the EU and Cape Verde is responsible for this performance, as this type of agreement has been deemed exploitative and unfair in many quarters [99] [100] [101]. Eliminating harmful fisheries' subsidies accounts for only 1% of the overall ocean-based actions in the combined NDCs. This is surprising (particularly for the island states, except Cape Verde), as fisheries' subsidies have posed significant

"Eliminating harmful fisheries' subsidies accounts for only 1% of the overall ocean-based actions in the combined NDCs."

13 "Ramsar Convention" or "Wetlands Convention"

14 https://treaties.un.org/doc/Publication/UNTS/Volume%201546/volume-1546-I-26842-English.pdf

15 The last protocol implementing the agreement entered into force on 20 May 2019 following the expiration of the previous protocol in December 2018 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:22019A0612(01)&from=EN

threats to the livelihoods of Africa's coastal communities, already reeling from the negative impacts of climate change, poverty and marine pollution, and have also caused colossal damage to the marine ecosystem [102]. In West Africa, 8% of actions to mitigate climate change are focused on fisheries management, with 4% in North Africa, 6% in Central Africa, 8% in Southern Africa and 2% in East Africa (Figures 13e, 14e, 15e, 16e and 17e). Although climate change is generally acknowledged as affecting Africa's fisheries [103] [104], the low integration of fisheries management actions to mitigate and adapt to climate change in Africa is revealed here. The precise and localised impacts of climate change on African fisheries are perhaps still poorly understood. This is because "the inherent unpredictability of climate change and the links that entwine fishery and aquaculture livelihoods with other livelihood strategies and economic sectors make unravelling the exact mechanisms of climate impacts hugely complex" [105]. The utilities of extending surveillance technologies for tracking fishing are clear; however, the cost implication of such actions might burden African countries, most of which are grappling with other socio-economic priorities. Effective coordination among government agencies at the national level and partnership with key regional and international organisations are essential to enhance joint fact-finding, data collection and project design/implementation.

Cultural shift, low-carbon diet

The food system is a significant contributor to climate change, and a global shift in diets has been promoted to add significant inroads in addressing climate change and achieving targets under the Paris Agreement. Livestock production is a significant source of greenhouse gases (GHGs) contributing to the greenhouse effect and climate change. However, livestock production is essential to the culture and diet of most rural and urban households, regarding protein intake and livelihoods. Creating incentives to shift diets to low-carbon protein (e.g., fish, seaweed) diets as an action to mitigate and adapt to climate change is considered only in Cape Verde's NDC, in contrast to the other 14 NDCs evaluated. In Cape Verde's NDC, local fish consumption is encouraged by ensuring that small, domestic-scale fisheries are protected over international supply, exportation and large-scale international fisheries and the tourism industry. This result would likely not represent all NDCs across Africa's 38 coastal and island states. Fish is the cheapest source of animal protein in Africa, providing nutrition and food security and accounting for 20% of animal protein intake [103]. However, apart from the fact that shifting to an ocean plant diet, such as seaweed, to mitigate and adapt to climate change falls most heavily on high-income countries, adopting this option would be less appreciated in Africa for many reasons, including that large-scale seaweed cultivation is restricted to few countries on the continent (e.g., Tanzania, Morocco, Namibia, Madagascar, etc. [106] [107]), and its introduction as a source of protein does not feature in the many culinary cultures in Africa. Although contributing the least to climate change, Africa's contribution to mitigating emissions would still require that people eat differently and use our ocean/land differently by embracing an organic or, more broadly, "blue-agroecological" diet. This dietary transition would not happen without action from businesses and the government. This would need to explore carbon tax on red meat and other carbon-intensive foods and mandatory accredited blue-labelling of foods to show their environmental impacts.

Enhance human and economic sectors and social systems (defend, co-exist or retreat)

Among the NDCs evaluated across the regions, only one from Southern Africa (Namibia) considers variable EHESS1 (relocate communities, structures and/or assets from areas that are impacted/

"Although contributing the least to climate change, Africa's contribution to mitigating emissions would still require that people eat differently and use our ocean/land differently by embracing an organic or, more broadly, "blue-agro-ecological" diet."

likely to be significantly affected) (FIGURE 16D), and the reason may not be far-fetched. Besides the poor implementation of environmental management laws and regulations and the inadequate evidence of climate change adaptation measures in coastal towns [108], desertification on Namibia's coast has been intensifying for decades [109], indicating the need to relocate inhabitants landward. However, overall, there is a 5% integration of variable EHESS2 (implement strategies to protect assets from the impacts of flooding) in NDCs evaluated in Southern Africa as an adaptation option, compared with 1%, 2%, 3% and 4% in West, Central, North and East Africa's NDCs, respectively (Figures 13d, 14d, 15d and 16d). Surprisingly, countries with high current and projected flooding, such as Nigeria and Egypt, did not integrate actions in this direction (in their NDC), despite their climate profile, painting a bleak outlook concerning the substantial risk of floods. This raises concerns about governments' and authorities' willingness to address risks and consequences associated with intense coastal flooding. Interestingly, coping and living with new conditions brought about by climate change is encouraged in both Namibia's and Mozambique's NDCs as an option for adaptation. Adopting actions in this direction could be what is considered practical perspectives of "intra-individual and social psychological" adaptation processes, meditating effective coping responses and resilience, overt behavioural adjustment and change [110].

Chapter 3

Review of existing ocean-related international and regional agreements and commitments that can be aligned or incorporated to strengthen the African position at COP27

Credit: Laura Pereira, Brenu Beach, Ghana

Several regional and international agreements and commitments are operational in Africa, aimed at different targets (biodiversity, environmental governance, transportation, fisheries, climate change, etc.). The alignment of targets within these agreements and commitments to the African position at COP27 can provide additional normative guidance for addressing ocean climate change issues. It also ensures that the countries on the continent are simultaneously on a path to fulfilling their international obligations – whether declarative or legally binding. This strengthens each country's position in the global climate change discourse and, as far as possible, could also be vital for leveraging climate finance from international sources. Reviewing cross-cutting regional/international agreements and frameworks and comparing their targets against important traditional and emerging ocean climate issues will reveal areas that are not yet in alignment (possibly helping as further drivers or entry points for climate change mainstreaming and negotiation at COP27). Whether ocean issues will feature in the common position and talking points of the African negotiators or mainstream into an existing national-level policy, the alignment of the climate change agenda with other processes to which African countries are committed is an excellent opportunity to consider other issues and principles, such as gender, human rights or pro-poor development, which can be mainstreamed simultaneously. This has the advantage of bringing valuable allies and champions into the process, ensuring that the intended positive impacts of the negotiations at COP27 are even more pronounced and transformative, for example, addressing the nexus between peace, migration, food security, climate and ocean health. Therefore, this section takes a comprehensive review and comparative analysis of these essential documents to reveal gaps and potential entry points for mainstreaming ocean and climate change concerns. Some of the papers already include climate-responsive language and actions and can be referenced as good practice, e.g., the Convention on Biological Diversity and the Global Compact for Safe, Orderly and Regular Migration.

Types and capacity of ocean-related international agreements and commitments operational in Africa

International ocean- and climate-related governance frameworks currently operational in Africa vary widely, with different countries having different policies, institutions, legislation and financing mechanisms. Accordingly, the state and form of international-level ocean-related policies (and whether they take climate change concerns into account) vary widely. Providing an overview that meaningfully speaks to how these agreements and commitments can be aligned or incorporated (mainstreamed) to strengthen the African position at COP27 is challenging, and therefore it is worthy to state that a significant part of this section adapts the generic synergy from identified agreements and commitments to their specific mainstreaming context for climate change. Nonetheless, common normative and operational recommendations can meaningfully inform an African position at COP27.

Global frameworks relevant to ocean and climate change

Over the past few years, many African countries have committed to several important global and regional development frameworks well aligned with ocean sustainability and climate change. Recent adoptions

“Whether ocean issues will feature in the common position and talking points of the African negotiators or mainstream into an existing national-level policy, the alignment of the climate change agenda with other processes to which African countries are committed is an excellent opportunity to consider other issues and principles, such as gender, human rights or pro-poor development, which can be mainstreamed simultaneously.”

of landmark United Nations (UN) agreements, such as the 2030 Agenda for Sustainable Development, the Convention of Biological Diversity, the Universal Declaration of Human Rights, the Paris Climate Agreement, the Sendai Framework for Disaster Risk Reduction, the International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families, the New Urban Agenda, the Addis Ababa Action Agenda on Financing for Development, the African Charter on Human and Peoples' Rights, etc., have created a significant opportunity to build coherence and cohesion across different but cross-cutting policy areas. Synergising these frameworks could enhance and accelerate progress on the overlapping agendas of sustainable ocean development, climate change mitigation and adaptation, and disaster risk reduction and management.

The systematic alignment of regional and international agreement with / commitment to the UNFCCC process could provide guidance and identify entry points for African negotiators at COP27 to mainstream various cross-cutting issues important for Africa's ocean sustainability into the negotiation process. Aligning cross-cutting issues in regional and international agreements/commitments would support the implementation of these regional and global processes while adequately reflecting the needs and realities of African coastal countries and island states vulnerable to climate change. Further, this alignment may also assist African negotiators with leveraging climate and development finance to support regional- and national-level policy implementation and open up opportunities for networking and highlighting national issues.

Relevant regional and global agreements related to ocean and climate change are summarised below. In addition, this section lists the provisions in these identified regional and global frameworks that speak directly or indirectly to climate change and ocean issues in Africa in unison. It provides more detailed information on the respective UNFCCC negotiation aspects.

2030 Agenda for Sustainable Development

Aim and focus: *Comprehensive development agenda covering social, economic and environmental dimensions of sustainable development*

Approved by: *193 UN member states*

Implementation period: *2016-2030*

Adopted by the United Nations as a follow-up to the Millennium Development Goals, the 2030 Agenda for Sustainable Development came into force in 2016. It is a voluntary, non-binding agreement that can be viewed as the overarching global development framework, with the other global agendas addressing more specific development aspects. The 2030 Agenda consists of four sections: a Political Declaration, 17 Sustainable Development Goals (SDGs) with 169 targets and 46 respective indicators, the Means of Implementation (finance, technology, capacity building, systemic issues) and a Framework for Follow-up and Review. The 2030 Agenda aims to be comprehensive, indivisible and universal, with the principle objective of "leaving no one behind". African countries, like others globally, have a shared responsibility to achieve the SDGs, taking into account national realities, capacities, levels of development and specific challenges, and the SDG targets and indicators, and to "conduct regular and inclusive reviews of progress at the national and sub-national levels". The 2030 Agenda is based on the concept of global partnership. Nonetheless, nationally owned and country-led sustainable development strategies will require significant resource mobilisation and additional financing strategies.

Sustainable ocean development: Given the ocean's enormously important and transformative role in the earth's system and society, a stand-alone SDG was agreed upon for the ocean. SDG14, "Conserve and sustainably use the oceans, seas and marine resources for sustainable development," aims to manage and protect marine and

"The systematic alignment of regional and international agreement with / commitment to the UNFCCC process could provide guidance and identify entry points for African negotiators at COP27 to mainstream various cross-cutting issues important for Africa's ocean sustainability into the negotiation process."

coastal ecosystems sustainably from pollution and address the impacts of ocean acidification, which involves addressing climate change, food security and partnership. However, beyond SDG14, of the 169 SDG targets, 38% of SDGs depend on achieving targets within SDG14, which addresses ocean sustainability, to succeed [111].

Climate change issues and actions: Climate change, under SDG13, also has a stand-alone goal in the 2030 Agenda as "urgent action to combat climate change and its impacts", while several other goals and targets contribute to enhancing resilience more generally and mitigating the impact of ocean-based anthropogenic stressors on climate change. However, after years of scientific research, it has become clear that restoring and maintaining ocean health, as outlined in Sustainable Development Goals (SDGs) 13 and 14, is a vital tool for fighting climate change. The emergence of "blue carbon" – carbon captured and stored by coastal and ocean ecosystems – indicates a shift in understanding the ocean's important, planet-saving role in curbing climate change. Likewise, SDG17 entails partnership, for the SDG is critical in promoting the needed partnership across the ocean and climate change mechanisms, thus benefiting international engagements (e.g., North-South and South-South), strengthening the means of implementation and revitalisation of national and regional collaboration for climate-smart ocean development, and improving policy coherence and increased multi-stakeholder cooperation. Moreover, the capacity enhancement for least developed countries and the Small Island Developing States is on the radar of target 17.18 of SGD17.

FIGURE 18. The 17 Sustainable Development Goals were adopted in New York in 2015 (Photo Credit: Lei Phyu / UNDP; Creative Commons license Attribution -NonCommercial- 2.0 Generic)

International Labour Organization

Aim and focus: *Advancing social and economic justice through setting international labour standards, and emphasising the need for workers to enjoy conditions of freedom, equity, security and human dignity through their employment*

Approved by: *Founded in 1919 under the League of Nations and incorporated into the UN as a specialised agency in 1946*

Implementation period: *N/A*

The International Labour Organization (ILO) is a United Nations (UN) agency that advances social and economic justice by setting international labour standards. The ILO has 187 member states headquartered in Geneva, Switzerland, with approximately 40 field offices worldwide. The ILO upholds broad standards intended to ensure accessible, productive and sustainable work worldwide in conditions of freedom, equity, security and dignity[16,17,18]. The ILO set forth labour standards that are reflected in 190 conventions and six protocols[19]. For example, these standards recognise the right to collective bargaining and attempt to eliminate forced or compulsory labour, abolish child labour and stop acts of discrimination regarding employment and occupation. Therefore, the protocols and conventions of the ILO are a significant contributor to international labour law[20].

Sustainable ocean development: Several of the ILO's standards and programmes have both direct and indirect connections with issues that are pertinent to the ocean, including labour, decent work, human rights at sea, etc. Notably, ILO member states have adopted the Maritime Labour Convention (MLC)[21] 2006 to provide international standards for the maritime sector. Known as the "Seafarers' Bill of Rights", the MLC 2006 was adopted at a special ILO International Labour Conference in February 2006 by governments, employers and workers' representatives. It protects economic interests by guaranteeing fair competition for quality ship owners, including decent work for seafarers. The Convention sets out, in one place, seafarers' rights to decent working conditions and covers the everyday aspect of their work and life on board. The Convention was designed to be applicable globally, easy to understand, readily updatable and uniformly enforced, and will become the "fourth pillar" of the international regulatory regime for quality shipping, complementing the key Conventions of the International Maritime Organization (IMO) dealing with safety and security of ships and protection of the marine environment.

Climate change issues and actions: Climate change is already occurring and has increasingly significant impacts on enterprises, workers and economic and social development. Increased average temperatures, the alteration of rainfall patterns, and rising sea levels will be the most significant effects in the longer term. In the short to medium term, the impacts are caused mainly by erratic weather patterns and extreme events, such as storms, floods and droughts. In Africa, these impacts on the world of work are negative, disrupting businesses, destroying workplaces and undermining income opportunities [98]. In developing countries and communities, the implications for income generation, employment and social security

16 International Labour Organization. "Mission and impact of the ILO." https://www.ilo.org/global/about-the-ilo/mission-and-objectives/lang--en/index.htm, 2022.

17 International Labour Organization. "Departments and offices." https://www.ilo.org/global/about-the-ilo/how-the-ilo-works/departments-and-offices/lang--en/index.htm, 2021.

18 International Labour Organization. "About the ILO." https://www.ilo.org/global/about-the-ilo/history/lang--en/index.htm, 2021.

19 https://www.ilo.org/dyn/normlex/en/f?p=1000:12000:26112042845947::::P12000_INSTRUMENT_SORT:4

20 https://www.ilo.org/global/standards/introduction-to-international-labour-standards/international-labour-standards-use/lang--en/index.htm

21 https://www.ilo.org/wcmsp5/groups/public/---ed_norm/---normes/documents/normativeinstrument/wcms_090250.pdf

can be particularly devastating. The brunt of the climate crisis is felt by governments and communities that have done the least to cause the problem, including the several island states, whose economy and job base depend on tourism. To prevent potentially uncontrollable climate changes, the causes of such change need to be tackled, and measures to reduce other greenhouse gas emissions are urgently required. At the same time, countries, communities and enterprises must adapt to the climate change already underway due to emissions since the Industrial Revolution to prevent losses and exposure. The substantial impacts of climate change on businesses, labour markets, workers, social protection and poverty levels imply that mitigation of and adaptation to climate change are critical to the ILO's work and mandate. This has been confirmed by the ILO Governing Body and the International Labour Conference, and is in sync with the ILO Constitution and International Labour Standards.

New Urban Agenda

Aim and focus: *Sustainable urban development*

Approved by: *167 UN member states*

Implementation period: *2016-2036*

The New Urban Agenda[22] (NUA) is the United Nations Conference on Housing and Sustainable Urban Development (Habitat III) outcome document. It is a non-binding agreement that sets global achievement standards in sustainable urban development by rethinking how we build, manage and live in cities. It is a comprehensive guide for global efforts toward sustainable urban development over the next 20 years, covering governance structures, social inclusion, spatial growth, urban prosperity and environmental sustainability. The NUA aims to bring together relevant stakeholders and partners at all levels of government and in the private sector. The NUA already resonates with the 2030 Agenda, whose SDGs (particularly SDG11) contain indicators against which the NUA can be measured. Conversely, the NUA itself broadly outlines more of the means of implementation for cities, critical for achieving SDG11 and other goals. The NUA calls for a progress report on the state of performance every four years.

Sustainable ocean development: The New Urban Agenda recognises the importance of the ocean and coasts in the evolution of cities. Countries that have adopted the Urban Agenda are committed to strengthening the sustainable management of resources, including oceans, seas and freshwater, with particular attention on the environmentally sound management and minimisation of all waste, greenhouse gases, noise and toxic chemicals, including air-based and short-lived climate pollutants. This is done in a way that considers urban-rural linkages, available supply and value chains vis-à-vis environmental impact and sustainability, while striving to transition to a circular economy and facilitate the conservation, regeneration, restoration and resilience of ecosystems in the face of new and emerging challenges. Likewise, safe, age- and gender-responsive, affordable, accessible and sustainable urban mobility concerning sea transport systems is also identified in the New Urban Agenda, to promote enabling stakeholder participation in social and economic activities in cities and human settlements, by integrating transport and mobility plans into overall urban and territorial programmes and promoting a wide range of transport and mobility options, including, for example, waterway transportation for Small Island Developing States and coastal cities.

Climate change issues and actions: Issues around climate change and actions are given prominence throughout the New Urban Agenda, focusing on the dual approach of mitigating and adapting to climate change through urban development. Reducing greenhouse gas emissions in cities to mitigate climate change whilst increasing the

“The brunt of the climate crisis is felt by governments and communities that have done the least to cause the problem, including the several island states, whose economy and job base depend on tourism.”

22 https://habitat3.org/wp-content/uploads/NUA-English.pdf

resilience of cities for adaptation is considered necessary in the New Urban Agenda. For sustainable cities and human settlements to be possible, the New Urban Agenda acknowledges that climate change and its related risks undermine efforts to end poverty in all its forms and dimensions and achieve sustainable development. Considering cities' central role in the global economy, in the mitigation of and adaptation to climate, and in the use of resources, the way cities are managed, financed, developed, built, governed and managed impacts sustainability and resilience directly well beyond urban boundaries. Promoting global, national, sub-national and local climate action, and taking measures consistent with the goals of the Paris Agreement, are considered necessary for the medium- to long-term adaptation planning process. This is the same for the assessments of climate vulnerability and impact to inform adaptation plans, policies, programmes and actions that build the resilience of urban inhabitants, including through the use of ecosystem-based adaptation.

Convention on Biological Diversity

Aim and focus: *Conservation and sustainable use of biological diversity, and equitable sharing of the benefits arising from the use of genetic resources*

Approved by: *198 UN member states*

Implementation period: *1992-future*

The Convention on Biological Diversity (CBD) is an international agreement covering all aspects of biological diversity, including the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits resulting from utilising genetic resources. The CBD calls for cooperation among the contracting states to conserve and sustainably use biological diversity. The CBD requires that contracting parties develop strategies, plans or programmes at the national level to conserve and use biological diversity sustainably. Contracting states are also committed to integrate conservation and sustainable use of biological resource considerations into national decision-making, whilst adopting the necessary ecological, economic and socially sound measures to protect and encourage customary and traditional practices for biodiversity conservation. Avoiding or minimising adverse impacts on biological diversity, supporting local communities to develop and implement remedial action in degraded areas, and encouraging public and private stakeholders in developing methods for sustainable use of biological resources are also central to countries' commitment to the CBD. It is noteworthy that exigencies of the CBD have birthed other sub-processes. These include the Cartagena Protocol on Biosafety to the Convention on Biological Diversity[23] (to ensure the safe handling, transport and use of living modified organisms (LMOs)), the Nagoya Protocol on Access and Benefit-sharing, and decadal strategies such as the Strategic Plan for 2011-2020 and its 20 Aichi Targets, and the Kunming Declaration[24,25] (which puts forward targets for the restoration and protection of biodiversity), which is being replaced by the Post-2020 Global Biodiversity Framework[26,27], with targets for 2030 and goals for 2050, to be adopted at COP15 in December 2022.

> "Considering cities' central role in the global economy, in the mitigation of and adaptation to climate, and in the use of resources, the way cities are managed, financed, developed, built, governed and managed impacts sustainability and resilience directly well beyond urban boundaries."

23 https://bch.cbd.int/protocol

24 https://www.cbd.int/doc/c/99c8/9426/1537e277fa5f846e9245a706/kunmingdeclaration-en.pdf

25 The document lists 17 commitments for member countries, urging both international collaboration on a number of issues and increased efforts at the domestic level.

26 https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.cbd.int%2Fdoc%2Fc%2Feb53%2F41ef%2F250d0d802e07ecd533a70697%2Fwg2020-03-l-02-en.docx&wdOrigin=BROWSELINK

27 Negotiations are still ongoing for the Post-2020 Global Biodiversity Framework, but the initial draft document sets 21 targets and 10 milestones for governments to meet by the end of the decade.

Oceans within the CBD: Ocean issues within the CBD are addressed under a marine and coastal initiative (with priority work on identification of Ecologically and Biologically Significant Areas (EBSAs)) and the Sustainable Ocean Initiative[28]. Ocean biodiversity is critical to implementing climate crisis solutions. Reducing carbon emissions is essential, but reducing excess carbon in the atmosphere and the ocean is even more important, and nature presents opportunities for achieving this. Scientific findings have clearly shown the need to protect and conserve the marine and coastal environment **112 113**; fully protected areas deliver immense benefits to ecosystem restoration and human well-being, including food provisioning. The Post-2020 Global Biodiversity Framework includes 22 targets, including one on conserving 30% of land and ocean areas by 2030 and another target on climate mitigation and adaptation biodiversity actions. Meanwhile, the conclusion of the Biodiversity Beyond National Jurisdiction (BBNJ) agreement includes solid provisions for establishing an effectively managed and connected system of ecologically representative marine protected areas in the high seas.

Climate change issues and actions: Recent climate changes have already impacted many organisms and ecosystems, so additional change exacerbates impacts, but thresholds are often challenging to identify. Nonetheless, biodiversity can be essential in increasing resilience to climate change. Pathways to remain within 1.5 or 2°C require careful management to conserve biodiversity and ecosystems and optimise their contribution to climate mitigation and adaptation. Issues around climate change and actions are given prominence in the CBD. Realising the two-way connection between biodiversity and the impact of climate change, Parties in 2000, during the fifth session of the Conference of the Parties (COP), committed to adaptation activities. Decision V/3 on marine and coastal biodiversity included adaptation within the framework of "priority areas for action on coral bleaching". Amongst others, adaptation is also integrated within the work programmes on forest biodiversity, inland water biodiversity, island biodiversity and protected areas. The Programme of Work on the biodiversity of dry and sub-humid lands refers specifically to the need to facilitate biodiversity adaptation, such as the contribution of biodiversity to broader adaptation activities, such as peatlands within the inland waters biodiversity programme.

The CBD process also includes biodiversity and climate change activities, which link to work on impacts, vulnerability and adaptation to climate change. Decision VIII/30 of the CBD COP acknowledged that this work, including the Nairobi work programme on impacts, vulnerability and adaptation to climate change (Nairobi work programme), could facilitate communication and cooperation between relevant organisations. The decision also encourages the development of quick assessment tools to design and implement biodiversity conservation and sustainable activities that contribute to adaptation. Also, the close nexus between the ocean's health, climate change and biodiversity must be sought through blue-carbon ecosystems to align the CBD and UNFCCC processes.

> "Ocean biodiversity is critical to implementing climate crisis solutions."

Biodiversity Beyond National Jurisdiction Treaty

Aims and focus: *Achieving more holistic management of high seas activities, and ensuring better balance of conservation, sustainable use of marine resources and equitable sharing of benefits*

Approved by: *To be approved by the UN member states (in progress)*

Implementation period: *N/A*

The Biodiversity Beyond National Jurisdiction Treaty ("BBNJ Treaty"), also known as the "Treaty of the High Seas", is a global agreement on

28 The Sustainable Ocean Initiative focuses centrally on facilitating partnerships to improve conservation and sustainable use of marine and coastal biodiversity. https://www.cbd.int/soi/about/approach

the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction, currently being negotiated within the framework of the United Nations Convention on the Law of the Sea (UNCLOS), the primary international agreement governing human activities at sea. Resulting from the high seas' vulnerability to both natural and anthropogenic stressors, the need for a more coherent approach to the conservation and sustainable use of marine biodiversity beyond national jurisdiction became important. The BBNJ Treaty aims to achieve more holistic management of high seas activities, which should better balance the conservation and sustainable use of marine resources. According to Resolution (A/RES/72/249)[29], adopted by the General Assembly on 24 December 2017, four elements of the BBNJ package include: 1) marine genetic resources (MGRs); 2) area-based management tools (ABMTs), including marine protected areas (MPAs); 3) environmental impact assessments (EIAs); and 4) capacity building and the transfer of marine technology.

Sustainable ocean development: Balancing sustainable development and conservation efforts in the Areas Beyond National Jurisdiction (ABNJ) has increasingly become concerning, considering the governance limitations under UNCLOS for this part of the ocean. Once agreed upon, the BBNJ Treaty has the potential to fill gaps left by UNCLOS that are critical to sustainable ocean development, including the legal gap in the ocean governance framework, regulation of resource extraction, equitable distribution of proceeds from the "common heritage of mankind", biodiversity protection, etc. The ecosystem approach[30] to ocean management and governance, which is featured prominently in the BBNJ context, would be invaluable to avoiding fragmentation and building a global legal regime that allows for an integrated assessment of human activities and their interactions with the marine environment **114**. It has also been argued that the BBNJ Treaty could be a vehicle of fast action for global plastic management through institutional layering or conversion into its packages or rules **115**. Capacity building and technology transfer, which are critical parts of the BBNJ Treaty, are critical for the effective delivery of innovative finance mechanisms necessary to foster sustainable ocean development. More so, an existing president's draft text of the BBNJ Treaty[31]already outlines obligations to cooperate, promote coherence and complementarity, and conduct environmental impact assessments (EIAs), including objectives and processes for the adoption of area-based management tools (ABMTs).

Climate issues and actions: Despite their remoteness, the high seas and deep ocean in areas beyond national jurisdiction (ABNJ) are at the forefront of CO_2-induced climate stress, both in their mitigation capacity and in their vulnerabilities. Article 1 (6) of the draft BBNJ Treaty recognises the "cumulative impact" of climate change on the ABNJ, identifying it as "impact from different activities, including past, present or reasonably foreseeable activities, or from the repetition of similar activities over time, including climate change, ocean acidification and related impacts".

However, the BBNJ Agreement provides a unique opportunity to address climate change's impact on the ABNJ. According to Article 5 of the draft treaty, "General Principles and Approaches", State Parties shall be guided by "[a]n approach that builds ecosystem resilience to the adverse effects of climate change and ocean acidification and restores ecosystem integrity". Also, Article 14, objective (e) emphasises building

> "Resulting from the high seas' vulnerability to both natural and anthropogenic stressors, the need for a more coherent approach to the conservation and sustainable use of marine biodiversity beyond national jurisdiction became important."

29 https://documents-dds-ny.un.org/doc/UNDOC/GEN/N18/244/47/PDF/N1824447.pdf?OpenElement

30 The ecosystem approach is also included as a guiding principle and/or approach under two agenda items, ABMTs and EIAs.

31 A/Conf.232/2019/6 (May 2019), "Draft text of an agreement under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction – Note by the President". Available at: https://undocs.org/en/a/conf.232/2019/6.

resilience to stressors related to climate change, ocean acidification and marine pollution. At the same time, Article 54 on funding recognises the importance of the Green Climate Fund in implementing the treaty. Opportunities also abound for climate mitigation and adaptation under the BBNJ package, for example, by utilising climate-smart area-based management tools (ABMTs), including assessing vulnerability to climate stressors within EIA's scope and leveraging technology transfer and capacity building to monitor the effects of climate change. Designing BBNJ supportive financing approaches that draw on development finance and climate finance could help to provide examples for relevant integrated pathways. In addition, a robust BBNJ treaty would enhance the effectiveness of the International Seabed Authority (ISA) in administering deep seabed mining for resources critical for developing renewable energy technology.

Global Compact for Safe, Orderly and Regular Migration

Aims and focus: *Mitigating the adverse drivers and structural factors that hinder people from building and maintaining sustainable livelihoods in their countries of origin*

Approved by: *UN member states*

Implementation period: *N/A*

The Global Compact for Safe, Orderly and Regular Migration, or the "Global Compact for Migration"[32] (GCM), is the most comprehensive UN intergovernmental negotiated agreement addressing migration in all dimensions. The global compact is non-legally binding and is grounded in state sovereignty values, responsibility-sharing, non-discrimination and human rights. It recognises that collaboration is needed to optimise the overall benefits of migration while solving risks and difficulties for individuals and communities in countries of origin, transit and destination. The Global Compact comprises 23 objectives for better managing migration at local, national, regional and international levels. The GCM aims to reduce the danger and vulnerabilities migrants face at different stages of migration by respecting, protecting and guaranteeing their human rights and providing them with care and assistance; it aims to address the legitimate concerns of states and communities while recognising that the world is undergoing changes, such as demographic, economic, social and environmental changes, that may have consequences for and result from migration; and it strives to create conditions conducive to enabling all migrants to enrich our societies through their human, economic and social capacities, and thus facilitate their contributions to sustainable development at the local, national, regional and global level.

Sustainable ocean development: The inextricable oceans-migration nexus is getting more focus than ever, particularly considering the links between ocean, livelihood and food security. However, there is still a lack of data and evidence on current internal and cross-border migration, especially for rural ocean-dependent communities. There is a solid need to elevate this issue and better understand the mobility dimensions linked to ocean threats and the sustainable use of marine ecosystems. Considering migration issues in the ocean debate allows us to look at the social and human consequences of climate change and place people at the centre of the discussions. Opportunities to include climate, oceans and migration dimensions strategically in international policy discussions are offered in the Global Compact for Migration. It mentions developing coherent approaches to address the issues of migration movements in the context of sudden-onset and slow-onset natural hazards, and embedding climate and environmental considerations, including the link to oceans, in the international migration governance agenda.

> "[The global compact] recognises that collaboration is needed to optimise the overall benefits of migration while solving risks and difficulties for individuals and communities in countries of origin."

32 https://documents-dds-ny.un.org/doc/UNDOC/GEN/N18/244/47/PDF/N1824447.pdf?OpenElement

Climate change issues and actions: The impacts of climate change, such as coastal erosion, have devastating consequences for livelihoods and the well-being of communities, including loss of coastal arable land and soil, and groundwater salination. Degradation of marine and coastal ecosystems impacts the physical, economic and food security of affected local communities and can, directly and indirectly, impact the decision to migrate and the necessity of doing so. Therefore, low-lying islands are likely to disappear, and communities in rural and urban coastal areas will be particularly affected by the slow-onset effects of environmental change that are expected to affect rural-urban migration and internal and international migration, and drive global urbanisation trends further. In these conditions, migration could represent an adaptation strategy for many people who are forced to leave uninhabitable areas or migrate to cities to find new income resources. Under the GCM, countries have committed to invest in programmes that accelerate the states' fulfilment of the Sustainable Development Goals to eliminate the adverse drivers and structural factors that compel people to leave their country of origin, including climate change.

Sendai Framework for Disaster Risk Reduction

Aim and focus: *Increasing countries' resilience to disasters*

Approved by: *UN member states*

Implementation period: *2015-2030*

The Sendai Framework for Disaster Risk Reduction (SFDRR)[33], adopted at the Third UN World Conference in Sendai in 2015, succeeded the instrument of the Hyogo Framework for Action (HFA) 2005-2015[34]: Building the Resilience of Nations and Communities to Disasters. It is a voluntary, non-binding agreement that aims for "the substantial reduction of disaster risk and losses in lives, livelihoods and health and the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries" by 2030. The SFDRR focuses on the need for an improved understanding of all disaster risk and exposure dimensions. These include assessing vulnerability and hazard characteristics, strengthening disaster risk governance, including national platforms, accountability for disaster risk management, and preparedness to "Build Back Better". Recognising stakeholders and their roles in mobilising risk-sensitive investment and strengthening international cooperation also centralise the framework to enhance global partnership, develop risk-informed donor policies and programmes, and attract financial support and loans from international financial institutions. The SFDRR has seven global targets, four priorities for actions across sectors by states at local, national, regional and global levels, and a set of 38 indicators.

Sustainable ocean development: The SFDRR recognises that state (local and national), global and other stakeholders have the primary role in reducing disaster risk in the marine environment, particularly in the coastal domain. The role of local, national and international bodies/stakeholders in preventing and reducing disaster risk is acknowledged in the SFDRR. For example, Priority 2 (Strengthening disaster risk governance to manage disaster risk), 28 (h) emphasises the need "[t]o promote transboundary cooperation to enable policy and planning for the implementation of ecosystem-based approaches concerning shared resources, such as within … and along coastlines, to build resilience and reduce disaster risk, including epidemic and

> "low-lying islands are likely to disappear, and communities in rural and urban coastal areas will be particularly affected by the slow-onset effects of environmental change that are expected to affect rural-urban migration and internal and international migration, and drive global urbanisation trends further"

33 https://www.unisdr.org/files/43291_sendaiframeworkfordrren.pdf

34 https://www.unisdr.org/2005/wcdr/intergover/official-doc/L-docs/Hyogo-framework-for-action-english.pdf

displacement risk". Consideration for the plight of disaster-prone developing countries, particularly the least developed countries, Small Island Developing States, archipelagic countries and African countries, is identified in Priority 4 (41) of the SFDRR. It implies the urgent need to strengthen international cooperation and ensure genuine and durable partnerships at the regional and international level to extend appropriate assistance to coastal countries.

Climate change issues and actions: The SFDRR adequately acknowledges climate change as a disaster risk driver. In its 50 paragraphs, the phrase "climate change" appears 15 times. Several sections in the SFDRR highlight that hazards exist that need to be addressed by disaster risk reduction but are not affected, and perhaps cannot be affected, by climate change. For example, Paragraph 6 describes how "[m]ore dedicated action needs to tackle underlying disaster risk drivers, such as the consequences of poverty and inequality, climate change and variability", while Paragraph 13 highlights the importance of "[a]ddressing climate change as one of the drivers of disaster risk". Paragraph 25b nicely connects climate change with disaster, particularly in understanding disaster risk. It states that "global and regional levels" should "[p]romote the conduct of comprehensive surveys on multi-hazard disaster risks and the development of regional disaster risk assessments and maps, including climate change scenarios". Likewise, Paragraph 13 is entirely about respecting the territory of climate change and aims at "[a]ddressing climate change as one of the drivers of disaster risk while respecting the mandate of the UNFCCC" **116**.

Areas of synergy for consideration and recommendations

- The period before 2030 is also the window within which the SDGs are to be achieved to leave no one behind. Therefore, accelerating the implementation of Agenda 2030 is critical for more effective ocean climate action in Africa. Ocean renewable energy is one option for energy transitions envisaged in SDG7 on sustainable energy for all in particular. It would contribute significantly to lowering GHG emissions in Africa, compared with the business-as-usual pathways, thereby fulfilling the objectives of the Paris Agreement. Also, more sustainable industrialisation under SDG9, sustainable food production systems, including seafood and resilient aquaculture and agriculture practices (SDG2), and changing patterns of consumption and production in line with SDG12 could all help Africa to contribute toward low-emission pathways, create new jobs and make long-term progress towards eradicating poverty on the continent.

- Simultaneously addressing climate change and sustainable development presents challenges that demand a decentralised, multi-level approach, recognising the critical role of sub-national and local governments, local communities, indigenous peoples and the marginalised. Governments at the national level need to work with other government levels to ensure coherence, vertical integration and alignment of climate policies while mainstreaming climate action into all public policy sectors to avoid silos.

- The Paris Agreement acknowledges that climate change is a common concern of humankind; African negotiators at COP27 take cognisance of obligations to human rights; the rights of

"It implies the urgent need to strengthen international cooperation and ensure genuine and durable partnerships at the regional and international level to extend appropriate assistance to coastal countries."

indigenous peoples, local communities, migrants, children, persons with disabilities and people in vulnerable situations rights and the right to development, as well as gender equality, empowerment of women and intergenerational equity. Negotiators must emphasise the importance of the climate action human rights of coastal communities and those working in the maritime sector, given that climate change impacts are already, directly and indirectly, affecting a broad range of human rights within coastal communities and human resources in the maritime sector. Under international human rights law, African countries have obligations to mitigate climate change urgently, build the capacity of all individuals to adapt to climate change and promote learning and cooperation across countries. To catalyse more focused effort and inclusive collaboration, a better understanding of exploiting synergies and co-benefits in implementing ocean-based solutions to climate change and SDGs at various governance levels and scales, is needed. Keen attention should be paid to marginalised groups who face discrimination based on their gender, race, ethnicity, age, religion, disability, age or other forms of socio-political disadvantage, and those who live in smaller, rural, impoverished coastal communities.

- African negotiators at COP27 must recognise that a more robust ocean science-technology policy interface for synergistic ocean climate actions is needed, including instruments like the Global Sustainable Development Report and the Technology Facilitation Mechanism. This is critical to evaluate how best to leverage awareness campaigns, policies, interventions, implementation and stewardship mechanisms, multi-stakeholder action, and resources and partnerships for both the SDGs and ocean-based climate actions on the continent, to maximise co-benefits and minimise trade-offs at all levels.

- Actions needed to mitigate climate change in Africa and globally have a transformative impact on the world of work and jobs, particularly for the island states, whose primary GDP earnings depend on the ocean and communities who rely on the ocean to sustain their livelihoods. Millions of new jobs could be created by adopting a sustainable ocean economy and blue technologies, while recognising that specific jobs would be lost and investment in resource-intensive industries withdrawn systematically as countries transition to zero carbon. The scale of disruption to businesses and workers that this transformation would cause should not be underestimated. But carefully designed and coherent response strategies hold the potential to ensure net gains and a just transition for all.

- Concessional finance from bilateral donors remains Africa's most critical component of climate finance, given the many fiscal constraints and the urgent need for adaptation.

- In response to the COP25 and COP26 UNFCCC sessions of the Conference for a Continuous Ocean and Climate Change Dialogue request annual convening by the Chair of the Subsidiary Body for Scientific and Technology Advice (SBSTA), COP27 offers an unprecedented opportunity to address climate change ambition and the ocean. African negotiators can take advantage of the outcomes of this dialogue to raise their ambitions in policies, plans, actions and investments and bring transformative partnerships to scaling-up ocean-based climate actions.

“Negotiators must emphasise the importance of the climate action human rights of coastal communities and those working in the maritime sector, given that climate change impacts are already, directly and indirectly, affecting a broad range of human rights within coastal communities and human resources in the maritime sector.”

Chapter 4

Review of best practices for indigenous and local knowledge in ocean-based adaptation actions in Africa

Credit: Gaby Barathieu / Ocean Image Bank

Indigenous Knowledge

Indigenous and local knowledge (ILK) has become a popular term used in environmental justice programmes and climate change discourses. IPBES acknowledges that decision-making processes that integrate indigenous and local knowledge with scientific knowledge have more just and sustainable social and ecological outcomes [117]. It is defined as "a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" [118]. Such knowledge cuts across local natural resource management, historical and contemporary experiences, social norms, socio-cultural governance structures and spiritual beliefs [118]. ILK may be used interchangeably with terms such as "indigenous knowledge" (IK), "local knowledge" (LK), "traditional knowledge" (TK), "traditional ecological knowledge" (TEK)," cultural knowledge" (CK) and "folk knowledge" (FK) [119]. IK is used mainly regarding indigenous peoples, while TK/TEK and LK are more often used for local people who may or may not be indigenous but hold the knowledge that is based on personal and collective experiences of their local environments over time [120].

Developed through experimentation, adaptation and co-evolution over long periods, indigenous and local knowledge systems can provide helpful and valuable knowledge, methods, theories and practices for sustainable ecosystem management [120]. Studies have shown that indigenous and local people hold empirical and cultural knowledge about the environment that contributes significantly to environmental governance [122]. Also, anthropologists and natural scientists have reported ILK related to plants, animals and natural phenomena [123] [124]. In many parts of the world, local people are believed to possess the sole knowledge of many aspects of governance in socio-ecological systems [125]. It has been documented how several communities in different parts of the world developed their initiatives to protect natural resources through local rules, showing that it is possible to govern the environment at the grassroots [126].

The recognition of the importance of ILK has led to its incorporation into the modern landscape of conservation and adaptation research and practice [119]. For instance, indigenous and local people, even though very vulnerable to the negative impacts of climate change, have been recognised as possessing specific knowledge necessary for adaptation actions [120]. One example is the role of agro-biodiversity in adapting to climate variability and sustaining local livelihoods in the tropics [125]. The urgency of the global climate, food and water crises presents an opportunity for engagement with the sustainable practices and solutions ILK presents [119] [127]. It is believed that the inclusion of ILK in research and practice can empower indigenous and local people and support them in finding suitable solutions to climate change and other threats [119] [128].

The UNFCCC, IPCC and IPBES have acknowledged the importance of ILK systems in climate change adaptation and biodiversity management. Areas affected by flood, drought and desertification, coastal zones, water resources and agriculture have been identified as priority areas for adaptation interventions [129]. Since 2002, after the World Summit on Sustainable Development held in South Africa, where the historical relationship that indigenous and local people have had to their lands over many generations was officially recognised, ILK has been incorporated into policy, research and practice across different aspects of sustainable development, including the management of land and ecosystemso [119].

Indigenous/local people are also able to provide information on the local weather and climate events and how this has impacted their areas, which can be used to verify past events and changes in ecosystems.

"For instance, indigenous and local people, even though very vulnerable to the negative impacts of climate change, have been recognised as possessing specific knowledge necessary for adaptation actions [120]."

General global overview of the role of indigenous knowledge in climate change adaptation

Adapting to the impacts of climate change is a global challenge. It has received increased attention among scholars in recent decades, as it has become evident that unprecedented climate change is inevitable, irrespective of the success of measures to reduce emissions of greenhouse gases [130]. Knowledge systems and practices of indigenous peoples are recognised as a "major resource" for climate change adaptation [131]. There is a growing body of literature on understanding how indigenous communities perceive and might adapt to climate change globally [132]. Adaptation here refers to the process of adjustment to actual or expected climate so as to moderate harm or exploit beneficial opportunities [28]. However, in some parts of the world, the social capital, cultural values and knowledge of indigenous communities that need to underpin efforts to build the adaptive capacity for climate change are often undervalued by outside researchers, policy makers and service providers.

This narrative is changing, as it is essential to build on the local community's strengths (e.g., existing resources, social networks and traditional knowledge) to explore and develop feasible adaptation options, rather than introducing adaptation measures that may be effective elsewhere for different populations [132]. Local and indigenous communities can hardly be said to be helpless in the face of the devastating impacts of climate change, as many of these indigenous communities have a historical record of adaptations to the variability of their environments [133]. Indigenous people who live close to natural resources often observe the activities around them and are the first to identify and adapt to any changes. The appearance of certain birds, the mating of certain animals and the flowering of certain plants are normal signals of change in times and seasons that are well understood in traditional knowledge systems. Indigenous people have used biodiversity as a buffer against variation, change and catastrophe; if one crop fails, another will survive in the face of the plague. In coping with risk due to excessive or low rainfall, drought or crop failure, some traditional people grow many different crops, including varieties with different susceptibility to drought and floods, and supplement these with hunting, fishing and gathering wild food plants. A similar diversity often matches the diversity of crops and food resources in the location of fields as a safety measure to ensure that some fields will survive to produce harvestable crops [134] [135].

Traditional weather and climate forecasting are used globally by several indigenous communities as a guiding framework for adapting to extreme climate events and conditions. For instance, many pastoral communities in Africa use traditional weather and climate forecasting as the most accessible and affordable source of weather and climate information [136]. There are also increasing calls for ecosystem-based adaptation (EbA) approaches, where local and external knowledge about ecosystems are integrated (such as in the building of climate-resilient buildings) and used as approaches to address climate change impacts [137]. Therefore, it is evident that integrating the different knowledge systems and decision-making processes is crucial in responding to climate change impacts across sectors and scales, as this approach improves the understanding of the issues and the management of associated risks. Traditional ecological and local knowledge contributes insight essential in understanding environmental and social change [138].

Indigenous and local knowledge practices in climate change adaptation across Africa both on land (100 km from the land-sea interface) and at sea

Africa is arguably the region most vulnerable to climate change impacts, partly due to its geographical peculiarities and its having

"Local and indigenous communities can hardly be said to be helpless in the face of the devastating impacts of climate change, as many of these indigenous communities have a historical record of adaptations to the variability of their environments [133]."

the lowest adaptive capacity for climate change impacts. Indigenous African communities have long been recognised as particularly vulnerable to climate change because their livelihoods, culture, spirituality and social systems largely depend on their immediate environment [139]. This is especially so in many African countries where food production, for example, is predominantly rainfed, and where, as a result, the dependence of indigenous people on agricultural livelihoods is negatively affected by extreme events [140]. However, Africans, particularly at the local level, are making efforts to adjust to the changes they observe. African farmers and natural resource-dependent communities have found varied ways of coping with these changes based on traditional knowledge and practices [134]. Their knowledge of ecological patterns could help reconstruct historical baselines. Traditional ecological knowledge of ecosystem health and species distributions could contribute to culturally appropriate climate change adaptation. Traditional knowledge related to water, harvesting and storage have allowed indigenous people to survive in arid lands and cope with drought for millennia. A better understanding of how they have done this is essential for designing incentives to enhance private adaptation on the continent [138] [141 – 143].

Given the relevance of climate change awareness in building a resilient society and in climate change adaptation in developing countries, including in Africa, several studies have shown an overwhelming awareness of climate impacts among indigenous communities (e.g. [144] [145]). Scholars have attempted to corroborate indigenous people's perception of observed changes in climatic conditions to the scientific meteorological recordings to show that observations by indigenous people are consistent with meteorological recordings [134] [146] [147]. Indigenous people may not understand the concept of climate change or global warming, but have accumulated IK about the changing climatic conditions and their effects on their livelihood [146]. This section, therefore, further examines some examples of the relevant application of ILK for climate adaptation and mitigation in Africa, cutting across both land and ocean. First, it showcases indigenous people's survival strategies and variations in their ability to adapt to and mitigate against a range of climate change hazards, such as floods and droughts (Table 5), and secondly, it shows the example of indigenous knowledge serving as a social capital that has enabled the necessary communal participation, networking and responsibility necessary for adaptation and mitigation (see boxes 1 to 3).

Country / Case study	Strategies	Adaptation/mitigation actions/capacity
Zimbabwe Case study: Local communities within the Zambezi Basin [135]	Indigenous flood prevention and coping	– (Adaptation) Placing barriers around a house, avoiding construction materials susceptible to cracking during flooding, constructing floating houses and raising the platforms of the kitchens and storerooms to keep food, water, fuel and valuables dry during flooding – (Mitigation) Reducing the number of meals, relying on inexpensive food, collecting wild fruits and honey, taking shelter on higher ground with one's personal belongings, searching for alternative sources of income, and selling assets

Table 5. Selected examples of strategies and adaptation/mitigation actions adopted by local indigenous people in Africa

Country / Case study	Strategies	Adaptation/mitigation actions/capacity
	Saving human lives and household items	– Given previous flooding experiences, communities tend to elevate their beds using bricks or stones. Some use raised platforms (dara) outside their houses as shelter, and others seek safety on higher ground.
	Crop protection	– Growing drought-resistant crops only increases the food security of households. – Selecting appropriate varieties that suit the local climate, the soil conditions and the time frame of floods
	Poultry and livestock protection	– During the initial flood stage, households keep their poultry and livestock in pens on slightly higher parts of their homestead. When this becomes unsafe, they move them to safer places on higher ground or sell the poultry and livestock to outsiders.
	Food and water conservation	– Stockpiling dry food, grain and seed in polythene bags that are kept in a special hut called a dura – Storing water in places higher than the standard floor – Relocation to higher ground with food and water containers
	Adaptations to food insecurity	– When faced with insufficient food supply occasioned by flooding, different adaptation measures are initiated by the head of the family, including reducing the number of meals per day and relying on inexpensive food, such as vegetable leaves and wild fruits.
Botswana 146 147	Climate change monitoring and surveillance	– Capacity to observe a decrease in rainfall and wind strength, increasing air temperature or heat, increasing drought conditions and drying rivers, resulting in an increased frequency of hunger and of human, crop and animal diseases
Ethiopia **Case study:** The Afar pastoralists in north-eastern Ethiopia 136	Climate change monitoring and surveillance	– Prediction of weather and climate variations by observing diverse bio-physical entities such as trees, insects, livestock, birds and wildlife
	Weather forecasting	– Collection of information from different sources, including modern weather forecasting systems

Country / Case study	Strategies	Adaptation/mitigation actions/capacity
	Information analysis, management and decision-making	– Information collected is passed through three traditional institutions that will share and analyse the collected information before it is used. The three traditional institutions include: (a) the Edo, or range scouting, which has traditional rangeland scouts who are sent out to evaluate weather and other spatially and temporally variable attributes on rangelands; (b) the Dagu, a traditional secure and reputable network that shares weather information among users; and (c) the Adda, or the traditional Afar governance system, whose role is to analyse traditional weather information before community decisions are made.
South Africa **Case study:** The local farmers in the Eastern Cape province 152	Weather forecasting and observation via belief systems	– The belief is that a brown animal, such as a brown Swiss (cattle breed suitable for beef and milk production), should not be kept among cattle because it brings bad luck (affecting breeding) to the herd. – The belief is that a rabbit's skin should not be put in the fire because they believe it causes dryness; rains will fail, which may lead to drought.
	Drought disaster preparedness rituals	– Community announcements at chief's meetings of the abundance of ants during dry periods (signifying that worse droughts are still to come) – Conduct ceremonies at sacred mountains / rivers to call the rain, slaughtering cattle in a request to their ancestors. Usually, after that ceremony, the rains come.
Ghana **Case study:** The indigenous rural communities in the basin of the River Offin 134	Water management	– Washing clothes or utensils outside to irrigate backyard gardens and nurseries – Water rationing by households to reduce the water use per person per day – Rainwater harvesting and storing of rainwater in big barrels placed under the roofs of houses
Kenya **Case study:** Farmers in Lake Victoria basin – pans to store water during rains 138	Water management	– Using drought animals, especially donkeys, to transport water – Construction of wells, roof-water harvesting using earthen pots and construction of water pans to store water during rains

Country / Case study	Strategies	Adaptation/mitigation actions/capacity
Cape Verde **Case study**: Local artisanal fishers [149] [150]	Weather forecasting and observation	– Traditional knowledge of the lunar calendar provides local artisanal fishers with information about where to fish – for example, during the new moon, they prefer to fish in the northern grounds, during the half moon in the south, and back in the north at full moon. – Moon observation to forecast the weather – if there is a green circle around the moon, the weather will be fresh and rainy; if it is a white circle, it will be windy
Comoros **Case study**: Male fishers of Ngazidja [151]	Fisheries / Marine resources management	– Formal and informal transmission of the knowledge of local folk taxonomy of fish species of fisheries from older siblings or parents to young children – Knowledge of fish habitat and movement patterns is used to judge the time, method and location required to catch certain species.

Communal farmers in the O.R. Tambo district in the Eastern Cape province of South Africa, which stretches along the Indian Ocean coastline for about 160 km, use local indigenous knowledge for drought risk reduction. Their indigenous knowledge approaches to drought risk reduction include:

1. **Use of local indigenous knowledge for drought early warning signs by communal farmers:** During the year, when farmers see an army of locusts moving in one direction, they interpret it to mean that drought is imminent. Future drought and rain could also be predicted by farmers from the behaviour of different animal species, such as snakes (snakes moving in the same direction signifies drought), bees (when bees fly in a specific direction, it signifies drought), frogs (when frogs make a noise in the afternoon, it signifies drought), horses (when a horse playfully jumps, it signifies rain) and butterflies (a kaleidoscope of butterflies flying together in the same direction signifies imminent drought).

2. **Use of local indigenous knowledge by communal farmers to preserve seed and ensure production:** In this approach, the older adults check maize crops while still in the field for good quality cobs. During harvesting, the big maize cobs are set aside and reserved for seed for the following growing season. Some maize cobs are kept in the farmers' round huts, locally known as intanyongo or iziswenye and hung from the ceiling to ensure complete dryness. Some farmers sprinkle ash around the seeds to keep ants away. If the production of maize and sorghum is good enough, farmers will take some of the bags after harvesting and keep them in giant water tanks as a reserve for difficult periods. Excess food or production could be stored in a big, deep hole dug in the middle of the kraal (homestead). This would prevent thieves from gaining access to the food, retrieved with care when needed, thus ensuring food security.

Box 1: Drought Risk Reduction Strategy adopted by communal farmers in the O.R. Tambo district in the Eastern Cape province of South Africa [152]

Box 2: The local and indigenous farmers of Ouémé, Benin Republic, and the practice of whédo [153]

In the Republic of Benin, local and indigenous farmers of the Ouémé valley, located in the south of the country and bounded by the lower delta of Ouémé River, have developed a remarkable ability to adapt to climate threats or, in some cases, have turned threats into opportunities. The practice of *whédo* is one of the indigenous and oldest innovations developed by Ouémé valley people to cope with climate vulnerability. The *whédo* are traditional fingerponds built in medieval times in the floodplains of rivers and lakes to trap the wild fish during low-water periods. Although this practice is of very ancient times, it has been improved over time and is adopted as an effective adaptation strategy for climate threats in the low valley of Ouémé. The *whédo* is a traditional fishing practice that enables Ouémé valley people to take advantage of succession and regularity of flooding and recession periods in floodplains. Indeed, the fingerponds, dug mainly in floodplains, serve as refuges for wild fish migrating during the flooding. At low-water levels, these indigenous fish species are tamed into the holes and become easy prey to farmers. This practice provides a wide range of economic and social benefits to populations who take it as a source of diversification, income safety and food security. But for several years, there has been a severe decline in income from this activity because of the continuous depletion of fishery resources in the river. At the same time, climate threats, namely flood risks, are increasingly surging, with a significant impact on crop yields; thus, the *whédo*, as traditionally constructed, is becoming inadequate to meet this challenge, and the farmers need new adaptation strategies to secure crop yields and livelihoods.

Also, Ouémé valley farmers have developed remarkable adaptation ability over time by practising diversified agriculture in floodplains at low-water level, followed by corn cropping during the rainy season. But, due to lack of water control, climate variability greatly affects crop yields, which causes precocious floods or rapid drying of floodplains. In this context, the fingerponds previously dug in floodplains to trap migrating fish during the flooding have become predilection areas for agriculture. Thus, from simple holes, the fingerponds have become agro-fishing techniques whose pits retain their traditional use of fish ponds, but whose dykes – henceforth broader and forming high strip lands – are used for dry-season cropping. This practice is locally called *kanfli*. The socio-economic and agronomic benefits of this practice are numerous. The *kanfli* promotes the earlier emergence of land at low water and, therefore, the sowing in time of dry-season crops. Long-cycle crops such as pepper and leaf vegetables are then sowed earlier, and crop harvests are sold in periods of best prices. Leafy vegetables are generally grown by women, the primary beneficiaries of this practice. In addition, the early emergence of the strip lands of agro-fingerponds allows for spreading dry season length and farming activities over a more extended period. This reduces labour and financial constraints, which generally characterise farming households. Besides, the water stored in the holes after flood recession and its traditional use for trapping wild fish enables the wetness of strip lands formed by the agro-fingerponds and, therefore, fights against the water stress of dry-season crops. Indeed, water retained in the holes is used to irrigate crops grown on the dykes during the off-season. However, despite the numerous benefits provided by agro-fingerponds, they now generate increasingly less interest for farmers. Thus, new farming practices are continuously developed in response to climate vulnerability in the low valley of Ouémé. This includes the building of dykes in the floodplains only for crop production. In this case, the dykes have been covered with mulching to hold water and reduce soil moisture loss.

In Nigeria, the coastal communities of Ayetoro, Awoye, Orioke, Araromi, Abereke and Obefela in Ondo State and Burutu, Gbekebor and Ogulaha in Delta State have developed indigenous meteorology signals and signs based on accumulated knowledge passed from generation to generation from tackling flooding in their communities. They have indigenous and local knowledge about weather patterns, the behaviour of ocean currents and the timing and magnitude of river and ocean flooding. Some of the indigenous signs of an approaching flood disaster in these communities include the following:

Lunar observation: An approaching full moon signifies approaching ocean flooding in the communities. Though moon sightings and observations cannot be used to estimate the level of flooding, the tidal level is believed to rise with the approaching new moon. The communities prepare for floods as soon as they sight the new moon. Indigenous cloud study: Thick, dark clouds signify approaching heavy rain and the likelihood that the rainfed river channels and waterways will inundate the villages. Knowledge of the local methodology is still enshrined in mystery, and some community members appear to be more gifted in reading and interpreting cloud patterns.

The behaviour of aquatic animals: The coastal rural communities also study certain aquatic species to understand the behaviour of floodwaters. In the Ayetoro, Awoye, Orioke, Araromi, Abereke and Obefela communities, the migration pattern of a crab species, often called lagbaja or sabutu in the local language, signifies approaching floodwater. When these crabs migrate en masse towards the Atlantic, it signifies approaching freshwater flooding (warm flood). On the other hand, if the same crab species move en masse towards the freshwater through the creeks, it signifies an impending flood from the Atlantic (cold flood). The speed at which these crabs migrate indicates the magnitude and the ravaging nature of the impending flood.

Water colour observation: The colour of water in the creeks changes to a dark brown, brownish or yellowish colour depending on the period of the year and the upstream activities. However, when there is a sudden change in the colour of the water as opposed to the six-hourly tidal movements of the Atlantic Ocean in the creeks, it signifies impending flooding. When the water suddenly changes to a very dark colour, it indicates an approaching sea flood (cold flood). When the water in the creeks suddenly changes to a brownish or yellowish colour, it signifies an impending river flood (warm flood). When all the community members understand the water colour changes and take action quickly, some may be trapped in neighbouring communities because of the ocean floods, and schools may be closed.

Leaf and particle observation: The creeks in some communities have water weeds (water hyacinth), which an approaching river flood often carries and moves rapidly towards the sea. When the water weeds rush toward the freshwater, it indicates an approaching sea flood (cold flood). Other floating particles and floating leaves are linked to flooding in all the communities.

Also, over time, these coastal communities in this region have developed local adaptation strategies to cope with climate change and flooding, including:

Social capital: The communities have put in place coping mechanisms, through mutual support, to reduce the effects of losses to flooding through cooperative society, religious organisations and age-grade groups. The assistance rendered to flood victims includes loans, outright grants, temporary accommodation for the victims and families until the floodwater recedes, help in scooping water out of their living room, and providing food items during events when floods ravage farmlands. These processes of assistance are informally organised and spontaneous.

Box 3: Indigenous knowledge and communal philosophy of coastal communities of Ayetoro, Awoye, Orioke, Araromi, Abereke and Obefela in Ondo State and Burutu, Gbekebor and Ogulaha in Delta State, Nigeria [154]

Building materials used and construction style: The communities have adapted their building materials and style to withstand the regular devastating flood disaster, taking a cue from natural features in the areas to construct their buildings. The river birds and mangroves provide insight to the people in the communities for building on piles and raft foundations.

Local public works: Community development in the coastal community is very active and dynamic. The community develops strategies to cope with coastal flooding by constructing wooden walkways and streets. They also construct shoreline protection and jetties with the assistance of the local or provincial governments. Communities have developed and constructed some infrastructure with the assistance of oil companies to mitigate the effects of flooding [138]. Indigenous technologies have helped with the construction of bridges using planks of wood, concrete embankments for the protection of villages, and rock embankments for the protection of the shoreline.

Knowledge gaps

- Climate change adaptation knowledge systems and practices of local and indigenous people in different African communities, especially coastal communities, are not well researched and documented. This has resulted in a lack of robust understanding of how adaptation is occurring currently in Africa and the prediction of future adaptation status and practices under different climate scenarios.
- The meagre investment in climate change adaptation research in Africa is a constraint for the integration of indigenous knowledge as part of an evidence base needed for climate change adaptation policy formulation and implementation.
- There is a need for a well-coordinated platform for inter-linkages and exchange among indigenous and local people across coastal communities in Africa for the exchange and transfer of indigenous knowledge and technology for climate change adaptation.
- Most African countries have not been able to integrate indigenous and local knowledge with scientific knowledge for practical climate change adaptation efforts at present or in the future.
- The gender dimension of climate change adaptation and cultural differences that may limit adaptation uptake needs should be considered.
- What the tipping points are where communities can no longer adapt using ILK awaits further research.
- Ultimately, local and indigenous communities must not be seen as helpless, but rather as partners in decision-making to take adaptation/mitigation measures with their support. However, ascertaining how aware these communities are of the climate change discussions needs to be prioritised.

“Ultimately, local and indigenous communities must not be seen as helpless, but rather as partners in decision-making to take adaptation/mitigation measures with their support. However, ascertaining how aware these communities are of the climate change discussions needs to be prioritised.”

Chapter 5

Review of existing methodologies and metrics to assess and track ocean-based adaptation and mitigation actions in Africa to propose a suitable methodological framework for assessing and tracking ocean-based actions and addressing knowledge gaps

Credit: Laura Pereira, Inhaca Island, Mozambique

Climate Change Adaptation and Mitigation Methodologies and Metrics

The need to understand progress in climate change adaptation is increasingly being recognised at the global, national and sub-national level, including in the context of the Paris Agreement. Indicators or metrics are critical to this process [155]. A set of "metrics", or indexes, can be defined as a system of measurement that includes the item being measured, the unit of measurement and the unit's value. Metrics may provide a tool for developing and implementing response strategies, measuring progress and improving performance [156]. Although indicators are subject to various definitions, they tend to be broadly consistent in describing a quantitative or qualitative variable that provides reliable means to measure a particular phenomenon or attribute [144]. Indicators are conceptually distinct from metrics, even though both are mutually dependent. Both concepts can be used interchangeably in frameworks for measuring, reporting and evaluating (MRE) the effectiveness and progress of adaptation and mitigation projects across different sectors and scales (local and global). Any given indicator could have several metrics, whereas any given metric could refer to several indicators in MRE frameworks [157].

For example, a universal consensus has emerged that the effectiveness of greenhouse gas emissions mitigation projects is to be measured in tCO_2 equivalent reduction. This metric is used for all project-based mechanisms and calculates projects' efficiency in currency units spent to achieve one tCO_2 equivalent reduction [158]. This is not the case with assessing adaptation projects across scales, as no universally accepted metric for assessing adaptation effectiveness exists [158]. However, the issue of how to establish meaningful metrics for climate change adaptation is gaining importance on both the political and academic agendas, as there is increased recognition of the need to prioritise and direct limited adaptation funding to the most vulnerable countries and population groups in the most cost-effective way [157]. In 2016, "[t]he metrics of Adaptation Conference took place in advance of COP22 in Morocco to develop a set of transferrable indicators to measure and track the success of adaptation projects" [159].

Similarly, Conservation International hosted a workshop to identify common metrics to quantify the benefits of ecosystem-based adaptation [160]. A standardised way of quantifying adaptation in the form of adaptation metrics is hoped to lead to more ambitious action, improved comparability and prioritisation of investments, better assessments of global progress and increased mobilisation of funds [155]. According to the IPCC fifth assessment report, adaptation metrics will serve three purposes, namely: a) identifying adaptation needs, b) tracking implementation of adaptation action, and c) assessing the achieved results of adaptation [161].

Adaptation metrics under the UNFCCC have evolved considerably over the last 20 years, from measuring the degree of vulnerability of countries (metrics to identify and prioritise adaptation needs) to monitoring and evaluating adaptation at the project, sectoral and subsequently national level (metrics to monitor and evaluate adaptation progress and actions). More recently, they have also included reviewing the adequacy and effectiveness of adaptation, support and collective progress made in achieving the global adaptation goal as established in the 2015 Paris Agreement (metrics to evaluate effectiveness, adequacy and collective progress) [157].

Despite the progress made so far in the evolution of adaptation metrics, there is no exact metric agreed upon by parties to be used in the proposed 2023 Global Stocktake (Article 14 of the Paris Agreement) for assessing the progress made on the global adaptation goal [162]. There have been several calls to adopt universal adaptation metrics to track the global goal of adaptation. However, some experts have

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opined that it is impossible to establish a single universal metric that can uniformly capture adaptation outcomes across scales, since adaptation is context-dependent [163].

There are different indicators used for different purposes and at different levels (e.g., local, national or global), and each of these require different characteristics. It becomes essential that adaptation indicators are defined for a particular purpose and context, rather than searching for all-purpose indicators. This is evident because the adaptation components of countries' nationally determined contributions (NDCs) differ and require country-specific monitoring systems. Therefore, tracking of the Global Stocktake should be by a mix of information from global sources and national and sub-national levels [163]. The need for accountability and transparency in adaptation funding through tracking outcomes and the progress of adaptation interventions by countries cannot be overemphasised. This will help ensure value for money regarding adaptation funding and ensure that the most vulnerable countries with highly impactful adaptation projects are prioritised in adaptation finance allocations. However, the frameworks and processes we develop for measuring, aggregating and comparing adaptation results must meet the needs of all stakeholders – from local to global levels [157].

Therefore, this chapter aims to overview widely agreed metrics and frameworks to inform a methodological proposal for African countries to measure and track their climate adaptation and mitigation progress.

Approaches to Climate Change Adaptation Tracking

Outcome-based evaluation approaches

Outcome-based evaluation approaches measure adaptation progress and effectiveness concerning reduced negative climate change impacts (i.e., the ultimate goal of adaptation) [164]. It is an approach characterised by tracking outcome indicators and metrics such as climate-related death, losses and morbidity over a period and in an adaptation context. It also examines the impacts of climate hazards before and after adaptation [164]. This approach obtains data from natural hazard loss databases (e.g., emergency events databases).

The strengths of these approaches include:

- Quantification of adaptation progress and effectiveness
- Monitoring of metrics over time
- Availability of standardised global datasets of hazard losses and mortality across regions
- Legitimacy within the policy evaluation community

Limitations of these approaches:

- Applicability only where outcomes are directly observable
- Difficulty of inferring causality between outcome and adaptation
- Potential for mal-adaptation not being captured
- Limited applicability to "soft" and mainstreamed adaptations
- No measurement for outcomes from adapting to wider (non-event-oriented) climate change

"The need for accountability and transparency in adaptation funding through tracking outcomes and the progress of adaptation interventions by countries cannot be overemphasised."

Systematic approaches for tracking adaptation

Due to the limitations of applying outcome measures in adaptation monitoring and evaluation, several systematic measures are available to assess various stages and aspects of adaptation. Here, adaptation can be assessed and tracked at various stages using these systemic measures:

- Adaptation readiness
- Adaptation process
- Adaptation policies and programmes
- Examining measures of changing vulnerability

A country's assessment of adaptation readiness can be used as a factor for tracking adaptation. In these approaches, key governance factors, which are believed to be crucial in determining if and how adaptation takes place, are evaluated 164. Key indicators and metrics measured under these approaches are political leadership, funding, institutional organisation, stakeholder involvement, climate change information, appropriate decision-making techniques, technology development and adaptation research, etc. Also, sources under these approaches include speeches at Conference of the Parties meetings, leadership identified in UNFCCC National Communications or National Adaptation Programmes of Action, national assessments and attendance at Conference of the Parties meetings.

Strengths of these approaches:

- No dependence on outcomes being visible
- Capturing of readiness for future action and ability to implement adaptations effectively

Limitations of these approaches:

- Need to validate if readiness translates to action
- Limited availability of readiness metrics

Process-based approaches

Process-based approaches assess and track the adaptation process at the development and implementation phase, while working towards a desired objective and outcome. Disconnecting between the period over which adaptation effectiveness is often manifested and the practical need to evaluate adaptation interventions spurred interest in process-based approaches to adaptation monitoring 164. The metric and indicator of measurement in this approach include comparing adaptation characteristics and steps of development to theoretically and empirically derived characteristics of adaptation success and best practice. Data sources also include National Adaptation Programmes of Action and adaptation inventories.

Strengths of these approaches:

- No dependence on outcomes being visible
- Capturing of the fundamental processes that are believed to underpin effective and successful adaptation

Limitations of these approaches:

- Limited systematically collected data on the process of adaptation development and implementation
- Limited transferability across nations
- Time-intensiveness
- Unproven link to adaptation success

Analysing policies and programmes approaches

Monitoring government policies and programmes is an approach for assessing and tracking national adaptation efforts. This approach is essential, as it can complement outcome-based tracking approaches, which require a longer time frame to be measured, given the time lag between adaptation actions and likely measurable outcomes. Indicators and metrics for these approaches include an analysis of

characteristics of reported adaptations and comparison across regions, by vulnerability categories, over time, and concerning adaptation "obligations". Several data sources for applying these approaches may include the UNFCCC National Communications, National Adaptation Programmes of Action, adaptation inventories and national adaptation assessments.

Strengths of these approaches:

- No dependence on outcomes being visible
- Systematic and quantitative analysis of progress
- Comparability across nations
- Suitability for global application
- Amenability to rapid assessment

Limitations of these approaches:

- Success not directly measured
- Results subject to reporting bias

Approaches of examining measures of changing vulnerability

In these approaches, indirect changes in vulnerability reduction can also predict successful adaptation, in contrast to outcome-based approaches, which focus on the direct manifestations of reduced risk following adaptation. They involve identifying many vulnerable locations of climate risk, future vulnerabilities prediction and informed adaptation planning using vulnerability indices and frameworks developed from several national and global adaptation projects. The projects further serve as a vulnerability baseline for assessing adaptation success. Indicators and metrics for these approaches include aggregate adaptation vulnerability indices, adaptive capacity and sensitivity to climate change impacts, and specific indicators such as poverty, health, access to education and inequality, all generic determinants of vulnerability. The data sources may include the Climate Change Vulnerability Index (CCVI), Notre Dame Global Adaptation Index (ND-GAIN), Environmental Sustainability Index (EVI) and Global Climate Risk Index (GCRI).

Strengths of these approaches:

- No dependence on outcomes being visible
- Readily available vulnerability indices globally
- Amenability to rapid assessment

Limitations of these approaches:

- Inability to incorporate vulnerability determinant factors
- Fundamental disagreement between indices on the magnitude of vulnerability
- Challenge of linking change in indices to adaptation

Identification and Review of Existing Methodologies and Metrics Used in Assessing and Tracking Ocean-Based Adaptation and Mitigation Actions (General or Global Perspective)

Over the years, several frameworks have been developed to assess climate change adaptation and resilience interventions across different sectors and scales. These frameworks contain the methods, indicators and metrics used to assess, successfully track, and monitor climate change adaptation projects and programmes, by various actors and

from local to global levels. Some frameworks employ the community-based monitoring and evaluation system, while others take the programme, project and policy-based approach 165.

Frameworks that employ community-based M&E initiatives are usually bottom-up approaches and involve highly localised vulnerabilities and immediate priorities of communities 166. According to 167, community-based M&E frameworks ensure increased authenticity of locally relevant findings and improve local capacity. Stakeholders are consulted at almost every step of a project's monitoring, evaluation and implementation phases. They are involved in developing tools, setting objectives and indicators, and sharing concerns, experiences and learning during the project life cycle 166 168. In contrast, the programme monitoring and evaluation system approach monitors and evaluates the direct and indirect adaptation outcomes. "Adaptation programs usually require multiple projects working towards achieving a particular goal. Uniform indicators that assist in aggregating the outcome for the program are selected across the individual projects" 166 168. National adaptation policy monitoring and evaluation frameworks are commonly developed and deployed for accountability and learning purposes 169.

A 2014 report[35] by the SEA Change Community of Practice and the UK Climate Impacts Programme (UKCIP) reviewed wide-ranging frameworks that have been developed by scholars and used in tracking, monitoring and evaluating climate change adaptation projects and programmes. Some of the frameworks include:

Monitoring and evaluation framework for adaptation to climate change (MEFACC)[36]. This framework was developed in 2007 for the United Nations Development Programme (UNDP) and Global Environment Facility (GEF) to address urgent and immediate adaptation needs in response to climate change within seven IPCC, UNDP and GEF climate change priority thematic areas and sectors (agriculture/food security, water resources and quality, public health, disaster risk management (DRM), coastal zone development, natural resource management (NRM) and infrastructure) and is applicable across local, sub-national, national and international project scales 170 - 172. This framework was developed for both portfolio and project level management, with a focus on National Adaptation Programmes of Action (NAPAs) under the Special Climate Change Fund (SCCF) and resilience under the Least Developed Countries Fund (LDCF). It provided valuable insights into the need for multi-level Monitoring and Evaluation (M&E) frameworks and was a valuable starting point for many later M&E resources 170 - 172.

While this framework does not address conceptual or theoretical matters in great detail, it provides valuable insight into some of the most fundamental issues to be tackled in establishing an M&E framework for climate change adaptation interventions. These have since been further elaborated on in more recent materials. It provides clear and concrete instruction on designing logical frameworks (logFrames) and indicators that can be used to measure an aggregated portfolio of endeavours in terms of coverage, impact, sustainability and replicability. The framework is designed to aggregate indicator data upwards into overall portfolios, which may be challenging in practice. The approach differentiates between "standard portfolio/project scale indicators", applicable across all thematic areas, and "supplementary

35 http://www.ukcip.org.uk/wp-content/PDFs/SEA-Change-UKCIP-MandE-review-2nd-edition.pdf

36 http://www.ukcip.org.uk/wp-content/PDFs/SEA-Change-UKCIP-MandE-review-2nd-edition.pdf

indicators", which are defined for each thematic area. Some of the suggested indicators seem oversimplified (e.g., the number of communities involved in projects), while others are vague and/or difficult to measure (e.g., perceived percentage change in participation). Furthermore, if interpreted as targets, such indicators could encourage "quantity over quality" 170 - 172.

AdaptME toolkit: This framework was developed in 2011 by the United Kingdom Climate Impact Programme (UKCIP). The toolkit's development was a response to a growing demand for practical support in evaluating adaptation progress and performance 173. It is relevant for all sectors and uses the logical framework approach as the primary M&E focus. This toolkit can be applied by community, sub-national, national and international climate change adaptation practitioners. It serves a practical purpose: to equip practitioners with critical information and guidance to devise a climate change adaptation M&E framework that fits their programme, context and purposes. AdaptME promotes the importance of context and the fact that there is no one-size-fits-all approach to adaptation M&E. Instead of providing step-based directions, the framework poses critical questions. A question-based approach can be beneficial, as it enables users to consider adaptation M&E within different contexts. The only consideration is that it may not be so readily usable by persons new to climate change adaptation; the user would already need a good general understanding 172 173.

Two distinct types of indicators can be used concerning adaptation evaluation using the AdaptME toolkit[37]. They are process and outcome indicators. "[P]rocess indicators are often used in adaptation as we have often not yet reached the point where the outcome of adaptation can be evaluated; hence, it can be challenging to apply a purely outcome-based approach. Using process indicators makes it possible to consider whether the 'direction of travel' is correct given the information we have at this point. For example, we may not be able to determine whether a 20-year project will deliver adaptation benefits in a socially equitable way in Year Three. However, we could evaluate the nature of engagement in the project's design to assess whether all social groups have had their voice heard." 173

Climate change adaptation monitoring and assessment tool (AMAT): This particular framework was developed in 2012 by GEF for climate change adaptation programme managers and M&E specialists. It is relevant for climate change adaptation assessment across all sectors. It also uses the logical framework approach as the primary M&E focus and is applicable across all scales (local, sub-national, national and international). This framework enables the Global Environment Facility (GEF) to measure outputs and outcomes from the Least Developed Countries Fund / Special Climate Change Fund (LDCF/SCCF) portfolios and aggregate them to report progress at an international level. It is intended that this will ultimately enable GEF to track and examine common indicators over time to assess progress and identify measurable achievements 172 174 175.

AMAT is a "tracking tool" that documents progress across the agency's overall results framework for climate change adaptation. This instrument is designed to track only information explicitly aligned with the agency's logical framework so that data can be aggregated and reported globally. This instrument was not designed to be a full-fledged toolkit. It does not discuss concepts or issues, nor justify or explain the agency's overall results-based management framework. However, it does provide succinct examples of how Climate Change Adaptation (CCA) objectives, outcomes and indicators might be categorised and aggregated. It also highlights the difference between resources developed to support adaptation M&E more generally and

"A question-based approach can be beneficial, as it enables users to consider adaptation M&E within different contexts."

37 https://www.ukcip.org.uk/wp-content/PDFs/UKCIP-AdaptME.pdf

those developed for a specific programme or portfolio. AMAT presents a more top-down approach to M&E, and it includes a predefined list of indicators (although there is some scope for additional indicators to be used). As a result, there is limited scope for other approaches to be incorporated. There is a strong focus on tracking progress against specified indicators rather than a more nuanced exploration of what worked (or did not), how and why [172] [174] [175].

Tracking adaptation and measuring development (TAMD): This was developed in 2013 by the International Institute for Environment and Development (IIED). It is relevant across all sectors and applicable at all scales. Its overall aim is to enable practitioners to assess an intervention's outputs, outcomes and impacts within and across sectors and levels of programming. TAMD has been applied in Ghana, Kenya, Mozambique, Nepal and Pakistan. For instance, the TAMD framework was used in Isiolo County, Kenya. The Isiolo County study shows that the TAMD framework can be used for both ex ante and ex post evaluation processes to explore links between climate risk management led at the sub-national level and development performances at the local level [172] [176] [177].

There are three main components to the TAMD framework: an (iterative) assessment of institutional capacity for climate risk management (CRM) that results in adaptation interventions (Track 1); a theory of change linking this or other activities to changes in resilience and well-being; and indicators to assess either resilience outcomes or well-being and developmental outcomes in the context of observed changes in climate hazards over time (Track 2) [178]. TAMD is a flexible framework for evaluating adaptation and adaptation-relevant development interventions in diverse situations. It can be modified for different contexts and types of adaptation. The framework can be used retrospectively, in real time and prospectively. TAMD explicitly addresses the assessment of outputs, outcomes and impacts, thereby seeking to go further than many existing or emerging adaptation M&E approaches [178]. Track 1 captures the institutions, policies and capacities for climate risk management that are needed for adaptation and other interventions. For example, these could be a set of national capacities needed to manage climate risks in the national climate change strategy, or the institutional capacities a village committee needs to deal with local climate risks with the support of district and national institutions [178].

Within Track 2, interventions should improve the underlying capacity of households, communities and other systems to anticipate, avoid, plan for, cope with, recover from and adapt to (climate-related) stresses or shocks. Such improvements may be characterised as outcomes in project or programme contexts. Improvements in resilience, improvements in adaptive capacity, and reductions in vulnerability represent intermediate goals that should ultimately improve human well-being and reduce the costs of damage to assets, livelihoods and lives from climate-related stresses and shocks. In government systems, improvements in human well-being and reductions in costs in terms of assets, livelihoods and mortality rates are generally referred to as developmental outcomes. In the language of programmatic interventions, they are generally referred to as impacts. These include common development indicators relating to health, nutrition, poverty and economic status, education, assets, livelihoods and lives, and they also relate to longer-term changes [178].

Saved health, saved wealth: This is an approach to quantifying the benefits of climate change adaptation. This framework was developed in 2014 for Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and is relevant to coastal zone management, including infrastructure and natural resources sectors and national and urban planners. This framework and the accompanying MS Excel tool present a methodology to quantify the adaptation benefits of coastal

"TAMD is a flexible framework for evaluating adaptation and adaptation-relevant development interventions in diverse situations. It can be modified for different contexts and types of adaptation. The framework can be used retrospectively, in real time and prospectively."

zone management projects and enable the users to conduct a cost-benefit analysis of physical infrastructure projects. The framework is based on quantifying two key indicators that allow the total value of an adaptation project to be assessed, i.e., saved wealth (SW) covers the monetary value of public infrastructure, private property and income loss, while saved health (SH) assesses avoided disease, disability and life loss.

Moreover, environmental impacts that are difficult to measure in terms of monetary wealth, such as biodiversity, can be considered qualitatively 172 179. The methodology is specific to flood prevention and flood mitigation in coastal zone areas, particularly coastal infrastructure, natural protection measures, erosion avoidance and soil restoration, and avoidance of salinisation 172. The saved health, saved wealth framework was successfully applied in Sóc Trăng, Vietnam, where two adaptation options, the "real" mangrove rehabilitation programme and a hypothetical dyke upgrade, were assessed 179. This allows for the evaluation of two different adaptation projects at exactly the same location and a comparison of the expected benefits 179.

Participatory monitoring, evaluation, reflection and learning (PMERL) framework[38]: This framework for community-based adaptation projects was developed by CARE International and the International Institute for Sustainable Development in 2012. It employs a participatory rural appraisal method to analyse stakeholders' own situations and develop a common perspective on particular issues 166. The established CARE Community-Based Adaptation (CBA) Monitor, Evaluate, Reflect on and Learn (MERL) strategy is at the heart of the approach and guides the process of developing pragmatic adaptation solutions at the community level. It is relevant for all sectors, especially disaster risk reduction (DRR), rural livelihoods, poverty reduction and vulnerable populations 172. According to the review of this framework by Bours and colleagues 172, "The CARE publications are outstanding resources tailored to community-based practitioners working in adaptation situations. However, they are primarily aimed at users with a good knowledge of local-level rural livelihoods programming: there is not much preamble on technical adaptation issues, nor do they address interventions on a larger scale. The approaches outlined in this framework are a welcomed change from the narrow focus on logical frameworks and performance measures. However, the methods used in PMERL would be time-consuming in the field. While they would be participatory and engaging, it would take some higher-level skills to analyse findings and prepare reports and logical frameworks based on this data. Also, the results would be difficult to aggregate and compare" 172.

The vulnerability reduction assessment (VRA) framework: This framework can be used for community-based adaptation (CBA) projects. It helps to test whether a project is successful or not by measuring the community perceptions of the changing climate vulnerabilities of communities 180. The fundamental VRA indicators include: i) vulnerability/livelihood/welfare concerning existing climate change and or climate variability; ii) vulnerability/livelihood/welfare concerning developing climate change risks; iii) vulnerability/livelihood/welfare concerning the magnitude of barriers to adaptation; and iv) ability and willingness of the community to sustain the project 166. In this framework, three to four community level meetings are held throughout the CBA project, where the four VRA indicator questions are repeatedly asked 166. The framework is set under the premise that "repeated evaluation of community perceptions of project

> "The approaches outlined in this framework are a welcomed change from the narrow focus on logical frameworks and performance measures."

38 https://www.care.org/wp-content/uploads/2020/05/CC-2012-CARE_PMERL_Manual_2012.pdf

effectiveness and climate change risks permits an indication of the relative change in vulnerability" [180].

Country-Specific Case Studies

Application of TAMD to local adaptation planning guidelines in Mozambique

The TAMD framework has been integrated into Local Adaptation Plans (LAPs) in Mozambique. The LAP process is a general local planning framework that supports local government stakeholders in working on their principal climate-related vulnerabilities and adaptation priorities through a structured process to draw up a local plan. The TAMD approach to M&E was added to the LAP process to support local stakeholders in monitoring and evaluating their efforts after they had chosen their adaptation activities. This approach was piloted in Guijá District and subsequently integrated into other districts [178].

Three aspects of TAMD were integrated into the ten-step process: the institutional scorecards, theories of change, and indicators of resilience and well-being [181]. The LAP guides the district technical staff in following the existing processes to monitor the work around adaptation, and it also informs the national framework through its strong links with district development plans. The data will be regularly tracked through government monitoring systems using existing available data both locally (inputs/outputs) and centrally (outcome/impact) [178].

First, institutional scorecards were adapted for Mozambique through stakeholder workshops and then used at the district level to assess institutional needs and performance around climate risk management (Table 6). The scorecards helped highlight where support might be needed to improve climate risk management and be used to create a baseline to compare future improvements. The results from Guijá District show that finance, climate change mainstreaming and planning under uncertainty are critical limitations in current climate risk management and potential areas for work under the LAPs. However, there is also a high awareness and good participation among stakeholders, with the capacity to understand climate change issues and use climate information both reasonably strong [178].

Secondly, the theories of change that were developed at the community level were integrated into the process to help elucidate the links between planned activities in the LAP and its improvements in promoting resilience and longer-term well-being. Following agreement on critical interventions to be undertaken under the LAP, the IIED/ACCRA team asked community participants in the plenary to present interventions, outputs, outcomes and impacts, and indicators for each level. A higher level (district level) theory of change was then developed with government officials to present an overall vision for the district, strengthened by community inputs. In Guijá District (Table 6), three groups were guided in developing a theory of change based on strengthening flood-control infrastructure (dykes and riverbanks), livelihoods and coping strategies, and the local early warning system. The three strands were thereafter put together to develop the overall theory of change for the district [178].

Thirdly, following an assessment of climate vulnerability and a theory of change process, the team identified and included Track 2 indicators for adaptation and development performance in consultation with district staff [178].

Result level	Adaptation indicators
Output	■ Amount of water available per person per household ■ Number of households adopting climate change coping strategies due to drought risk ■ Number of households affected by floods
Outcome (resilience)	■ Number of cases of disease per year ■ Quantity and availability of crops produced locally for the market (according to the Agricultural Marketing Information System for crops) ■ Number of investors in the district ■ Number of households affected by floods and drought per event ■ Hours taken to fetch water
Impact (well-being)	■ % crop yield increase ■ % unemployment rate ■ % literacy rate ■ % disease occurrence ■ % water supply coverage ■ % increase in improved housing

TABLE 6. TAMD resilience and well-being indicators used in Guijá District in Mozambique [178] [182]

Use of Monitoring, Reporting and Verification (MRV+) for national and sub-national adaptation tracking in Kenya [182]

The Kenyan government developed a monitoring system that is used to monitor and document the progress and benefits of mainstreaming climate change in various sectors. This framework, which is referred to as Monitoring, Reporting and Verification (MRV+), has a system that incorporates the measurement, reporting and verification (MRV) of greenhouse gas (GHG) emissions in respect of mitigation activities, and the monitoring and evaluation of adaptation activities [182]. According to a report on "Development of national and sub-national adaptation metrics: Lessons from Kenya", MRV+ functions through a three-stage process, which includes [182]:

- Measurement and monitoring (and evaluation), where data and information are gathered and fed into the system and then quality-assured before being released for evaluation purposes
- National verification, where the data gathered is analysed to produce results that must be cross-checked and verified to ensure they form a realistic estimate of the outcomes being monitored
- Reporting where the results, which have been verified, are then packaged and used for reporting to both internal and external audiences

The design of national adaptation metrics in MRV+ was based on the tracking adaptation and measuring development (TAMD) concept. TAMD was adopted in the design of national adaptation metrics in

Kenya (Table 7) because it provided a framework that could be used to aggregate data from the sub-national level to the national level [182].

During the development of the MRV+ system, the NAP had not been completed. Therefore, adaptation indicators were formulated using national and sectoral indicators identified in planning documents [182].

TABLE 7. MRV+ indicators for national and sub-national adaptation tracking in Kenya [182]

National level indicators (process indicators)	Country level indicators
% classified roads maintained and rehabilitated	% of country roads that are or that have been made "climate-resilient"
Number of people by gender permanently displaced from their homes due to drought, flood or rises in sea level	% of people by gender in the country permanently displaced from their homes as a result of flood, drought or rises in sea level
% urban households with access to piped water	% of water demand that is supplied in the country
Cubic metres per capita of water storage	% of poor people by gender in drought-prone areas of the country with access to reliable and safe water supplies
% rural households with access to water from a protected source	% of total livestock numbers killed by drought in the country
Number of hectares of productive land lost to soil erosion	% area of natural terrestrial ecosystems in the country that have been disturbed or damaged
% land area covered by forest	% poor farmers and fishermen in the country with access to credit facilities or grants
Number of urban slums with physical and social infrastructure installed annually	% population by gender in areas subject to flooding and/or drought in the country who have access to climate information on rainfall forecasts
Number of households in need of food aid	Number of ministries at the country level that have received training for relevant staff on the costs and benefits of adaptation, including valuation of ecosystem services
Number of country stakeholder forums held on climate change	% new hydroelectric projects in the country that have been designed to cope with climate change risks

Application of TAMD in the Ngorongoro district, Tanzania

The TAMD framework was used to draw up resilience and well-being indicators in Tanzania while tracking adaptation action in the Ngorongoro district of Tanzania (Table 8). Here, adaptation benefit and development indicators were developed to assess adaptation actions. There was a similarity in results for measuring adaptation benefits and the measurement of development indicators, since the community and local government were responsible for developing these indicators [182]. This shows how adaptation action benefits are viewed in the same light as development benefits in developing countries due to the development deficits. It also explains why adaptation at the sub-national level can be measured along with resilience and well-being or development indicators, as was done in the Ngorongoro district [178].

TABLE 8. Resilience and well-being indicators from the Ngorongoro district in Tanzania [182]

Result level	Adaptation indicators
Output	– Number of district staff trained in climate change – Number of community members trained in climate change – Number of community planning systems in councils' standing committees identified, recognised and approved – Amount of special or discretionary funds for contingency planning for climate change hazards available
Outcome (resilience)	– Number of climate change activities mainstreamed into district plans – Number of climate change activities mainstreamed into community activities – Number of decisions and actions made based on climate information – Number of community plans integrated into planning and budgeting processes – Number of community plans implemented in collaboration with the district
Impact (well-being)	– Number of community members able to afford social services – Quantity of livestock per household – Quantity of livestock that recovers after a drought period

Knowledge Gaps

1. The TAMD framework has been the most applied framework for tracking adaptation actions in Africa. However, just a few case studies exist on TAMD application in Africa; therefore, there is a need for scaling up its application in tracking climate change adaptation efforts in more African communities and countries.

2. There is a need to adapt and scale up the application of the saved wealth, saved health framework to track coastal protection and adaptation efforts in Africa.

3. Countries need to develop or adopt suitable frameworks for tracking their adaptation strategies as contained in their NDCs, as most of the updated NDCs of African countries do not have frameworks for climate change adaptation monitoring, evaluation and tracking.

4. African countries do not invest enough in data collection, hence posing a considerable challenge to effective tracking of their NDC implementation.

5. Fragmented policies and procedures on climate change management in most African countries make tracking climate change adaptation and finance difficult.

Credit: Laura Pereira, Gulf of Aqaba, Sharm el Sheikh, Egypt

Chapter 6

Potential starting point for a common African position on issues related to ocean-based adaptation and mitigation actions: A way forward to COP27

Credit: Omoeko Media

Following the various understandings from previous sections (particularly chapters 2, 3, 4 and 5), this section offers recommendations on what could be done to advance ocean-based actions for climate solutions in Africa under different intervention areas and their alignment with existing UNFCCC processes (excluding Technology Mechanism, Capacity Building, and Transparency and the Global Stocktake) (Box 4). These recommendations are then further cross-referenced with the possible ways forward under the UNFCCC to reveal what options are available for African negotiators to identify, strengthen and advance efforts in addressing ocean climate challenges and solutions during negotiations at COP27.

Mitigation

Recent reports by the IPCC, including the Special Report on the Ocean and Cryosphere, the SBSTA Informal Report on Ocean and Climate, and the IPCC AR6 on climate adaptation and mitigation, have all reiterated, on the one hand, the vulnerability of the ocean and coast to the effect of climate change, and on the other hand, the potential of the ocean and associated ecosystem to offer a range of solutions to the climate crisis. Even though Africa's contribution to GHG emissions is almost negligible, the continent has the comparative advantage of assisting with climate change impact responses, climate change-associated conflicts and other attendant crises which could be mitigated. However, the evaluation of 15 NDCs from 15 African countries revealed that they are early integrators of ocean-based actions for climate integration across many intervention areas, including ocean-based renewable energy, ocean-based transport, coastal and marine ecosystem fisheries and other cross-cutting areas.

Box 4

Mitigation	Nationally Determined Contributions (NDCs)
Adaptation	Nationally Determined Contributions (NDCs) National Adaptation Plans (NAPs) Nairobi Work Programme (NWP) and Its Thematic Expert Group on Oceans Adaptation Committee (AC) Least Developed Countries Expert Group (LEG)
Loss and Damage	Warsaw International Mechanism for Loss and Damage (WIM)
Indigenous Peoples Knowledge and Engagement	Facilitative Working Group of the Local Communities and Indigenous Peoples Platform (LCIPP FWG)
Finance	Standing Committee on Finance (SCF) Green Climate Fund (GCF) Global Environment Facility (GEF) Adaptation Fund (AF)
Science	Research and Systematic Observation (RSO) Intergovernmental Panel on Climate Change (IPCC)
Technology Mechanism	Technology Executive Committee (TEC) Climate Technology Centre and Network (CTCN)
Capacity Building	Paris Committee on Capacity-building (PCCB)
Transparency and the Global Stocktake	Consultative Group of Experts (CGE) Biennial Transparency Reporting (BTR) Technical Expert Review (TER) Global Stocktake (GST)

It is, therefore, imperative for African countries to:

- **Ocean renewable energy (ORE):**

Take advantage of the ORE potential to reduce emissions, protect biodiversity and advance just energy transition by:

- Developing marine spatial plans that include ORE and that are mainstreamed into NDCs and national development plans
- Prioritising investment in research to assess the cost and benefits of the development of ORE in regard to impacts on critical biodiversity areas
- Designing regulatory frameworks for ORE to ensure countries deliver on their climate and energy objectives for the post-2020 period
- Defining an energy vision that includes ORE by identifying and extending best practices, encouraging technological innovation and analysing the cost of continued operation of non-renewable energy sources
- Prioritising the hybridisation of ORE with other renewable energy sources in energy systems and power grids (e.g., using various forms of marine biomass-fuelled energy with carbon capture on land, marine biochar, etc.)

- **Seabed carbon storage:**

- Take the benefit of the next SBSTA Ocean Dialogue meeting to seek clarification on the most reliable scientific guarantees and technologies to support the use of the seabed for carbon storage.
- Encourage the SBSTA Chair to encourage the IPCC to include, in its Seventh Assessment Report (AR7), an in-depth synthesis of the contribution and potential of seabed carbon storage and existing technologies

- **Solar radiation management:**

- Take the benefit of the next SBSTA Ocean Dialogue meeting to seek clarification on the most reliable scientific guarantees and technologies to support geoengineering techniques such as cloud brightening and albedo enhancement for climate mitigation.
- Encourage the SBSTA Chair to encourage the IPCC to include, in its Seventh Assessment Report (AR7), an in-depth synthesis of the contribution and potential of geoengineering techniques such as cloud brightening and albedo enhancement in climate mitigation.

- **Decarbonise ocean-based transport by:**

- Encouraging operational measures and adopting policies to reduce emissions of GHG in shipping (e.g., speed reduction and regulation, energy consumption optimisation)

- Encouraging African countries to include measures relating to energy efficiency (including redesigning the Energy Efficiency Design Index (EEDI) formula, ship design and developing and implementing hybrid power systems – wind, waves, currents and sun) of vessels and energy transition in ports in their NDCs
- Adhering to the Ship Energy Efficiency Management Plan (SEEMP) as adopted by the IMO in 2011 to inform national legislation for energy efficiency requirements
- Initiating pan-African monitoring, reporting and evaluation processes in the maritime transportation sector regarding climate change mitigation, namely carbon intensity of the sector and greenhouse gas emissions (reporting to UNFCCC), using renewable energy sources, and environmental performance. There is no Africa-wide, obligatory and legislation-based reporting providing an overview of impacts, vulnerabilities and adaptation of maritime transport in AU member countries.
- Encouraging green port development

- Developing energy management systems and optimisation methods, defining criteria for hybrid system selection for ships' electrical components and architectural design according to operational and architectural characteristics

■ **Protect and restore key marine and coastal ecosystems and support species by:**

- Introducing measures to conserve, protect and restore blue carbon ecosystems such as mangroves, kelp, seagrass, salt marsh and seaweed beds as an integral part of the mitigation and carbon stock conservation plan in African countries and the island states
- Reporting trends of blue carbon ecosystems, including improved methodology and techniques to map their change through time, threats and status
- Including the management of marine and coastal ecosystems and species in MSP, ICZM and other tools for managing multi-use ocean space
- Encouraging countries to join initiatives such as the Global Ocean Accounting Partnership to benefit from technical and advisory help to develop accounts that capture the stocks, flows and total value of the blue carbon ecosystem
- Assessing and promoting opportunities for conservation and restoration of marine and coastal ecosystems, including quantifying GHG benefits at the national level
- Integrating source-to-sea assessments into the climate mitigation planning process to ensure that implications of the full range (flow) of upstream activities and ocean ecosystems are well understood
- Seeking clarity at the next SBSTA Ocean Dialogue meeting on the most reliable scientific guarantees and technologies to support geoengineering techniques such as enhancing open-ocean productivity by adding nutrients (fertilisation) and addition of natural or man-made alkalinity to enhance CO_2 carbon storage

■ **Improve fishery management by:**

- Encouraging national negotiators at the World Trade Organization (WTO) to liaise with the Chair of the fisheries subsidies negotiations to intensify efforts toward eliminating harmful fisheries' subsidies
- Mandating fishers to fish more selectively and avoid unwanted catches by introducing landing obligation rules such as ash catch limits, minimum size, fishers' quotas and the redirection of bycatch with no other use for pet food, fish meal, or pharmaceutical and food supplements
- Reducing GHG emissions and pressures on stocks related to fish farming by substituting fish feed, i.e., feed made of wild fish, with alternative feeds (e.g., insect-based) with a lower carbon footprint
- Developing a national low-carbon strategy to encourage and promote low-carbon ways of life (e.g., shift diets to low-carbon proteins such as shellfish and seaweed)
- Introducing regulations to reduce the use of HCFCs in on-board freezing refrigerants and developing subsidised HCFCs and accessible onshore refrigerating facilities, particularly for artisanal fishers

■ **Improve ocean climate finance by:**

- Adopting disclosure frameworks such as the Task Force on Climate-related Financial Disclosures (TFCFD)[39] to help minimise unanticipated impacts arising from climate change

39 TFCFD is a private sector-led task force that provides a standardised disclosure framework so that carbon-related assets and climate risks can be better assessed and decisions better informed.

- Launching innovative financing vehicles in support of climate change mitigation through public-private partnerships.
- Designing new, innovative tools to assess and drive improvements in national expenditure and revenue processes in alignment with climate and other environmental goals
- Evaluating the environmental impacts of budgetary and fiscal policies and assessing their coherence towards delivering national and international climate mitigation commitments
- Launching carbon finance projects aimed at protecting blue carbon and supporting both nature conservation and climate change mitigation goals
- Adopting the United Nations Environment Programme Finance Initiative (UNEPFI) Sustainable Blue Finance Principles to develop and implement regulatory, technical and financial strategies to designate, by 2030, 30% of the ocean as highly and fully protected MPAs

■ **People-centred response to multiple oceans and coastal threats by:**

- Creating specific ocean literacy initiatives to climate-proof and ensure continued education and support of all children and adolescents, teachers and families under different climate change scenarios
- Committing ministries of education and training to promote education on climate change issues to the extent that it covers 10% of geography and biology curricula
- Co-producing knowledge with indigenous communities to have the best available knowledge to make decisions in favour of climate mitigation
- Prioritising the development and implementation of area-based management/governance tools such as MPS, ICZM and MPAs to protect marine and coastal ecosystems of ecological importance with high potential for carbon sequestration

■ **Monitoring:**

- Encouraging African countries to build the capacity of their National Statistical Office to compile ocean accounts using recognised and standardised frameworks such as the System of National Accounting, the System of Environmental-Economic Accounting (SEEA), the Ocean Accounts Framework, etc., to measure progress and enhance transparent reporting
- Encouraging countries to integrate both terrestrial and ocean early warning systems into national programmes
- Developing common methodology and techniques for ocean vulnerability assessment

In consideration of the above, the following are actions within the UNFCCC process and ongoing negotiations that African negotiators at COP27 could focus on, related to ocean-based efforts to mitigate climate change:

Nationally Determined Contributions

- Considering Article 5 of the Paris deal and the guidance of the information that countries could include in their NDCs finalised under the "Katowice Climate Package", the potential contribution by African countries in the form of emissions avoidance, reductions and carbon stock enhancement from the ocean and blue carbon ecosystems should be uniquely recognised as exceptional support provided by developed countries as guaranteed by the Convention and the Paris Agreement.
- Encourage nations to incentivise ocean-based activities that reduce emissions, and support conservation projects, the

sustainable management of blue carbon and the enhancement of coastal forest carbon stocks in Africa.

- Include in future NDCs links to principles and guidelines for incorporating wetland issues.
- On the advent of the full implementation of the Africa Continental Free Trade Agreement, identify synergies with the IPCC, IMO, UNCTAD and WTO to foster joint mitigation efforts with the African Union towards reducing emissions from shipping and improving the energy efficiency of both ships and port facilities and other forms of transportation.

Adaptation

All climate change projections indicate that the impacts of climate change will be increasingly severe; it is urgent to prioritise adaptation to climate impacts on ecosystems and populations, particularly many vulnerable coastal communities. As revealed in Section 2, ocean-based actions can provide critical adaptation solutions and improve resilience against many threats, including storm surges, sea-level rise, ocean warming and ocean acidification. Accelerating adaptation efforts would mean that African countries would have to implement local actions while synergising national commitments with global ones to address adaptation needs, access to finance and capacity building. Section 2 of this report shows that despite the challenges, Africa is focusing on ocean-related matters in their NDCs, but more needs to be done, and the advantages provided by the UNFCCC-based or associated institutions, including the Adaptation Committee (AC), the Least Developed Countries Expert Group (LEG) and the NAP technical working group, need to be utilised.

It is, therefore, imperative for African countries to:

- **Ocean renewable energy (ORE):**

Take advantage of the ORE potential to reduce emissions, protect biodiversity and advance just energy transition by:

- Integrating MSP into NDCs and implementation to help meet and strengthen national and international climate change commitments, and bolster commitments in the next review of NDCs
- Establishing a framework providing the basis for adaptation intervention for ORE that includes clear climate rationale, by using robust climate methodologies and the best available science
- Developing incentive programmes to shift energy mix and consumption patterns
- Carrying out periodic multisector assessments that encompass social, economic and institutional aspects to engage a broad range of local and regional stakeholders, with the ORE sector being taken into account
- Embedding ORE into sectoral adaptation policies, programmes and projects across local and national levels to expand the range of opportunities for reducing vulnerability, ensuring more efficient use of scarce resources and helping all key stakeholders (policy makers, public and private investors and local communities)

- **Decarbonise ocean-based transport by:**

- Facilitating the collaboration and participation of a broad range of actors to enhance the assessment of impacts and the planning, development and implementation of effective adaptation measures

“Accelerating adaptation efforts would mean that African countries would have to implement local actions while synergising national commitments with global ones to address adaptation needs, access to finance and capacity building.”

- Implementing adaptation action in maritime transportation within the AU Strategy on Climate Change in an integrated manner that aligns with AU-related flagship projects of Agenda 2063 (such as the African Continental Free Trade Area (AfCFTA)) and international commitments (such as the IMO protocols and regulations)
- Providing appropriate regulatory and policy frameworks to facilitate an enabling environment that promotes climate change adaptation for coastal transport networks and assets. Coordinated action that cuts across policy domains is required to operationalise systemic approaches needed to respond to and reduce the likelihood and impacts of climate change.
- Funding scientists and modellers to develop a range of Integrated Impact Assessment Models (IAMs) to calculate damage costs arising from climate change and appropriately provide adaptation measures and actions. Efficient adaptation and resilience-building for coastal transport infrastructure and operations depend on assessing the risks posed by climate variability and change.
- Encouraging AU member states to develop policies and legislation in line with the new International Standard, ISO 14090[40], "Adaptation to climate change – principles, requirements and guidelines", which commits organisations in the maritime sector to build their infrastructure to technical standards related to future climate projection

■ Innovative adaptation strategies and action plans:

Promote the development of innovative adaptation strategies and action plans to protect and restore coastal and ocean ecosystems by:

- Prioritising nature-based adaptation solutions over "grey" engineering (e.g., concrete, dykes); in particular, restoring mangroves, seagrass beds, coastal marshes, kelp forests, coral reefs and other coastal ecosystems that help moderate flooding and reduce the impacts of extreme weather events and rising sea levels
- Partnering with the relevant AU institutions and other organisations to encourage the inclusion of strong components focusing on mapping and assessing the state of marine ecosystems and their services in their national territory within their National Biodiversity Strategy, NAP, etc., including the critical role that ecosystems play in adapting to the impacts of climate change as essential ecosystem services
- Identifying and protecting ecologically significant ("critical") areas such as nursery grounds, spawning grounds and areas of high species diversity
- Recognising the role of natural water retention measures for preventing flood risk when producing co-benefits
- Developing innovative programmes aimed at acquiring degraded coastal lands for conservation, for instance, land acquisition programmes through purchasing coastal land that is damaged or prone to damage and using it for conservation, and land exchange programmes involving owners exchanging property that is prone to climate impact for country-owned land outside of the vulnerable areas
- Creating and effectively managing marine areas with an appropriate level of monitoring and protection, mainly in locations particularly vulnerable to climate change and/or ocean acidification, to protect biodiversity, ensure coastal protection and regenerate and sustain fish stocks
- Prioritising and supporting adaptation measures focused on the most vulnerable coastal communities, including those threatened

40 ISO 14090 describes international best practice for adaptation that transport and other organisations can use to develop their own adaptation plans. Currently, much infrastructure is built to technical standards that relate to the past climate, not the future one.

by rising sea levels (e.g., the island states, overpopulated megacities, etc.)
- Expanding the planning horizons of MSP, ICZM and MPAs to incorporate longer-term climate predictions
- Integrating MSP, ICZM, MPAs and Integrated Watershed Management (IWSM) into land-use planning

■ **Improve fishery management by:**

- Reducing the lag between changes in stock status and management through the use of empirical indicators and simple analytical tools, to assess stock status rapidly and reduce the risk of overfishing associated with climate change
- Generating and using timely data streams and incorporating technologies that allow adjustment of management measures in response to climate-induced changes
- Prioritising the application of the precautionary approach to primary fisheries management for both artisanal and large-scale commercial fishing, to reduce the risk of stock collapse and the adverse socio-economic consequences associated with it
- Creating incentives for lower trophic level aquaculture (such as reduced licensing fees for aquaculture sites, tax reductions, free extension and advisory services, etc.) to improve livelihoods while sustaining food and nutritional security in the face of climate change
- Developing models that incorporate climate change impacts on fish stocks to improve the planning horizons of policy makers, potentially shortening the time it takes to make difficult policy decisions, such as negotiating an international fishery agreement
- Increasing the deployment and availability of low-cost technology and better analytical approaches to expand further our ability to project future change accurately enough to help us begin the process of climate adaptation sooner rather than later
- Developing sustainable fisheries and climate-smart infrastructure for storage facilities, incorporating renewable energy generation

■ **Enhance human and economic sectors and social systems (defend, co-exist or retreat) by:**

- Creating permitting rules that constrain the choice of locations for landfills, hazardous waste dumps, mine tailings and toxic chemical facilities
- Creating a sediment management plan
- Incorporating consideration of climate change impacts into planning for new infrastructure (e.g., homes, businesses)
- Managing realignment and deliberately realigning engineering structures affecting estuaries and coastlines
- Restricting or prohibiting development in erosion zones
- Allowing coastal wetland dwellers to migrate inland (e.g., through setbacks, density restrictions, land purchases)

■ **Improve ocean climate finance by:**

- Boosting private sector funding to finance time-bound adaptation projects
- Integrating, or mainstreaming, climate action across the entire annual budget at national levels
- Encouraging information flow to ensure that capital flows to the most impactful climate solutions and provides investors and other stakeholders with briefings and connections around the practical intersection of investment and climate adaptation and resilience
- Encouraging philanthropic investment and innovative financial mechanisms to develop new financial tools for the ocean, to fund scientific research and the preservation of ocean ecosystems (e.g., payment for ecosystem services and result-based payments)

- Integrating blue finance approaches into marine and coastal infrastructure financing, fully considering marine ecosystem services and blue natural capital
- Setting up an ocean natural capital financing facility in collaboration with the African Development Bank and other financial institutions to provide loans and investments for projects delivering on ocean natural capital, including adaptation to climate change

■ **People-centred response to multiple oceans and coastal threats by:**

- Establishing centres and institutions that provide research, education and scientific and technical support concerning climate change and adaptation
- Facilitating a multi-stakeholder, participatory process that incorporates a gender- and rights-based approach to ensure active participation, and integrates local and traditional knowledge for the long-term success of adaptation processes
- Establishing social safety nets to protect the vulnerable, particularly in coastal communities, to help them confront the economic and environmental impacts of climate change (for example, addressing the interlinked challenges of food security and climate change)
- Investing in and prioritising job creation and livelihoods, both in the short term and the longer term, for sustainable adaptation to climate change
- Providing free training for farmers, fishers and others on a wide range of topics, including fisheries' value chain improvement, sustainable preservation and storage methods/techniques, etc.
- Developing MSP and ICZM to build capacity in local communities, manage fragile ecosystems and fisheries better and help people find new sources of income in industries such as aquaculture, apiculture and eco-tourism
- Implementing a livestock and fisheries sector development project that integrates climate change considerations into good fishing and agricultural practices, while supporting coastal households in critical industries – including fishing and aquaculture, dairy, poultry and small livestock – to become more productive, secure and better connected to markets
- Formulating national policies, long-term and multi-year development plans, sectoral budgetary allocation processes, and regulatory processes at the national level that integrate adaptation at each level of governance architecture and identify entry points where the consideration of climate change adaptation can be incorporated
- Working to facilitate the implementation of the Sendai Framework for Disaster Risk Reduction and the Global Compact for Migration at the policy-making and practical implementation levels
- Setting up platforms to help implement the New Urban Agenda, BBNJ Agreement and relevant IMO and ILO conventions, regulations and standards in the context of climate adaptation

■ **Improve monitoring by:**

- Developing and testing tools and methods necessary for the development and provision of new research tools and methods
- Pilot testing of new and existing tools and methods in the field to assess their value and efficiency and identify those best suited to specific needs and contexts, while enhancing the dissemination and providing guidance (i.e., through training) on use of the methods and tools
- Ensuring ongoing monitoring and evaluation (M&E) in terms of validating adaptation actions (including projects, policies and

programmes) to enhance decision-making, the implementation of practical adaptation approaches, learning by doing and the potential to adapt planned actions to changing conditions, while supporting the necessary generation of an evidence base of ocean-based climate actions in general
- Seeking to close observation gaps and expand country capacities for issuing warnings, while simultaneously improving countries; increasing the ability to respond by means of a people-centred, inclusive and accessible early warning system that builds on existing World Meteorological Organization and Intergovernmental Oceanographic Commission of UNESCO activities and partnerships, including those with critical agencies, countries and groups already active in the field
- Encouraging local initiatives to set up an early warning system to redirect the local knowledge and communicate warnings

In consideration of the above, the following are actions within the UNFCCC process and ongoing negotiations that African negotiators at COP27 could focus on, related to ocean-based efforts to adapt to climate change:

Nationally Determined Contributions (NDCs)
- If negotiations on additional guidance for developing NDCs continue, efforts to include blue-climate justice, human rights at sea, the rights of indigenous and coastal communities, access to equitable jobs, and the rights of climate migrants should be intensified, following Article 2.2, which states that the Agreement's implementation will reflect equity and the principle of Common but Differentiated Responsibilities and Respective Capabilities (CBDR–RC). Given the peculiar circumstances and development priorities of developing country Parties like those in Africa, differentiated guidance to developing country Parties that acknowledges the importance of the coastal and marine ecosystem must be provided.
- Mobilise tools to support African countries' efforts to identify the best options for enhancing NDCs in line with the Paris Agreement, while pushing for a proper alignment of NDCs with international processes such as the Sustainable Development Goals and the role of ocean-based actions in NDC enhancement.

National Adaptation Plans (NAPs)
- Request the UNFCCC Secretariat to develop and publish a guideline for countries to align adaptation objectives from various global processes, e.g., CBD, BBNJ, ILO, IMO, New Urban Agenda, Global Compact for Migration, etc., in the future formulation of NAPs to encourage the inclusion of coastal and marine ecosystems as part of national adaptation goals.
- Amidst all the uncertainties, initiate a political discussion on the need to adopt Draft Rule 42 of the Rules of Procedure[41] mandated by Article 7.3 of the Convention, to see the option for decision-making through consensus in support of additional finance to formulate and implement NAPs in African countries and other countries in the global south, including through dedicated funding windows tailored to coastal and marine adaptation solutions.
- Encourage building bridges with the CBD, ILO, IMO, WMO and UN Human Rights Council (UNHRC), and especially between the SBSTA, the CBD's Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), the ILO's Independent Oversight Advisory Committee (IOAC), the IMO's Marine Environment

41 UNFCCC, 1996. "Organizational Matters, Adoption of the Rules of Procedure". httpsa://undocs.org/en/FCCC/CP/1996/2

Protection Committee (MEPC) and the Advisory Committee of the Human Rights Council, to identify mutual benefits of preserving nature, and so to achieve the objectives of both conventions and avoid the duplication of efforts by both secretariats.

Nairobi Work Programme (NWP) and Its Thematic Expert Group on Oceans

- Request/motivate for more representation of African experts in the NWP Thematic Expert Group on Oceans, and request an African-centred intervention from the group to look into the challenges of and opportunities for ocean-based actions for climate mitigation and adaptation.
- Request the appointment of liaison officers by the UNFCCC Secretariat to facilitate continued collaboration between Parties and stakeholders on ocean climate actions.
- Advocate that the work of the NWP on the ocean be deepened, and its focus broadened, to explore ocean geoengineering intervention for climate change[42] and include less mundane issues, such as maritime labour, security, migration and anti-colonialism in ocean conservation and development objectives.

Adaptation Committee (AC)

- Question why the AC's Workplan for 2022–2024,[43] as requested by the 17th Session of the COP, did not include any milestones, activities or deliverables related to the ocean.
- African Parties should request the AC to lend its technical expertise, in collaboration with regional and national experts, to offer advice on how to leverage the adaptation potential of ORE and ocean transportation in Africa.
- Request the AC to lend its technical expertise, in collaboration with regional and national experts, to develop knowledge materials and training programmes to build the capacity of national organisations to strengthen the adaptation role of marine and coastal ecosystems and contribute input to the Global Stocktake.
- Request the AC to develop concepts at the regional and international level to address the precarious situation facing people affected by ocean disasters and meet the challenges of migration movements and displacement in regard to climate change and its impacts.

Least Developed Countries Expert Group (LEG)

- Follow up with the recommendations presented in Katowice 2018 by the working group set up on climate change-induced displacement and migration, to see how they correspond with the LEG, particularly on issues such as maritime migration included by climate change, and the nexus between climate change and (in) security in coastal areas, etc.
- Request technical guidance and support from the LEG on accelerating and mainstreaming area-based ocean management tools and nature-based approaches in African countries to incorporate coastal waters into formulating and implementing NAPs.

42 While this may be a useful review document, it is still mostly theoretical. Geoengineering has many challenges, and at this stage would not be a feasible intervention.

43 https://unfccc.int/sites/default/files/resource/ac_workplan_2022_24.pdf

Loss and Damages

Africa is a hotspot of vulnerability to the adverse impacts of climate change. The ocean is warming and acidifying, corals are bleaching, species are becoming extinct, sea levels are rising, water stress is compounding, tropical cyclone-induced storm surges are increasing, ecosystems and essential infrastructure are getting damaged, etc. Thus, the need for adaptation measures to cope with these projected impacts is significant, even at 1.5-2˚C warming. Nonetheless, despite ongoing adaptation efforts in the region, considerable adverse effects of climate change will be felt, resulting in further loss and damage, costing at least up to 6% of Africa's GDP annually by 2080 under all warming scenarios **183**. Damages can be reduced by adaptation measures, but cannot be eliminated, as "residual damages" will remain at all levels of adaptation. The issue of loss and damage has fundamental importance to Africa, whose communities and economies are trying to cope with losses for which they have limited capacity to respond.

The advent of the Warsaw International Mechanism for Loss and Damage (WIM), the Sendai Framework and the Santiago Network for "averting, minimising and addressing loss and damage associated with the adverse effects of climate change" give Africa the impetus to harness resources to strengthen international cooperation and capacity to understand and reduce loss and damage associated with the adverse effects of climate change. Additionally, technical assistance from relevant organisations, bodies, networks and experts will be catalysed to implement relevant local, national and regional approaches.

It is, therefore, imperative for African countries to:

- **Recognise the losses and damages to the ocean ecosystems and livelihoods of coastal communities due to climate change, while striving to monitor changes and provide people-centred responses by:**
  - Taking inventory of the status of the coastal and marine ecosystems and species and their ability to provide the respective adaptation or risk reduction benefits
  - Initiating projects that seek to develop standard metrics to assess and grade climate change impacts at local and national levels, including loss and damage, and inform national mitigation and adaptation planning
  - Supporting the AU in launching an integrated regional framework to address disaster and climate change-related risks in the coastal and marine environment and build resilience in a way that also contributes to sustainable development
  - Establishing several regional risk pooling mechanisms at the national level to complement the African Risk Capacity (ARC)[44] to allow countries to respond more effectively in the wake of a climatic event in the ocean domain
  - Providing incentives to vulnerable people in coastal communities, for instance, to increase the number of

> "The issue of loss and damage has fundamental importance to Africa, whose communities and economies are trying to cope with losses for which they have limited capacity to respond."

44 African Risk Capacity (ARC) is a specialist insurance company that was established by the African Union to help African governments improve their capacities to plan, prepare and respond better to extreme weather events and natural disasters, and adapt to climate change. https://www.arc.int/

particularly vulnerable people in coastal communities holding climate risk insurance
- Establishing state-led platforms, initiatives and programmes focusing specifically on disaster- and climate change-induced migration and displacement in coastal communities
- Establishing blue trust funds at the national and regional level to finance a variety of climate change-related activities in coastal and marine communities, with a substantial share of the fund reserved for emergency disaster relief and ecosystem restoration
- Dedicating a significant portion of the national yearly budget to establishing a dedicated national mechanism on loss and damage, considering that national financing will be needed in addition to international funding
- Adopting strategies to deal better with climate change impacts on the ocean ecosystem and sectors by further integrating DRR and CCA on the national level
- Considering the increasingly intolerable risks of rising sea levels, making concrete plans to relocate communities in low-lying areas, particularly in the island states. This could include options to relocate populations to other African countries permanently.
- Developing or experimenting with subsidised blue insurance programmes to respond to the risks associated with the effects of climate change in the ocean domain
- Promoting and encouraging community level comprehensive risk management approaches and initiatives, like the World Food Programme's R4 Rural Resilience Initiative45, and combining improved resource management, insurance, livelihood diversification, microcredit and savings.
- Emphasising the "polluter pays principle" and encouraging developed states to provide grants and not loans for adaptation and mitigation programmes

In consideration of the above, the following are actions within the UNFCCC process and ongoing negotiations that African negotiators at COP27 could focus on, related to loss and damage in the ocean domain:

Warsaw International Mechanism for Loss and Damage (WIM)
- Request that the WIM encourage inputs to the Santiago Network Portal on the types and magnitudes of losses and damages (for habitats and communities) and resilience measures, with a specific focus on ocean issues, namely marine biodiversity loss, sea-level rise, flood and coastal storm damages and risks, ocean warming and acidification, and relevant resilience strategies.
- Emphasise the importance of strengthening the focus on ocean-based actions to enhance resilience to climate change impacts on Africa's oceans, including sea-level rise, ocean acidification and coral bleaching.
- Request that the WIM provide technical guidance and support to African countries to incorporate ocean-based actions and approaches into the formulation and implementation of NAPs, including encouraging the utilisation of the Guidelines for Integrating Ecosystem-based Adaptation into National Adaptation Plans.
- Place a request through the Executive Committee of the WIM for possible legal avenues to pursue corrective justice and hold governments or major polluters accountable, despite Paragraph 52 of the Paris Decision having shut the door to liability and compensation based on Article 8 of the Paris Agreement. Beyond burden-sharing, there is a need for further remedies to address

45 https://www.wfp.org/r4-rural-resilience-initiative

residual impacts of climate change, some of which are already "locked in" by historical emissions, mainly in the ocean domain.

- Request that the WIM cooperate with the IPCC, LEG and SBSTA to provide solid attribution science that can link extreme weather events and slow onset impacts in the ocean domain to specific anthropogenic climate drivers, to boost the possibility of instituting interstate and beyond-interstate litigation of corrective justice.
- Call for an improvement in understanding the costs of loss and damage and the scale of finance required to enhance coastal habitat and coastal community resilience in Africa.
- Call for an expansion of the Roster of Experts of the Warsaw International Mechanism and its terms of reference[46] to target resilience solutions and expertise on ocean-based climate actions.
- Through the Executive Committee, request collaboration between the WIM, AC, TEC and African research institutions to develop a continuous cross-body work stream on climate resilience through ocean-based actions, concentrate knowledge, identify and inform African Parties of global best practices, connect negotiators with international experts and develop technology transfer platforms.
- Present a case for establishing a single, stable source of finance for loss and damage, highlighting the need to combine and layer different sources of funding and utilising insurance mechanisms and bonds to accomplish the goals of buffering losses in the most vulnerable nations, including Africa's island states, whose economies are reliant on ocean-based activities.
- Request the Task Force on Displacement to include deliverables related to the ocean in its Plan of Action for the third phase (starting in 2022), and lend their technical expertise by developing briefs on ocean issues in collaboration with the WIM's Executive Committee, particularly on climate-related maritime security, migration and peace.

46 UNFCCC. (2020). "Terms of reference for the expert groups, subcommittees, panels, thematic advisory groups or task-focused ad hoc working groups of the Executive Committee of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts." https://unfccc.int/documents/66477.

Indigenous Peoples' Knowledge and Engagement

For centuries, African indigenous and local communities have utilised their knowledge systems to respond to changing climatic conditions. Following the Paris Agreement, African governments must tap into these knowledge systems to design and implement their climate response strategies, including a component in their NDCs. In the Paris Agreement, African countries also agreed to develop a knowledge platform with local communities and indigenous peoples (LCIP) as a first step to formally recognising their contributions to addressing climate change. Likewise, under the UNFCCC process, African countries have agreed to formulate a Facilitative Working Group (FWG) to undertake the work of the LCIP Platform with representation from countries, indigenous peoples and representatives of local communities. Unfortunately, traditional knowledge is receiving little attention from African governments in their NDCs and in the LCIP Platform. The second chapter of this report indicates that out of the 15 NDCs evaluated, only four consider traditional or indigenous knowledge important for mitigating and adapting to the impacts of climate change on the ocean environment. The four are Benin, the Democratic Republic of Congo, Tanzania and Seychelles. Also, at the LCIP negotiations at COP26, African governments had almost no participation, denying the continent the opportunity to take

"Following the Paris Agreement, African governments must tap into these knowledge systems to design and implement their climate response strategies, including a component in their NDCs."

leadership on this critical issue. These are the realities, despite the wealth of indigenous knowledge on the continent available for climate mitigation, adaptation and resilience (see chapter 3).

It is, therefore, imperative for African countries to:

- **Protect and restore key marine and coastal ecosystems and support species by:**
  - Restoring indigenous land rights in coastal areas to unlock traditional knowledge and repair ecosystems
  - Developing programmes and techniques to harness indigenous knowledge necessary for marine and coastal conservation
  - Advancing the use of local ecological knowledge for assessing data-poor species in coastal ecosystems
  - Giving priority to reforming national laws, policies and conservation programmes, so that they respect indigenous peoples' rights and allow marine protected areas to be owned and managed by indigenous peoples
  - Establishing effective mechanisms for open dialogue, the redress of grievances and the transparent exchange of information between conservationists and indigenous peoples
  - Recognising and respecting indigenous lands and tenure in coastal areas, enabling indigenous-led conservation efforts
  - Supporting subsistence harvesting practices by indigenous people as part of broader marine and coastal conservation strategies
  - Using indigenous knowledge to facilitate citizen science by producing documents that the indigenous populace can understand
- **Improve fishery management by:**
  - Including representatives of indigenous people on all councils, committees and commissions formed at national levels to address fishing issues
  - Creating collaborative fisheries management arrangements and processes that respect free, prior and informed consent (FPIC), incorporate local voices and visions and include indigenous leaders and elders in decision-making bodies
  - Incorporating indigenous worldviews, customary management practices and traditional knowledge into fisheries management decisions, making them more effective and culturally inclusive to foster climate adaptation and mitigation
  - Supporting subsistence harvesting practices by indigenous people as part of broader fisheries conservation strategies[47]
  - Developing a Code of Conduct for responsible fisheries and indigenous peoples
- **Foster a people-centred response to multiple ocean and coastal threats by:**
  - Increasing the formal involvement of indigenous peoples in MSP, ICZM, MPAs and other area-based ocean management/governance tools
  - Creating effective mechanisms for the formal recognition, inclusion and valorisation of indigenous, local and traditional forms of knowledge, to build trust and encourage stewardship in coastal and marine management/governance

47 In Madagascar, there are traditional local laws called dina, which restrict destructive fishing practices and enforce temporary closures of fishing grounds and mangrove reserves to ensure species are able to reproduce and thrive.

- Fostering transdisciplinary engagements with scientists and policy makers
- Piloting novel methodologies for further understanding of climate change impacts, adaptation and mitigation, using indigenous traditional knowledge
- Integrating ITK with contemporary science to encourage the co-production of knowledge and policy outcomes that are necessary for climate mitigation and adaptation in coastal areas
- Empowering indigenous people to anchor the responsibility for peace-building and conflict resolution at local levels as well as higher levels of decision-making
- Revitalising local and indigenous knowledge and resource governance institutions in the coastal and marine areas, enhancing dispute resolution mechanisms, and bringing about a sustained approach to national adaptation planning and dealing with cross-border tensions over livestock, water, fisheries and other resources
- Recognising and respecting indigenous peoples' institutions and organisations at the local, national and international levels, and ensuring space for their advocacy and participation in making decisions
- Developing and implementing the traditional and ancestral science, knowledge and practices of coastal communities as part of climate policies, plans, programmes and projects
- Developing cultural management processes for indigenous territories in the coastal and marine domain as a mechanism for resilience and adaptation. This should include actions for analysis, planning, evaluation, monitoring and communications in indigenous languages on disaster risk management and response
- Documenting relevant indigenous knowledge and partnerships with the private sector, academia and other sectors for enhancing TK contributions to climate action and SDGs

- **Monitoring:**
  - Including indigenous knowledge alongside scientific knowledge in ocean management, including the monitoring of climate vulnerability and variability
  - Building on and supporting pre-existing or traditional systems of monitoring climate change in the ocean and on coasts, while factoring in community events and obligations when designing climate monitoring initiatives
  - Developing training programmes for climate scientists and resource managers in participatory and cross-cultural approaches to climate mitigation and adaptation in the marine and coastal domain
  - Including individuals with dual scientific and indigenous knowledge of coastal ecosystems in climate adaptation plans

In consideration of the above, the following are actions within the UNFCCC process and ongoing negotiations that African negotiators at COP27 could focus on, related to ocean-based efforts that incorporate indigenous peoples' knowledge and engagement:

Facilitative Working Group of the Local Communities and Indigenous Peoples Platform (LCIPP FWG)

- Strongly highlight the importance and influence of African indigenous knowledge and worldviews towards climate mitigation and adaptation.
- Request the FWG to facilitate a two-way sharing of knowledge and experience between the global north and global south on

integrating indigenous knowledge into ocean management and governance.

- Request the FWG to collaborate with other UNFCCC mechanisms and relevant organisations to develop a guideline for effective collaboration with the private sector to foster the application of indigenous knowledge in climate change mitigation and adaptation. This is also important for addressing intellectual property rights on indigenous knowledge, human rights privacy for indigenous peoples, etc.
- Call on FWG to include ocean-based actions and the tremendous knowledge of indigenous peoples to restore, conserve, protect and co-manage local aquatic and coastal ecosystems in its discussions and processes.
- Call on the FWG to lend its expertise in producing learning materials and incorporating indigenous knowledge into the marine science curriculum in African universities.

Finance

For the African continent to adapt to the increasing impact of climate change whilst ensuring that future development paths align with the global goal of limiting warming to 1.5˚C, a critical enabler will be climate finance. It is evident that the contribution of Africa to global emissions is negligible compared with other regions, but is still confronted with the severest impacts. In the coming decades, energy use and Africa's development are critical to future global emissions, given that energy use projection for the continent is expected to increase to meet its development needs in the face of a projected population increase from 17% to 40% by 2100. Following the analysis of NDCs in chapter 2 above, it is clear that this will require a significant ramp-up in the scale and quality of investments in three critical areas. These three areas are energy transitions and related investments in sustainable infrastructure, climate change adaptation and resilience, and restoration of natural capital (through climate-smart MSP, ICZM, MPAs, sustainable agriculture, etc.) and biodiversity. All three areas are essential for the continent, although relative needs vary by country.

Africa will need to invest around $200 billion per year by 2025 and close to $400 billion per year by 2030 on these priorities. National and multilateral funders and development banks have begun to align their activities and investments with the objectives of the Paris Agreement, and it is fast becoming evident that voluntary pledges and contributions by countries in the global north will be inadequate to meet Africa's quest to mitigate and adapt to climate change. For Africa, a current priority of the financial world must be to reorient public and private investments toward a low-carbon economy to prepare for the 2050 low-carbon emission pathway and deliver on the SDGs and the biodiversity agenda. However, ocean-related projects remain marginal and underfunded, indicating the need to consider the potential of net zero opportunities from the ocean ecosystem and various sectors and activities in Africa, through several proposals to generate new funds within the context of the UNFCCC.

It is, therefore, imperative for African countries to:

- **Increase investment in ocean-based renewable energy (ORE) by:**
  - Developing policies that establish transparency and predictability and provide confidence for investors in the ability to recover investments in ORE power generation. Such policy may include having bankable, standardised power purchase agreement (PPA) templates, allowing independent power producers (IPPs), holding transparent auctions and having transparent and fair rate adjustments and public participation.

"For Africa, a current priority of the financial world must be to reorient public and private investments toward a low-carbon economy to prepare for the 2050 low-carbon emission pathway and deliver on the SDGs and the biodiversity agenda. However, ocean-related projects remain marginal and underfunded..."

- Having an integrated, multi-year energy strategy with medium- and long-term targets for retiring fossil fuel plants, and building ORE
- Establishing a carbon market or other carbon-pricing mechanism and governance/legislation around carbon removal
- Passing a binding decommissioning schedule for coal-fired power plants, engaging with private power plant owners to develop coal phase-out schedules, and implementing a tax on carbon for larger coal-fired power plants
- Introducing general business-friendly measures to facilitate ORE investment. These may include tax policy (such as not withholding taxes on profits, and no value-added tax (VAT) on clean power sales), allowing foreign direct investment (FDI), improved permitting processes, and foreign currency / ability to repatriate profits.
- Considering various innovative financial mechanisms to create more ORE investment opportunities, including synthetic corporate power purchase agreements (CPPAs), which can offer a hedge against a corporate buyer's fluctuations in power cost while providing demand for ORE; and an energy transition mechanism (ETM)[48], which allows investors to buy high-carbon-emitting assets, decommission them and replace them with ORE

- **Protect and restore key marine and coastal ecosystems and support species by:**
  - Redirecting payments, especially those considered most harmful to biodiversity, to incentivise the protection and restoration of critical marine and coastal ecosystems and species while mitigating climate change and improving food security
  - Increasing domestic budgets for marine biodiversity conservation, introducing tax policies favouring marine and coastal ecosystems, and discouraging activities that harm nature. Examples of policies that would create new funding streams to protect and restore the coastal and marine ecosystem include taxes, fees, debt relief, loans and tariffs.
  - Encouraging financial institutions to expand investment opportunities in blue/green bonds, low-interest blue/green loans, environmental impact bonds and other blue/green financial products. Governments can assist by creating incentives, clear guidance, and standards for these investments.
  - Expanding biodiversity offset mechanisms to ensure that manufacturing and extractive industries and economic sectors that unavoidably and negatively impact the marine ecosystem, offset the harm they cause by carrying out impact mitigation measures or paying to restore degraded ecosystems or protect at-risk ecosystems
  - Encouraging investment in marine ecosystem infrastructure, such as reefs, mangrove forests, wetlands and other marine natural systems, to provide and protect wildlife habitats while delivering essential ecosystem services such as watershed and coastal protection

48 Financial returns in an ETM investment come from operating the high-carbon and renewable-energy assets supplemented by, for example, carbon credits for accelerated retirement.

- Encouraging investment in marine nature-based solutions, allowing governments to meet their climate goals and protect marine ecosystems
- Including emission reductions from the coastal and marine domain in carbon markets or leveraging other financial incentives to create additional economic rationale to protect the marine ecosystem
- Creating structural opportunities to deploy insurance mechanisms – particularly parametric insurance[49] to provide immediate cash for restoration activities following a damaging event

- **Improve fishery management by:**
  - Designing a sustainable seafood fund to overcome current implementation and funding hurdles, by providing a vehicle for both impact investors and seafood companies to invest in Fishery Improvement Projects (FIPs) and help scale sustainability initiatives
  - Encouraging blended finance, or blended capital, at the national level, to help bridge the financing gaps in the fisheries sector by combining different types of capital to improve the risk-return proposition for the private sector
  - Supporting mechanisms that signal the opportunity for private finance and help prepare subsequent investment in the fisheries sector, including risk underwriting (through guarantees that absorb initial losses, or insurance policies that provide compensation against negative events) and market incentives (e.g., purchase contracts or advance market commitments, impact bonds, matching funds, challenge funds, etc.)
  - Creating better access to local knowledge, including existing investments related to the targeted geography or fishery, to help investors more effectively identify and target investments from the outset
  - Designing fisheries credit programmes and revolving funds, particularly for the Small-Scale Fisheries (SSF) sector

- **Enhance human and economic sectors and social systems by:**
  - Dedicating part of the national annual budget to ocean-based climate actions and protecting frontline communities
  - Facilitating and providing funding for buy-out-high risk, or repeatedly damaged homes and other properties
  - Establishing a flood insurance programme at the national level to discourage construction in high-risk coastal and marine environments
  - Requiring that the flood insurance rate map considers climate projections, reflects actual risk and continues to ensure the affordability of premiums
  - Delivering faster access to funding for community-based, small-scale and educational initiatives

In consideration of the above, the following are options within the UNFCCC process and ongoing negotiations to help inform Africa's negotiating position related to financing ocean-based climate solutions at COP27:

49 Parametric insurance is insurance that pays out a predefined sum of money in the case of a predefined triggering event or condition, rather than requiring the formal assessment of actual losses involved. In coastal resilience cases, it may be triggered by agreed wind speed or barometric pressure thresholds. It can pay out in a matter of days, which is often critical for immediate post-disaster recovery efforts.

Standing Committee on Finance (SCF)

- Call for strengthening ocean-based climate action under the 2022 SCF Forum on Financing Nature-based Solutions by focusing intensely on coastal and marine ecosystems, forests, grasslands and other ecosystems.
- Request the SCF to prepare an Information Note exploring coastal and marine NbS climate finance flows, gaps and opportunities. SCF Forum reports are presented annually to the COP and used to inform the COP's guidance to the Green Climate Fund and Global Environment Facility.
- Call on the SCF to support the development of ocean-specific institutions and funding mechanisms to quickly provide the necessary funding for the sustainable management of marine ecosystems,
- resources and activities, without duplication of the interventions from the GCF and GEF.

Green Climate Fund (GCF)

- In the COP's guidance to the GCF, call for new or elaborated pilot programmes in Africa with dedicated funding for "Resilient, Blue Infrastructure", "Blue Carbon and Results-Based Finance" and/or "Resilient Coastal Communities".
- Call on the GCF to prioritise projects and initiatives focused on creating opportunities for local entrepreneurship and job creation, involving youth and women and strengthening small and medium enterprises (SMEs). In addition to the climate change adaptation and mitigation benefits, this approach will support vulnerable communities' overall economic and social well-being.

Global Environment Facility (GEF)

- In the COP's guidance to the GEF, call for new or elaborated pilot transboundary programmes in Africa, with dedicated funding for ORE, climate change-smart MSP, MPA and ICZM.
- Call for the continued financing of projects and programmes to strengthen Africa's coastal and marine ecosystem resilience.
- Call on the GEF Secretariat to collaborate with the Africa Development Bank (AfDB) on its African Adaptation Acceleration Program (AAAP) to help governments unlock and enable private capital investment in ocean-based solutions to climate change and ocean sectors toward adaptation and mitigation.
- Request that the GEF and others carry out robust oversight to ensure recipients' timely utilisation of funds for disaster recovery and approval of hazard mitigation action plans.
- Request the GEF to ease some of the stringent procedures for climate mitigation and adaptation funding for ocean-based interventions, the basis of the discussions held during the ocean climate dialogue.

Science

There is still a great deal about climate change in Africa that we do not know. In its Sixth Assessment Report, the IPCC emphasises that climate change and variability will negatively impact Africa's economic activities and exacerbate its current development challenges. With this warning in mind, various efforts are being made to reduce greenhouse gas emissions, plan for immediate and future adaptation, and integrate climate change considerations into development programmes and strategies at national and regional levels. Climate-smart ocean interventions and actions are a veritable option for confronting the

“There is still a great deal about climate change in Africa that we do not know.”

climate issue while achieving sustainable development. However, confronting many of Africa's developmental challenges through the sustainable utilisation of the ocean and coasts under the current and future climate projection will be dictated mainly by reliable baselines and future climate information. But herein lie several challenges: improving the predictability of the contemporary African climate is severely hampered by inadequate data, preventing validation of model predictions. Meanwhile, climate change projections over Africa are also characterised by significant uncertainties.

Doing justice to these issues will require the rigorous and strategic pursuit of strategic ocean climate science research that is more responsive to Africa's socio-economic needs, advancing new frontiers of demand-driven research. This research should use the latest technology to mine, meld and synthesise big data to close gaps in our understanding of changing climate patterns and refine existing climate products and services, making them more appropriate for policy and decision-making.

Therefore, integrating climate research into the ocean climate information and services chain is critical to improving models and climate prediction tools to enhance ocean climate knowledge and boost Africa's oceans, coasts and people's resilience to climate change, while steering the continent on the path toward sustainable development. Nonetheless, achieving this requires continuous investment in user-driven ocean climate science research, which should be earmarked in national budgets and recognised as an essential component of countries' short- and long-term development plans. Indeed, previous chapters of this report have shown areas where the fruits of investing in user-driven ocean climate science (including social science) research are immensely needed to increase the capacity of Africa to predict climate patterns effectively, understand the variability and impacts of climate, and thus enhance timely monitoring of and response to threats.

It is, therefore, imperative for African countries to:

- **Improve ocean-based renewable energy (ORE) by:**

Taking advantage of the ORE potential to reduce emissions, protect biodiversity and advance just energy transition by:

- Prioritising investment in research to assess the cost and benefits of the development of ORE in regard to impacts on critical biodiversity areas
- Scaling out research and development activities to build up national expertise and competence
- Participation of governments in regional and international research and development collaboration to share and complement national strengths
- Increasing research to understand the applicability of existing technologies for ORE storage and develop long-term and short-term storage energy concepts to decrease capital cost and increase the energy conversion efficiency of ORE
- Allocating national resources to support the identification of geographical areas with high renewable energy potential, and devoting significant efforts to understanding the production costs of ORE in the short and long term

- **Seabed carbon storage:**

- Take the benefit of the next SBSTA Ocean Dialogue meeting to seek clarification on the most reliable scientific guarantees and technologies to support the use of the seabed for carbon storage.
- Encourage the SBSTA Chair to encourage the IPCC to include, in its Seventh Assessment Report (AR7), an in-depth synthesis of the contribution and potential of seabed carbon storage and existing technologies.

“Doing justice to these issues will require the rigorous and strategic pursuit of strategic ocean climate science research that is more responsive to Africa's socio-economic needs, advancing new frontiers of demand-driven research.”

- **Solar radiation management:**

- Take the benefit of the next SBSTA Ocean Dialogue meeting to seek clarification on the most reliable scientific guarantees and technologies to support geoengineering techniques such as cloud brightening and albedo enhancement for climate mitigation.
- Encourage the SBSTA Chair to encourage the IPCC to include, in its Seventh Assessment Report (AR7), an in-depth synthesis of the contribution and potential of geoengineering techniques such as cloud brightening and albedo enhancement for climate mitigation.

- **Decarbonising ocean-based transport:**

- Financing research and development to speed up the development of technologies that will aid in creating a more sustainable shipping industry
- Encouraging collaboration between international, regional and national research institutes to expand research on ammonia-based engines, including H2 options
- Prompt R&D institutions to analyse the upstream dynamics of renewable fuel production for shipping

- **Protect and restore key marine and coastal ecosystems and support species by:**

- Conducting top-notch scientific research that helps increase the knowledge of critical ocean threats, and provides the foundation for more innovative ocean policy and new frameworks for improved ocean conservation
- Putting science at the heart of ocean protection and conservation work, and ensuring that people and nature thrive together
- Supporting science space/hubs in developing and using immersive science experiences in Africa to advocate and foster ocean science literacy

- **Improve fishery management by:**

- Developing effective ways to inform decision-makers about the critical role that a sound, science-based approach can play in protecting and even improving the health of fish populations and fisheries
- Mobilising and encouraging the fisheries department to provide timely and quality scientific findings and objective advice vital to support the management, conservation and sustainable management of fisheries' resources
- Exploring partnership opportunities with the commercial fishing sector towards securing vessels for research expeditions

In consideration of the above, the following are options within the UNFCCC process and ongoing negotiations to help inform Africa's negotiating position on the science need to advance ocean-based climate solutions at COP27:

Research and Systematic Observation (RSO)

- Call for the development of monitoring and forecasting capacities, and increase the use of ocean and coastal observations to advance ocean-related adaptation and mitigation potential in Africa, as well as address ocean-related resilience challenges.
- Encourage the SBSTA Chair to encourage the IPCC to include, in its Seventh Assessment Report (AR7), an in-depth synthesis of the contribution and potential of geoengineering techniques such as cloud brightening and albedo enhancement for climate mitigation.

Intergovernmental Panel on Climate Change (IPCC)

- Call for the development of guidance materials / knowledge products that give clarity to the utility of geoengineering in the planetary system and updates on the most reliable scientific

guarantees and technologies to support geoengineering techniques.

- Request the IPCC, in collaboration with SBSTA, FAO and other relevant bodies, to define a long-term work process to deliberate on crucial climate mitigation issues for fish species and other commercially important species migrating northward as a result of the warming ocean (e.g., the African sardine), and establish a reporting system to keep parties informed of their reflections and progress, e.g., through the SBSTA ocean and climate dialogue.
- Call on IPCC to collaborate with the World Trade Organization (WTO), the UN Food and Agriculture Organization (FAO) and other bodies to measure and take into account in future policy recommendations the impact of harmful fisheries' subsidies on the ocean ecosystem, particularly in Africa.
- "Call for developing practical accounting tools for strengthening ocean climate action, such as a below-tide area proxy tool" [184].

Glossary

Abrupt climate change
Sudden (on the order of decades), large changes in some major component of the climate system, with rapid, widespread effects

Adaptation
Adjustment or preparation of natural or human systems to a new or changing environment, which moderates harm or exploits beneficial opportunities

Adaptive capacity
The ability of a system to adjust to climate change (including climate variability and extremes) in order to moderate potential damages, take advantage of opportunities or cope with consequences

Afforestation
Planting of new forests on lands that historically have not contained forests

Albedo
The amount of solar radiation reflected from an object or surface, often expressed as a percentage

Alternative energy
Energy derived from non-traditional sources (e.g., compressed natural gas, solar, hydroelectric, wind)

Annex I Countries/Parties
Group of countries included in Annex I (as amended in 1998) to the United Nations Framework Convention on Climate Change, including all the developed countries in the Organization of Economic Co-operation and Development, and economies in transition. By default, the other countries are referred to as Non-Annex I countries. Under Articles 4.2 (a) and 4.2 (b) of the Convention, Annex I countries commit themselves specifically to the aim of returning individually or jointly to their 1990 levels of greenhouse gas emissions by the year 2000.

Anthropogenic
Made by people or resulting from human activities, usually used in the context of emissions that are produced as a result of human activities

Atmosphere
The gaseous envelope surrounding the earth. The dry atmosphere consists almost entirely of nitrogen (78.1% volume mixing ratio) and oxygen (20.9% volume mixing ratio), together with a number of trace gases, such as argon (0.93% volume mixing ratio), helium, radiatively active greenhouse gases such as carbon dioxide (0.035% volume mixing ratio), and ozone. In addition, the atmosphere contains water vapour, whose amount is highly variable but typically 1% volume mixing ratio. The atmosphere also contains clouds and aerosols.

Biofuels
Gas or liquid fuels made from plant material (biomass), including wood, wood waste, wood liquors, peat, railroad ties, wood sludge, spent sulphite liquors, agricultural waste, straw, tyres, fish oils, tall oil, sludge waste, waste alcohol, municipal solid waste, landfill gases, other waste, and ethanol blended into motor gasoline

Biogeochemical Cycle
Movements through the earth system of key chemical constituents essential to life, such as carbon, nitrogen, oxygen and phosphorus

Biomass
Materials that are biological in origin, including organic material (both living and dead) from above and below ground, for example, trees, crops, grasses, tree litter, roots, animals and animal waste

Biosphere
The part of the earth system comprising all ecosystems and living organisms in the atmosphere, on land (terrestrial biosphere) or in the oceans (marine biosphere), including derived dead organic matter, such as litter, soil organic matter and oceanic detritus

Black carbon aerosol
Black carbon (BC) is the most strongly light-absorbing component of particulate matter (PM), and is formed by the incomplete combustion of fossil fuels, biofuels and biomass. It is emitted directly into the atmosphere in the form of fine particles ($PM_{2.5}$).

Carbon dioxide
A naturally occurring gas, and also a by-product of burning fossil fuels and biomass, as well as of land-use changes and other industrial processes. It is the principal human-caused greenhouse gas that affects the earth's radiative balance. It is the reference gas against which other greenhouse gases are measured, and therefore has a global warming potential of 1. See "Climate change" and "Global warming".

Glossary

Carbon dioxide equivalent
A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). Carbon dioxide equivalents are commonly expressed as "million metric tons of carbon dioxide equivalents" ($MMTCO_2Eq$). The carbon dioxide equivalent for a gas is derived from multiplying the tons of the gas by the associated GWP.

$MMTCO_2Eq$ = (million metric tons of a gas) * (GWP of the gas)

Carbon dioxide fertilisation
The enhancement of the growth of plants as a result of increased atmospheric CO_2 concentration. Depending on their mechanism of photosynthesis, certain types of plants are more sensitive to changes in atmospheric CO_2 concentration.

Carbon footprint
The total amount of greenhouse gases that are emitted into the atmosphere each year by a person, family, building, organisation or company. A person's carbon footprint includes greenhouse gas emissions from fuel that an individual burns directly, such as by heating a home or driving in a car. It also includes greenhouse gases that come from producing the goods or services that the individual uses, including emissions from power plants that make electricity, factories that make products, and landfills where trash gets sent.

Carbon sequestration
Terrestrial, or biologic process by which trees and plants absorb carbon dioxide, release the oxygen and store the carbon. Geologic sequestration is one step in the process of carbon capture and sequestration (CCS), and involves injecting carbon dioxide deep underground, where it stays permanently.

Carbon Capture and Sequestration
Carbon capture and sequestration (CCS) is a set of technologies that can greatly reduce carbon dioxide emissions from new and existing coal- and gas-fired power plants, industrial processes and other stationary sources of carbon dioxide. It is a three-step process that includes capture of carbon dioxide from power plants or industrial sources; transport of the captured and compressed carbon dioxide (usually in pipelines); and underground injection and geologic sequestration, or permanent storage, of that carbon dioxide in rock formations that contain tiny openings or pores that trap and hold the carbon dioxide.

Chlorofluorocarbons
Gases covered under the 1987 Montreal Protocol and used for refrigeration, air conditioning, packaging, insulation, solvents or aerosol propellants. Since they are not destroyed in the lower atmosphere, chlorofluorocarbons (CFCs) drift into the upper atmosphere, where, given suitable conditions, they break down ozone. These gases are being replaced by other compounds: hydrochlorofluorocarbons, an interim replacement for CFCs that is also covered under the Montreal Protocol, and hydrofluorocarbons, which are covered under the Kyoto Protocol. All these substances are also greenhouse gases. See "Hydrochlorofluorocarbons", "Hydrofluorocarbons", "Perfluorocarbons" and "Ozone-Depleting Substance".

Climate
Climate, in a narrow sense, is usually defined as the "average weather" or, more rigorously, as the statistical description in terms of the statistical mean and variability of relevant quantities over a period of time, ranging from months to thousands of years. The classical period is three decades, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation and wind. Climate, in a wider sense, is the state, including a statistical description, of the climate system. See "Weather".

Climate change
Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation or wind patterns, among others, that occur over several decades or longer.

Climate feedback
A process that acts to amplify or reduce direct warming or cooling effects

Climate lag
The delay that occurs in climate change as a result of some factor that changes only very slowly. For example, the effects of releasing more carbon dioxide into the atmosphere occur gradually over time, because the ocean takes a long time to warm up in response to a change in radiation.

Climate model
A quantitative way of representing the interactions of the atmosphere, oceans, land surface and ice. Models can range from relatively simple to quite comprehensive.

Climate sensitivity
In Intergovernmental Panel on Climate Change (IPCC) reports, equilibrium climate sensitivity refers to the equilibrium change in global mean surface temperature following a doubling of the atmospheric (equivalent) CO_2 concentration. More generally, equilibrium climate sensitivity refers to the equilibrium change in surface air temperature following a unit change in radiative forcing (degrees Celsius per watts per square metre (C/[W/m^{-2}])). One method of evaluating the equilibrium climate sensitivity requires very long simulations with Coupled General Circulation Models (climate models). The effective climate sensitivity is a related measure that circumvents this requirement. It is evaluated from model output for evolving non-equilibrium conditions. It is a measure of the strengths of the feedback at a particular time and may vary with forcing history and climate state.

Climate system (or Earth system)
The five physical components (atmosphere, hydrosphere, cryosphere, lithosphere and biosphere) that are responsible for the climate and its variations

Coal mine methane
Coal mine methane is the subset of coalbed methane that is released from coal seams during the process of coal mining.

Co-benefit
The benefits of policies that are implemented for various reasons at the same time, including climate change mitigation, acknowledging that most policies designed to address greenhouse gas mitigation also have other, often at least equally important, rationales (e.g., related to objectives of development, sustainability and equity)

Concentration
The amount of a chemical in a particular volume or weight of air, water, soil or other medium. See "Parts per billion" and "Parts per million".

Conference of the Parties
The supreme body of the United Nations Framework Convention on Climate Change (UNFCCC). It comprises more than 180 nations that have ratified the Convention. Its first session was held in Berlin, Germany, in 1995, and it is expected to continue meeting on a yearly basis. The COP's role is to promote and review the implementation of the Convention. It will periodically review existing commitments in light of the Convention's objective, new scientific findings, and the effectiveness of national climate change programmes. See "United Nations Framework Convention on Climate Change".

Coral bleaching
The process in which a coral colony, under environmental stress, expels the microscopic algae (zooxanthellae) that live in symbiosis with their host organisms (polyps). The affected coral colony appears whitened.

Deforestation
Those practices or processes that result in the conversion of forested lands for non-forest uses. Deforestation contributes to increasing carbon dioxide concentrations for two reasons: 1) the burning or decomposition of the wood releases carbon dioxide; and 2) trees that once removed carbon dioxide from the atmosphere in the process of photosynthesis are no longer present.

Desertification
Land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities. Further, the UNCCD (United Nations Convention to Combat Desertification) defines land degradation as a reduction or loss, in arid, semi-arid and dry sub-humid areas, of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest or woodland resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical and biological or economic properties of soil; and (iii) long-term loss of natural vegetation.

Ecosystem
Any natural unit or entity including living and non-living parts that interact to produce a stable system through the cyclic exchange of materials

Emissions
The release of a substance (usually a gas when referring to the subject of climate change) into the atmosphere

Emissions factor
A unique value for scaling emissions to activity data in terms of a standard rate of emissions per unit of activity (e.g., grams of carbon dioxide emitted per barrel of fossil fuel consumed, or per pound of product produced)

Energy Efficiency
Using less energy to provide the same service

Fluorocarbons
Carbon-fluorine compounds that often contain other elements such as hydrogen, chlorine or bromine. Common fluorocarbons include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Fossil Fuel
A general term for organic materials formed from decayed plants and animals that have been converted to crude oil, coal, natural gas or heavy oils by exposure to heat and pressure in the earth's crust over hundreds of millions of years

Global average temperature
An estimate of the earth's mean surface air temperature averaged over the entire planet

Global warming
The recent and ongoing global average increase in temperature near the earth's surface

Greenhouse effect
The trapping and build-up of heat in the atmosphere (troposphere) near the earth's surface. Some of the heat flowing back toward space from the earth's surface is absorbed by water vapour, carbon dioxide, ozone and several other gases in the atmosphere and then reradiated back toward the earth's surface. If the atmospheric concentrations of these greenhouse gases rise, the average temperature of the lower atmosphere will gradually increase.

Greenhouse gas (GHG)
Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride.

Hazard

The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems or environmental resources.

Heatwave
A prolonged period of excessive heat, often combined with excessive humidity

Hydrocarbons
Substances containing only hydrogen and carbon. Fossil fuels are made up of hydrocarbons.

Hydrochlorofluorocarbons (HCFCs)
Compounds containing hydrogen, fluorine, chlorine and carbon atoms. Although ozone-depleting substances, they are less potent in destroying stratospheric ozone than chlorofluorocarbons (CFCs). They have been introduced as temporary replacements for CFCs and are also greenhouse gases.

Hydrofluorocarbons (HFCs)
Compounds containing only hydrogen, fluorine and carbon atoms. They were introduced as alternatives to ozone-depleting substances in serving many industrial, commercial and personal needs. HFCs are emitted as by-products of industrial processes and are also used in manufacturing. They do not significantly deplete the stratospheric ozone layer, but they are powerful greenhouse gases with global warming potentials ranging from 140 (HFC-152a) to 11,700 (HFC-23).

Human mobility

The permanent or semi-permanent movement by a person for at least one year and involving crossing an administrative, but not necessarily a national, border.

Human rights

Rights that are inherent to all human beings, universal, inalienable and indivisible, typically expressed and guaranteed by law. They include the right to life; economic, social and cultural rights; and the right to development and self-determination.

Human security

A condition that is met when the vital core of human lives is protected, and when people have the freedom and capacity to live with dignity. In the context of climate change, the vital core of human lives includes the universal and culturally specific material and non-material elements necessary for people to act on behalf of their interests and to live with dignity.

Hydrologic cycle
The process of evaporation, vertical and horizontal transport of vapour, condensation, precipitation and flow of water from continents to oceans. It is a major factor in determining climate through its influence on surface vegetation,

the clouds, snow and ice, and soil moisture. The hydrologic cycle is responsible for 25-30% of the mid-latitudes' heat transport from the equatorial regions to the polar regions.

Hydrosphere
The component of the climate system comprising liquid surface and subterranean water, such as oceans, seas, rivers, freshwater lakes, underground water, etc.

Indirect emissions
Emissions of greenhouse gases that occur as a result of the generation of electricity used in a building, home or business. These emissions are called "indirect" because the actual emissions occur at the power plant which generates the electricity, not at the building, home or business using the electricity.

Impacts (Consequences, Outcomes)

The consequences of realised risks for natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather/climate events), exposure and vulnerability. Impacts generally refer to effects on lives, livelihoods, health and well-being, ecosystems and species, economic assets, social and cultural assets, services (including ecosystem services) and infrastructure. Impacts may be referred to as consequences or outcomes, and can be adverse or beneficial. See also "Adaptation", "Loss and Damage" and "Natural Systems".

Incremental adaptation

See "Adaptation".

Indigenous knowledge (IK)

The understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings. For many indigenous peoples, IK informs decision-making about fundamental aspects of life, from day-to-day activities to longer-term actions. This knowledge is integral to cultural complexes, which also encompass language, systems of classification, resource use practices, social interactions, values, rituals and spirituality. These distinctive ways of knowing are important facets of the world's cultural diversity.

Industrial revolution
A period of rapid industrial growth with far-reaching social and economic consequences, beginning in England during the second half of the 18th century and spreading to Europe and later to other countries, including the United States. The Industrial Revolution marked the beginning of a strong increase in combustion of fossil fuels and related emissions of carbon dioxide.

Intergovernmental Panel on Climate Change (IPCC)
Established jointly by the United Nations Environment Programme and the World Meteorological Organization in 1988, the IPCC is official advisory body to the world's governments on the state of the science of the climate change issue .

Megacities
Cities with populations over 10 million

Methane (CH_4)
A hydrocarbon that is a greenhouse gas with a global warming potential most recently estimated at 25 times that of carbon dioxide (CO_2). Methane is produced through anaerobic (without oxygen) decomposition of waste in landfills, animal digestion, decomposition of animal waste, production and distribution of natural gas and petroleum, coal production and incomplete fossil fuel combustion. The GWP is from the IPCC's Fourth Assessment Report (AR4). For more information, visit the EPA's "Methane" page.

Mitigation
A human intervention to reduce the human impact on the climate system; examples are strategies to reduce greenhouse gas sources and emissions and enhance greenhouse gas sinks.

Natural variability
Variations in the mean state and other statistics (such as standard deviations or statistics of extremes) of the climate on all time and space scales beyond those of individual weather events. Natural variations in climate over time are caused by internal processes of the climate system, such as El Niño, as well as changes in external influences, such as volcanic activity and variations in the output of the sun.

Ocean acidification
Increased concentrations of carbon dioxide in sea water, causing a measurable increase in acidity (i.e., a reduction in ocean pH). This may lead to reduced calcification rates of calcifying organisms such as corals, molluscs, algae and crustaceans.

Ozone-Depleting Substance (ODS)
A family of man-made compounds that include, but are not limited to, chlorofluorocarbons (CFCs), bromofluorocarbons (halons), methyl chloroform,

carbon tetrachloride, methyl bromide and hydrochlorofluorocarbons (HCFCs). These compounds have been shown to deplete stratospheric ozone, and therefore are typically referred to as ODSs.

Ozone layer
The layer of ozone that begins approximately 15 km above the earth and thins to an almost negligible amount at about 50 km, and shields the earth from harmful ultraviolet radiation from the sun. The highest natural concentration of ozone (approximately 10 parts per million by volume) occurs in the stratosphere at approximately 25 km above the earth. The stratospheric ozone concentration changes throughout the year as stratospheric circulation changes with the seasons. Natural events such as volcanoes and solar flares can produce changes in ozone concentration, but man-made changes are of the greatest concern.

Reforestation
Planting of forests on lands that have previously contained forests but that have been converted to some other use

Relative sea-level rise
The increase in ocean water levels at a specific location, taking into account both global sea-level rise and local factors, such as local subsidence and uplift. Relative sea-level rise is measured with respect to a specified vertical datum relative to the land, which may also be changing in elevation over time.

Renewable energy
Energy resources that are naturally replenished, such as biomass, hydro, geothermal, solar, wind, ocean thermal, wave action and tidal action.

Resilience
A capability to anticipate, prepare for, respond to and recover from significant multi-hazard threats with minimum damage to social well-being, the economy and the environment

Salt water intrusion
Displacement of freshwater or groundwater by the advance of salt water due to its greater density, usually in coastal and estuarine areas

Scenario
A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships

Sea surface temperature
The temperature in the top several feet of the ocean, measured by ships, buoys and drifters

Sink
Any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol from the atmosphere

Soil carbon
A major component of the terrestrial biosphere pool in the carbon cycle. The amount of carbon in the soil is a function of the historical vegetative cover and productivity, which in turn is dependent in part upon climatic variables.

Solar radiation
Radiation emitted by the sun. It is also referred to as short-wave radiation. Solar radiation has a distinctive range of wavelengths (spectrum) determined by the temperature of the sun.

Storm surge
An abnormal rise in sea level accompanying a hurricane or other intense storm, whose height is the difference between the observed level of the sea surface and the level that would have occurred in the absence of the storm.

United Nations Framework Convention on Climate Change (UNFCCC)
Sets out basic legal framework and principles for international climate change to tackle the challenges posed by climate change. It recognises that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases.

Vulnerability
The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed; its sensitivity; and its adaptive capacity.

Annexe I: Scoring system for the different intervention areas and variables

Scoring system related to "Marine spatial planning, MPAs for ocean-based renewable energy"	
0	Policy does not suggest the application of MSP, MPA and other area management tools.
1	Policy suggests the application of MSP, MPA and other area management tools for either climate mitigation or adaptation.
2	Policy suggests the application of MSP, MPA and other area management tools for both climate mitigation and adaptation.
Scoring system for "Design policy or regulatory frameworks for renewable energy"	
0	Policy does not mention the design of any policy or regulatory frameworks for renewable energy.
1	Policy mentions policy or regulatory framework for renewable energy regarding either adaptation or mitigation.
2	Policy mentions policy or regulatory framework for renewable energy addressing both adaptation and mitigation.
Scoring system for "Advance storage capacity and design"	
0	Policy does not suggest advancing storage capacity and design.
1	Policy suggests advancing storage capacity and design for either mitigation or adaptation.
2	Policy suggests advancing storage capacity and design for both mitigation and adaptation.
Scoring system related to "Improving performance of energy systems"	
0	Policy does not suggest improving the performance of energy systems.
1	Policy suggests improving the performance of energy systems for either adaptation or mitigation.
2	Policy suggests improving the performance of energy systems for both adaptation and mitigation.
Scoring system for "Marine biomass-fuelled energy with carbon capture on land, marine biochar, etc."	
0	Policy does not mention marine biomass-fuelled energy with carbon capture on land, marine biochar, etc.
1	Policy mentions marine biomass-fuelled energy with carbon capture on land, marine biochar, etc. for either adaptation or mitigation.
2	Policy mentions marine biomass-fuelled energy with carbon capture on land, marine biochar, etc. for both adaptation and mitigation.

Scoring system for "Exploring potential environmental impacts of seabed carbon storage"	
0	Policy does not include exploring the potential of environmental impacts.
1	Policy includes exploring the potential of environmental impacts for either adaptation or mitigation.
2	Policy includes exploring the potential of environmental impacts for both adaptation and mitigation.
Scoring system for "Map marine geophysical potential for seabed carbon storage"	
0	Policy does not suggest the mapping of marine geophysical potential for seabed carbon storage.
1	Policy suggests the mapping of marine geophysical potential for seabed carbon storage for mitigation.
Scoring system for "Exploring the integrity of long-term storage technologies for seabed carbon storage"	
0	Policy does not include exploring the integrity of long-term storage technologies for seabed carbon storage.
1	Policy mentions exploring the integrity of long-term storage technologies for seabed carbon storage for mitigation.
Scoring system for "Developing regulatory frameworks for seabed carbon storage"	
0	Policy does not mention developing regulatory frameworks for seabed carbon storage.
1	Policy mentions developing regulatory frameworks for seabed carbon storage.
Scoring system for "Scale up technologies for seabed carbon storage"	
0	Policy does not mention scaling regulatory frameworks for seabed carbon storage.
1	Policy mentions scaling regulatory frameworks for seabed carbon storage.
Scoring system for "Invest in research to minimise environmental impacts of long-term storage of carbon in the seabed"	
0	Policy does not suggest investing in research to minimise environmental impacts of long-term storage of carbon in the seabed.
1	Policy suggests investing in research to minimise environmental impacts of long-term storage of carbon in the seabed.
Scoring system for "Cloud brightening"	
0	Policy does not suggest cloud brightening.
1	Policy suggests cloud brightening.

Scoring system for "Albedo enhancement"	
0	Policy does not suggest albedo enhancement.
1	Policy suggests albedo enhancement.
Scoring system for "Redesign the Energy Efficiency Design Index (EEDI) formula" to decarbonise ocean-based transportation	
0	Policy does not suggest redesigning the Energy Efficiency Design Index (EEDI) formula to decarbonise ocean-based transportation.
1	Policy suggest redesigning the Energy Efficiency Design Index (EEDI) formula to decarbonise ocean-based transportation for either adaptation or mitigation.
2	Policy suggests redesigning the Energy Efficiency Design Index (EEDI) formula to decarbonise ocean-based transportation for both adaptation and mitigation.
Scoring system for "Adopt policies to reduce emissions of other greenhouse gases" to decarbonise ocean-based transportation	
0	Policy does not suggest adopting policies to reduce emissions of other greenhouse gases to decarbonise ocean-based transportation.
1	Policy suggests adopting policies to reduce emissions of other greenhouse gases to decarbonise ocean-based transportation.
Scoring system for "Improve ship designs" to decarbonise ocean-based transportation	
0	Policy does not suggest improving ship designs to decarbonise ocean-based transportation.
1	Policy suggests improving ship designs to decarbonise ocean-based transportation for either mitigation or adaptation.
2	Policy suggests improving ship designs to decarbonise ocean-based transportation for both mitigation and adaptation.
Scoring system for "Develop and implement hybrid power systems – wind, waves, currents and sun" to decarbonise ocean-based transportation	
0	Policy does not suggest developing and implementing hybrid power systems – wind, waves, currents and sun – to decarbonise ocean-based transportation.
1	Policy suggests developing and implementing hybrid power systems – wind, waves, currents and sun – to decarbonise ocean-based transportation for either adaptation or mitigation.
2	Policy suggests developing and implementing hybrid power systems – wind, waves, currents and sun – to decarbonise ocean-based transportation for both adaptation and mitigation.

Scoring system for "Enhance protection measures for mangroves, kelp seagrass, salt marsh and seaweed beds to prevent further losses" to protect and restore key marine and coastal ecosystems and support species	
0	Policy does not suggest enhancing protection measures for mangroves, kelp seagrass, salt marsh and seaweed beds to prevent further losses.
1	Policy suggests enhancing protection measures for mangroves, kelp seagrass, salt marsh and seaweed beds to prevent further losses for either adaptation or mitigation.
2	Policy suggests enhancing protection measures for mangroves, kelp seagrass, salt marsh and seaweed beds to prevent further losses for both adaptation and mitigation.
Scoring system for "Map blue carbon ecosystems to understand the impacts of carbon capture and storage" to protect and restore key marine and coastal ecosystems and support species	
0	Policy does not suggest mapping blue carbon ecosystems to understand the impacts of carbon capture and storage.
1	Policy suggests mapping blue carbon ecosystems to understand the impacts of carbon capture and storage.
Scoring system for "Advance biorefining techniques" to protect and restore key marine and coastal ecosystems and support species	
0	Policy does not suggest advancing biorefining techniques.
1	Policy suggests advancing biorefining techniques for either adaptation or mitigation.
2	Policy suggests advancing biorefining techniques for both adaptation and mitigation.
Scoring system for "Application of MSP, ICZM, MPAs, etc." to protect and restore key marine and coastal ecosystems and support species	
0	Policy does not suggest the application of MSP, ICZM, MPAs, etc.
1	Policy suggests the application of MSP, ICZM, MPAs, etc. for either adaptation or mitigation.
2	Policy suggests the application of MSP, ICZM, MPAs, etc. for both adaptation and mitigation.
Scoring system for "Expand farmed seaweed as an alternative fuel and feed source" to protect and restore key marine and coastal ecosystems and support species	
0	Policy does not mention expanding farmed seaweed as an alternative to fuel and feed sources.
1	Policy mentions expanding farmed seaweed as an alternative to fuel and feed sources for either mitigation or adaptation.
2	Policy mentions expanding farmed seaweed as an alternative to fuel and feed sources for both mitigation and adaptation.

Scoring system for "Restore and enhance degraded habitats and ecosystems and create new ones" to protect and restore key marine and coastal ecosystems and support species	
0	Policy does not suggest restoring and enhancing degraded habitats and ecosystems and creating new ones.
1	Policy suggests restoring and enhancing degraded habitats and ecosystems and creating new ones for either mitigation or adaptation.
2	Policy suggests restoring and enhancing degraded habitats and ecosystems and creating new ones for both mitigation and adaptation.
Scoring system for "Assisted evolution and genetic modification" to protect and restore key marine and coastal ecosystems and support species	
0	Policy does not suggest assisted evolution and genetic modification.
1	Policy suggests assisted evolution and genetic modification for either mitigation or adaptation.
2	Policy suggests assisted evolution and genetic modification for both mitigation and adaptation.
Scoring system for "Maintain and restore coastal hydrology regimes" to protect and restore key marine and coastal ecosystems and support species	
0	Policy does not suggest maintaining and restoring coastal hydrology regimes.
1	Policy suggests maintaining and restoring coastal hydrology regimes for either mitigation or adaptation.
2	Policy suggests maintaining and restoring coastal hydrology regimes for both mitigation and adaptation.
Scoring system for "Reduce pollution from all sources, including land and rivers" to protect and restore key marine and coastal ecosystems and support species	
0	Policy does not mention reducing pollution from all sources, including land and rivers.
1	Policy does mention reducing pollution from all sources, including land and rivers, for either mitigation or adaptation.
2	Policy does mention reducing pollution from all sources, including land and rivers, for both mitigation and adaptation.
Scoring system for "Enhance open-ocean productivity by adding nutrients (fertilisation)" to protect and restore key marine and coastal ecosystems and support species	
0	Policy does not suggest enhancing open-ocean productivity by adding nutrients (fertilisation).
1	Policy does suggest enhancing open-ocean productivity by adding nutrients (fertilisation) for either mitigation or adaptation.
2	Policy does suggest enhancing open-ocean productivity by adding nutrients (fertilisation) for both mitigation and adaptation.

Scoring system for "Addition of natural or man-made alkalinity to enhance CO_2 carbon storage" to protect and restore key marine and coastal ecosystems and support species	
0	Policy does not suggest the addition of natural or man-made alkalinity to enhance CO_2 carbon storage.
1	Policy suggests the addition of natural or man-made alkalinity to enhance CO_2 carbon storage.
Scoring system for "Eliminate harmful fisheries' subsidies" to improve fisheries management	
0	Policy does not mention eliminating harmful fisheries' subsidies.
1	Policy mentions the elimination of harmful fisheries' subsidies for either mitigation or adaptation.
2	Policy mentions the elimination of harmful fisheries' subsidies for both mitigation and adaptation.
Scoring system for "Reduce discards" to improve fisheries management	
0	Policy does not mention reducing discards.
1	Policy mentions reducing discards for either mitigation or adaptation.
2	Policy mentions reducing discards for both mitigation and adaptation.
Scoring system for "Reduce HCFCs in refrigerants" to improve fisheries management	
0	Policy does not suggest reducing HCFCs in refrigerants.
1	Policy suggests reducing HCFCs in refrigerants.
Scoring system for "Create incentives for lower trophic level aquaculture" to improve fisheries management	
0	Policy does not suggest creating incentives for lower trophic level aquaculture.
1	Policy suggests creating incentives for lower trophic level aquaculture for either mitigation or adaptation.
2	Policy suggests creating incentives for lower trophic level aquaculture for both mitigation and adaptation.
Scoring system for "Optimise wild catch and shift to low-carbon feed options" to improve fisheries management	
0	Policy does not mention optimising wild catch and shifting to low-carbon feed options.
1	Policy mentions optimising wild catch and shifting to low-carbon feed options for either mitigation or adaptation.
2	Policy mentions optimising wild catch and shifting to low-carbon feed options for both mitigation and adaptation.

Scoring system for "Extend surveillance technologies for tracking fishing" to improve fisheries management	
0	Policy does not suggest extending surveillance technologies for tracking fishing.
1	Policy suggests extending surveillance technologies for tracking fishing for either mitigation or adaptation.
2	Policy suggests extending surveillance technologies for tracking fishing for both mitigation and adaptation.
Scoring system for "Shifting to low-carbon feed options for cultured fish" to improve fisheries management	
0	Policy does not suggest shifting to low-carbon feed options for cultured fish.
1	Policy suggests shifting to low-carbon feed options for cultured fish.
Scoring system for "Create incentives to shift diets to low-carbon protein (e.g., fish, seaweed) diets" to achieve cultural shift, low-carbon diet	
0	Policy does not mention creating incentives to shift diets to low-carbon protein (e.g., fish, seaweed) diets.
1	Policy mentions creating incentives to shift diets to low-carbon protein (e.g., fish, seaweed) diets for either mitigation or adaptation.
2	Policy mentions creating incentives to shift diets to low-carbon protein (e.g., fish, seaweed) diets for both mitigation and adaptation.
Scoring system for "Explore carbon tax on red meat and other carbon-intensive foods" to achieve cultural shift, low-carbon diet	
0	Policy does not suggest exploring a carbon tax on red meat and other carbon-intensive foods.
1	Policy suggests exploring a carbon tax on red meat and other carbon-intensive foods for either mitigation or adaptation.
2	Policy suggests exploring a carbon tax on red meat and other carbon-intensive foods for both mitigation and adaptation.
Scoring system for "Relocate communities, structures and/or assets from areas that are impacted / likely to be significantly affected" to enhance human and economic sectors and social systems	
0	Policy does not suggest the relocation of communities, structures and/or assets from areas that are impacted / likely to be significantly affected.
1	Policy suggests the relocation of communities, structures and/or assets from areas that are impacted / likely to be significantly affected.
Scoring system for "Implement strategies to protect assets from the impacts of flooding" to enhance human and economic sectors and social systems	
0	Policy does not suggest implementing strategies to protect assets from the impacts of flooding.
1	Policy suggests implementing strategies to protect assets from the impacts of flooding.

Scoring system for "Encourage coping with the new conditions" to enhance human and economic sectors and social systems	
0	Policy does not suggest encouraging coping with the new conditions.
1	Policy suggests encouraging coping with the new conditions.
Scoring system for "Common funding arrangement or budget using innovative blue/green financing" to improve ocean climate finance	
0	Policy does not suggest a common funding arrangement or budget using innovative blue/green financing.
1	Policy suggests a common funding arrangement or budget using innovative blue/green financing for either mitigation or adaptation.
2	Policy suggests a common funding arrangement or budget using innovative blue/green financing for both mitigation and adaptation.
Scoring system for "Financial commitments/budget by governments, private sector" to improve ocean climate finance	
0	Policy does not include financial commitments/budget by governments, private sector.
1	Policy includes financial commitments/budget by governments, private sector for either mitigation or adaptation.
2	Policy includes financial commitments/budget by governments, private sector for both mitigation and adaptation.
Scoring system for "Ocean literacy and public awareness"	
0	Policy does not propose ocean literacy and public awareness.
1	Policy proposes ocean literacy and public awareness for either adaptation or mitigation.
2	Policy proposes ocean literacy and public awareness for both adaptation and mitigation.
Scoring system for "Include indigenous perspectives" in response to multiple ocean and coastal threats	
0	Policy does not mention the inclusion of indigenous perspectives.
1	Policy mentions the inclusion of indigenous perspectives for either mitigation or adaptation.
2	Policy mentions the inclusion of indigenous perspectives for both mitigation and adaptation.
Scoring system for "Coastal community participation" in response to multiple ocean and coastal threats	
0	Policy does not suggest coastal community participation.
1	Policy suggests coastal community participation for either mitigation or adaptation.
2	Policy suggests coastal community participation for both mitigation and adaptation.

Scoring system for" Provide materials and financial incentives for coastal communities" in response to multiple ocean and coastal threats	
0	Policy does not mention the provision of materials and financial incentives for coastal communities.
1	Policy mentions the provision of materials and financial incentives for coastal communities.
Scoring system for "Integration between different government levels" in response to multiple ocean and coastal threats	
0	Policy does not suggest integration between different government levels.
1	Policy suggests integration between different government levels for either mitigation or adaptation.
2	Policy suggests integration between different government levels for both mitigation and adaptation.
Scoring system for "Development of labour and enhancement of professional skills" in response to multiple ocean and coastal threats	
0	Policy does not suggest the development of labour and enhancement of professional skills.
1	Policy suggests the development of labour and enhancement of professional skills.
Scoring system for "Development of MSP, MPA, etc. and ocean legislation" in response to multiple ocean and coastal threats	
0	Policy does not suggest the development of MSP, MPA, etc. and ocean legislation.
1	Policy suggests the development of MSP, MPA, etc. and ocean legislation for either mitigation or adaptation.
2	Policy suggests the development of MSP, MPA, etc. and ocean legislation for both mitigation and adaptation.
Scoring system for "Implement a system of monitoring and evaluation (e.g., reef check surveys, etc.) of productivity of coastal and marine ecosystems" for climate monitoring	
0	Policy does not suggest the implementation of a system of monitoring and evaluation of the productivity of coastal and marine systems.
1	Policy suggests the implementation of a system of monitoring and evaluation of the productivity of coastal and marine systems for either mitigation or adaptation.
2	Policy suggests the implementation of a system of monitoring and evaluation of the productivity of coastal and marine systems for both mitigation and adaptation.

Scoring system for "Measuring and transparently reporting climate change impacts on ocean ecosystem resilience and disaster risk reduction"	
0	Policy does not suggest measuring and transparently reporting climate change impacts on ocean ecosystem resilience and disaster risk reduction.
1	Policy suggests measuring and transparently reporting climate change impacts on ocean ecosystem resilience and disaster risk reduction.
Scoring system for "Improve methods for monitoring mitigation benefits to the ocean"	
0	Policy does not propose improving methods for monitoring mitigation benefits to the ocean.
1	Policy proposes improving methods for monitoring mitigation benefits to the ocean.

Annexe II:

Intervention area	Variables	Variable code	Algeria	Benin	CV	CMR	NG	C. DR	Eq Guinea	Mzbq	NM	Mad	TZ	SY	MCC	EGY	KN
Increase ocean-based renewable energy	Apply marine spatial planning, MPAs	ORE1	0	0	0	0	0										
	Design regulatory frameworks for renewable energy	ORE2	0	1	1	2	1	1	1	1	1	1	2	1	1		1
	Advance storage capacity and design	ORE3	0	1	1		0				1	1		1			
	Improve performance of energy systems	ORE4	2	1	1		1	1				1		1	1		
	Marine biomass-fuelled energy with carbon capture on land, marine biochar, etc.	ORE5	0	1	1		0	1			2			1			
Seabed carbon storage	Explore potential environmental impacts	SCS1	0	0	0		0										
	Map marine geophysical potential	SCS2	0	0	0		0										
	Explore the integrity of long-term storage technologies	SCS3	0	0	0		0										
	Develop regulatory frameworks	SCS4	0	0	0		0										
	Scale up technologies	SCS5	0	0	0		0										
	Invest in the research necessary to minimise environmental impacts of long-term storage of carbon in the seabed	SCS6	0	0	0		0										

Algeria, Benin, CV=Côte d'Ivoire, CMR= Cameroon, NG = Nigeria, C. DR = Democratic Republic of Congo, Eq Guinea = Equatorial Guinea, Mzbq = Mozambique, NM = Namibia, Mad = Madagascar, TZ = Tanzania, SY = Seychelles, MCC = Morocco, EGY = Egypt, KN = Kenya

Intervention area	Variables	Variable code	Algeria	Benin	CV	CMR	NG	C. DR	Eq Guinea	Mzbq	NM	Mad	TZ	SY	MCC	EGY	KN
Solar radiation management	Cloud brightening	SRM1	0	0	0		0										
	Albedo enhancement	SRM2	0	0	0		0										
Decarbonising ocean-based transport	Redesign the Energy Efficiency Design Index (EEDI) formula	DOCT1	0	0													
	Adopt policies to reduce emissions of other greenhouse gases	DOCT2	0	0	1	0	0	0	1		1		1	2		1	
	Improve ship designs	DOCT3	0		0				0	0	0	0	0				
	Develop and implement hybrid power systems – wind, waves, currents and sun	DOCT4	0	1	0								1			1	
Protect and restore key marine and coastal ecosystems and support species	Enhance protection measures for mangroves, kelp seagrass, salt marsh and seaweed beds to prevent further losses	PRES1	2	2	2		2	2		1	2	1		2	2	1	2
	Map blue carbon ecosystems	PRES2	0		2	0	0	1	1	1	2			2	1	0	1
	Advance biorefining techniques	PRES3	0	0	0												
	Apply MSP, ICZM, MPAs, etc.	PRES4	1		2				1	1	2	1	1	2	1	1	2
	Expand farmed seaweed as an alternative fuel and feed source	PRES5	0	0	0					1							
	Restore and enhance degraded habitats and ecosystems and create new ones	PRES6	2	1	2	2	2	2	1	1	1	1	1	1	2		2

Intervention area	Variables	Variable code	Algeria	Benin	CV	CMR	NG	C. DR	Eq Guinea	Mzbq	NM	Mad	TZ	SY	MCC	EGY	KN
	Assisted evolution and genetic modification	PRES7	0	0	0												
	Maintain and restore coastal hydrology regimes	PRES8	0	1	1						1		1		1	1	
	Reduce pollution from all sources, including land and rivers	PRES9	0	1	1	1	2	1	1	1	1	1	1	2	1	1	1
	Enhance open ocean productivity by adding nutrients (fertilisation)	PRES10	0	0	0	0	0	0									
	Addition of natural or man-made alkalinity to enhance CO_2 carbon storage	PRES11	0	0	0	0	0										
Improve fishery management	Eliminate harmful fisheries' subsidies	IFM1	0	0	1												
	Reduce discards	IFM2	0	0	1												
	Reduce HCFCs in refrigerants	IFM3	0	0	0	0	1				1			1			
	Create incentives for lower trophic level aquaculture	IFM4	0	0	1	0	1			1							
	Optimise wild catch and shift to low-carbon feed options	IFM5	0	0	0										1		
	Extend surveillance technologies for tracking fishing	IFM6	0	0	1						1		1		1		
	Shifting to low-carbon feed options for cultured fish	IFM7	0	0	0						1						
Cultural shift, low-carbon diet	Create incentives to shift diets to low-carbon protein (e.g., fish, seaweed) diets	CSLCD1	0	0	1												

Intervention area	Variables	Variable code	Algeria	Benin	CV	CMR	NG	C. DR	Eq Guinea	Mzbq	NM	Mad	TZ	SY	MCC	EGY	KN
	Explore carbon tax on red meat and other carbon-intensive foods	CSLCD2	0	0	0												
Enhance human and economic sectors and social systems (defend, coexist or retreat)	Relocate communities, structures and/or assets from areas that are impacted / likely to be significantly affected	EHESS1									1						
	Implement strategies to protect assets from the impacts of flooding (involve the construction of seawalls and reforestation of riparian areas)	EHESS2	1		1			1	1	1	1	1	1	1			1
	Encourage coping with the new conditions	EHESS3	0	0	0					1	1						
Improve ocean climate finance	Common funding arrangement or budget using innovative blue/ green financing, including blue bonds, debt-for-nature swaps, resilience credits, nature insurance, etc.	IOCF1	0	0	1			1		1	1		2	2			2
	Financial commitments/ budget by governments, private sector, etc.	IOCF2		2							1	2	2	2	2		1
People-centred response to multiple ocean and coastal threats	Ocean literacy and public awareness	PRMT1	1	1	1			1		2	1	1	1	2	2	1	1
	Include indigenous perspectives	PRMT2	0	2				2					1	2			

Intervention area	Variables	Variable code	Algeria	Benin	CV	CMR	NG	C. DR	Eq Guinea	Mzbq	NM	Mad	TZ	SY	MCC	EGY	KN
	Coastal community participation	PRMT3	2	2	1			2		1	1		1	2		1	1
	Integration between different government levels	PRMT4	2	2	1		1	1	1	1	1		1	2			
	Provide materials and financial incentives for coastal communities	PRMT5	0	1	1			1		1	1		1	1	1	1	1
	Development of labour and professional skills enhancement	PRMT6	0	0	1								1	2			
	Development of MSP, MPA, etc. and ocean legislation	PRMT7	1	2	2			1	1	1	1	1	1	1			
Monitoring	Implement a system of monitoring and evaluation (e.g., reef check surveys, etc.) of productivity of coastal and marine ecosystems	MON1	1	2	2	1	1	1	2	2	1	1	1	2	2	1	1
	Measuring and transparently reporting climate change impacts on ocean ecosystem resilience and disaster risk reduction	MON2		1	1			1	1	1	1	1	2	2	1	1	1
	Improve methods for monitoring mitigation benefits to the ocean	MON3	0	2	2			1		2	1		2	1		1	

References

[1] K. Lyu, X. Zhang, and J. A. Church, "Projected ocean warming constrained by the ocean observational record," *Nat. Clim. Chang.*, vol. 11, no. 10, pp. 834–839, 2021, doi: 10.1038/s41558-021-01151-1.

[2] NOAA, "Ocean Heat Content reaches its highest level in recorded history," 2020. https://www.ncei.noaa.gov/news/ocean-heat-content-rises (accessed Mar. 05, 2022).

[3] NOAA, "What is Coastal Blue Carbon?," *Coastal Blue Carbon*, 2022. https://oceanservice.noaa.gov/ecosystems/coastal-blue-carbon/ (accessed Mar. 24, 2022).

[4] M. von Unger *et al.*, "Blue Nature-Based Solutions in Nationally Determined Contributions Blue Nature-Based Solutions in Nationally Determined Contributions a Booklet for Successful Implementation," Bonn, 2020.

[5] UNECA, *Africa's Blue Economy: A policy handbook*. Addis Ababa: Economic Commission for Africa, 2016.

[6] B. Neumann, A. T. Vafeidis, J. Zimmermann, and R. J. Nicholls, "Future coastal population growth and exposure to sea-level rise and coastal flooding--a global assessment," *PLoS One*, vol. 10, no. 3, pp. e0118571–e0118571, Mar. 2015, doi: 10.1371/journal.pone.0118571.

[7] AU-IBAR, *Africa Blue Economy Strategy*. Nairobi: African Union – Inter-African Bureau for Animal Resources (AU-IBAR), 2019.

[8] I. Okafor-yarwood, "The effects of oil pollution on the marine environment in the Gulf of Guinea — the Bonga Oil Field example," *Transnatl. Leg. Theory*, 2018, doi: 10.1080/20414005.2018.1562287.

[9] I. Okafor-Yarwood, "Illegal, unreported and unregulated fishing, and the complexities of the sustainable development goals (SDGs) for countries in the Gulf of Guinea," *Mar. Policy*, vol. 99, pp. 414–422, 2019, doi: https://doi.org/10.1016/j.marpol.2017.09.016.

[10] I. J. Adewumi *et al.*, "Climate Change and the Sustainable Ocean Economy," 11, 2021.

[11] WMO, "State of the Climate in Africa 2019," Geneva. Accessed: Apr. 13, 2022. [Online]. Available: https://library.wmo.int/doc_num.php?explnum_id=10421.

[12] D. Eckstein, V. Kunzel, L. Schafer, E. Opfer, and R. Schwarz, "Global Climate Index 2021," Berlin. Accessed: Apr. 14, 2022. [Online]. Available: https://www.germanwatch.org/sites/default/files/Global Climate Risk Index 2021_2.pdf.

[13] C. Welsh, "Statement before the House Foreign Affairs Subcommittee on Africa, Global Health, and Global Human Rights 'The Effects of Climate Change in Africa.,'" 2021, doi: 10.4060/ca9692en.

[14] A. L. Dahir, "Lagos, Abidjan, Durban, Dar es Salaam among coastal African cities most vulnerable to climate change — Quartz Africa," *Quartz Africa*, Jun. 02, 2017. https://qz.com/africa/997384/lagos-abidjan-durban-dar-es-salaam-among-coastal-african-cities-most-vulnerable-to-climate-change/ (accessed Apr. 14, 2022).

[15] UNEP, "How a UN climate deal can help prevent refugee crises," Geneva, 2015. [Online]. Available: http://www.rtcc.org/2015/09/10/how-a-un-climate-deal-can-help-prevent-refugee-crises/%5Cnpapers3://publication/uuid/F1E5E380-2E89-493B-8513-90A7DB3D7DB1.

[16] UNEP, "Displacement and Environment in Africa: What is the relationship?," *Story: Disaster and Conflicts*, 2016. https://www.unep.org/news-and-stories/story/displacement-and-environment-africa-what-relationship (accessed Apr. 14, 2022).

[17] NASA, "NASA-led study reveals the causes of sea level rise since 1900 – NASA Sea Level Change Portal," 2020. https://sealevel.nasa.gov/news/191/nasa-led-study-reveals-the-causes-of-sea-level-rise-since-1900 (accessed Apr. 14, 2022).

[18] IPCC, "Climate Change 2022: Impacts, Adaptation and Vulnerability," Bonn, 2022. [Online]. Available: https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_FinalDraft_FullReport.pdf.

[19] IPCC, "Climate Change 2022: Impact, Adaptation and Vulnerability: Summary for Policymakes," Bonn, 2022. [Online]. Available: https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_FinalDraft_FullReport.pdf.

[20] O. Fashae and O. David, "Impact of climate change on sea level rise in Lagos, Nigeria," *Int. J. Remote Sens.*, vol. 32, pp. 9811–9819, Dec. 2011, doi: 10.1080/01431161.2011.581709.

[21] L. Croitoru, J. J. Miranda, and M. Sarraf, "The Cost of Coastal Zone Degradation in West Africa : Benin, Cote d'Ivoire, Senegal, and Togo," Washington, DC, 2019. Accessed: Nov. 05, 2020. [Online]. Available: http://documents1.worldbank.org/curated/en/822421552504665834/pdf/The-Cost-of-Coastal-Zone-Degradation-in-West-Africa-Benin-Cote-dIvoire-Senegal-and-Togo.pdf.

[22] M. I. Vousdoukas *et al.*, "African heritage sites threatened as sea-level rise accelerates," *Nat. Clim. Chang. 2022 123*, vol. 12, no. 3, pp. 256–262, Feb. 2022, doi: 10.1038/s41558-022-01280-1.

[23] Y. Hamed *et al.*, "Climate impact on surface and groundwater in North Africa: a global synthesis of findings and recommendations," *Euro-Mediterranean J. Environ. Integr. 2018 31*, vol. 3, no. 1, pp. 1–15, Jul. 2018, doi: 10.1007/S41207-018-0067-8.

References

[24] T. E. Idowu and K. H. Lasisi, "Seawater intrusion in the coastal aquifers of East and Horn of Africa: A review from a regional perspective," *Sci. African*, vol. 8, p. e00402, Jul. 2020, doi: 10.1016/J.SCIAF.2020.E00402.

[25] K. Makoye, "Tanzania: Costal Communities Forced to Drink Seawater - allAfrica.com," *All Africa*, 2013. https://allafrica.com/stories/201310220888.html (accessed Apr. 14, 2022).

[26] IOC-UNESCO, "Technical report on the status of coastal vulnerability in Central African countries," Paris, 2020. [Online]. Available: https://unesdoc.unesco.org/ark:/48223/pf0000373623.

[27] G. of Angola, "National Adaptation Programme of Action Under the United Nations Framework Convention on Climate Change (UNFCCC)," Luanda, 2011.

[28] IPCC, "IPCC Special Report on Global Warming of 1.5 °C," *Intergovernmental Panel on Cli*, 2018. .

[29] A. Mather and D. Stretch, "A Perspective on Sea Level Rise and Coastal Storm Surge from Southern and Eastern Africa: A Case Study Near Durban, South Africa," *Water*, vol. 4, pp. 237–259, Dec. 2012, doi: 10.3390/w4010237.

[30] K. Dube, G. Nhamo, and D. Chikodzi, "Flooding trends and their impacts on coastal communities of Western Cape Province, South Africa," *GeoJournal*, pp. 1–16, Jun. 2021, doi: 10.1007/S10708-021-10460-Z/FIGURES/7.

[31] L. Croitoru, J. J. Miranda, and M. Sarraf, "The coast of coastal zone degredation in West Africa: Benin, Côte d'Ivoire, Senegal and Togo," 2019. Accessed: Apr. 15, 2022. [Online]. Available: https://documents1.worldbank.org/curated/en/822421552504665834/pdf/The-Cost-of-Coastal-Zone-Degradation-in-West-Africa-Benin-Cote-dIvoire-Senegal-and-Togo.pdf.

[32] R. Nicholls *et al.*, "Coastal systems and low-lying areas," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, 2014.

[33] UNDRR/CRED, "Human Cost of Disasters: An Overview of the Last 20 Years 2000-2019," 2020. Accessed: Apr. 15, 2022. [Online]. Available: https://reliefweb.int/sites/reliefweb.int/files/resources/Human Cost of Disasters 2000-2019 Report - UN Office for Disaster Risk Reduction.pdf.

[34] UNICEF, "Cyclone Idai and Kenneth | UNICEF," *2019*, 2019. https://www.unicef.org/mozambique/en/cyclone-idai-and-kenneth (accessed Apr. 14, 2022).

[35] MECN-EF, "Profil de la Zone Côtière de la RDC," Kinshasa, 2007.

[36] UNDP, "Mozambique Cyclone Idai Post Disaster Needs Assessment Conference Version," 2019. [Online]. Available: https://www.undp.org/content/dam/undp/library/Climate and Disaster Resilience/PDNA/PDNA Mozambique Cyclone Idai - Post-Disaster Needs Assessment_Executive Summary.pdf.

[37] IPCC, "Climate Change 2021: The Physical Science Basis - Summary for Policymakers," Bonn, 2021. [Online]. Available: https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf.

[38] F. E. Asuquo and O. C. Oghenechovwen, "Detection and spatio-temporal variation of marine heatwaves in the Gulf of Guinea, Nigeria," *J. Oceanogr. Mar. Sci.*, vol. 10, no. 2, pp. 11–21, doi: 10.5897/JOMS2019.0152.

[39] D. Obura *et al.*, "Vulnerability to collapse of coral reef ecosystems in the Western Indian Ocean," *Nat. Sustain. 2021 52*, vol. 5, no. 2, pp. 104–113, Dec. 2021, doi: 10.1038/s41893-021-00817-0.

[40] A. Sangomla, "Ocean heat takes a toll on coral reefs and tourism in Africa," *DownToEarth - Widlife and Biodiversity*, 2018. https://www.downtoearth.org.in/news/wildlife-biodiversity/shadow-over-coral-reefs-60590 (accessed Apr. 15, 2022).

[41] D. Shepard, "Africa feeling the heat of climate change | Africa Renewal," *Africa Renewal*, 2017. https://www.un.org/africarenewal/magazine/may-july-2017/africa-feeling-heat-climate-change (accessed Apr. 15, 2022).

[42] M. Shaalan, M. El-Mahdy, M. Saleh, and M. El-Matbouli, "Aquaculture in Egypt: Insights on the Current Trends and Future Perspectives for Sustainable Development," 2017, doi: 10.1080/23308249.2017.1358696.

[43] B. Adeleke, D. Robertson-Andersson, G. Moodley, and S. Taylor, "Aquaculture in Africa: A Comparative Review of Egypt, Nigeria, and Uganda Vis-À-Vis South Africa," *Rev. Fish. Sci. Aquac.*, vol. 29, no. 2, pp. 167–197, 2020, doi: 10.1080/23308249.2020.1795615/FORMAT/EPUB.

[44] C. Collins *et al.*, "Impacts of climate change on aquaculture," Jan. 2020, doi: 10.14465/2020.arc21.aqu.

[45] R. Pearson and R. Connolly, "Climate change impacts on coastal fisheries and aquaculture," Gold Coast, Australia, 7, 2016. [Online]. Available: https://coastadapt.com.au/sites/default/files/factsheets/T312_8_Fisheries and aquaculture.pdf.

[46] UNEP, "Paper on the sagassum seaweed invasion of West African and Caribbean Coasts: UNEA-2 Side Event," 2016, doi: 10.1038/nature12860.

[47] International Center for Biosaline Agriculture, "Improving agricultural resilience to salinity and climate change through development and promotion of pro-poor technologies and management strategies (RESADE)," 2019. https://www.biosaline.org/projects/improving-agricultural-resilience-salinity-and-climate-change-through-development-and (accessed Sep. 01, 2022).

References

[48] I. Maluleke, "The effects of drought on agriculture," Jan. 2020. https://www.grainsa.co.za/the-effects-of-drought-on-agriculture (accessed Sep. 01, 2022).

[49] UNICEF, "The climate crisis is a child rights crisis: Introducing the Children Climate Risk Index," New York, 2021. [Online]. Available: https://www.unicef.org/media/105376/file/UNICEF-climate-crisis-child-rights-crisis.pdf.

[50] P. H. Olayiwola, "A Systematic Review of Climate Change, Water Security, and Conflict Potentials in Kwazulu-Natal Province, South Africa," *African Renaiss.*, vol. 19, no. 1, pp. 125–145, Mar. 2022, doi: 10.31920/2516-5305/2022/19n1a6.

[51] IPCC, "Summary for Policymakers," in *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, 2022.

[52] UNPOS, "Piracy off the Somali Coast: Workshop commissioned by the Special Representative of the Secretary General of the UN to Somalia Ambassador Ahmedou Ould-Abdallah." United Nations Political Office for Somalia, Nairobi, 2008.

[53] IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge; New York: Cambridge University Press, 2014.

[54] A. Savelli *et al.*, "Impact Pathways and Research Agenda for the Climate-Mobility-Security Nexus." CGIAR FOCUS Climate Security;, Rome, 2021.

[55] B. Yuen and A. Kumssa, *Climate Change and Sustainable Urban Development in Africa and Asia*. Dordrecht: Springer Science, 2011.

[56] A. M. Song *et al.*, "Intersectorality in the governance of inland fisheries," *Ecol. Soc.*, vol. 23, no. 2, p. 17, 2018, doi: https://doi.org/10.5751/ES-10076-230217.

[57] K. Fakoya, A. Oloko, and S. Harper, "Understanding Vulnerability of Urban Waterfront Communities to Rapid Development: The Case of Lagos Lagoon, Nigeria.," in *Blue Justice*, Cham: Springer, 2022, pp. 451–467.

[58] O. Akinmoladun and O. Adejumo, "Urban agriculture in Metropolitan Lagos: an inventory of potential land and water resources," *J. Geogr. Reg. Plan.*, vol. 4, no. 1, pp. 9–19, 2011.

[59] N. Bhattacharya, J. Godinez, S. Goldmuntz, V. G. Polanco, and M. Shayan, "Addressing climate adaptation for waterfront communities in Lagos, Nigeria through improved land tenure and access to basic services," in *Climate Resiliency and Climate Change, Inter-Policy School Summit, Harris Public Policy, University of Chicago*, Chicago: University of Chicago, 2020.

[60] T. McDonnell, "Slum Dwellers in Africa's Biggest Megacity Are Now Living in Canoes," *NPR*, 2017. .

[61] R. Roberts and O. Okanya, "Measuring the socio-economic impact of illegal demolitions; a comparative study between displaced and existing informal settlements," *Soc. Sci. J.*, 2018, doi: https://doi.org/10.1016/j.soscij.2018.12.003.

[62] S. Kaye, "Climate change and maritime security," in *Climate Change and the Ocean*, Cheltenham and Northampton: Edward Elgar Publishing, 2012, pp. 153–165.

[63] C. Jasparro and J. Taylor, "Climate change and regional vulnerability to transnational security threats in Southeast Asia," *Geopolitics*, vol. 13, no. 2, pp. 232–256, 2008, doi: 10.1080/14650040801991480.

[64] FAO/OECD, "Fishing for development." FAO/OECD, Paris, 2014.

[65] C. Finegold, "The importance of fisheries and aquaculture to development," *Fish. Sustain. Dev.*, pp. 353–364, 2009.

[66] E. H. Allison *et al.*, "Vulnerability of national economies to the impacts of climate change on fisheries," *Fish Fish.*, vol. 10, no. 2, pp. 173–196, 2009.

[67] D. Herr and G. R. Galland, *The Ocean and Climate Change: Tools and Guidelines for Action*. Gland: International Union for Conservation of Nature and Natural Resources, 2009.

[68] S. Axbard, "Income Opportunities and Sea Piracy in Indonesia: Evidence from Satellite Data," *Am. Econ. J. Appl. Econ.*, vol. 8, no. 2, pp. 154–94, 2016.

[69] R. M. Desai and G. E. Shambaugh, "Measuring the global impact of destructive and illegal fishing on maritime piracy: A spatial analysis," *PLoS One*, vol. 16, no. 2 February, pp. 1–17, 2021, doi: 10.1371/journal.pone.0246835.

[70] N. L. Bindoff *et al.*, "Changing Ocean, Marine Ecosystems, and Dependent Communities," in *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*, Cambridge; New York: Cambridge University Press, 2019, pp. 447–587.

[71] D. Belhabib, V. W. Y. Lam, and W. W. L. Cheung, "Overview of West African fisheries under climate change: Impacts, vulnerabilities and adaptive responses of the artisanal and industrial sectors," *Mar. Policy*, vol. 71, pp. 15–28, 2016, doi: 10.1016/j.marpol.2016.05.009.

[72] V. W. Y. Lam, W. W. L. Cheung, W. Swartz, and U. R. Sumaila, "Climate Change Impacts on Fisheries in West Africa: Implications for Economic, Food and Nutritional Security," *African J. Mar. Sci.*, vol. 34, no. 1, pp. 103–117, 2012, doi: 10.2989/1814232X.2012.673294.

[73] BBC, "'Fish are vanishing' - Senegal's devastated coastline," *BBC*, 2018. .

[74] A. Kamara, "Mauritanian coast guard arrests 70 Senegalese fishermen," *AA*, 2017. .

References

[75] U. E. Daxecker and B. C. Prins, "Searching for sanctuary: Government power and the location of maritime piracy," *Int. Interact.*, vol. 41, no. 4, pp. 699–717, 2015, doi: 10.1080/03050629.2015.1016159.

[76] B. Germond and A. D. Mazaris, "Climate change and maritime security," *Mar. Policy*, vol. 99, pp. 262–266, 2019, doi: 10.1016/j.marpol.2018.10.010.

[77] USAID, "Climate Change Risk Profile: Senegal," no. February. USAID, Washington, D.C., pp. 1–4, 2017.

[78] M. de l'Environnement et de la P. de la Nature, "Deuxième communication nationale à la Convention Cadre des Nations Unies sur les Changements Climatiques," Dakar, 2010.

[79] D. Gueye and P. Deshingkar, "Irregular Migration in Senegal Faith, Dreams and Human Smuggling through the Desert and Sea." Migrating out of Poverty, Brighton, 2020.

[80] J. Carling, "Unauthorized migration from Africa to Spain," *Int. Migr.*, vol. 45, no. 4, pp. 3–37, 2007, doi: 10.1111/j.1468-2435.2007.00418.x.

[81] M. Poeze, "In search of greener pastures? Boat-migrants from Senegal to the Canary Islands." African Studies Centre, Leiden, 2010, doi: 10.5822/978-1-59726-377-1_4.

[82] K. Koser, "Irregular migration, state security and human security." Global Commission on International Migration, Geneva, 2005.

[83] K. Levin *et al.*, "Designing and Preparing INDCs," Washington, D.C, 2015. [Online]. Available: https://www.undp.org/sites/g/files/zskgke326/files/publications/designing-preparing-indcs.pdf.

[84] H.-O. Pörtner *et al.*, "The Ocean and Cryosphere in a Changing Climate Special Report of the Intergovernmental Panel on Climate Change Edited by," 2022, doi: 10.1017/9781009157964.

[85] R. Trebilco *et al.*, "Warming world, changing ocean: mitigation and adaptation to support resilient marine systems," *Rev. Fish Biol. Fish.*, vol. 32, no. 1, pp. 39–63, 2022, doi: 10.1007/s11160-021-09678-4.

[86] Because the Ocean Initiative, "Ocean for Climate Ocean Related Strategies for Climate Measures (Nationally Determined Contributions, National Adaptation Plans, Adaptation Communications, and National Policy Frameworks.)," p. 48, 2019, [Online]. Available: https://www.becausetheocean.org/wp-content/uploads/2019/10/Ocean_for_Climate_Because_the_Ocean.pdf.

[87] Lecerf M., Herr D., Thomas T., Elverum C., Delrieu E., and Picourt L., "Coastal and marine ecosystems as Nature-based Solutions in new or updated Nationally Determined Contributions, Ocean & Climate Platform,Conservation International, IUCN, GIZ, Rare, The Nature Conservancy and WWF," *PLoS One*, vol. 11, no. 5, 2021.

[88] J.-P. Gattuso *et al.*, "Opportunities for increasing ocean action in climate strategies," Paris, France, N°02/19, 2019. [Online]. Available: https://www.iddri.org/sites/default/files/PDF/Publications/Catalogue Iddri/Propositions/201911-PB0219-ocean NDCs_0.pdf.

[89] K. Caldeira *et al.*, "The Ocean as a Solution to Climate Change: Five Opportunities for Action," Washington, DC, 2019. [Online]. Available: http://www.oceanpanel.org/climate.

[90] J. P. Gattuso *et al.*, "Ocean solutions to address climate change and its effects on marine ecosystems," *Front. Mar. Sci.*, vol. 5, no. OCT, 2018, doi: 10.3389/fmars.2018.00337.

[91] P. Canals Ventin and L. Lazaro Marin, "Towards Nature-based Solutions in the Mediterranean," 2019.

[92] L. Sinay and R. W. Carter, "Climate Change Adaptation Options for Coastal Communities and Local Governments," *Climate*, vol. 8, no. 1, pp. 1–15, 2020, doi: 10.3390/cli8010007.

[93] O. Hoegh-Guldberg *et al.*, "The Ocean as a Solution to Climate Change Five Opportunities for Action," 2019. Accessed: Mar. 28, 2022. [Online]. Available: http://www.oceanpanel.org/climate.

[94] S. Grafakos, K. Trigg, M. Landauer, L. Chelleri, and S. Dhakal, "Analytical framework to evaluate the level of integration of climate adaptation and mitigation in cities," *Clim. Change*, vol. 154, no. 1–2, pp. 87–106, 2019, doi: 10.1007/s10584-019-02394-w.

[95] M. Hallsworth, S. Parker, and J. Rutter, *Policy Making in the Real World: Evidence and Analysis*. London: Institute for Government, 2011.

[96] P. Heckendorn *et al.*, "The impact of geoengineering aerosols on stratospheric temperature and ozone," *Environ. Res. Lett.*, vol. 4, p. 12, 2009, doi: 10.1088/1748-9326/4/4/045108.

[97] M. Burden and R. Fujita, "Better fisheries management can help reduce conflict, improve food security, and increase economic productivity in the face of climate change," 2019, doi: 10.1016/j.marpol.2019.103610.

[98] C. M. Free *et al.*, "Realistic fisheries management reforms could mitigate the impacts of climate change in most countries," *PLoS One*, vol. 15, no. 3, p. e0224347, 2020, doi: 10.1371/JOURNAL.PONE.0224347.

[99] The Guardian, "EU accused of exporting problem of overfishing with Mauritania deal ," Jun. 09, 2016. https://www.theguardian.com/global-development/2016/jun/09/eu-european-union-accused-exporting-problem-overfishing-mauritania-deal (accessed Apr. 26, 2022).

[100] G. Brunswijck, "EU Fishing deals in Africa: Scraping the Bottom of the Barrel," *AEFJN*, Sep. 10, 2016. http://aefjn.org/en/eu-fishing-deals-in-africa-scraping-the-bottom-of-the-barrel/ (accessed Apr. 26, 2022).

References

[101] I. Okafor-Yarwood and D. Belhabib, "The duplicity of the European Union Common Fisheries Policy in third countries: Evidence from the Gulf of Guinea," *Ocean Coast. Manag.*, vol. 184, p. 104953, 2020, doi: https://doi.org/10.1016/j.ocecoaman.2019.104953.

[102] CGTN Africa, "Experts say Africa's fisheries sector threatened by subsidies ," *Africa News*, Jul. 14, 2021. https://africa.cgtn.com/2021/07/14/experts-say-africas-fisheries-sector-threatened-by-subsidies/ (accessed Sep. 01, 2022).

[103] World Bank, "Climate Change and Marine Fisheries in Africa: Assessing Vulnerability and Strengthening Adaptation Capacity," 2019. Accessed: May 07, 2022. [Online]. Available: https://documents1.worldbank.org/curated/en/280891580715878729/pdf/Climate-Change-and-Marine-Fisheries-in-Africa-Assessing-Vulnerability-and-Strengthening-Adaptation-Capacity.pdf.

[104] V. Muhala *et al.*, "Climate Change in Fisheries and Aquaculture: Analysis of the Impact Caused by Idai and Kenneth Cyclones in Mozambique," *Front. Sustain. Food Syst.*, vol. 5, p. 420, Nov. 2021, doi: 10.3389/FSUFS.2021.714187/BIBTEX.

[105] FAO, "Impact of climate change on fisheries and aquaculture in the developing world and opportunities for adaptation," Rome, 2018. Accessed: Sep. 01, 2022. [Online]. Available: https://reliefweb.int/attachments/bbcdec01-0666-3718-962f-1dc46a013dfe/i9705en.pdf.

[106] F. E. Msuya, J. Bolton, F. Pascal, K. Narrain, B. Nyonje, and E. J. Cottier-Cook, "Seaweed farming in Africa: current status and future potential," vol. 1, p. 3, doi: 10.1007/s10811-021-02676-w.

[107] FAO, "FAO Aquaculture News," *FAO Aquaculture News*, Rome, May 2021.

[108] S. Likela, "Coastal environment at risk of degradation ," - *The Namibian*, Jul. 13, 2018.

[109] M. K., M. Seely, and K. Jacobson, "Desertification and Namibia: a perpective," *J. African Zool.*, vol. 108, pp. 21–36, Jan. 1994.

[110] J. P. Reser and J. K. Swim, "Adapting to and coping with the threat and impacts of climate change.," *Am. Psychol.*, vol. 66, no. 4, pp. 277–289, 2011, doi: 10.1037/a0023412.

[111] G. G. Singh *et al.*, "A rapid assessment of co-benefits and trade-offs among Sustainable Development Goals," *Mar. Policy*, vol. 93, pp. 223–231, 2018, doi: https://doi.org/10.1016/j.marpol.2017.05.030.

[112] K. L. Wilson, D. P. Tittensor, B. Worm, and H. K. Lotze, "Incorporating climate change adaptation into marine protected area planning.," *Glob. Chang. Biol.*, vol. 26, no. 6, pp. 3251–3267, Jun. 2020, doi: 10.1111/gcb.15094.

[113] F. Simard, D. Laffoley, and J. M. Baxter, Eds., "Marine protected areas and climate change: adaptation and mitigation synergies, opportunities and challenges," 2016, [Online]. Available: https://portals.iucn.org/library/sites/library/files/documents/2016-067.pdf.

[114] V. De Lucia, "The BBNJ negotiations and ecosystem governance in the arctic," *Mar. Policy*, p. 103756, Dec. 2019, doi: 10.1016/J.MARPOL.2019.103756.

[115] R. Tiller and E. Nyman, "Ocean plastics and the BBNJ treaty—is plastic frightening enough to insert itself into the BBNJ treaty, or do we need to wait for a treaty of its own?," *J. Environ. Stud. Sci. 2018 84*, vol. 8, no. 4, pp. 411–415, May 2018, doi: 10.1007/S13412-018-0495-4.

[116] I. Kelman, "Climate Change and the Sendai Framework for Disaster Risk Reduction," *Int. J. Disaster Risk Sci.*, vol. 6, 2015, doi: 10.1007/s13753-015-0046-5.

[117] M.H. Ruckelshaus *et al.*, "The IPBES global assessment: pathways to action." Trends in Ecology & Evolution, vol. 35, no. 5, pp. 407-414, 2020, doi: 10.1016/j.tree.2020.01.009.

[118] F. Berkes, "Community conserved areas: policy issues in historic and contemporary context," *Conserv. Lett.*, vol. 2, no. 1, pp. 20–25, 2009, doi: 10.1111/j.1755-263x.2008.00040.x.

[119] P. A. Williams, L. Sikutshwa, and S. Shackleton, "Acknowledging indigenous and local knowledge to facilitate collaboration in landscape approaches- lessons from a systematic review," *Land*, vol. 9, no. 9, pp. 1–17, 2020, doi: 10.3390/LAND9090331.

[120] J. Nalau, S. Becken, S. Noakes, and B. Mackey, "Mapping tourism stakeholders' weather and climate information-seeking behavior in Fiji," *Weather. Clim. Soc.*, vol. 9, no. 3, pp. 377–391, 2017, doi: 10.1175/WCAS-D-16-0078.1.

[121] M. Tengö, E. S. Brondizio, T. Elmqvist, P. Malmer, and M. Spierenburg, "Connecting diverse knowledge systems for enhanced ecosystem governance: The multiple evidence base approach," *Ambio*, vol. 43, no. 5, pp. 579–591, 2014, doi: 10.1007/s13280-014-0501-3.

[122] S. Boillat and F. Berkes, "Perception and Interpretation of Climate Change among Quechua Farmers of Bolivia," *Ecol. Soc.*, vol. 18, no. 4, p. 21, 2013.

[123] A. C. Johnson, J. Noel, D. P. Gregovich, L. E. Kruger, and B. Buma, "Impacts of submerging and emerging shorelines on various biota and indigenous alaskan harvesting patterns," *J. Coast. Res.*, vol. 35, no. 4, pp. 765–775, 2019, doi: 10.2112/JCOASTRES-D-18-00119.1.

References

[124] J. Bongaarts, "Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services," *Popul. Dev. Rev.*, vol. 45, no. 3, pp. 680–681, 2019, doi: https://doi.org/10.1111/padr.12283.

[125] D. Mijatović, F. Van Oudenhoven, P. Eyzaguirre, and T. Hodgkin, "The role of agricultural biodiversity in strengthening resilience to climate change: Towards an analytical framework," *Int. J. Agric. Sustain.*, vol. 11, no. 2, pp. 95–107, 2013, doi: 10.1080/14735903.2012.691221.

[126] L. A. German, A. Karsenty, and A.-M. Tiani, *Gouverner les forêts africaines à l'ère de la mondialisation*, no. January. 2010.

[127] A. Venkatesan *et al.*, "Astro2020 APC White Paper: Collaboration with Integrity: Indigenous Knowledge in 21st Century Astronomy," *Baas*, vol. 57, pp. 20–28, 2019.

[128] D. McGregor, "Lessons for collaboration involving traditional knowledge and environmental governance in Ontario, Canada," *AlterNative*, vol. 10, no. 4, pp. 340–353, 2014, doi: 10.1177/117718011401000403.

[129] FAO, "Adaptation to Climate Change in Agriculture, Forestry and Fisheries: Perspective, Framework and Priorities," 2007.

[130] H. Dannevig, *Agenda-setting the unknown : A study of local and regional governance of adaptation in Norway Aalborg Universitet Agenda-setting the unknown Dannevig , Halvor*, no. January. 2016.

[131] C. H. et al. Adger, W.N, Pulhin, J.M., Barnett, J., Dabelko, G.D., Hovelsrud, G.K., Levy, M, Oswald Spring, U., Vogel, "Adaptation Needs and Options. In Climate Change 2014 – Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects: Working Group II Contribution to the IPCC Fifth Assessment Report," Cambridge, 2014. doi: https://doi.org/10.1017/CBO9781107415379.

[132] K. K. Zander, Y. T. Maru, D. Race, S. Mathew, and J. Rainbird, *Perceptions About Climate Change Impacts and Adaptation—Case Studies from Indigenous Communities in Northern and Central Australia*, no. September. 2021.

[133] S. Boillat and F. Berkes, "Perception and interpretation of climate change among quechua farmers of bolivia: Indigenous knowledge as a resource for adaptive capacity," *Ecol. Soc.*, vol. 18, no. 4, 2013, doi: 10.5751/ES-05894-180421.

[134] B. A. Gyampoh, S. Amisah, M. Idinoba, and J. N. Nkem, "Using traditional knowledge to cope with climate change in rural Ghana," *Unasylva*, vol. 60, no. 231–232, pp. 70–74, 2009.

[135] Salick Jan and Byg Anja, "Indigenous peoples and climate change," 2007.

[136] M. Balehegn, S. Balehey, C. Fu, and W. Liang, "Indigenous weather and climate forecasting knowledge among Afar pastoralists of north eastern Ethiopia: Role in adaptation to weather and climate variability," *Pastoralism*, vol. 9, no. 1, 2019, doi: 10.1186/s13570-019-0143-y.

[137] J. Mercer, I. Kelman, B. Alfthan, and T. Kurvits, "Ecosystem-based adaptation to climate change in caribbean small island developing states: Integrating local and external knowledge," *Sustainability*, vol. 4, no. 8, pp. 1908–1932, 2012, doi: 10.3390/su4081908.

[138] D. O. Awinda, R. Kapiyo, and J. J. Kitetu, "Indigenous Local Knowledge in Climate Change Adaptation by Smallholder Farmers in Lake Victoria," *Merit Res. J. Agric. Sci. Soil Sci.*, vol. 9, no. 4, pp. 29–36, 2021, doi: 10.5281/zenodo.4725974.

[139] J. O. Ajibade, L.T. and Eche, "Indigenous knowledge for climate change adaptation in Nigeria. In: Indigenous knowledge systems and climate change management in Africa," CTA, Wageningen, The Netherlands, 2017.

[140] J. Sheffield *et al.*, "A drought monitoring and forecasting system for sub-sahara african water resources and food security," *Bull. Am. Meteorol. Soc.*, vol. 95, no. 6, pp. 861–882, 2014, doi: 10.1175/BAMS-D-12-00124.1.

[141] T. F. Thornton and A. M. Scheer, "Collaborative engagement of local and traditional knowledge and science in marine environments: A review," *Ecol. Soc.*, vol. 17, no. 3, 2012, doi: 10.5751/ES-04714-170308.

[142] P. Girot *et al.*, "Integrating Community and Ecosystem Based Approaches in Climate Change Adaptation Responses," *Ecosyst. Livelihoods Adapt. Netw.*, pp. 1–19, 2012.

[143] B. R. Johnston, M. Barber, V. Strang, I. Klaver, L. Hiwasaki, and A. R. Castillo, *Water, cultural diversity, and global environmental change: Emerging trends, sustainable futures?* Paris, 2012.

[144] Catherine Marciniak, "Impact of climate change on Indigenous communities - ABC News," *ABC News*, Apr. 14, 2016.

[145] W. Leal Filho *et al.*, "Impacts of climate change to African indigenous communities and examples of adaptation responses," *Nat. Commun.*, vol. 12, no. 1, p. 6224, 2021, doi: 10.1038/s41467-021-26540-0.

[146] E. Nyadzi, O. C. Ajayi, and F. Ludwig, "Indigenous knowledge and climate change adaptation in Africa: a systematic review.," *CAB Rev. Perspect. Agric. Vet. Sci. Nutr. Nat. Resour.*, vol. 16, no. 029, 2021, doi: 10.1079/pavsnnr202116029.

[147] F. O. Akinyemi, "Climate change and variability in semiarid palapye, eastern Botswana: An assessment from smallholder farmers' perspective," *Weather. Clim. Soc.*, vol. 9, no. 3, pp. 349–365, 2017, doi: 10.1175/WCAS-D-16-0040.1.

References

[148] E. Mavhura, S. B. Manyena, A. E. Collins, and D. Manatsa, "Indigenous knowledge, coping strategies and resilience to floods in Muzarabani, Zimbabwe," *Int. J. Disaster Risk Reduct.*, vol. 5, no. July 2017, pp. 38–48, 2013, doi: 10.1016/j.ijdrr.2013.07.001.

[149] J. McLean, K. Galloway, A. Ramos-Castillo and J. Rubis, "Indigenous peoples, marginalized populations and climate change: Vulnerability, Adaptation and Traditional Knowledge. Proceedings of the Expert Workshop on Indigenous Peoples, Marginalized Populations and Climate Change," *Proc. Expert Work. Indig. Peoples, Marginalized Popul. Clim. Chang. IPMPCC/2011/Mex/Report*, no. January 2011, 2011, doi: 10.13140/2.1.2114.2728.

[150] UNFCC, "National Adaptation Programme of Action on Climate Change," *UNFCC, NAPA CAPE VERDE*, pp. 1–34, 2007, doi: https://unfccc.int/resource/docs/napa/cpv01.pdf.

[151] M. Hauzer, "Community-based governance of artisanal fisheries Ngazidja island, Comoros," University of Victoria, 2011.

[152] F. Muyambo, Y. T. Bahta, and A. J. Jordaan, "The role of indigenous knowledge in drought risk reduction: A case of communal farmers in South Africa," *Jamba J. Disaster Risk Stud.*, vol. 9, no. 1, pp. 1–6, 2017, doi: 10.4102/jamba.v9i1.420.

[153] R. A. B. Kpadonou, P. Y. Adégbola, and S. D. Tovignan, "Local Knowledge and Adaptation to Cliamate Change in Ouémé Valley, Benin," *African Crop Sci. J.*, vol. 20, no. s2, pp. 181–192, 2012.

[154] O. Fabiyi and J. Oloukoi, "Indigenous Knowledge System and Local Adaptation Strategies to Flooding in Coastal Rural Communities of Nigeria," *J. Indig. Soc. Dev.*, vol. 2, no. 1, pp. 1–19, 2013.

[155] Leiter Timo and Pringle Patrick, *Pitfalls and potential of measuring climate change adaptation through adaptation metrics*. UN-City Copenhagen: UNEP DTU Partnership, 2018.

[156] F. N. Tubiello and C. Rosenzweig, "Developing climate change impact metrics for agriculture," *Integr. Assess. J.*, vol. 8, no. 1, pp. 165–184, 2008.

[157] L. Christiansen, G. Martinez, and P. Naswa, *Adaptation metrics: Perspectives on measuring, aggregating and comparing adaptation results*. UN-City Copenhagen: UNEP DTU Partnership, 2018.

[158] M. Stadelmann, M., Michaelowa, A. Butzengeiger-Geyer, S. and Kohler, "Universal metrics to compare the effectiveness of climate change adaptation projects," *Handb. Clim. Chang. Adapt.*, pp. 2143–2160, 2011.

[159] UN Climate Change Conference: COP22 & CMP12, "Metrics of Adaptation Conference: Measuring Adaptation for Concrete Action", Marrakech, pp 1-2, 27 September 2016.

[160] H. Donatti,C., Andrade, A., Burke,L., Chhetri,N., Cook, J., Fedele, G and Schurman, "Measuring the adaptation outcomes of Ecosystem-based adaptation Technical Brief," *Conserv. Int.*, 2016.

[161] IPCC, "Climate change 2014: Mitigation of climate change. Contribution of working group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)," *Cambridge Univ. Press*, 2014.

[162] UNEP, "The Adaptation Gap Report 2017," Nairobi Kenya, 2017.

[163] P. Leiter, Timo and Pringle, "Climate Change Policy Brief: Adaptation metrics and the Paris Agreement," *Dtsch. Gesellschaft für Int. Zusammenarbeit GmbH*, pp. 1–5, 2017.

[164] J. D. Ford, L. Berrang-Ford, A. Lesnikowski, M. Barrera, and S. Jody Heymann, "How to track adaptation to climate change: A typology of approaches for national-level application," *Ecol. Soc.*, vol. 18, no. 3, 2013, doi: 10.5751/ES-05732-180340.

[165] M. Spearman and H. McGray, "Making Adaptation Count: Concepts and Options for Monitoring and Evaluation," *Dtsch. Gesellschaft fur*, p. 96, 2011.

[166] S. Matthew, S. Truck, C. Truong, and P. Davies, *Monitoring and evaluation in adaptation Final Report*, no. July. 2016.

[167] J. Estrella, M. and Gaventa, "Who counts reality? Participatory monitoring and evaluation: A literature review", IDS Working Paper, no. 70," *IDS, Sussex*, vol. 5.

[168] J. Lennie, J. Tacchi, B. Koirala, M. Wilmore, and A. Skuse, "Equal Access Participatory Monitoring and Evaluation Toolkit," p. 13, 2011.

[169] OECD, *National Climate Change Adaptation: Emerging Practices in Monitoring and Evaluation*, no. June. 2015.

[170] P. Kurukulasuriya, "UNDP monitoring framework for climate change adaptation," *United Nations Dev. Program.*, pp. 1–28, 2008.

[171] UNDP, "UNDP Monitoring and evaluation framework for adaptation to climate change, draft for comments," *United Nations Dev. Program.*, 2007.

[172] D. Bours, C. McGinn, and P. Pringle, "Monitoring & evaluation for climate change adaptation : A synthesis of tools, frameworks and approaches," *SEA Chang. CoP, Phnom Penh UKCIP*, no. October, pp. 1–67, 2013, doi: 10.13140/RG.2.1.1151.4645.

[173] P. Pringle, "AdaptME Toolkit for monitoring and evaluation of adaptation activities, manual," *United Kingdom Clim. Impacts Program.*, pp. 1–37, 2011.

[174] GEF, "Climate change adaptation – LDCF/SCCF Adaptation monitoring and assessment tool (AMAT), Excel tracking file," *Glob. Environ. Facil.*, 2012.

[175] GEF, "Climate change adaptation – LDCF/SCCF Adaptation monitoring and assessment tool (AMAT), guidance note," *Glob. Environ. Facil.*, 2012.

References

[176] N. Brooks, S. Anderson, I. Burton, S. Fisher, N. Rai, and I. Tellam, *An operational framework for Tracking Adaptation and Measuring Development (TAMD)*, no. 5. 2013.

[177] I. Karani, N. Kariuki, and F. Osman, *Tracking Adaptation and Measuring Development in Kenya* . Research Report. IIED, London 2014.

[178] S. Fisher, and Anderson, "Developing meaningful local metrics for climate adaptation: learning from applying the TAMD framework at local scales," In: L. Christiansen, G. Martinez, P. Naswa (eds), Adaptation metrics: Perspectives on measuring, aggregating and comparing adaptation results *UNEP DTU Partnership*, pp. 75 - 85, 2018.

[179] GIZ, "Saved health, saved wealth: an approach to quantifying the benefits of climate change adaptation; Practical application in coastal protection projects in Viet Nam," *Dtsch. Gesellschaft für Int. Zusammenarbeit*, p. 56, 2013.

[180] A. Droesch, A.C., Gaseb, N., Kurukulasuriya, P., Mershon,A., Moussa, K.M., Rankine, D., and Santos, "United Nations Development Programme Community-Based Adaptation Programme A Guide to the Vulnerability Reduction Assessment," 2008.

[181] L. Artur, I. Karani, M. Gomes, S. Maló, and S. Anlaué, *Tracking Adaptation and Measuring Development in Mozambique*. 2014.

[182] I. Karani, "Development of national and sub-national adaptation metrics: Lessons from Kenya," In: L. Christiansen, G. Martinez, P. Naswa (eds), Adaptation metrics: Perspectives on measuring, aggregating and comparing adaptation results *UNEP DTU Partnership*, 2018, pp. 113 – 125, 2018.

[183] UNECA/ACPC, "Loss and Damage in Africa," Kigali, 2014. Accessed: May 01, 2022. [Online]. Available: https://climateanalytics.org/media/uneca__2014__loss_and_damage_in_africa.pdf.

[184] D. Herr and J. Hamilton, "Building on the Ocean-Climate Dialogue: Options for strengthening action on the ocean under the UNFCCC," 2021. [Online]. Available: https://www.conservation.org/docs/default-source/publication-pdfs/building-on-the-ocean-climate-dialogue_6-october-2021.pdf.


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