

Scenarios: WIO Coastal and Marine Environmental Futures

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Opposite page: Can WIO coastal landscape paradises like this one in Seychelles still exist in the future under change scenarios? © Lawrence Hislop / www.grida.no

INTRODUCTION

The 45 649 km long coastline of Africa is shared by 33 mainland countries and six island states. The continents' coastal and marine resources support many economic activities such as shipping, transportation and recreation. The state of the coastal environment is an indicator of the potential economic benefit that can be derived from the natural goods and services that accrue to government accounts and their people. An analytical exploration of the future state of coastal resources is required to understand the relationship between the use and exploitation of natural goods and services and the concept of sustainable development. The western Indian Ocean (WIO) Regional State the Coast Report (RSOCR) presents an exploratory scenario and policy analysis to better inform anticipatory planning and management of coastal and marine resources. To address gaps and policy failures in the governance of ocean and coasts, there is a need to explore a more holistic approach to managing complex seascapes, such as spatial management approaches like the use of marine protected areas (MPAs) and marine spatial planning, which both seek to implement ecosystem-based management. This integrated approach to management that considers the entire ecosystem, including humans, can be employed across the WIO region through futuristic analyses.

Complex issues such as environmental change are best communicated by way of contrasting 'scenarios' or 'worlds', which explore future trends, trade-offs, implications and

policy lessons derived from our understanding of the drivers of environment change. Scenarios are imagined 'futures'. They are seldom presented as a single forecast, but rather as a set of alternative plausible future pathways that can provide options for decision- and policy-making. The range of future options describes both optimistic and problematic futures in the hope of benchmarking both 'extremes' and 'middle-grounds' in order to steer decision- and policy-making to achieve a desirable future. For better results of an assessment process, scenarios should explore different ramifications and extensions of critical uncertainties and interaction of factors within specific themes.

Long-range planning, informed by scenarios, enables decision-makers to predict and explore a range of possible alternative futures in order to identify possible corrective actions and the subsequent and resulting consequences. In this regard, scenario analysis can be effective in supporting strategies for resource-use management and conservation. Scenario analysis goes beyond simple contingency planning, sensitivity analysis and computer simulations by presenting comprehensive exploration of alternative futures.

It is thus desirable for regional, national and sub-national stakeholders in the WIO region to mainstream scenario planning in order to anticipate weaknesses and inflexibilities in coastal and marine resources management towards growth and development. If understood and anticipated, such weaknesses can be avoided, or their impact reduced, through appropriately targeted and costed interventions, rather than engaging mitigation measures as they

emerge. One benefit of scenario planning is that by expanding the range of future outcomes considered in strategic decision-making, managers avoid the risk of “putting all their eggs in one basket”. The results are more robust plans and decisions that allow for adaptation to changing circumstances. Furthermore, scrutinizing the underlying assumptions of current decisions and management practices enables policy-makers to test ideas, make mistakes, and learn from them without risking real-life management failures or collapsing resources.

This chapter aims to: 1) develop and explore explicit relationships between issues addressed throughout this report, 2) identify priority challenges, and 3) identify promising policy options and their plausible trajectories. Using a diametric scenario framework (considering opposite extremes), the chapter explores the emerging and future relationships between the opportunities, successes and challenges in the management of coastal resources in line with the Drivers, Pressures, States, Impact and Response (DPSIR) Framework (UNEP 2013). Two diametrically-opposed scenarios or pathways were explored, namely:

- The ‘**challenge scenario**’ articulating longer-term options for achieving goals and targets and reversing /redirecting any undesirable; and,
- The ‘**business as usual**’ pathways.

An indicator-based environmental future assessment is then used to elaborate the scenarios. The chapter presents the methodology and approach used in the scenario building process, theme-based future trends and an exposition of how to use and refine the scenarios going forward as well as a set of scenario adaptation recommendations. Policy and management options emanating from this futures assessment process are also presented.

METHODOLOGY AND APPROACH

Overall Approach

Scenario building for the RSOCR was designed to offer an inclusive and systematic approach to think about the future of the WIO environment, using selected themes, issues and indicators as prioritized by stakeholders of the reporting process. The scenario approach adopted the DPSIR framework and was integrated based on variables, links, and feedbacks relevant to dynamic modelling of marine social–ecological systems. Adopting a systems approach, the process also included domains that influence human behavioural change, including society, knowledge systems,

political and institutional setting, and the economy. The approach involved multi-disciplinary teams of experts, and authors, and representatives of stakeholders to design the scenario framework, scope (both temporal and thematic) and elaborate narratives as the building blocks for the storylines. This ensured the involvement of different individual and collective actors, including implementing organisations as well as the activities of actors such as capture fisheries, land use, and aquaculture, which will ultimately affect the ecological system assessed in the scenario building processes. As an example, Figure 32.1 illustrates the framework for exploring future interlinkages in fisheries.

The Two Pathways

The assessment explored the evolution of sector changes for creating social–ecological scenarios (future marine ecosystem dynamics) with respect to the physical environment, the biogeochemical environment, food-web dynamics (low- and high- trophic-level species), and the human dimension. Many recent environmental and socio-economic assessments have adopted this integrated approach (UNEP, IOC-UNESCO 2009). The assessment used two main scenarios (or worlds):

- The Conventional World Scenario (CWS) representing a business as usual pathway (BAU) with current trajectories extrapolated towards 2050; and,
- The Challenge Scenario or Sustainable World Scenario (SWS) representing sustainable future as captured in the Western Indian Ocean Strategic Action Programme (WIO-SAP) aspirations (UNEP/Nairobi Convention Secretariat 2009) and the Sustainable Development Goals (SDGs).

The main assumptions integral to the scenarios are summarized in Table 32.1.

Business as Usual – Baseline Scenario

Under this scenario (Conventional World Scenario), growth and development of the WIO moves along a trajectory representing a continuation of current trends, without major policy shifts. People aspire for personal independence, material wealth and greater mobility, to the detriment of wider societal and coastal environmental goals.

Challenge Scenario – Towards a Sustainable World

The Sustainable World Scenario (SWS) depicts a future where deliberate attempts are made to manage the coastal

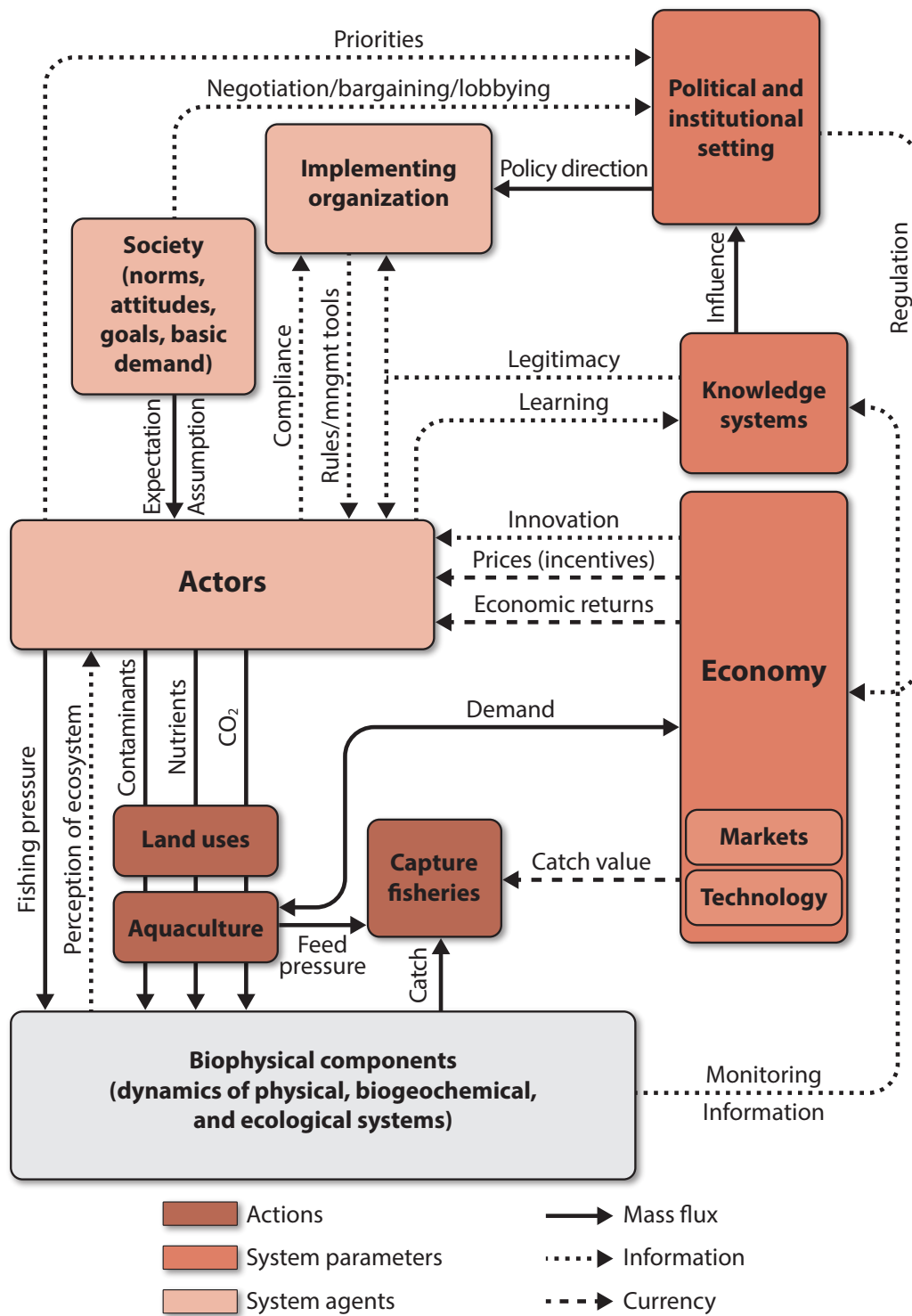


Figure 32.1. Framework for thematic assessment - human dimensions for creating social-ecological scenarios using the fisheries example. Source: Österblom and others (2013).

environment in ways that meet internationally agreed development goals with clear targets for associated coastal and marine activities. These targets are articulated, especially in the WIO-SAP document, but also the Sustainable Development Goals (SDGs), particularly the targets of goal

14 - *Conserve and sustainably use the oceans, seas and marine resources for sustainable development*), and related regional and national targets. SWS is based on the assumption that the management of coastal and marine resources will proceed in a manner that limits degradation and associated

Table 32.1. Key assumptions of the future trends in drivers and issues under two future scenarios.

Driver/Issues	Conventional World Scenario (CWS)	Sustainable World Scenario (SWS)
Climate Change and Ocean Systems	Global climate change +0.94°C by 2020 Surface temperature rises occasioning increase in ocean currents/wind speed Sea level rises in WIO	Global climate change +0.88°C by 2050 Surface temperature rises at a lower rate occasioning weaker increase in ocean currents /wind speed Sea level rises in WIO
Fisheries and Mariculture	Common Fisheries Policy plays only a minor role The industry becomes more industrialised and global in scale Indigenous supplies supplemented with increasing inputs	The main goal is local self-sufficiency The industry is heavily subsidised to protect local resources There is strenuous effort to protect wildlife and habitats Management responsibility transfers to regional committees An effort-based management system is introduced The number of small inshore vessels increases within sustainable range and under strict controls. This varies from country to country A network of closed areas to protect stocks, habitats and species Rapid growth in organic and low-input aquaculture
Oil & Gas	Primary energy consumption increases by 1.5% per year Emphasis is on maintaining national supplies, control over exports Drive to exploit all remaining domestic resources, including oil and gas Exploration throughout the WIO regional & into deeper waters Many new (short-lived) installations, wide scale decommissioning of rigs High energy prices associated with increased difficulty in extracting remaining resources	Primary energy consumption increases by 0.5% per year Some local coal and oil exploited, but with stringent environmental controls High energy prices lead to large-scale adoption of energy efficiency measures Reduced demand for oil and gas results in lower risk of spillage etc. Installations commissioned and decommissioned according to local/ regional needs
Ports and Shipping	Exports from the WIO expand to 35 % of regional GDP Growth in international trade and removal of trade barriers/constraints Port development largely market-driven Deep-water ports in WIO expand, smaller ports close Few environmental controls, greater pollution risks New shipping routes created	Exports from the WIO increases by over 40 % of GDP Sectors operating in global markets experience growth prospects Closure of some international ports and supply chains to increase efficiency Greater reliance on regional scale maritime activities Stakeholder input into port development plans More international vessels but stricter environmental regulations Increased monitoring and legal control of passing ships
Tourism	Few constraints on international travel Increased domestic tourism Domestic travellers more inclined to go overseas Cruise ship industry and use of marinas continue to expand More attractive resorts Competition between resorts for investment and development Resorts become more homogeneous	Focus on local and regional identity Unique selling points of destinations heavily drawn upon Increased visitation by domestic tourists Destinations will provide more eco-friendly activities Development in-keeping with existing natural landscape WIO residents support cultural heritage including historical sites Co-operatives and joint ventures encourage development
Energy	Renewable electricity generation viable, but not widely adopted Low priority attached to climate change 'Climate Levy' abandoned as it would constrain economic growth Slow growth in offshore electricity generation at today's level No regional electricity grid WIO energy generation and trading policy in place but challenges in implementation	Wide range of small-scale renewable technologies exploited, particularly wind Global climate targets viewed as being of primary importance Imported energy or electricity less important, local resources become main focus Offshore electricity generation expands contributing over 2% of global electricity in 2050 due largely to expansion of renewables such as wave power (Hammer and others, 2012) Growth in offshore wind/thermal/tidal and solar energy expand

deleterious human and ecological outcomes. The main objective of the scenario is to reveal the choices of policies and management programmes that would ensure the attainment of both the desired environmental and related human well-being outcomes.

A strong momentum already exists in drivers playing out in current trends (as outlined by the CWS), and as a result, to deflect such trends so as to meet WIO-SAP targets is expected to remain a daunting challenge. This is largely due to social and demographic dynamics, climate change, habitat changes, and other inland and offshore developments. There is a realisation that the attractive route to the future requires considerable investments, coupled with mind set and behavioural change of stakeholders, policy makers and other communities, institutions and nations and, that long-term goals are best achieved through cooperation at a regional level. The scenario reveals ‘what it would take to overcome barriers to meeting sustainability goals’ (UNEP 2013).

The WIO State of the Coast scenario analysis aimed at transforming the current baseline trends into the desirable WIO-SAP targets as they relate to regional and international goals, especially SDGS (see Box 32.1) and targets, using the following process:

- Selection of themes consistent with those found in the chapters of the WIO State of the Coast Report;
- Selection of relevant models or results from existing scenario analyses in order to provide qualitative and quantitative trends and storylines for each of the thematic areas; Identification of long-term goals including internationally agreed goals (eg 2°C target, WIO-SAP targets), as well as environmental limits consistent with the scenario time line of 2050. Note that 2050 is the maximum long-range scenario time limit. Mindful that each theme/goal might have a different time horizon, the future explorations were guided by the specific target milestones for the theme;
- Analysis of possible synergies and trade-offs between the goals and targets in different coastal and marine domains by linking the different scenario findings with the goals and health targets in order to construct the narrative;
- Identification and analysis of possible alternative strategies (or wedges) – transformative policies – with necessary national, local and regional differentiation but globally consistent. The intention was to ensure that the alternative strategies and policies should close the gap between the current trend and the identified goals for 2050 through policy changes, technological solutions, lifestyle

and behavioural changes and promotion of existing good practices. The associated risks, human and ecological benefits were then appropriately flagged along the way to complete the storyline; and,

- Identification and analysis of transformative policies necessary to realise long-term goals. The identified goals were developed from promising initiatives, decisions, actions and development that are already underway such as regional efforts to create marine protected areas (MPAs) and Locally Managed Marine Areas (LMMAs) (Rocliffe and others, 2014). The analysis also points out where desirable outcomes cannot be met in order to influence further research, capacity development and policy innovations.

The process of transforming the baseline trend towards achieving the targets identified under the Sustainability World (and WIO-SAP) scenario, is illustrated in Figure 32.2.

EXPLORING THE WIO COASTAL FUTURES

Drivers of Future WIO-Coastal Changes

The main regional drivers of change include destructive and unsustainable pelagic and coastal fishery practices (dynamite and overfishing), climate change, land-based sedimentation, watershed pollution and soil run-off, population growth and urbanisation, poorly planned infrastructure, tourism and shipping activities.

Demography and Socio-cultural inertia

Population growth, urbanisation and other demographic changes will invariably affect the state of the coastal and marine resources in WIO region. The current over 60 million inhabitants of the coastal area of the WIO region is expected to double by 2050. Complications from population growth will be felt in countries where a youthful cohort outstrips economic growth rates, resulting in increased unemployment and unprecedented pressure on resources with subsequent social consequences (Halpern and others, 2008). Tied to this is ongoing urbanisation and the growth and development of coastal “mega-cities”. Expansion of military and naval presence in response to the growth and spread of militant Islamist movements will continue to pose challenges in relation to governance and population growth/economic opportunities. Increase in human pressure on coastal and marine resources in the WIO region is evident from decreasing fish catches, increasing use of destructive fishing practices and by the increasing volume of untreated sewage and nutrient runoff released into near-

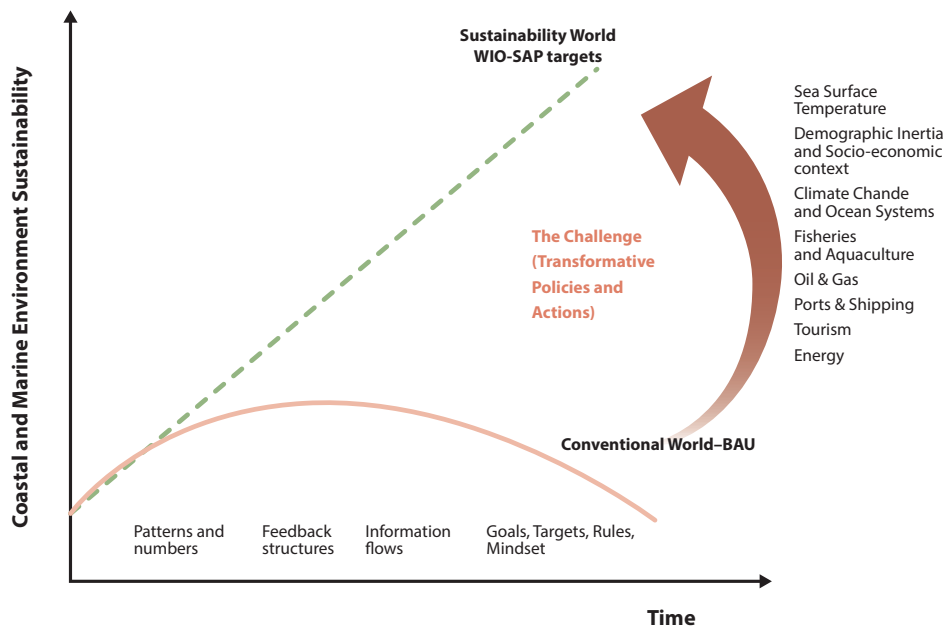


Figure 32.2. The WIO State of Coast Report Scenario Framework.

BOX 32.1. SDG 14 – CONSERVE AND SUSTAINABLY USE THE OCEANS, SEAS AND MARINE RESOURCES FOR SUSTAINABLE DEVELOPMENT

- 14.1: by 2025, prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution
- 14.2: by 2020, sustainably manage, and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience and take action for their restoration, to achieve healthy and productive oceans
- 14.3 minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels
- 14.4: by 2020, effectively regulate harvesting, and end overfishing, illegal, unreported and unregulated (IUU) fishing and destructive fishing practices and implement science-based management plans, to restore fish stocks in the shortest time feasible at least to levels that can produce maximum sustainable yield as determined by their biological characteristics
- 14.5: by 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on best available scientific information
- 14.6: by 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, and eliminate subsidies that contribute to IUU fishing, and

- refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organisation (WTO) fisheries subsidies negotiation
- 14.7: by 2030 increase the economic benefits to Small Island Developing States (SIDS) and Least Developed Countries (LDCs) from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism
- 14.8: increase scientific knowledge, develop research capacities and transfer marine technology taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular SIDS and LDCs
- 14.9: provide access of small-scale artisanal fishers to marine resources and markets
- 14.10: ensure the full implementation of international law, as reflected in UNCLOS for states that are parties to it, including, where applicable, existing regional and international regimes for the conservation and sustainable use of oceans and their resources

shore areas (Ausubel and others, 2010).

Climate Change

The fifth assessment report of the IPCC (2013, 2014) indicates that the climate of the WIO is already changing and different sectors are already feeling the impacts. Further climate change is inevitable in the coming decades and will continue to affect national growth and development of WIO states. Current plans for climate change adaptation can mitigate the impacts, but relative to the size of WIO national economies, the cost of adaptation is high (Jäger and others, 2013). The region will benefit from systematic integration of climate adaptation, mitigation and development approaches. This will require new patterns of coastal development to include low-carbon growth and clean investment while international cooperation will remain vital to reduce global carbon emissions.

The waters of the WIO have already warmed by over 1°C over the last 3 decades and the sea surface temperatures are projected to continue warming to more than 2°C by 2100 (Figure 32.3). The combined effects of changes in precipitation and evaporation patterns are highly likely to cause a greater freshwater deficit which in turn causes increased ocean water salinity (OSS), a potential increase

of more than 0.5 units over the next five decades (Crooks and others, 2011). The projected changes in both temperature and salinity are likely to affect other oceanographic processes including thermohaline circulation, upwelling systems, ocean acidification and formation of deep-water masses. The uncertainty surrounding sea level rise, ocean water temperature and salinity with climate change make it difficult to predict the actual sea-level changes in the region, hence the wide range of values offered by IPCC (2014) and Jäger and others (2015).

Climate change has already affected the availability and stability of marine and coastal resources (IPCC 2014). Predicted long-term climatic changes include: rainfall and wind variation, intensity and frequency of cyclones, rise and fall of sea level, wave-height and temperature (atmospheric and sea surface). These changes will not only affect human activities such as fishing, agriculture, transport and the coastal communities but also coastal and marine ecosystems and habitats. Over the next two to three decades, regional coastal and marine ecosystems will continue to provide critical services and benefits to the well-being of the dependent communities. These include food security, climate regulation, water provision and recreation. These services will likely to be directly

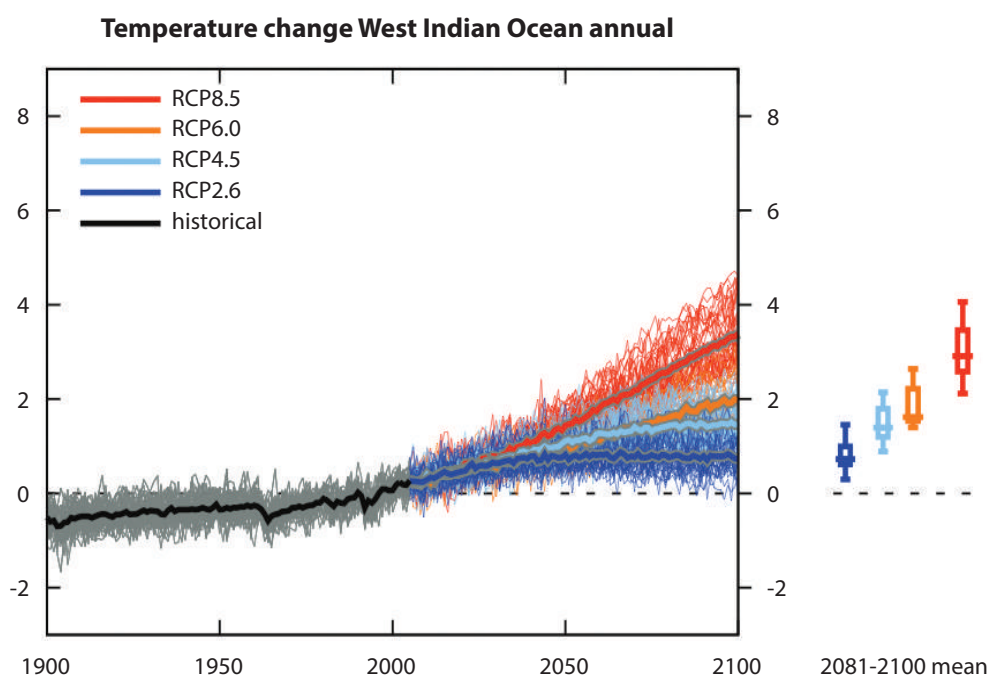


Figure 32.3. Time series of annual sea surface temperature change relative to 1986–2005, averaged in the West Indian Ocean (25°S to 5°N, 52°E to 75°E). Thin lines denote one ensemble member per model, thick lines the multi-model mean. On the right-hand side the 5th, 25th, 50th (median), 75th and 95th percentiles of the distribution of 20-year mean changes are given for 2081–2100 in the four Regional Climate Projection (RCP) scenarios. Source: IPCC (2013).

and indirectly affected by climate change and some of these are indicated below:

- *Fisheries:* Although the WIO fisheries are already overfished (75 per cent of stocks) or fully exploited, the vulnerability of fish diversity and fishing catches to climate change is likely to escalate due to the accompanying increases in salinity, acidification of the ocean, increasing sea temperatures and the spread of invasive species (FAO 2008, FAO-SOSA 2013). The small-scale fishing industry is expected to be less resilient to climate change;

- *Tourism:* Impacts of climate change on tourism are complex and multifaceted. The expected reductions in freshwater resources and local food shortages (through impacts on agriculture) may increase the costs of running tourism, while coastal erosion, flooding and habitat loss could significantly affect tourist access to beaches and other destination and sports attractions. The eminent aftermath would be consequences for revenues and job security; and,

- *Effects on oceans and coasts including protected areas:* The projected rise in temperatures and ocean acidification may lead to regime shift, moving from one stable state. Regime shifts are likely to be driven by a combination of human and natural factors, including increased nutrients from septic systems, drought, water diversion, and removal

of grazers (IPCC 2013). A further complicating factor is that driver variables in marine ecosystems operate at different scales, with some variables responding to perturbation quickly, eg water clarity and salinity. Shifts in distribution of species may cause existing MPAs to be inappropriately sited.

Thematic Scenario Analysis

The goals and targets defined by the WIO-SAP for the Protection of the Coastal and Marine Environment of the region formed the basis for benchmarking future trajectories which are illustrated in Figure 32.4. Both the sustainable development goals (Box 32.1) and WIO-SAP goals (Box 32.2) focus on sustainable coastal and marine management through assessments and capacity building; development and implementation of ecosystem based management including MPAs; environmental governance including implementation of the protocol for the protection of the marine and coastal environment of the WIO from land-based sources and activities (LBSA protocol); development of protocol on integrated coastal zone management (ICZM) under the Nairobi Convention; information and awareness; policy options on climate change; ports and harbours development; oil and gas; green economy; and partnerships for activities on description of Eco-



Figure 32.4. Images of the future: Selected targets of WIO scenario analysis

logically or Biologically Significant Marine Areas (EBSAs), National Jurisdiction (ABNJ), and Particularly Sensitive Vulnerable Marine Ecosystems (VMEs), Areas Beyond Sea Areas (PSSAs).

BOX 32.2.

WIO-SAP PROJECT GOALS. SOURCE: UNEP/NAIROBI CONVENTION SECRETARIAT (2009)

Objective A: Critical coastal habitats in the WIO region protected, restored and managed for sustainable use

1. Incentives to encourage compliance with best practice in critical habitat management established
2. Coastal zoning based on integrated economic, social and environmental considerations implemented
3. Critical habitat management strategies in place and contributing to ecologically sustainable ecosystem services and regional protection
4. A regional monitoring and evaluation plan established and implemented for critical habitats, coasts and shorelines
5. Integrated Coastal Zone Management legislation in place in all countries
6. National legislation to improve management of bilateral and regional issues strengthened
7. Awareness of the importance of critical habitats raised significantly

Objective B: Water quality in the WIO region meets international standards by year 2035

1. Effluent discharge standards developed and regionally harmonized
2. Marine water standards developed and regionally harmonized
3. Regional best practice framework models for municipal wastewater management developed and adopted
4. Collection, treatment and disposal of effluents undertaken in accordance with regional standards
5. Environmental Management Systems and Cleaner Production Technologies encouraged
6. Stakeholders sensitized and political support harnessed in favour of pollution prevention

Objective C: River flows in the WIO region are wisely and sustainably managed by the year 2035

1. Awareness of Environmental Flow Assessment (EFA) as a tool for wise river basin management raised
2. Capacity for applying EFA increased amongst key stakeholders

3. EFA conducted and operating rules integrated into river basin management plans for selected basins

4. Methodologies agreed upon and tools developed for coherent application of EFA in both freshwater and coastal management
5. Policy discussion on coastal and marine issues catalysed through collaboration between

Shared Water Courses Institutions and the Nairobi Convention secretariat

6. National freshwater management and coastal zone management frameworks fully integrated.
7. Effects of impoundments and dam operations on river flow variability and sediment discharge analysed and results implemented
8. Significance of identified wetlands on flow variability, sediment discharge and coastal and marine productivity investigated and wisely managed
9. Impacts of catchment management on coastal habitats, shorelines and water quality investigated and results adopted in river basin and coastal and marine management

Objective D: By 2015, stakeholders will collaborate effectively at the regional level in addressing transboundary challenges

1. Capacity for ecosystem-based management improved
2. Appropriate legal and regulatory frameworks for LBSA management in place and implemented at the national level
3. Awareness of the importance of good marine and coastal management raised among policy makers and legislators, civil society and the private sector
4. Regional legal frameworks for LBSA management updated and harmonized with multilateral environmental agreements
5. Regional coordination and inter-sectoral governance improved
6. Appropriate financial mechanisms developed and implemented
7. Knowledge management undertaken effectively

Conventional World Scenario

Current inadequacies in governance frameworks remain unaddressed and result in ongoing degradation of the coastal and marine environment of the WIO. The prevailing governance issues include poor coordination of government, lack of environmental awareness amongst policy-makers, inappropriate and weak legislation and a lack of adequate institutional frameworks and capacities for managing development pressures. Major developments, such as Lamu port construction, oil and gas infrastructure, Bagamoyo and other projects, are implemented without evidence of appropriate mitigation, or risk analyses.

With these trends, the decline in capture fish production and diversity continue. Damage of reef quality and extent may affect reef fish resources, and further affect reef-based tourism and associated livelihoods, while reduction in reef formation may reduce coastal protection from storms and increase erosion and storm damage.

The diversity of nearshore habitats (including beaches, rocky shores, muddy shores and mangroves, coral reefs and seagrass beds) continue to diminish due to continued impact of climate, alteration of nearshore geomorphology

and unsustainable coastal land-use. Direct exploitation of coastal resources lead to greater vulnerability of species such as sea turtles. Non-compliance with regulations and inappropriate fisheries methods continue to be a major cause of turtle mortalities. Other species affected by habitat destruction/degradation include molluscs and crustaceans, invertebrates, cephalopods and various seaweeds. Table 32.2 illustrates a comparison of the level of exploitation of the stocks of three invertebrate groups in WIO countries, under the two scenarios.

The projected exponential increase in population, coupled with a high reliance on coastal and marine resources for sustenance and livelihoods is likely to compound the challenges facing biodiversity conservation in the WIO. This is in addition to other human activities such as continued mining and exploration, sand harvesting, trawl fishing and mega developments such as ports and oil rigs.

Major maritime activities such as shipping and development of ports and communication infrastructure, such as submarine cables, continue without any evidence of risk minimisation or of mitigative action to reduce costs to the coastal environment. The volume of seaborne trade in the WIO is expected to increase by over 5 per cent annually

Table 32.2. The status of invertebrate stocks in WIO countries. Source: data from FAO-SWIOFC (2012).

Country	Invertebrate	Current Status (2012)	Conventional Worlds	Sustainability Worlds
Comoros	Cephalopods	Under-exploited	Fully exploited	Moderately exploited
	Bivalves	Under-exploited	Moderately exploited	Moderately exploited
Kenya	Octopus	Fully exploited	Over-exploited	Fully exploited
	Sea Cucumbers	Over-exploited	Depleted	Fully exploited
	Bivalves	Fully exploited	Depleted	Fully exploited
Madagascar	Octopus	Over-exploited	Over-exploited	Fully exploited
	Sea cucumbers	Over-exploited	Depleted	Fully exploited
	Bivalves	Fully exploited	Over-exploited	Fully exploited
Mauritius	Octopus	Moderately exploited	Over-exploited	Moderately exploited
	Sea cucumbers	Depleted	Depleted	Fully exploited
Seychelles	Sea cucumbers	Over-exploited	Depleted	Fully exploited
South Africa	Octopus	Under-exploited	Fully exploited	Moderately exploited
	Bivalves	Fully exploited	Over-exploited	Fully exploited
Tanzania	Octopus	Over-exploited	Depleted	Fully exploited
	Cuttlefish and squid	Fully exploited	Over-exploited	Fully exploited
	Sea cucumbers	Over-exploited	Depleted	Fully exploited
	Bivalves	Over-exploited	Depleted	Fully exploited

KEY: Under-exploited (light green), Moderately exploited (yellow), Fully exploited (brown), Over-exploited (black), Depleted (red)

towards 2040. More merchant ships of 100 Gross Tonnage and over will increase their operations in the region, with the capacity of the fleet expected to increase by over 60 per cent by 2030 (DNV 2012). The majority of the increased shipping will be cargo vessels and oil tankers. Consequently, the concerns about pollution, resulting from day-to-day operational activities and accidents, as well as translocation of invasive alien species through ballast water and hull-fouling, will remain. Various socio-economic concerns continue to prevail under CWS including piracy, the illegal dumping of toxic waste and potential impacts of climate change on shipping and uncontrolled growth in urbanisation and port infrastructure.

Sustainability World Scenario

Implementation of the WIO-SAP has supported the adoption of legislation and development of management tools and training for the domestication and implementation of ICZM and LBSA. The empowerment of inter-ministerial committees and regional task forces strengthened implementation of ICZM or EBM approaches. As a result, the region is arresting ecological disturbance and in some cases has seen the restoration of ecosystems and habitats with high levels of biodiversity and endemism. Thus, the WIO region maintains its value as a 'global refuge' of coastal and marine biodiversity. On-going regional dialogue and implementation of normative frameworks for policy reforms will limit degradation of the coastal and marine environment of the region.

The value of healthy, critical, coastal and marine habitats is secured through the development of tools and methodologies to support their sustainable management and restoration critical coastal and marine habitats. National Plans of Action (NPAs), Integrated Coastal Zone Management (ICZM) plans or National Environmental Management (NEM) plans should be developed by all WIO countries by 2025. Development of tools and skills contributes substantially to the understanding and sustainable management of critical habitats. Importantly, transboundary collaboration and harmonized management within the region, including on-the-ground site-specific management interventions and habitat restoration such as the management of Tana Delta (Kenya), Tanga Coastal Area (Tanzania), and the Zambezi Delta (Mozambique), provide an opportunity to sustain ecosystem health using a "ridge-to-reef" approach, alongside other WIO-SAP interventions.

The WIO region has a very active Coral Reef Task

force, that promotes the protection of coral reefs from further degradation by supporting governments to manage marine water quality, pollution, siltation as well as through concerted reef restoration based on lessons-learned from work that begun in 2012 in Cousin Island, Seychelles and in Tanzania. Further work on local, national and regional environmental conservation, maintenance of connectivity corridors through sustainable MPAs, fisheries and coastal management, will all contribute to healthy coral reefs.

Regionally, the Coral Reef Task Force, under the Nairobi Convention, coordinates the Global Coral Reef Monitoring Network (GCRMN) and partnerships through diverse but well-coordinated projects, such as the Indian Ocean Commission's ISLANDS project. It is anticipated that by 2020 all WIO countries will have achieved 10 per cent CBD target of coverage of marine zones under effective management as per the Aichi Target 11 (*By 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape*).

Despite an increase in shipping activities in the region, consideration given to management of related environmental risks has been achieved through the strengthening of port and flag state controls. This is being implemented in order to realise the African Union's 2050 Africa's Integrated Maritime (AIM) Strategy of increasing African ownership of ships, but at the same minimising environmental risks. Countries have intensified efforts towards the development of a regional maritime surveillance system and establishment of pollution monitoring and reporting systems. Further efforts targeted the development of a regional approach to the management of ships as vectors of alien and invasive species, as well as mainstreaming of climate change adaptation of the maritime sector.

Adequate capacity to regulate ships, provide them with appropriate maritime services (such as navigational aids) and respond to shipping accidents were built continuously throughout the period 2015 – 2040. The draft Regional Contingency Plan developed under the WIO Marine Highway Project in 2012 was established within the framework of the Emergency Protocol and establishment of a Regional Coordination Centre (RCC) for Marine Pollution Preparedness and Response in the Western Indian Ocean by

2018. All countries in the region, including Somalia, will develop and operationalize National Oil Spill Contingency Plans by 2017 and update them continuously towards 2040 to better serve the region.

USING THE SCENARIOS

How might the WIO 2050 scenarios be used?

The WIO scenarios presented in this chapter can be used by stakeholder throughout the WIO region and beyond. Potential users include conservation managers, regional land-use planners, as well as coastal and flood-defence managers. The analytical approach, discussion document and tools developed as part of the scenarios approach is combined and presented as a ‘scenarios gateway’. The WIO coastal scenarios targeted government departments, fisheries organisations, offshore oil and gas operators, coastal engineers, marine biologists, conservationists, regional development agencies and tourist authorities, amongst others. The information and decision-making needs of these stakeholders will determine how they use the futures assessed in this chapter. The various users should employ the scenarios as a starting point of discussions but should draw their own conclusions through elaboration and evaluation in tune with their own needs.

The use of the scenario framework in this chapter must be adaptive and respond accordingly as new challenges, opportunities or threats emerge. The various management and policy platforms of the Nairobi Convention can adopt the scenario framework for engagement between actors. It can also be used to communicate evidence for decision-making and as a tool for medium- and long-term planning and environmental monitoring. This will make the qualitative exploration of trends more participative; draw from the experience of practitioners (policy, science and management practice); and use the scenarios as powerful communication tools.

To achieve the benefits of this approach there’s a need for ‘champions’ of scenario planning at a senior level of stakeholder organisations, in order to attract interest and to stimulate creative thinking. The scenarios could also be instrumental in motivating for monitoring and research programmes. Scenarios provide heuristic frameworks and approaches for addressing uncertainty in climate change impact assessments and supporting research. Research and development for coastal management will thus benefit from robust quantitative assessment of potential outcomes,

application of scientific methods combined with consultation as well as effective use of data, simulation methods and expert knowledge.

Options for Policy and Management

As presented in this chapter, there is bound to be varying degree of change, and regional stakeholders will therefore need to adopt policies, strategies and long-term plans to take account of these future changes. Guidelines are needed on dealing with uncertainty in decision-making, risk assessment packages and cost-benefits analysis for stakeholders. This chapter documented a ‘scenario gateway’ to aid the development and assessment of possible adaptation strategies.

The use of scenarios is new to most regional stakeholders and the state of coast reporting. It is therefore necessary to expand its use within the context of existing programmes, processes and tools developed and adapted for coastal and marine management. This may require provision of a guidance document and appropriate consultative platforms to engage stakeholders in exploring future changes and undertake a constant review of principles of good adaptation strategies based on the scenarios. The documentation and platforms should showcase long-term adaptation case-studies, and interactive tools and methodologies for costing the effects of current decisions/actions, risk-uncertainty and the use of decision-making frameworks. The proposed fora for science-policy engagement could disseminate the scenarios among organisations with responsibilities to manage coastal and marine resources. In this regard, scenarios will highlight the importance of consultation and inter-disciplinary thinking.

The following options emerged from the scenario analysis:

- Application of the principles of good governance within WIO countries but also globally.
- Control and sustainable management of coastal and marine goods and services and other activities in WIO region that have or may have a negative impact on the status of coastal and marine environment. These activities must not compromise uses and activities of future generations nor the capacity of marine ecosystems to respond to changes.
- Improved management and control of pollution in the WIO in order to reduce impacts or risks to human and/or on ecosystem health and/or uses of the ocean.
- Protect and, where practicable, restore the function-

ing of marine ecosystems in order to achieve and maintain good environmental status of these ecosystems.

Managing the Coasts and Oceans- MPA example

Current trends in coastal development, climate change and other pressures are poised to disrupt the functioning of ecosystems and the goods and services they offer. This will have adverse impacts on human interest especially in coastal areas where MPAs are located and human dependencies on marine resources are high. There is need for immediate and substantive actions to increase the adaptive capacity of coastal marine ecosystems and the people that depend on them, especially in relation to MPAs. To do this, SWS indicate that, it will be prudent to address the options for strengthening MPAs in the WIO, as listed in Box 32.3.

Adaptive Management

Adaptive management is an environmental management strategy that attempts to reduce the inherent uncertainty in ecosystems (Green and Garmestani 2012, Garmestani and Harm 2013). Adaptive management operates in an iterative manner, rather than providing discrete conclusions based on science, acknowledging that our understanding of natural systems is constantly evolving (Benson and Garmestani 2011a, 2011b). On the other hand, adaptive governance is a form of governance that is dependent upon adaptive management and incorporates formal institutions, informal groups/networks, and individuals at multiple

scales for purposes of collaborative environmental management (Folke and others, 2005). Cosens (2010) notes the broadened understanding of adaptive governance to include not only formal legal frameworks and institutions but also collaboration and cooperation across different levels of government, as well as nongovernmental and individual action.

Refining the WIO Scenarios

An important aspect of the scenario approach is its subsequent and on-going elaboration and quantification. For any scenario to be robust and defensible, it is important to include as much quantitative data as possible. It should be understood that the scenarios must be used beyond numbers as numbers alone may reduce the utility of the scenarios beyond shear sensitivity analysis. Qualitative complementation of quantitative trends normally solves this dilemma, especially since there are clear, highly significant qualitative differences in the pathways and their implications to biophysical processes and human well-being as presented in the state of the coast. It is therefore prudent to build the scenarios with subsequent and continuous refinement for policy and management use. This is a balance that involves seamless and consistent integration of quantification and modelling versus flow and imaginative speculation - something that cannot be achieved with one round of scenario development.

Stakeholder consultation revealed some isolated cases

BOX 32.3.

OPTIONS FOR STRENGTHENING MARINE PROTECTED AREA (MPA) MANAGEMENT IN THE WIO

- Create no-take zones (as vital pulse of MPAs) and adjust buffer zones to protect areas of upwelling and nursery habitats that provide high marine productivity and protect areas that are naturally resilient to climate change;
- Implement communication and education programmes for communities, stakeholders (fishers, divers, tourists and tourism operators, developers) to create consensus and an awareness that the issue of coastal environmental change, monitoring and management are complex and require the involvement and cooperation of all stakeholders;
- Limit fishing gear and species-specific catches that are detrimental for sensitive fish species, for species that have major ecological roles or those in competition with alien species;
- Minimize modification of the coastline to retain natural habitats that protect water and species and regulate local climate;
- Identify and reduce impacts and stressors on sensitive species;
- Identify and set up monitoring programmes for sentinel species, climate-sensitive indicators and invasive species, to track changes and inform management decisions. Species monitoring should be integrated within overall coastal environmental quality monitoring; and,
- Understand the impacts on the environment by tourism and global trade activities and what future scenarios may hold. This will require assessments of climate-induced impacts and future scenarios specific to particular MPAs for developing management adaptation strategies.

of scepticism about the precision of some indicators. There was however general agreement on many of the trends, indicators and implications for a shift towards sustainable management of coastal resources in the WIO region towards 2050. To further strengthen the WIO scenarios, the following will be required:

i) Human capacity building and research investment in relevant sectors in order to strengthen the evidence-base for continued futuristic exploration of policy and natural resource management;

ii) On-going identification, refinement and description of major drivers of change in the various sector (such as international markets, social preferences, new legislation, coastal governance) that might necessitate a shift in the trends explored in this chapter; and,

iii) The intermittent assessment of the relationship between the drivers (new and old) and relevant trends in regional and national priority level themes and sectors.

The two selected scenarios enabled wider and deeper consultation and refinement for their development. It was deemed that the conventional four-scenario process could limit the depth of the analyses. The choice of this pair of diametrically-opposed scenarios (Baseline – CWS and Best Case – SWS) may have, by reducing complexity, narrowed down the imaginative thinking. It is therefore recommended that future use of the scenarios should include broadening the understanding of each scenario variant to further explore other pathways within the two chosen scenarios.

The scenarios developed for the WIO State of Coast Report have been primarily a ‘scoping exercise’ to outline basic but coherent storylines reporting of relevant issues without providing comprehensive quantification. This will be a priority as the scenarios are used and advanced for refinement at a later stage, including their use in integrating engaging science and policy, and for specific issues identified in the report. As more comprehensive and standard indicators are developed, the scenario refinement processes will become apparent, especially as more data becomes available. Stakeholder consultation will also continue and more elaborate additional modelling work may be conducted to improve the present scenario outlines. Specifically the following could be performed to improve the current scenarios:

- Spatial analysis of baseline coastal and marine habitat maps and plausible vulnerabilities under each scenario as linked to climate change, offshore development, maritime

development and other drivers of change;

- Refinement of the ‘cause and effect’ chains and inter-linkages between sectors and processes as well as their financial costs and human and ecological benefits;

- Deeper analysis of impacts and opportunities of specific development projects, risks and potential uncertainties under the two scenarios and their variants;

- Indicators of ‘where we are now’ and possible legal implications of actions or non-actions;

- Improving the development, use and capacity for deploying models/simulations and other scenario-based tools for coastal management decision making; and

- Further research and capacity development on spatial-temporal coastal planning tools (above sea-level, below sea-level as well as offshore).

CONCLUSION

The cross-cutting narratives of the diametrically-opposed scenarios offer valuable insight for the development of regional coastal management strategies, policies and other frameworks. The scenarios will assist with defining the logical implications of following, or not, a particular policy route. They also help to highlight internal conflicts and inconsistencies, for example between the aspirations of different resource users or nations.

Globalisation, including world-trade, is having significant impact on marine ecosystems the need for port facilities and cargo vessels, the ability of non-native species to be transported around the world. Whether local resources are exploited for local use, exported or imported from elsewhere, there will be an ever-increasing demand for ecosystems goods and services, which will in turn cause localised overexploitation, land-based sources and activities that lead to habitat loss, degradation or pollution. Intensity from human use, coupled with climate change, will invariably lead to impacts on marine ecosystems. Planning for the future use of the goods and services offered by the coastal and marine ecosystems will always be influenced or disrupted by unpredictable events, whether in the human environment (eg wars, famines or new discoveries) or in the natural environment (eg rapid climate change and extreme events, tsunamis, disease/pests).

By adopting an exploratory and synthetic approach to the two pathways, uncertainties in future, especially drastic changes or shocks, may demand greater resilience within

the WIO. It will be beneficial to follow plausible future shocks, and integrate anticipatory management actions and policies in response. These include: changing human environment; climatic events; biological and ecological events, major infrastructural developments such as port, oil and gas drilling installations, urban expansion; global socio-economic changes; and other geological and astronomical events such as earthquakes, volcanic activity, tsunamis, cyclones and floods.

There is a need to initiate a scenario based 'Network of Excellence' within future science policy fora of the Nairobi

Convention with reference to management of WIO coastal and marine resources, to detail future foresight exercises in various themes, to define the key challenges and risks facing policies, research and development in the WIO region over the coming decades. This will allow more informed anticipation of the management, research and policy needs in various fields, including fisheries and aquaculture, tourism, climate change, energy and others, over the medium and long-terms. The WIO scenarios will also be of use to other national and international fora and processes and conventions.

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