

Climate Change in the Western Indian Ocean:

A Situation Assessment and Policy Considerations



October 2012

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LIST OF ACRONYMS

ACF	Action Contre la Faim
AGRA	Alliance for Green Revolution in Africa
ASARECA	Association for Strengthening Agriculture research in Eastern and Central Africa
ASCLME	Aghulla and Somali Currents Large Marine Ecosystems
BMZ	German federal Ministry for Economic Cooperation and Development
CCISC	Canadian Center for International Studies and Cooperation
CCNUCC	Convention Cadre des Nations Unies sur le Changement Climatique
CDB	Convention sur la Diversité Biologique
CNICC	Communication Nationale Initiale sur le Changement Climatique
CORDIO	Coastal Ocean research and Development in the Indian Ocean
CRS	Catholic Relief Services
DFID	Department For International Development
FANPRAN	Food, Agriculture and Natural Resource Policy Analysis Network
FAO	Food and Alimentation Organization
FFEM	Fonds Français pour l'Environnement Mondial
GCAP	Global Climate Adaptation Partnership
GEF	Global Environment Facility
GIZ	German Agency for Technical Cooperation
GoK	Government of Kenya
GoM	Government of Mauritius
ICRISTAT	International Crop Research institute for Semi Arid tropics
ICZM	Integrated Coastal Zone Management
IDRC	International Development Research Center
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
INGC	Instituto Nacional de Gestao de Calamidades

IOC	Indian Ocean Commission
IOM	International Organization for Migration
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
KARI	Kenya Agricultural research Institute
LDCF	Least Developed Country Fund
MA	Millennium Ecosystem Assessment
MAPE	Ministère de l'Agriculture, de la Pêche et de l'Elevage
MDRPAE	Ministère du Développement Rural, de la Pêche, de l'Artisanat et de l'Elevage
MDG	Millennium Development Goals
MEEF	Ministère de l'Environnement, des Eaux et Forêts
MEF	Ministère de l'Environnement et des Forêts
MEFT	Ministère de l'Environnement, des Forêts et du Tourisme
MENR	Ministry of Environment and Natural Resources
MICOA	Ministry for the Coordination of environmental Affairs
MPA	Marine Protected Area
NAPA	National Action Plans for Adaptation
NCCRS	National Climate Change Response Strategy
NEMA	National Environmental Management Authority
ODINAFRICA	Ocean Data and Information network for Africa
PIK	Potsdam Institute for Climate Impact research
REDD	Reduction of Emissions from Deforestation and Degradation
RoM	Republic of Mauritius
SCCF	Special Climate Change Fund
SIDA	Swedish International development Agency
SSN	South South North
TCMP	Tanzania Coastal Management Partnership

TNC	The Nature Conservation
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
USAID	United States Agency for International Development
VPO	Vice-President's Office
WCS	Wildlife Conservation Society
WHO	World Health Organization
WIO-C	Consortium for the Conservation of Coastal and Marine Ecosystems in the Western Indian Ocean
WIO-CC	Western Indian Ocean Coastal Challenge
WIOMSA	Western Indian Ocean Marine Science Association
WOC	World Ocean Conference
WWF	World Wildlife Fund
ZALF	Leibniz Centre for Agricultural Landscape Research

EXECUTIVE SUMMARY

The Western Indian Ocean countries are composed of Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles and Tanzania. These are either island or long coastlines states. Together, they have a total area of 2.76 million km², and a population of over 135 million. The proportion of the population occurring in the coastal zone varies from one country to another, and it is particularly high in small islands. In these countries, community livelihoods are heavily dependent on natural resources, particularly on goods and services provided by marine and coastal ecosystems: the total area of coral reefs is 11,060 km² (8% of the global area), and the mangrove is 8,897 km² (1.5% of the global area). However, the region has a high reef biodiversity, and two countries (Madagascar and Mozambique) are among the fifteen countries sharing the most extensive mangrove in the world.



These countries are not spared by climate change. Historical observations indicate a temperature increase of 0.6°C to 1.1°C over the last fifty years, a rise in sea level between 0.4 and 1.2 mm per year, and a decrease in precipitation (except for Seychelles). UNDP Climate Change Profiles of the countries in the region predict that in the future (horizon 2090), the region will experience more severe temperature increase (between 2.8°C and 3.9°C and a sea level rise up to 56 cm. Precipitation will be less abundant during dry seasons and more intense during rainy seasons, and the average rainfall will be higher for the Comoros, Kenya, Seychelles, Tanzania, and reduced for Madagascar, Mozambique and Mauritius. The increased frequency of intense cyclones registered in recent years will continue.

The coastal and marine ecosystems of these Western Indian Ocean countries are particularly vulnerable to climate change: coral reefs are highly exposed to bleaching, mangroves exposed to sedimentation and sea level rise, and coastal lands to flooding and erosion. Community livelihoods have the same vulnerability scale particularly coastal agriculture, fisheries, human health and industrial activities.

For these reasons, WIO countries have developed national adaptation action plans (Comoros, Madagascar, Mozambique, Tanzania), and national response strategies for climate change (Kenya, Mauritius, Seychelles). At the same time, integrated coastal zones management approaches are being implemented. However, marine and coastal ecosystem's potential to support community adaptations are rarely formalized in national adaptation policies, and climate issues are not integrated to coastal zones management approaches.

Climate change adaptation policies are implemented through specific country driven projects (1 project in the Comoros, 3 projects in Kenya, 2 projects in Madagascar, 3 projects in Mauritius, 7 projects in Mozambique, 1 project in Seychelles and 3 projects in Tanzania) and regional or multi-national adaptation initiatives (31 in total). In addition, even if their initial objectives are biodiversity conservation, marine protected areas (MPAs) (a total area of 17,186 km² within the WIO counties) provide the core foundation for ecosystem-based adaptation.

Created in 2007, the WIO-Consortium aims to address sustainable management of coastal and marine resources in the region. The WIO-C is formed by intergovernmental institutions (Nairobi Convention and the Indian Ocean Commission), and NGOs working in the region (WIOMSA, IUCN, CORDIO, WCS, WWF, TNC, Blue Ventures, BirdLife International and RARE Conservation). Through the actions of its members, the Consortium realizes environmental research and supports management of seascapes and marine protected areas. In total, 51 resilience-oriented projects at different scales are implemented by WIO-C.

To a considerable extent, WIO-C activities are focused on biodiversity conservation, and there are few climate change focused activities. For this reason, a paradigm shift is necessary, to move from biodiversity conservation to ecosystem resilience. In addition, ecosystem-based adaptation (EbA) must be adopted as a common issue. This option will be in accordance with Rio +20 Summit, the World Congress for the Oceans and the African Ministers' Council on the Environment's recommendations. To this end, current WIO-C activities and interventions may be considered as first steps towards an ecosystem-based adaptation approach. Upstreaming and upscaling EbA are necessary for resilience of ecosystems, and to support communities' resilience to climate change. Finally, resilience of these ecosystems (particularly mangroves) can be considered as a long-term global warming mitigation option through blue carbon sequestration.

INTRODUCTION

The Western Indian Ocean (WIO) region presents challenges that are different from other regions with similar initiatives/challenges. There have been many discussions in the past to ensure better coordination of marine and coastal activities across the region with varying degrees of success. Individual countries have tended to focus on national priorities for coastal management, rather than prioritizing regional partnerships and collaboration. In addition, many regional initiatives have not been adequately linked to national priorities and processes, and as a result have had difficulty in sustaining their actions over the long term.

Through regional frameworks such as the Nairobi Convention and Indian Ocean Commission, integrated management of coastal and marine resources has been identified as a common concern for all the south west islands of the Indian Ocean and the coastal countries of East Africa. The marine and coastal ecosystems of these countries share common characteristics. Their respective coastal environments are under similar human pressures and are experiencing the effects of similar natural phenomena in the region, including climate change, the influence of marine currents at the south of the Equator and the impacts of monsoon winds or cyclones which particularly affect the island countries. Collaboration between institutions, information exchange and the sharing of experience and resource management tools will enhance regional cooperation and economic integration.

The region is characterized by economies and livelihoods that are highly dependent on their natural resources, primarily for fishing, tourism and shipping. Approximately 30 million people in the WIO depend directly or indirectly on the coastal environment for goods and services¹. In Kenya, coastal tourism is a major foreign exchange earner, with its beach and coral reef resources, coastal heritage sites and forest reserves being major assets². According to UNEP studies cited by the Africa Environment Outlook 2 (2006), in the WIO islands, fisheries contribute significantly to all national economies. Fish processing and transshipment provides additional employment and revenue. In Mozambique and Tanzania, estuarine prawn fisheries make an important economic contribution. Nonetheless, overfishing in key fisheries in the region threatens this important component of the local livelihoods and national economies.

Without taking into account the impacts of climate change, the region is already suffering from pressing development issues such as poverty, overfishing, food security and environmental degradation which threaten the economic sectors mentioned above and the livelihoods of its people. Climate

¹ World Tourism and Travel Council, 2008 (www.wttc.org)

² Africa Environment Outlook 2, 2006

(http://www.unep.org/DEWA/Africa/docs/en/AEO2_Our_Environ_Our_Wealth.pdf)

change will exacerbate existing social and environmental issues and present an additional challenge for the sustainable development of the region due to sea level rise, coral bleaching and the livelihoods of coastal communities, which depend on local fisheries for food security. Some of the climate change impacts already taking place in the region and its consequences are:

- Sea level rise, which threatens the very existence of low lying islands, coastal zones and its population.
- Sea temperature increases and coral bleaching affecting coral reef systems and the livelihoods of coastal communities which depend on local fisheries for food security, and the tourism and fisheries industries³.
- Seawater intrusion into fresh water sources will present major challenges.

Responding to climate change will require the integration of adaptation into all aspects of policy development⁴. Islands and coastal zones throughout the world are receiving growing attention not only for vulnerability to climate change and their important natural resources and, but also for their potential as demonstration models of sustainable development. Many island and coastal countries have started exploring new solutions to take action on adaptation. Within this context, the WIO region can become an example on how to integrate climate change adaptation, ecosystem management, clean energy and sustainable livelihoods.

In a response to this context, the nation states of the region are in the process of launching the “**Western Indian Ocean Coastal Challenge**” to mobilize political, financial, and technical commitments and actions of WIO countries at regional and national levels focused on climate change adaptation, promoting resilient ecosystems, sustainable livelihoods and human security within a 20-year vision. This initiative builds on the efforts of the Nairobi Convention, WIO/LAB Strategic Plan, and the Indian Ocean Commission’s efforts to put into place Integrated Coastal Zone Management Action Plans and Locally Management Marine Areas (LMMA) at the country level. The proposed overall goal of the WIO-CC is: “**Coastal economies and communities sustained by safeguarding the region’s vulnerable marine and coastal ecosystems**”

Climate change and coastal areas

Coastal areas are spatial zone where interaction of the sea and land

3 Payet, R. and D. Obura, 2004: The negative impacts of human activities in the Eastern African region: an international waters perspective. *Ambio*, 33, 24-33. (cited by Boko, M., I. Niang, A. Nyong, C. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo and P. Yanda, 2007: Africa. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge UK, 433-467.)

4 UNDP Development Report 2007/2008

processes occurs and where climate change constitutes a major issue. On one hand, being situated between land and sea, coastal zones will be affected by the impacts of both land and sea driven climate change impacts. Further, a large portion of human populations is settled in coastal areas and an important proportion of industrial and economic infrastructure is installed there. Finally, coastal areas communities heavily depend on goods and services provided by these marine and coastal ecosystems vulnerable to climate change.

Climate change will strongly affect coastal areas. The rise in global temperature and changes in global rainfall patterns will increase flooding and sedimentation resulting from erosion upstream in some areas with increasing desertification in other areas. Coastlines will be affected by rising sea levels and intensification of sea surge. These phenomena have strong impacts on natural ecosystems, which will impair their health and production capacity, and harm the goods and services they provide for human well-being.

The WIO-C

The Consortium for the Conservation of Coastal and Marine Ecosystems in the Western Indian Ocean (WIO-C) was officially launched at the Fifth Meeting of the Contracting Parties to the Nairobi Convention held in Johannesburg, South Africa in November 2007. The founding members included a group of like-minded international and regional organizations and agencies who wished to work together to support partnerships that advance marine research, conservation and management in WIO region.

Founding members of the WIO-C include IUCN, WCS, WIOMSA, WWF, EAWLS, CORDIO, IOC, IOC-UNESCO, Nairobi Convention and NEPAD-Cosmar. Other organizations including Birdlife International, Wetlands International, Blue Ventures, Rare and TNC have since become full members of the Consortium.

The objective of the WIO-C is to align, harmonize, and move forward marine and coastal management activities within the context of a regional and country level framework. WIO-C's vision is that the Western Indian Ocean's unique and globally significant natural resource base provides the essential goods and services that support biodiversity as well as economic development and the livelihoods of present and future generations. WIO-C's Mission is to achieve a healthy marine and coastal environment that sustainably support people's livelihoods in WIO-region.

Outline of this Report

The present report assesses climate change in the Western Indian Ocean and summarizes regional, national and WIO-C member interventions in the field of adaptation of climate change. The report undertakes to review existing national and regional climate change strategies prepared by countries; review existing climate change strategies and plans of the WIO-C members; prepare an inventory of ongoing national and regional Climate Change programs in the region; identifying important gaps in regional climate change programs.

CLIMATE CHANGE IN THE WESTERN INDIAN OCEAN



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Climate change and climate variability

The concept of climate change

Climate changes are defined as “changes which are attributed directly or indirectly to human activity that alters the composition of the global atmosphere, and which is in addition to natural climate variability observed over comparable time periods” (UNFCCC, 1992). They are observed over a long period, on the climate’s components: temperature, rainfall, wind power. Currently existing data and knowledge attest to climate warming, to changes in rainfall and to sea level rise (IPCC, 2007).

The correlation between current climate change and the accumulation of greenhouse gases in the atmosphere is established with high certainty (IPCC, 2007). Consequently, the need to fight against climate change has been recognized worldwide (UNFCCC, 1992), through the reduction of greenhouse gases (Kyoto Protocol, 1997), so as to limit climate warming to 2°C (Copenhagen, 2009).

The climate system responds slowly to changes in greenhouse gases emissions, owing to the fact that these gases have long lifetime in the atmosphere (IPCC, 2007): even if their emission is stabilized, their accumulation in the atmosphere will be more consistent. Thus, the climate will continue to change, and impacts of this change will be inevitable (IPCC, 2007).

The concept of climate variability

Climate variability refers to climate change observed over a short period, and which is due to a change in the atmosphere or the ocean. It can be caused by the natural change of the climate process, or by endogenous factors.

Climate variability is the most perceivable indication of climate change. Sometimes this perception affects the options selected, prioritizing adaptation to climate variability on long-term considerations: climate change is an ongoing, long-term process, the premises of which are the currently observed climate variability.

Several climate change-related impacts, such as droughts and flooding, are caused by climate variability. Yet, climate trends indicate an intensification of this climate variability in the future.

Adaptation to climate change, from adaptation to resilience

The concepts of vulnerability and adjustment to climate change

The **vulnerability** of a system to climate change is 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, the magnitude, and the rate of climate variation to which a system is exposed; it is also linked to its sensitivity and its adaptive capacity.

The **adaptation ability** of a system refers to its ability to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Adaptation can be described as adjustment in natural or human systems, in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Adaptation and resilience

These climate change notions are broad. However, the current changes, whether coping-oriented or resilience-oriented allow the narrowing of the adaptation concept.

The differences between adaptation and resilience are summarized in the table below (Dazé et al, 2010):

	Adaptation (coping)	Resilience
Time span	Short term	Long term
Driver	Survival	Subsistence
Continuity	Occasional	Continuous
Results	Immediate	Sustainable
Impacts on resources	Frequent degradation	Efficient and sustainable use of resources
Causes / implications	Lack of alternatives	Focus on the search for alternatives Combines old and new know-how

Vulnerability of natural capital to climate change

Water resources

Water resources are derived from rain and melting glaciers. Some of these resources, like rivers, lakes and marshes remain at the surface, some seep to form groundwater. The volume and distribution of water resources are different, even for neighboring countries.

Because of climate change, the temperature rise will exacerbate evapotranspiration, and a larger share of surface water will return directly into the atmosphere. In some areas, rainfall itself will reduce. The two phenomena will reduce groundwater (Bates et al, 2007).

Moreover, theoretically, an increase in rainfall should lead to more available water resources; this assumption is refuted in practice when the rainfall intensifies. Indeed, torrential rain leads to runoffs, which will be directly carried to the sea, thus creating upstream flooding and riverbed floods. There is a temporary excess of water resources, but the recharge of groundwater is not necessary performed.

Land and production

Land constitutes the main production capital for many households in developing countries. Given the conversion of forestland into agricultural areas, and given the used cultivation technique, land use is considered unsustainable in these countries. Erosion is recognized as one of the drivers of the loss of natural capital and of the worsening of livelihoods.

Climate change will intensify rainfall: rain will be more concentrated over smaller periods. This will exacerbate erosion, and promote the transportation of topsoil into rivers and oceans. Climate change will exacerbate the vulnerability of land.

Forests

Forests cover 30% of the world's surface, representing around 4 billion hectares (FAO, 2005). Tropical forests shelter approximately 70% of vascular plants, 30% of all bird species and 90% of invertebrates. These tropical forests host more than 200 species per hectare (FAO, 2006).

The impact of climate change on forests is mixed. While temperature rise improves the productivity of plants, it also influences the distribution of pollinating species, which will eventually affect the diversity within forests, and will lead to gradual invasion by more tolerant species.

This diversity erosion caused by climate change will affect the provision of environmental services by forests, such as non-wood products, fruit, pharmaceutical products, and even wood products. Such biodiversity erosion

will also affect the fauna, which feeds on forest products, triggering a degradation circle, should the resilience of forests not be maintained.

Mangroves

Mangroves are forest formations, which lie between latitude 40°S and latitude 25°N (Giri, 2010). They consist of trees, shrubs and palm trees that grow only in the tidal and intertidal zones of tropical and subtropical regions (Kathiresan, 2006), in rustic conditions of salinity and sedimentation and muddy anaerobic soils (Alongi, 2002).

Rising sea level poses a serious threat to this ecosystem (Giri, 2010). Indeed, the former results in a displacement of inter-tidal areas inland. In the absence of sufficient supply of fresh water and sediment, and with increasing temperature, this extension will cause land salinisation at the back of the mangroves areas (Shumway, 1999). Taking into account the historical data of the last 7000 year, the rate of sea level rise foreseen by the IPCC scenarios is nine times higher than that which allows mangroves to accommodate (Ellison & Stoddart, 1991). It is suggested that a rise in sea level of 36cm over the period of 2000-2080 will cause the loss of 33% of wetlands (including mangroves), and a rise of 72cm will result in the loss of 44% of those (McFadden et al, 2006).

Coral reefs

Coral reefs are marine habitats consisting of both a physical structure and slow growth organisms found there. (Spalding et al, 2001). Corals live in tropical and subtropical seas, in hot, shallow, and clear areas of low nutrient levels (Grimsditch & Slam, 2006). They consist of colonies of polyps, living in symbiosis with unicellular algae called zooxanthellae, on their bodies; zooxanthellae provide the necessary photosynthesis for the development of coral reefs. They secrete a limestone skeleton (which will form the reefs themselves); other colonies of polyps will subsequently colonize the limestone skeleton, and form an ecological system, covering 0.2% of seabeds (Gimsditch & Slam, 2006).

Coral reefs live at the upper limit of temperature tolerance in their environment. While their range varies from Florida (18°C in the summer) to the Persian Gulf (32°C in the summer), a 1°C increase in summer temperature over one month may lead to their bleaching, and a 2 ° C increase (for the same duration) leads to mass extinction (Goreau, 2007). Coral reefs located between 5°S and 10°S latitudes are affected by sea warming every five years (Sheppard, 2003). Thus, climatic stress constitutes a major threat to coral reefs: 50% of the bleaching phenomena can be attributed to the increase in sea temperature (Wilkinson, 2008).

Anthropogenic pressure may also contribute to the deterioration or destruction of coral reefs. Such pressure stems from coastal development, which constitutes the main source of pollution, through nutrients and sediments,

marine pollution, overexploitation and destructive fishing, coastal erosion and inputs in sediment and nutrients caused by agriculture and land use (Spalding et al, 2001). Worldwide, it is estimated that 58% of coral reefs are exposed to anthropogenic pressure.

The importance of natural ecosystems for human well-being

The concept of environmental services provided by ecosystems

The services provided by ecosystems can be classified into four categories:

Provisioning services are services derived from ecosystems' products, such as food, energy, fibers, biochemicals, genetic resources and fresh water.

Regulating services are derived from the ecosystems' intrinsic physical, chemical and biological processes, such as protection against floodings and erosion, water purification, maintenance of air quality and climate regulation.

Cultural services consist of cultural, intellectual and spiritual aesthetic inspiration, such as knowledge, tourism, recreation, etc.

Supporting services maintain ecosystems' basic functions and processes. They ensure provision, regulation and cultural services.

Environmental services provided by forests

Forests, especially tropical forests, provide environmental services (Costanza et al, 1997), which are of high value (Sukhdev, 2009). These services include the maintenance of the local climatic process, the retention and filtering of water, the regulation of watersheds, carbon sequestration, production (wood and non-wood products), and the provision of medicinal plants (Nasi et al, 2002).

Environmental services provided by mangroves

Mangroves constitute very important and vital coastal resources for socio-economic development (Giri et al, 2010). Worldwide, mangroves cover 137.760 km² (Giri et al, 2010). Around 75% of the mangroves are located in 15 countries (Spalding et al, 2001), including Mozambique and Madagascar.

The ecosystem services provided by mangroves include provisioning services (wood for construction, fuel-wood, honey, fish, crabs, shellfish, medicinal plants, tannin), regulating services (protection against waves and cyclones, water purification, carbon sequestration, coastal erosion prevention, sediment settlement, nutrient settlement and recycling), cultural services (tourism and amenity), and supporting services (Kathiresan, 2006).

Environmental services provided by coral reefs

Coral reefs constitute 25% of the diversity of marine species (Burke et al, 2011), hence the reason why this ecosystem is considered marine tropical forests (Roberts, 2003). Worldwide, coral reefs' total surface area is of 600.000 km² of which 284.300 km² are shallow, located near the coastlines of over 100 countries (Spalding et al, 2001). This ecosystem is among the most resilient in the world: some species have existed for 1 to 10 million years, and survived during the glacial-interglacial climate oscillations (Burke et al, 2011).

Coral reefs provide production services (food, materials, ornamental resources), regulating services (climate regulation, pollution treatment, biological control), cultural services (tourism and recreation), and maintenance of biological diversity (Constanza, 1997). These services yield an enormous economic value.

Natural ecosystems and climate change

Natural ecosystems and adaptation potential

Natural ecosystems are endowed with a natural resilience capacity, which shields them from the impacts of climatic stress. As long as this capacity is not constrained by anthropogenic pressures, ecosystems will continue to provide basic environmental services, including protection against floodings, filtration of rain water, coastal protection against the tides and waves, and disaster mitigation. These are the reasons why ecosystem-based adaptation is considered important (Seimon et al., 2012). The scale and pace of climate change, as well as the level of uncertainty regarding some of its impacts imply that ecosystem-based adaptation is the most recommended approach for populations which heavily dependent on natural resources. Finally, the use of natural resources to adapt to climate change is both non-destructive and low cost (compared to the construction of infrastructure, for example) (Reid, 2011). Thus, it is suitable for countries with limited financial resources, and for countries with significant natural resources (Clarke and Jupiter, 2010).

Natural ecosystems and mitigation potential

The regulation of the global climate through carbon sequestration is one of the environmental services provided by natural ecosystems. This service is provided by mangroves (Kathiresan, 2006), seagrasses (Nellemen, 2009), forests (Sukhdev, 2009), and to some extent, coral reefs (Moberg and Folke, 1999). In any case, the use of natural resources for the mitigation of emissions of greenhouse gases is cheaper industrial processes change (Chomitz, 2006). Other environmental benefits can be derived.

Analysis of international recommendations for the region

World Ocean Conference (WOC)

The World Ocean Conference is both a forum of the different countries, for sharing common concerns on the management of oceans and marine resources, and a global initiative. Its resolutions must be taken into account by the countries in their policy definition and in their implementation of activities relating to the environment and to the marine and coastal resources.

In 2009, the Conference adopted the following resolutions (Manado Declaration):

- *Healthy and productive coastal ecosystems have an increasingly prominent role in the mitigation of climate change, at the level of the economy and of the coastal communities.*
- *National strategies are necessary for the sustainable management of marine and coastal ecosystems, especially mangroves, wetlands, seagrass beds and coral reefs, as protective and productive buffer zones providing valuable ecosystem goods and services to address the various effects of climate change.*

Bamako Declaration of Environment African Ministers

The African Ministerial Conference on the Environment is also a forum for sharing common concerns among the countries in the region. It deals with a broader subject (the environment in general), but at a smaller scale, that of the African continent. During its meeting in Bamako in 2010, African Environmental Ministers adopted the following resolutions in relation to the, management of marine and coastal environment and of climate change:

- *Have African countries adopt an ecosystem-based approach to adaptation.*
- *Accelerate the implementation of the Hyogo Framework for Action (disaster risk reduction at the global level) and of the regional strategy's action program for disaster risk reduction, to increase the resilience of the Continent to the negative impacts of climate change.*

Rio Declaration for Oceans

Topic	Recommendations
Adaptation	Implement ecosystem-based adaptation strategies, to reduce vulnerability and build the capacity to react, to

	<p>adapt, as well as the resilience of coastal communities. This includes coastal restoration and the effective management of the marine protected areas' network.</p> <p>Provide sufficient funding, based on better estimates of the adaptation costs, to support the adaptation of coastal and island communities that are exposed to climate change.</p> <p>Develop and support measures to address issues relating to the displacement of coastal populations resulting from climate change</p>
Mitigation	<p>Accelerate efforts to reduce the emissions of marine industries, including the International Maritime Organization</p> <p>Protect and manage coastal ecosystems in a sustainable manner, as important sources of blue carbon; integrate blue carbon in the UNFCCC political and financial process, as an important instrument to mitigate climate change</p> <p>Sustainably develop ocean-based renewable energies, such as wind energy, tidal energy and wave energy, based on the planned use of marine spaces</p> <p>Plan and develop regulation systems for the sequestration and storing of carbon</p>
Capacity-building, scientific monitoring and education of the public	<p>Provide technical and financial assistance to Small Islands Developing States and coastal countries, to create the capacity for the implementation of mitigation and adaptation measures, of early warning systems and for disaster risk reduction</p> <p>At the country level, set up the scientific capacity for the assessment of the marine and coastal environment, for monitoring and prediction, including the network for the observation of the acidification of oceans</p> <p>Promote public information and education efforts, to increase its sensitivity in general, and specifically to increase their sensitivity to the risks threatening small islands and coastal communities, and also to catalyze support to find mitigation and adaptation responses.</p>

IUCN

As its name implies, IUCN gathers nature conservation organizations. It is a global organization, hence the compliance to its prescriptions in the field of biodiversity conservation.

IUCN encourages the appropriate integration of ecosystem-based adaptation in the adaptation policies:

- *Include ecosystem-based adaptation in the adaptation policy, as well as the shared vision for the adaptation framework for the years following 2012.*
- *Further integrate ecosystem-based adaptation in the strategies and national action plans for adaptation, including NAPAs.*
- *Align the ecosystem-based strategies with the ongoing activities, in the context of the Convention on Biological Diversity, the Convention to Combat Desertification, the Ramsar Convention for the protection of wetlands, and other international commitments by countries.*

UNEP-FAO-IOC/UNESCO-IUCN-CSCIC

The above organizations have formulated the following recommendations in 2009 (Nellemen et al, 2009):

- *Create a global fund for blue carbon, for blue carbon sequestration and the protection and management of marine and coastal ecosystems.*
- *Immediately and urgently protect at least 80% of the remaining seagrass beds, salt marshes and mangroves, through effective management.*
- *Initiate management practices, which reduce and eliminate the pressures, and support the robust recovery potential inherent in blue carbon pools.*
- *Maintain safe livelihoods and food provided by the oceans, through the implementation of an open and integrated ecosystem approach, to increase the resilience of natural and human systems to change.*
- *Implement a win-win mitigation strategy across ocean-related sectors.*

TNC-World Bank-WWF/US

Experts from the above institutions made the following recommendations, which are exclusively drawn from the ecosystem-based adaptation approach:

- *Protect and restore marine and coastal ecosystems as a basis for adaptation in coastal areas.*
- *Fully integrate ecosystem-based adaptation strategies in the national action programs for adaptation.*

- *Include ecosystem-based adaptation in the shared vision on adaptation, in the climate negotiations and cooperation actions for the long term.*
- *Mainstream ecosystem-based adaptation in the concepts that constitute the program of actions for enhanced adaptation in post 2012 agreements.*
- *Consider the ecosystem-based adaptation in the marine and coastal environment as a focus for development and for transfer of new technologies.*
- *Increase financial resources and investments to support the ecosystem-based adaptation for marine and coastal ecosystems.*

Conclusions

Being a global and unavoidable phenomenon, climate change will severely affect the marine and coastal ecosystems of the Western Indian Ocean States. In particular, coral reefs will be affected by rising sea temperature, the mangroves by flooding, sedimentation and rising sea level, and water resources by rainfall change and rising temperature. These ecosystems and resources provide invaluable goods and services for communities living in coastal areas. For the region, an ecosystem-based adaptation approach is highly recommended by international bodies, specialized agencies, and experts in marine and coastal resources management.

CLIMATE CHANGE IN THE WESTERN INDIAN OCEAN: COUNTRY LEVEL ANALYSIS AND REGIONAL APPROACHES



photo credit: © WCS

The Western Indian Ocean States

The Western Indian Ocean countries are composed of Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles and Tanzania. These are either island or long coastlines states. Together, they have a total area of 2.76 million km², and a population of over 135 million. The proportion of the population occurring in the coastal zone varies from one country to another, and it is particularly high in small islands. In these countries, community livelihoods are heavily dependent on natural resources, particularly on goods and services provided by marine and coastal ecosystems: the total area of coral reefs is 11,060 km² (8% of the global area), and the mangrove is 8,897 km² (1.5% of the global area). However, the region has a high reef biodiversity, and two countries (Madagascar and Mozambique) are among the fifteen countries sharing the most extensive mangrove in the world.



The economic value of the region's biodiversity is significant⁵:

- The value of coral reefs in the WIO is estimated at US\$ 7,291 million per year.
- The total economic value of mangrove forest goods and services in the WIO region may be estimated at US\$ 8,791 million per year, concentrated mainly in Mozambique, Madagascar and Tanzania.

⁵ UNEP/Nairobi Convention Secretariat, 2009. Transboundary Diagnostic Analysis of Land-based Sources and Activities Affecting the Western Indian Ocean Coastal and Marine Environment, UNEP Nairobi, Kenya 378p

- The total value of the coastal forest in the WIO region is estimated at US\$ 5,581 million per year.
- The total value of seagrass beds in the WIO region reaches US\$ 1,045 million per year.

However, the coastal and marine ecosystems of these Western Indian Ocean countries are particularly vulnerable to climate change: coral reefs are highly exposed to bleaching, mangroves exposed to sedimentation and sea level rise, and coastal lands to flooding and erosion. Community livelihoods have the same vulnerability scale particularly coastal agriculture, fisheries, human health and industrial activities.

Comoros

Overview of the country

The Comoros archipelago consists of three islands: Grande Comore, Anjouan and Mohéli, lying between latitude 11°S and 11°20'S (Persand, 2008), and extends over 1,869 km² (MAPE, 2007). The total population is 0.8 million (with a growth rate of 2.5%), the human development index 0.433 and per capita GDP US\$ 1,183 (UNDP, 2011). Most agglomerations and 41% of the population of the country lie on the coastal area.

The Comoros' climate is tropical (MDRP AE, 2006). The average temperature varies between 23°C and 27°C (MDIPTTI, 2002), and average rainfall is 1.955 mm per annum (McSweeney et al., 2009); it exceeds 1.380 mm per year in Grande Comore, 1.187 mm/year in Mohéli and 1.371 mm per annum in Anjouan. Average humidity is around 85% (MDIPTTI, 2002).

The inventory of the country greenhouse gas emissions (MDRP AE, 2006) showed that the annual emission volume (all direct greenhouse gas emissions combined) were 1.3 million tCO₂. 58.9% of emissions are due to change of land use and 35% to agriculture. The contribution of energy in this emission is only at 5.4%.

Climate change: recent trends and predictions

Recent trends

Rise in temperature

The temperature has risen by 1°C since 1960 (MDRP AE, 2006). This increase was faster in MAM, with a rate of increase of 0.22°C per decade (McSweeney et al, 2009). It has been noted that minimal temperature has raised the most, compared to maximum temperature (Acclimate, 2011).

Change in rainfall

Rainfall has reduced between 1960 and 2006 (-7.9 per month, per decade (McSweeney et al, 2009). This reduction occurs all year long (both during the dry and rainy seasons) and is greater in Grande Comore than on the other islands.

Sea level rise

Sea level observations were performed in Dzaoudzi (which was originally a Comorian territory). These observations support the conclusion that in recent decades, a rise of +0.40 mm per year was recorded (Ragoonaden, 2006).

Cyclones

Due to Madagascar's proximity and shielding, the Comoros are relatively immune to the Indian Ocean's cyclones. However, recent trends tend to show that the frequency of such cyclones increases. Between 1911 and 1961, the archipelago that been hit by 23 cyclonic events, an average of one hurricane every two years. Between 1967 and 1986, the country experienced 13 cyclonic events, an average of one hurricane per year (MDRPAE, 2006).

Future climate

Temperature rise

The annual average temperature increase will range between 0.8°C and 1.0°C in 2030, between 1.3°C and 1.9°C in 2060, and between 1.5°C and 3.0°C by 2090. By the year 2060, 30 to 61% of the days will be hot, and in 2090, this proportion will lie between 82 and 100%. Similarly, the frequency of warm nights will range from 31 to 64% in 2060, and from 44 to 94% in 2090. The increase in hot days and nights will occur faster in DJF. Meanwhile, there will be a rapid decrease in the number of cold days and nights (McSweeney et al, 2009).

Change in rainfall

The change in rainfall will be characterized by reduced precipitation in the dry season (it might reach -16% in 2030, -17% in 2060 and 2090) and increased precipitation during the rainy season (it could reach +12% in 2030, +18% in 2060, +31% in 2090) (McSweeney et al, 2009). The annual average will increase from 1 to 3% in 2030, from 1 to 6% in 2060, and from 2 to 4% in 2090. Drought will intensify, so will rainfall.

Sea level rise

By 2050, sea level rise will range between 0.20 and 0.22 m (MDIPTI, 2002), and by 2090, it might reach 0.56 m (in reference to the 1980-1999 period) (Acclimate, 2011).

Cyclones

The Indian Ocean basin is very prone to cyclone formation (Acclimate, 2011a). The potential increase in the number of cyclones in the next few years has not been formally assessed. However, the number of intense cyclones will increase (Acclimate, 2011a).

Vulnerability of the natural capital

Water resources

Water resources are not evenly distributed across the three islands in the archipelago: unlike the islands of Mohéli, which accounted 49 permanent rivers in 1950 and around ten currently, and Anjouan (less than 20, most of which dry up in the dry season), the Grande Comore lacks permanent rivers (MDRPAE, 2006). On the Grande Comore (the most populated island) water is supplied by tanks and reserves from the aquifers.

Currently, quality water demand stands at 57,000 m³ per day, and will increase to 103,000 m³ per day in 2025 (against an estimated availability of 20,000 m³ per day). Thus, current water availability stands at 35 litres per person, and will decrease to 19 litres per day in 2025, assuming that current climatic conditions are maintained. The country is highly exposed to water scarcity, which will be increased by the delicate balance of salty and fresh water, the risk of groundwater contamination (Mohéli and Grande Comore), as well as the reduced quality of surface water (Mohéli and Anjouan) (MDRPAE, 2006). Therefore, the vulnerability of access to water resources is considered high (Acclimate 2011).

Land and agriculture

The current combination of intense rainfall, pronounced dry seasons and high temperature is responsible for the degradation of agricultural land; it also seems to indicate that a desertification process is taking place (Acclimate, 2011). Currently, 57.5% of lands are degraded (MDRPAE, 2006). Assuming future rainfall intensification, increased temperature and the extension of the dry season (MacSweeney et al, 2009), the access to land resources can be considered highly vulnerable (Acclimate, 2011).

Forests

Total forested area in the Comoros is equal to 50 km². It accounts for 2.8% of the surface area (FAO 2006). The archipelago's deforestation rate is very high (+4% per annum between 1990 and 2000, and +7.4% per annum between 2000 and 2005) (FAO 2006). Agricultural expansion, demand for fuel-wood, for softwood lumber and for construction wood are the main causes of deforestation (MAPE, 2007). The archipelago's deforestation rate ranks as one of the highest in the world (MDRPAE, 2006).

In itself, forest biodiversity is very rich in the Comoros (Acclimate, 2011), so that it can be considered resistant to climate change, although the latter will favor some more resistant species than others. For this reason, its vulnerability to climate change is considered low to medium (Acclimate, 2011). However, the reduced fertility of cultivated land will impact more on the forest areas, and additional anthropogenic pressure, more so than climate stress, could lead to their demise.

Mangroves

Mangroves in the Comoros account for 108 ha: 91 ha in Mohéli, 9 ha in Anjouan and 8 ha in Grande Comore) (MDRP AE, 2006). Overall, Mohéli and Anjouan's mangroves are considered in good condition and have not been subjected to over-exploitation (MAPE, 2007). Yet, the mangroves in the Comoros have a limited natural regeneration capacity (MAPE, 2007), and they will be increasingly exposed to excessive sedimentation, due to future torrential rain. Their vulnerability to climate change can be considered high.

Coral reefs

Coral reefs of the Comoros stretch over 430 km² (Spalding et al, 2001). Covering 100% of the coastline in Moheli, 80% of the coastline in Anjouan and 60% of the coastline in the Grande Comore (MAPE, 2007), they constitute a protective strip of land. Their level of exposure to risk is 99% (Spalding et al, 2001): coral reefs of the Comoros are the most exposed in the region.

Moreover, they are highly sensitive to the rise of sea temperature: the bleaching of 1998 destroyed 80% of the coral reef flat and 60% of corals on the outer reef slope (MAPE, 2007). Initially, their recovering capacity was moderate (between 36% and 61% in 2002) (Wilkinson, 2008) and has subsequently improved (recovery in 2007 reached the level preceding the bleaching) (Wilkinson, 2008). Thus, although highly exposed and very sensitive to climate change, the coral reefs of the Comoros have good resilience. Their vulnerability can be considered medium.

Vulnerability of livelihoods

Agriculture

Agriculture is already currently facing significant difficulties, due to the substantial increase in temperature and irregular rainfall (Acclimate, 2011a). On the one hand, field food crops are highly exposed to the lengthening of the dry season and the change in rainfall; on the other hand, the cash crops (mainly located in coastal areas) are exposed to the disruption caused by flooding and saltwater intrusion. Moreover, the lengthening of the dry season, the temperature increase and changes in rainfall will favor the spread of diseases that affect them (cassava mosaic, Panama disease, blight, cankers, anthracnose, etc.), and outbreaks of pests (rats, beetles, termites, caterpillars, aleyrodides, bugs, etc) (MDRP AE, 2002). As a result, the Comorian

agriculture is highly exposed and sensitive to climate change, and diversification alternatives are virtually nonexistent. Thus, vulnerability can be considered high.

Livestock breeding

Livestock breeding in the Comoros yields low productivity (Acclimate, 2011a), and high exposure to disease (on Grande Comore, 80% of the livestock has been decimated by parasitic and viral diseases in 2005) (Acclimate, 2011a). A longer dry season will cause the drying of grasses, reducing the availability of fodder. Moreover, less water resources are available for both the population and livestock. Therefore, herds are more exposed to viral and parasitic diseases. Due to the combination of these circumstances, Livestock breeding in the Comoros can be considered highly vulnerable.

Fishing

Fishing is the second traditional activity in the archipelago (Allaoui, 2011), and is largely artisanal. Fishery products provide the animal protein intake of the population, with an estimated annual consumption at 22 kg per capita (Allawi, 2011). Due to the near absence of a continental shelf, artisanal fishing is done on the coral reef beds, close to the shore. Currently available studies (Spalding, Acclimate) predict a high vulnerability of coral reefs to bleaching in the Comoros, especially since the archipelago has only one single marine protected area. Therefore, fishing in the Comoros is highly vulnerable.

Food security

Nearly all arable land is cultivated: 61% on Grande Comore, 80% on Mohéli and 88% in Anjouan (MDRP AE, 2006) and there are clues indicating that the system has been stretched to the limits: the staple, rice, is mainly imported and fields are cultivated without fallow or input of organic matter (MDRP AE, 2006). Population growth and the fragility of the supply system add to this (Acclimate, 2011a). Thus, food security is highly exposed to climate change. However, social organization and mobilization lessen the risk of malnutrition, so that the vulnerability of food security can be considered medium.

Drinking water supply

The Comoros have experienced a scarcity of water resources (MDRP AR, 2006) in the past, and currently drinking water supply is insufficient to meet the needs. Although an increase in rainfall is expected for the coming years (McSweeney et al, 2009a), it will not keep up with population increase (or, in addition to the latter, the increase in industrial and agricultural requirements). The supply-and-demand ratio will increase from 1-to-4 in 2002, to 1-to-12 in 2050 (MDRP AE, 2006). Moreover, the low-coverage supply system in place (Acclimate, 2011), and the adjustments made by the population involve risks (open tanks to capture rain water). Thus, the water supply is highly vulnerable to climate change, and coping skills are low, resulting in high vulnerability.

Health

The increase in temperature will increase the extent of occurrence of malaria to the highlands, through the increase of the vectorial capacity of Anopheles; currently, malaria is the leading cause of death of children of less than five years old (25%) and the main reason for hospital admission among the population in general (30%) (Acclimate, 2011a). Other vector-borne diseases (arboviruses) will also increase. Furthermore, diseases related to the change in the diet (consequent to the decreased availability of locally-produced fresh food) will rise. Thus, human health is highly vulnerable to climate change.

Adaptation and coastal resources management policies

Adaptation policy

The Initial Communication in the context of the Convention on Climate Change (MDIPTTI, 2002) and the National Adaptation Action Plan (PANA) (MDRPAAE, 2006) set the priorities regarding adaptation to climate change in the Comoros.

	Planned actions	Type
Human capital	Set up of an early warning system	Resilience
	Fight malaria	Coping
	Support medical care (eye care)	Coping
	Establishment of a national support framework in the event of a disaster	Coping
Natural capital	Micro-climates valorization	Resilience
	Agricultural intensification	Resilience
	Protection and restoration of degraded land	Resilience
	Rebuilding of watersheds	Resilience
	Fish concentration system	Coping
	Use of varieties that are more resistant to drought	Coping
	Improvement of cattle feed (fodder, feeds)	Coping
Adjustment of growing seasons	Coping	
Physical capital	Road construction inland	Coping
	Fish freezing	Coping
	Protection works (breakwaters, sea walls)	Coping
	Construction of public tanks	Coping

	Better weather-resistant materials	Coping
	Renovation and extension of the water supply system	Coping

Coastal zones' management policy

In the Comoros, coastal zones' management policy is enacted through sectoral policies relating to fisheries, the environment, tourism and transportation (Allaoui, 2011). No specific structure is yet in place for the implementation of an integrated coastal zones' management, which is currently deprived of any legal status.

Currently, only one marine protected area has been created and another one (Coelacanth Park) is being set up. None of the sectoral policies relating to coastal areas makes reference to climate change. The characteristics of the Moheli marine park are listed in the table below:

Name	Surface area (km ²)	Year of creation	IUCN category
Moheli Marine Park	404	2001	II

Review of ongoing adaptation actions

Only one climate change adaptation project is ongoing in the Comoros. It relates to the management of water resources.

Project	Type	Focus	Donors	Implementing Agency
Adaptative management of water resources 2010-2014	Resilience	Capacity-building and pilot initiatives to reduce risks relating to the impacts of climate change on water supply	LDCF	UNDP, UNEP

This project addresses one of the targeted priorities for the country. It focuses on the adaptation to ongoing climate change. Other priorities have been identified in the national action plan, but they are yet to be addressed.

Kenya

Overview of the country

Kenya lies on the Equator, between 6°N and 6°S. It has a land area of 582,350 km² (GoK, 2010), consisting of 83% of dry and semi dry land. Its coastline is 600 km and the coastal area has a land area of 67,500 km², which represents around 11.5% of the country's total land area (NEMA, 2007).

Kenya has 41.6 millions inhabitants and its population growth rate is 2.7%. Its HDI is 0.509, and its GDP per capita 1,573 US\$ (UNDP, 2011). Approximately 9% of the population lives in the coastal area, which has higher growth rate than the national average (3.1%) (NEMA, 2007). More than half of the population lives in absolute poverty (MENR, 2002).

Kenya's climate is dry to sub-arid, with precipitation averaging 687.6 mm per annum. It varies from 200 mm in the dry areas, to 2,000 mm around Lake Victoria and in the Central Highlands. However, the climate varies greatly: observed temperatures in the arid areas escalate to 40°C, while Mount Kenya, which culminates at 5 000 m, is covered with ice (MENR, 2002).

The inventory of the country greenhouse gas emissions (MENR, 2002) showed that the annual emission volume (all direct greenhouse gas emissions combined) amounted to 34.3 million teCO₂. Emissions are mainly due to energy production (41.5%) and agriculture (35.3%). Land use change contributes 19.5% to the country emissions.

Climate change: recent trends and predictions

Recent trends

Rise in temperature

Between 1960 and 2006, the average annual temperature increased by 1.0°C (McSweeney et al, 2009), and Mount Kenya lost 92% of its ice cap over the last century (MENR, 2002). The average number of warm days has increased by 57 and the average number of hot nights has increased by 113. Over the same period, the average number of cold nights has decreased by 16 and the average annual number of cold nights has reduced by 42. The strongest increase in temperature took place in March, April and May and the weakest in June, July, August and September (McSweeney et al, 2009).

Rainfall

Rainfall has decreased over the last decades. Between 1960 and 2006, the change ranged around -1.5 mm/annum per decade (McSwenney et al, 2009), which implies that the climate is drier.

Sea level rise

Data relating to the change in sea level refer to the 1986-2001 period, over which a tendency to rise by 0.8mm per annum was recorded (Mahongo, 2009).

Future climate

Temperature rise

The temperature will increase between 1.0°C and 1.2°C in 2030, between 1.7°C and 2.4°C in 2060, and between 2.0°C and 3.7°C in 2090. The frequency of hot days will vary between 17 and 45% in 2060, and between 23 and 75% in 2090. Finally, the frequency of hot nights will be around 32-75% in 2060, and 40-95% in 2090 (McSweeney et al, 2009).

Change in rainfall

Rainfall will tend to increase. It will stand between 2 and 5% in 2030, between 6 and 8% in 2060, and between 10 to 20% in 2090 (McSweeney et al, 2009). The tendency will vary during the year: there will be less rainfall in the dry season (-5% in 2030, -6% in 2060 and -1% in 2090), and more rainfall during the rainy season (+17% in 2030, +26% in 2060, and +48% in 2090). Thus, drought will worsen while more intense torrential rainfall will occur in the rainy season.

Sea level rise

The estimated sea level rise is the same as the one in the Indian Ocean basin: between 0.22m and 0.56m by 2090 (IPCC, 2007).

Vulnerability of the natural capital

Water resources

Kenya's water resources come from rain and the melting of Mount Kenya's ice cap (GoK, 2002). The increased temperature will result in increased evapotranspiration, which will limit groundwater table recharge and rivers' water supply. Moreover, the torrential rains, in combination with the melting of glaciers (case of the Tana River) will increase runoff and the discharge of fresh water and sediments in the sea. The increase in rainfall will not result in greater availability of water resources. Estimations predict the scarcity of water resources, 2030 (GoK, 2002).

Surface water provides 85% of Kenya's water supply, and groundwater tables provide 15%. In time, the recharge of the groundwater table will reduce, and surface water will no longer be used. Thus, access to water resources is extremely precarious.

Land and production

Approximately 18% of the land has medium to high agricultural potential and provides for 80% of the population. The remaining 20% of the population live on 80% of the land, in arid to semi-arid areas (Gok, 2002).

Arid and semi-arid areas are used for herding. It also constitutes a habitat for wildlife, the vital component of the country's tourism industry. Arable areas

enable the production of food, fruits, flowers and tea (Kenya ranks second for tea production in the world). Climate change will affect the productivity of savannas in semi-arid areas and threatens the survival of wildlife. Moreover, the decreasing availability of water resources will hamper agricultural production in the arable areas. Thus, land resources are highly vulnerable to climate change, and agricultural activities are highly vulnerable (GoK, 2002).

Forests

Forests in Kenya cover 35,220 km², 7 040 km² of which are primary forests (FAO, 2006). They account for 6.2% of the land and are subject to +0.3% deforestation rate per year (constant since 1990). Coastal forests cover 660 km² (Burgess et al, 2000) and shelter 50% of the country's plant species, 60% of bird species and 65% of its mammal species (Matiku, 2004). The largest forests are Arabuko-Sokoke: 370 km², ranking second worldwide for bird conservation in Africa and Simba Hills: 63 km², containing 54 species of the world's threatened species.

The reduction in forest cover is caused by anthropogenic pressure (agricultural expansion, harvesting, illegal exploitation, uncontrolled fires). The rise in temperature and the extension of the dry season will lead to a loss of diversity (due to some pollinating species' sensitivity to temperature). However, 80.3% of coastal forests are protected (Matiku, 2004) and, according to different scenarios, they will remain stable (GoK, 2002). Thus, their vulnerability can be considered medium, if not low.

Mangroves

Kenya's mangroves cover 516 km² (Spalding et al, 2001) and are concentrated in the northern part of coastal areas, especially on the Lamu archipelago (67%), and the estuaries of the Tana and Athi-Sabaki rivers (Baie de Malindi) (GoK, 2009). They are not very much exposed to climate change. The decrease in mangroves in the Tana River estuary is mainly caused by the retention of fresh water and of sediments by the hydroelectric plant located on the river (Glazewski et al, 2008). Conversely, the increase in mangroves in the Athi-Sabaki river estuary is derived from extra inputs of sediments and water.

Kenya's mangroves are, however, sensitive to climate variations. The 1997, 1998 and 2006 torrential rains drain excessive amounts of sediments, leading to the significant destruction of mangroves in several places on the coast (GoK, 2010). Finally, mangroves are facing strong anthropogenic pressure, which reduces their adaptation capacity. Despite their protected status, which was established as early as 1895 (Kairo et al, 2007), approximately 103 km² have been lost, prior to 2001 (Abuodha and Kairo, 2001). Thus, their vulnerability to climate change can be ranked medium.

Coral reefs

Coral reefs in Kenya stretch over 630 km² (Spalding et al, 2001), along the

600 km of coast (NEMA, 2009). They are very (91% exposure rate) exposed to risks, and very sensitive to climate change; the massive bleaching in 1998 strongly affected the corals (50 to 90% of them) (Spalding et al, 2001).

Although not linked to the access type (open to fishing or protected areas), virtually the whole area of coral reefs has visibly recovered. Ten years on, the recovery rate is 30% for protected marine areas, and 20% for fishing areas (Wilkinson, 2008), demonstrating weak resilience. Their vulnerability is high.

Vulnerability of livelihoods

Agriculture

Agriculture plays an important role in rural livelihoods, food and the national economy in Kenya (Mutimba et al, 2010). Rainfed agriculture is heavily dependent on the rainfall and the length of the dry season. Horticulture, which experienced significant development in recent years, also suffers from low availability of irrigation water, and rising sea level (for crops cultivated along the coast). Although an increase in rainfall is expected for Kenya in the long run, it will occur in parallel with a longer dry season (McSweeney et al, 2009b). Thus, both rain-fed agriculture and horticulture are highly vulnerable.

Livestock breeding

Pastoralism is the main form of Livestock breeding, especially for populations living in arid and semi arid regions. The lengthening of the dry season, and the increase in temperature will have significant impacts on water and food availability for livestock in the rangelands. Furthermore, these changes will exacerbate the epidemics (Rift Valley fever and other viral diseases) (Mutimba et al, 2010). Therefore, this activity is highly vulnerable to climate change.

Fishing

Kenyan artisanal fishery mainly takes place along the coastal reef area, particularly in the North Kenya Banks, the Malindi-Ungwana Bay complex and the Funzi-Vanga Complex (Ruwa et al, 2003). Over 95% of catches come from these areas (GoK, 2009). This activity strongly depends on the status of corals, and Kenya's coral reefs are known to be highly exposed to bleaching (Spalding, 2001), and their capacity to recover low (Wilkinson, 2008). However, the governance of fisheries resources is well developed, and a network of marine protected areas established since 1968 ensures the preservation and renewal of species. Thus, the vulnerability of fishing can be considered medium.

Food security

The poor performance of food production creates food insecurity, which is increasingly becoming chronic in Kenya: the cycle of famine is reduced from 20 years (1964 to 1984) to one year (2007, 2008, 2009) (Mutimba et al, 2010). This famine is due both to the lengthening of the dry season (Mutimba et al,

2010), and to the variability of the start of the rainy season. Despite the forecast increase in rainfall (McSweeney et al, 2009b), the dry season's rainfall will further reduce, and the duration on the season is not expected to shorten. Thus, food security will have a high level of vulnerability.

Health

The increase in temperature will extend the occurrence areas of diseases such as malaria and yellow fever to the highlands, so that by 2055, the proportion of rural population affected by those diseases will reach 89% (SEI, 2009). Moreover, the intensification of the rainfall forecast for the coming years will promote the spread of microbial and viral diseases related to dirty water, including cholera (Mutimba et al, 2010). An important system has been set up to address these epidemics and includes surveillance systems, a clear commitment from the State, and considerable international mobilization. This is why the level of vulnerability of health in Kenya can be considered medium.

Adaptation and coastal resources management policies

Adaptation action plan

Kenya lacks a national adaptation action plan to climate change. However, it has a national response strategy to climate change, established in 2010 (GoK, 2010); it includes activities, which were initially identified in the first National Communication, developed in 2002. The targeted activities are as follows:

	Planned actions	Type
Human capital	Implementation of a climate information system for the rural populations	Coping
	Institutionalization of an early warning system on drought, floods and epidemics	Coping
	Information and awareness-raising of people from arid and semi-arid areas	Resilience
	Implementation of a monitoring mechanism of new epidemics	Coping
	Provision of pesticides and mosquito nets	Coping
Natural capital	Promotion of irrigated agriculture	Coping
	Implementation of measures for the efficient use of water resources	Coping
	Investment in research on the correlations between climate change and biodiversity at the national level	Resilience

	Elaboration of a national adaptation strategy for wildlife	Resilience
	Use of short-cycle, drought resistant varieties	Coping
	Set up of water-retention and quality-improvement infrastructures	Resilience
	Development of an insurance system for livestock farming	Coping
	Promotion of participative management of transects	Resilience
Physical capital	Restriction of water withdrawal, to ensure water availability for hydroelectric plants	Coping
	Promotion of renewable energy (solar, biomass, etc.)	Resilience
	Building of protection structures against floods	Coping
	Use of improved stoves	Resilience
Financial capital	Diversification of the rural economy, to reduce dependency on agricultural practices	Resilience

Coastal zones' management policy

Kenya's integrated coastal zones' management was elaborated in 2010 (Ruwa, 2011). It addresses the following issues:

- Integrated planning, coordination of coastal development, and communication between the different stakeholders.
- Capacity building of communities and resolution of conflicts relating to resource use.
- Conservation marine and coastal habitats.
- Management of environmental risks, especially emerging issues relating to the change of the coastal line due to climate change and extreme events.
- Awareness raising, education and research on coastal zones.
- Establishment of a legal framework for the implementation of the integrated coastal zones' management.

Marine protected areas play an essential role for the implementation of this policy. Their creation started in 1968 and the current network covers 1,031.3 km².

Name	Surface area (km ²)	Year of creation	IUCN Category
Kiunga National Marine Park	250	1979	VI
Malindi National Marine Park	6.30	1968	II
Watamu National Marine Park	10	1968	II
Malindi-Watamu National Marine Park	245	1968	VI
Malindi-Watamu Biosphere Reserve	196	1970	
Mombassa National Marine Park	10	1986	II
Mombassa National Marine Reserve	200	1986	VI
Kisite National Marine Park	28	1978	II
Mpunguti National Marine Reserve	11	1978	VI
Diani National Marine Reserve	75	1995	VI

Kenya's integrated coastal zones' management policy has the merit of formally integrating climate change, especially the issue of the coasts' vulnerability. However, the link between the protection of coasts and natural ecosystems has not been grasped yet.

Review of ongoing adaptation actions

Despite the fact that the country lacks a national adaptation action plan that would identify priorities for adaptation to climate change, several projects are targeting that issue.

Project	Type	Focus	Donors	Implementing agency
Adaptation to climate change for small-scale agriculture 2009-2014	Resilience	Impact evaluation, searching for alternatives, dissemination of good practices, policy formulation	World Bank	IFPRI, ILRI, KARI, University of Georgia
Adaptation to climate change in arid areas 2010-2013	Resilience	Policy formulation and capacity-building to manage measures relating to climate change adaptation	Special Climate Fund, World Bank	World Bank, UNDP
Support to	Coping	Agroforestry,	USAID	

projects on the reduction of vulnerability in rural areas 2010-2014	and Resilience	introduction of drought-tolerant varieties, improvement of forest watersheds, support to the conservation of mangroves and coral reefs
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The vast majority of ongoing adaptation activities set out to strengthen capacity and to lead to policy formulation, which both constitute the first steps towards resilience. They simultaneously target arid and semi-arid areas, wetlands and coastal zones. However, very few activities are being implemented at the field level (Mutimba et al, 2010).

Madagascar

Overview of the country

Madagascar is a large mountainous island, located in the Southwestern Indian Ocean, 400 km off the coast of mainland Africa, between latitudes 11°57'-25°35'S. It covers 587,041 km² and has 6,603 kilometers of coastline (MEFT, 2008). It measures 1,600 km from North to South, and 580 km from East to West. The island is considered a megadiversity country (Mittermeier, 2003), due to its highly endemic fauna and flora.

Overall, Madagascar's climate is of the tropical type, with variations across regions. Average annual temperature varies between 23°C and 27°C. Annual temperature range is around 3°C in the North, and 7°C in the dry South West. Annual rainfall varies from the West (hot and humid) to the West and the South West (semi-arid and hot), between 3,700 mm and 400 mm (MEF, 2010). The central highlands, the West and the South are characterized by two very distinct seasons: a rainy season from November to April, and a dry season from May to October. The eastern part of the island is rainy nearly all year-round, and the dry season is hardly noticeable.

Madagascar has 21.3 million inhabitants, a population growth rate of 2.8% per year (MEFT, 2008), which ranks as one of the highest in the region. The GDP is US\$ 1,004 (one of the lowest in the region), and the human development index is 0.480, ranking Madagascar 151st in the world (UNDP, 2011).

Madagascar's annual direct greenhouse gas emissions are 86.4 million teCO₂ (MEF, 2004). Land use change contributing most significantly (65.3%) and agriculture (30.7%). The volume emitted by energy production represents only 3.2% of national emissions.

Climate change: recent trends and predictions

Recent trends

Rise in temperature

Between 1955 and 2005, Madagascar's average annual temperature has risen, and its range varies across regions. It varies between 0.2°C and 1.5°C in DJF, and between 0.1°C and 1.2°C in JJA (MEFT et al, 2008); it is more emphasized in the South than in the North (Tadross et al, 2008). Moreover, the increase of minimal temperature is larger than that of maximum temperature (Raholijao, 2007).

Change in rainfall

Given the island's wide climate diversity, change in rainfall is not even (Tadross et al, 2008). Between 1901 and 2000, rainfall in the Northern part of the island has reduced, while increasing in the South. This rainfall increase coincides with the rise in temperature in the South; rainfall in the dry season decrease and that of the rainy season increases, giving way to torrential rains. The East and the Central Highlands are also affected by an observed increase in rainfall.

Sea level rise

Between 1955 and 2003, the average sea level rise varied between 0.8 mm and 2.4 mm per year (Raholijao, 2007). The highest rise occurred in the South (between 1.6 mm and 2.4 mm per year), and in the North (between 1.2 mm and 1.6 mm per year). Sea level rise has been less important in the East and the West.

Cyclones

Madagascar is regularly hit by cyclones, which form in the Indian Ocean basin. Around ten cyclones form in the region every year (Mavume et al, 2009); 3 to 5 of them hit Madagascar. Since 1990, more intense cyclones have been observed: between 1975 and 1989, 18 strong cyclones have been recorded (in other words, one strong cyclone out of 10); between 1990 and 2004, the number has risen to 50 (in other words, one strong cyclone out of four).

Future climate

Rise in temperature

During the next few decades, Madagascar will experience an overall rise in temperature (Tadross et al, 2008). The rise is expected to range between + 0.5°C and +1.0°C in 2030, between +1.0°C and +1.5°C in 2050, and between +2.5°C and +3.0°C at the end of the century (Raholijao, 2007). The rise will be more important in the South than in the North. By 2050, it will range between +1.1 and +1.5°C in the

Northern end of the country, and between +1.6°C and +2.6°C in the South.

Change in rainfall

Annual rainfall will decrease across the entire island (Tadross et al, 2008). It will reach 5% in 2099, and will not be uniformly distributed throughout the year; rainfall will significantly decrease during the dry season (between 5% and 30%), while it will increase by about 10% in the rainy season (Raholijao, 2007). Rainfall will intensify. The South will experience the most significant rainy season rainfall increase.

Sea level rise

By 2090, sea level rise will range between 0.20m and 0.56m, as per IPCC's Global Climate Model (Acclimate, 2011).

Cyclones

Based on 1,000 simulations, predictions foresee the maintenance of the current trend, i.e. the same number of cyclones and the same importance of intense cyclones. However, the cyclone period will start later, and more cyclones will hit the North of Madagascar (Tadross et al, 2008).

Vulnerability of the natural capital

Water resources

Given the diversity of the country's climate, its water resources are not evenly distributed. The main river courses (3,000 km) provide for 57% of the country's surface area (Acclimate, 2011).

Climate change will affect the availability of water resources. First, the rainfall decrease in the dry season will reduce groundwater's supply. Then, the rainfall intensification will provoke runoffs, which will lead to floods, without increasing availability for domestic or agricultural use as waterspouts will swell the riverbeds and will be discharged directly into the sea.

Thus, water resources are very much exposed to climate change, and access to these resources is considered vulnerable (Acclimate, 2011).

Land and production

Madagascar is affected by chronic soil erosion (Rakotoarison, 2003), because of the fragility of its soil and its rainfall. Moreover, the Southern and Southwestern part of the island, where rainfall is low, suffers from wind erosion.

Land resources will mostly be affected in two ways. The decrease rainfall during the dry season will increase the exposure to wind erosion (in the South

and South-West), while increased rainfall will increase water erosion on the rest of the island. Thus, land resources are very vulnerable to climate change.

Agriculture prevails in Madagascar; 80% of the population lives in rural areas (MEFT, 2008). Cultivation techniques have remained archaic (MEFT, 2008), and highly dependent on weather conditions. Thus, agriculture is highly vulnerable to climate change (Acclimate, 2008).

Forests

Madagascar's forests cover 128,380 km² (FAO, 2006), which represent 22% of the country's surface area. The rate of deforestation has improved, from 0.5% in 1990-2000, to 0.3% in 2000-2005 (FAO, 2006). Forest-clearing for agriculture, fuel-wood and illicit exploitation are the main anthropogenic threats to the country's forests (MEF, 2010).

Climate change will have impacts on the living conditions of households, and increase pressure. However, the changes in agro-climatic conditions will significantly affect forests and will lead to reduced plant diversity and ranges. The fauna will be affected in a similar manner. Thus, the forests of Madagascar are very exposed to climate change.

Mangroves

Madagascar's mangroves stretch over 2,797 km², spread across 98% of the Western coast (Giri et Mulhausen, 2008), where 95% of the mangroves are concentrated between the Mahavavy's estuary sites (13°S) Mangoky delta (21°S) (Cooke, 2002). Moreover, 70% of the mangroves of the West coast exceed 500 ha, and significant mangrove swamps (over 200 km²) are located within the estuaries of the Mangoky, Tsiribihina, Ranobe-Besalampy, Betsiboka, Mahajamba and Mahavavy rivers. The bay of Mahajamba alone accounts for 10% of the country's mangroves (Giri and Mulhausen, 2008).

Anthropogenic pressures on mangroves are weak. Between 1975 and 2005, the latter have lost 7% of their cover; their deforestation rate, +0.23% per year, is lower than that of other forest types on the island (+0.5% per year) (MEF et al, 2009). It is even much lower than the rates reported for the mangroves of other regions of the world, for the same period (between 20% and 50%) (Giri and Mulhausen, 2008). The main deforestation causes are conversion for agriculture (35%), wood collection (16%), conversion for aquaculture (3%), and urban development (Giri and Mulhausen, 2008).

Mangroves of the West and Northwestern coast are exposed to climate change, due to increased rainfall and seasonal floods. However, they simultaneously benefit from freshwater and sediment inputs caused by the same phenomenon; they also have a "mangrove hinterland" on a low slope, allowing the extension of swamps inland, in case of an increase of the tidal amplitude (MEFT et al, 2008). By contrast, the mangroves of the Southwest will suffer from the decline in upstream rainfall, and from extraction along the river courses, and are therefore more exposed to the rising sea level.

Finally, mangroves of the small islands will lack sufficient intake of fresh water and sediment, and will experience the same level of exposure to climate change.

Mangroves level of sensitivity to climate change is not yet determined. However, the diversity of species in the West and Northwest supports that they are more resilient than those of the Southwest. Thus, for the whole island, it can be argued that the vulnerability of mangroves is very high on the small islands, high in the Southwest, and medium in the West and Northwest.

Coral reefs

The coral reefs of Madagascar extend over 2,230 km², 87% of which are at risk (Spalding et al, 2001). Limited data is available on reef status before 1998, and the analysis of the ability to recover is performed on the basis of the 2004 bleaching. Subsequently, the rate of live coral reached 20% in intensive fishing areas (almost no recovery), and the recovery varies between 30% (in the unexploited areas of the Southwest) and 70% (in the unexploited areas of the North) (Wilkinson, 2008). Thus, Madagascar's coral reefs are at high risk, are sensitive, and present different adaptation capacity. Their vulnerability may be considered average for the under-exploited areas, and high for exploited areas.

Vulnerability of livelihoods

Agriculture

Malagasy agriculture is exposed to various impacts of climate change: greater frequency and intensity of cyclones, increased risk of floods, locust invasion (in the south), increased risk of drought (MEFT, 2008). The distribution of each respective impact across the country will differ, with more drought risk in the arid south, and more intensive rainfall in major production areas. Increased rainfall, coupled with deforestation, will have negative impacts on soil fertility, the irrigation systems, and on the performance of irrigated agriculture (MEFT, 2010). For rain-fed agriculture, the change in the start of the rainy season (consistent with the prolongation of the dry season) will make production less efficient. Moreover, despite the management system of it, Malagasy agriculture is underperforming (World Bank, 2003). These factors will make agriculture increasingly vulnerable (MEFT, 2010).

Fishing

Artisanal fishing occurs in mangroves, coral banks, and close to the shores (Randrianarisoa, 2011). It is heavily dependent on two types of ecosystems: mangroves and coral reefs. Climate change will increase the sedimentation in coastal areas, which will affect the condition of the reefs, and to a certain extent, that of mangroves. In relation to coral reefs, climate change will increase exposure to bleaching, which is already known to be high (Spalding, 2001). Consequently, livelihoods and the ecological diversity of fish will also

be negatively affected. For the mangroves, the forecast will be more subtle given that mangroves under the same level of degradation are do not always have the same level of resilience (Clausen et al 2011). Moreover, the governance of marine and coastal resources reveals significant flaws (Randrianarisoa, 2011). Fishing is highly vulnerable to climate change.

Livestock breeding

In Madagascar, livestock breeding consists of extensive livestock breeding, and short-cycle domestic husbandry. Extensive livestock breeding occurs in low stocking density ranges (MEEF, 2004), because the production of natural fodder is slow. This situation is worsened by the annual bushfires occurring in savannahs, for different reasons. Even if no significant changes in rainfall are expected in the future, a reduction of rainfall in the dry season and an increase of it during the rainy season are still expected (Tadross et al, 2008). The combination of such factors will promote the outbreaks of viral and bacterial diseases. Should the current level of vulnerability not be considered high (the current evaluations do not conclude so), it will increasingly become so.

Food security

Certain clues point to the fact that currently, Madagascar is already facing food security issues: a large volume of rice, the staple food, is imported annually because agricultural production does not keep up with population growth (World Bank, 2003); starvation becomes increasingly common in the southern part of the island (Ratsimamanga and Bettencourt, 2008). The diet is heavily dependent on subsistence agriculture, which will be affected by a change in rainfall, a more severe drought, the locust invasion and land erosion. In parallel, Madagascar's population is significantly growing, and has low purchasing power (UNDP, 2011), and a weak capacity to adapt (Ratsimamanga and Bettencourt, 2008). Thus, food security can be considered highly vulnerable to climate change.

Drinking water supply

Madagascar is endowed with sufficient water resources, even though the main rivers provide water to only 57% of the country (Acclimate, 2011c). However, only 25% of households, mainly urban, have access to drinking water, and the needs of rural households are only partially covered (Acclimate, 2011c). A longer period of low water and the erosion resulting from intense rains will make drinking water increasingly difficult to access, in many regions of the island. As for governance, the country is implementing an integrated water resources management approach at basin level; the outcomes of the approach depend on the level of protection of such basins, therefore, on forest cover). Thus, the vulnerability of water supply can be considered high.

Health

Several climate sensitive diseases are rampant in Madagascar (Acclimate, 2011c). The occurrence of some of them (malaria, arboviruses, influenza, plague) will extend, and flooding will encourage epidemics of diseases related to dirty water. Moreover, the level of prevention is still low, and health services coverage by adequate infrastructure is insufficient (MEEF, 2009). Thus, the health of the population is highly vulnerable to climate change (Acclimate, 2011c).

Adaptation and coastal resources management policies

Adaptation policy

The country's adaptation policy is spelt out in three reference documents: the initial national Communication on climate change (MEF, 2003), the National Action Plan for Adaptation to climate change (MEF, 2003), and the National Policy on Climate Change (MEF, 2011).

The priority actions can be summarized as follows:

	Planned activities	Type
Human capital	Improvement of basic health services	Coping
	Promotion of information, education and communication, through relevant medium	Resilience
Natural Capital	Planting of mangroves	Resilience
	Reforestation of rural areas with relevant species	Resilience
	Forest management transfer to local communities	Resilience
	Soil protection and restoration	Resilience
Physical capital	Build windscreens and replant casuarinas	Coping
	Stabilization of sand dunes	Coping
	Opening up of potential production areas	Coping
	Development of construction norms	Resilience
	Rock filling of the seafronts	Coping
	Building of protection sea walls, wave-breakers, dikes	Coping
	Building of dams	Coping

Coastal zones' management policy

Madagascar elaborated a Policy for the Sustainable Development of Coastal and Marine Areas in 2010. It constitutes the formal approach for the integrated management of these areas. The strategic components of the policy are the following:

- Improvement and strengthening of the governance of marine and coastal areas.
- Improvement of the economic and social environment of the coastal communities.
- Protection and conservation of the natural resources and of the ecosystems.

Marine protected areas are the main medium used for the conservation of ecosystems at the national level.

Name	Surface area (km ²)	Year of creation	IUCN Category
Nosy Atafana Marine Park	10	1989	II
Masoala (Tampolo, Masoala-Ambodilaitry, Tanjona) National Park	100	1997	II
Nosy Tanikely	0.10	1995	n.a.
Nosy Ve	10	1999	n.a.
Sahamalaza – Nosy Radama Biosphere Reserve	322	2001	n.a.
Tulear Biosphere Reserve	n.a.	2003	n.a.
Andavadoaka Marine Protected Area	28.75	2007	n.a.
Nosy Hara Marine Protected Area	1,254.71	2007	II
Velondriake Community conservation area	n.a.	n.a.	n.a.

Review of ongoing adaptation activities

Only a few activities are formally recognized as adaptation actions to climate change:

Project	Type	Focus	Donors	Implementing agency
Rice sector resilience to climate Since 2012	Resilience	Research, capacity-building and field implementation	Adaptation Fund	UNEP
Food security and disaster risk reduction	Coping and resilience	Capacity building, field implementation	FAO	FAO

Mauritius

Overview of the country

The Republic of Mauritius (Mauritius) consists of two main islands, namely Mauritius (1,865 km²) and Rodrigues (109 km²), and some groups of islands called St. Brandon (3 km²) and Agalega (21 km²). It is located 800 km east of Madagascar on latitude 20°10'S. The population of Mauritius, including Rodrigues and the Agalega, is 1.3 million inhabitants, with an annual growth rate of 1.4%. Gross domestic product per capita is US\$ 12,838, and the human development index is 0.728 (UNDP, 2011). The island is ranked 77th in the world.

Mauritius' climate is sub-tropical; average annual rainfall is 1,600 mm, and average temperature is 24.3°C. The lowest average temperature is 22°C, the highest, recorded in JFM is 27°C.

Green house gas emissions for Mauritius amount to 4.8 million teCO₂ (RoM, 1999). Energy production is the largest contributor with 66%, and 27.4% is attributed to waste. Agriculture contributed 4.1%.

Climate change: recent trends and predictions

Recent trends

Rise in temperature

Data on the 1950-2010 period show a 2°C increase in the average temperature for the minimum temperature, and 1.1°C for the maximum temperature. The same trend is observed for the islands of Rodrigues, St. Brandon and Agalega (Acclimate, 2011).

Change in rainfall

The average annual rainfall is declining: it was 2.260 mm between 1931 and 1960, 2.100 mm between 1961 and 1990, and 2.000 mm between

1971 and 2000 (Acclimate, 2011). Thus, in 70 years, the average annual precipitation has decreased by 260 mm, averaging 3.7 mm per year.

Sea level rise

According to tide gauge data, between 1950 and 2001, the sea level rose by an average of 7.8 cm in Mauritius and 6.7 cm in Rodrigues (Acclimate, 2011), representing an average +1.56 mm and +1.34 mm per year of respectively.

Future climate

Rise in temperature

The increase in average temperature will range between 0.7 and 0.9°C in 2030, between 1.2°C and 1.7°C in 2060, and between 1.4°C and 2.8°C in 2090 (McSweeney et al, 2009).

Change in rainfall

There will be an overall reduction of average rainfall. It will range between -7.02% and -7.88% in 2030, between -11.09% and -13.96% in 2050, and between -20.96% and -22.22% in 2080. The decrease in rainfall will range between -22.44% and -26.76% in 2100 (GoM, 2011).

Sea level rise

Sea level rise will range between 7.8 cm and 8.2 cm in 2030, between 14.6 cm and 16.2 cm in 2050, and between 29.2 cm and 34.6 cm in 2080. By 2100, it will range between 41.7 cm and 48.6 cm (GoM, 2011).

Vulnerability of the natural capital

Water resources

There are 90 rivers and streams in Mauritius, and 43 in Rodrigues. Assuming that rainfall will reduce, the potential volume of used water will be 1.091 million m³ per year in 2020, and 1.070 million m³ per year in 2030. Demand will be 586 million m³ per year in 2020, and 613 million m³ per year in 2030. Access to water resources will be slightly affected by climate change.

Forests

The forests of Mauritius cover 370 km². The deforestation rate is increasing: +0.3% per annum between 1990 and 2000, and +0.5% per year between 2000 and 2005 (FAO, 2006).

These forests are highly exposed to climate change (rise in temperature and decrease in rainfall); and because of the small size of the primary vegetation cover, the forests' ability to adapt is limited. Moreover, it is sensitive to climate change, due to the stress caused by the heat affecting the trees and

pollinating species (Acclimate, 2011). Their vulnerability can be considered high.

Mangroves

The mangroves of Mauritius covered 20 km² in 1987 and 14 km² in 1994: since then, the country lost 30% of its mangroves, because of the collection for fuel-wood and construction. Given the relative abundance of water resources in the country, mangroves in Mauritius are not vulnerable to climate change. This ecosystem has been protected since 2007, and restoration activities have been carried out since 2005. Currently, the restored area covers 25 ha. Given these conditions and ongoing activities, the vulnerability of the ecosystem to climate change can be considered intermediate.

Coral reefs

Coral reefs in Mauritius cover 870 km² (Spalding et al, 2001), 87% of which are at risk. The main island, Mauritius is almost completely surrounded by coral reefs. The 1998 bleaching affected 30% to 40% of corals (Spalding et al, 2001), and that of 2004 affected 22% to 56% of corals (GoM, 2009). For Rodrigues, the extent of dead coral is also low. Thus, coral reefs are sensitive to the increase in sea temperature.

It was observed that 90% of the corals bleached in 1998, and 98% of the bleached corals in 2004 have subsequently recovered (GoM, 2011), indicating strong resilience on the part of this ecosystem. Thus, vulnerability can be considered intermediate.

Vulnerability of livelihoods

Agriculture

The Mauritian agriculture consists of industrial agriculture of sugar cane and intensive food cropping (RoM, 1999). Given the available varieties, sugar cane cultivation can accommodate to climate change (Acclimate, 2011d); food cropping of vegetables and fruit, on the other hand, have low resistance to long low water periods and to violent winds, and are therefore very exposed to climate change. Similarly, the increasing temperature promotes accelerated insect growth and parasite vectors (Acclimate, 2011). However, the policy in place and the level of supervision of farmers being adequate, the vulnerability of agriculture can be considered medium.

Fishing

Fishing in Mauritius consists of deep-sea fishing and artisanal fishing (GoM, 1999). The effect of climate change on oceanic fisheries is poorly understood (Acclimate, 2011d), although the change at the global level could lead to spatial and temporal changes, affecting fish migration and concentration. By cons, artisanal fishing is subservient to the reefs (Acclimate, 2011); its

vulnerability is therefore linked to that of coral reefs. Thus, the vulnerability of artisanal fishery is medium.

Livestock breeding

Only intensive farming is practiced in Mauritius, for the production of meat or dairy produces (Acclimate, 2011c). It is anticipated that heat stress will reduce livestock productivity and stretch the distribution area of pests and diseases (Acclimate, 2011c). However, the policy in place and the supervision system limit the impacts of these factors. Thus, the vulnerability of livestock can be considered low.

Food security

70% of the foodstuffs consumed in Mauritius are imported (Acclimate, 2011), the rest being provided by local production. Moreover, the population's purchasing power is high (UNDP, 2011), giving it a highly adaptive capacity; transportation inside the and outside (port and airport) the country is well developed. However, the availability of food is highly dependent on transportation costs, and on the availability of products in producing countries (Acclimate, 2011c); should the latter be hit by climate change, some products will become scarcer and therefore more expensive. Thus, food security will be affected indirectly by climate change. For Mauritius, vulnerability toward food security can be considered low.

Drinking water supply

Mauritius is endowed with sufficient water resources (RoM, 1999). Despite the rainfall reduction prediction for the coming years (McSweeney et al, 2009c), sufficient drinking water is expected to from the potentially available volume of water (Acclimate, 2011c). Moreover, large hotels have the legal duty to desalinate seawater to fulfill the demand. Thus, the vulnerability of drinking water supplies to climate change is low.

Health

The increased temperature and the intensive rainfall will have impacts on the health of the population; the climate-linked diseases, such as chikungunia and dengue, are likely to spread significantly across the region (Acclimate, 2011). However, the good preventive activities and supervision system in place reduce the vulnerability of health to medium (Acclimate, 2011d).

Adaptation and coastal resources management policies

Adaptation policy

Given its level of economic development, Mauritius does not require a formal plan for adaptation to climate change. The country's necessary adaptation activities are highlighted in the Initial National Communication on Climate

Change (elaborated in 1999) (see table below) (RoM, 1999). Maurice was the first country to ratify the Framework Convention on Climate Change.

The necessary adaptation activities for the country are listed in the National Communication (RoM, 1999).

	Planned actions	Type
Human capital	Collect data on the change in the circulation of ocean currents, which are due to temperature	Resilience
	Perform cost and benefit analyses of coastal protection options	Resilience
Natural capital	Implement integrated coastal zone management, taking adaptation into account	Resilience
	Collect data to evaluate stocks and sustainable harvesting level (fisheries)	Resilience
	Evaluate the period between planting and harvest	Resilience
	Test sugarcane varieties which are resistant to drought and strong winds	Resilience
	Diversify agricultural production	Coping
	Encourage the use of recycled water for secondary domestic use	Coping
	Preserve and protect the residual forest blocks	Coping
	Set up an efficient water resources management system	Coping
	Create marine parks and wetlands reserves	Resilience
	Initiate reforestation programs	Resilience
	Forbid the cutting of mangroves	Resilience
Regulate the use of water for agriculture	Coping	
Physical capital	Build water-retaining tanks	Coping

Coastal zones' management Policy

Mauritius has adopted an integrated approach to coastal zone management that integrates concerns for beach preservation, addresses pollution, and

promotes marine and coastal ecosystems management. Marine protected areas have been established since 1983.

Name	Surface area (km ²)	Year of creation	IUCN Category
Balaclava Marine Park	5	1997	II
Blue Bay Marine Park	3.50	1997	II
Black River Fishery Reserve	7.80	1983	IV
Grand Port Fishery Reserve	18.30	1983	IV
Port Louis Fishery Reserve	3.30	1983	IV
Poste Lafayette Fishery Reserve	6	1983	IV
Poudre d'Or Fishery Reserve	25.40	1983	IV
Rivulet Terre Rouge Estuary Reserve	n.a.	1999	IV
Trou d'Eau Douce Fishery Reserve	5.70	1983	IV
Anse aux Anglais/Grande Baie Fishery Reserve	1.20	1998	IV
Carcasse and Grand Bassin Fishery Reserve	9.50	1998	IV
Passe Demie and Islets Fishery Reserve	5.20	1998	IV
Rivière Banane Fishery Reserve	0.30	1998	IV

Review of ongoing adaptation activities

Three projects are presently implemented within the framework of the Adaptation National Plan:

Project	Type	Focus	Donor	Implementing agency
Awareness-raising on environmental protection, emphasis on climate change	Resilience	Communication on climate change at school, youth and women groups' level	GEF	Environment Care Association
Reduction of migration	Coping	Research, dissemination of		IOM

caused by progressive environmental change		knowledge and capacity-building of national institutions		
Adaptation of the coastal zone to address climate change	Coping and resilience	Policy formulation, capacity-building, knowledge dissemination, site-based implementation	Adaptation Fund	UNDP

Mozambique

Overview of the country

Mozambique is located on the eastern coast of Africa, between latitude 10°27'S and 26°52'S (MICOA, 2003). It covers 784,090 km² (799,380 km² including inland waters); its coastline is 2,700 km, the longest in East Africa; its maritime territory stretches over 666 km². Mozambique also includes an exclusive economic zone of 562 km² (MICOA, 2003). The country accounts 100 rivers, including the Zambezi, which is the biggest river in East Africa. Mozambique also boasts the largest forest cover in East Africa, which covers 41.6 million hectares in total (MICOA, 2003).

Mozambique's estimated population is 23.9 million in 2010 (UNDP, 2011), and its annual increase rate is 3.2%, one of the highest across Africa. Mozambique ranks among the poorest countries in the region; its human development index is 0.322 and its gross domestic product per capita is US\$ 885 (UNDP, 2011). Approximately two-thirds of the population lives in coastal areas (MICOA, 2003). Agriculture is the main economic activity; it contributes to 28% to the GDP and employs 81% of the labor force (World Bank, 2011).

The climate in Mozambique is tropical, of the arid type. Rainfall decreases from North to South, and its annual average varies between 800 and 1 200 mm (McSweeney et al, 2009). The observed temperature is higher near the coasts (25°C -27°C in the summer, 20°C-23°C in the winter), and lower inland (24°C-26°C in the summer and 20°C-22°C in the winter) (Banque Mondiale, 2011).

Mozambique has annual direct greenhouse gas emissions of 17.5 million teCO₂ (MICOA, 2003), which are mainly due to land use change (51.6%) and to agriculture (26.9%). Energy contributes at 10.5% to national emissions.

Climate change: recent trends and predictions

Recent trends

Rise in temperature

Between 1960 and 2006, temperature increased by +0.6°C, averaging 0.13°C per decade, particularly during the rainy season. Between 1960 and 2003, the average annual number of hot days (exceeding the usual observed seasonal or regional temperature by 10%) increased by 25, and the average annual number of warm nights has increased by 31. In parallel, the average annual number of cold days has decreased by 14, and the average annual number of cold nights by 27.

Reduction of rainfall

Between 1960 and 2006, rainfall has decreased by 2.5 mm per month, or 3.1% per decade. This decrease in rainfall is observed mainly during the rainy season. In southern Mozambique, this led to long dry seasons (McSweeney et al, 2009).

Sea level rise

Available observations for the period from 1961-2001 infer that the elevation of sea level (recorded in Maputo) is +0.73 mm per year (Mahongo, 2009).

Future climate

Rise in temperature

The annual average temperature will increase between 1.0 and 1.3°C in 2030, between +1.7°C and +2.3°C in 2060, and between +2.1 and +3.9°C in 2090. The rise in temperature will occur faster in inland areas than in coastal areas (McSweeney et al, 2009).

Change in rainfall

The average annual rainfall will not alter much, even though the country will experience a reduction in rainfall in the dry season (further accentuating drought), and increased rainfall in the rainy season (causing more flooding). The reduction in rainfall in the dry season will reach 13% in 2030 and 15% in 2090. The increase in rainfall during the rainy season will reach 7% in 2030, 13% in 2060, and 34% in 2090 (McSweeney et al, 2009).

Sea level rise

According to the existing scenarios, by 2100, the rise in sea level will vary between 0.5 m and 2.0 m by (MICOA, 2003). This prediction is by far higher than that for the region (0.56 cm).

Vulnerability of the natural capital

Water resources

Mozambique has considerable water resources. However, the modeled results predict a reduction in rainfall of 2 to 9%, and an increase in evapotranspiration of 9 to 13%, reducing the availability of water resources (MICOA, 2009). Meanwhile, water demand will increase (for domestic, agricultural and industrial). Thus, one is faced with a paradox: access to water resources will be increasingly difficult (MICOA, 2009), while the country is heavily exposed to flooding (World Bank, 2011).

Current predictions, which are based on future climate change, envisage a 15% reduction in the flow of the Zambezi River; they also foresee saline intrusions 30 km inland for the Zambeze, Save and Limpopo rivers. Access to water resources will be increasingly difficult for people located in major river basins, while water-storage dams are insufficient (Bambaige, 2007). Water resources are highly vulnerable to climate change, and access to these resources is highly vulnerable.

Land and production

Mozambique's coastal line is 2,700 km. It can be divided in 3 areas: the bays area, 670 km, between the mouth of the Rovuma river and the Mozambique Island, the estuaries area, 900 km between the Mozambique Island and Bazaruto Island, and the lagoons area between Bazaruto Island and Ponta de Ouro. The bays area is relatively not very vulnerable to the signs of climate change, which include rising sea level and increased coastal erosion in this case. The lagoons area has an intermediate level of vulnerability, especially in relation to erosion. Finally, the estuaries area is highly vulnerable to climate risks (MICOA, 2009).

Forests

Mozambique's forests cover 401,000 km² (MICOA, 2010), which represents 51% of the country's surface area. The deforestation rate has increased from 0.21% between 1972 and 1990 (Saket, 1994), to 0.58% per year between 1990 and 2002 (Marzoli, 2007). The main pressures on forests are anthropogenic, namely agricultural conversion, collection of fuel-wood, illegal logging, and wildfires (MICOA, 2010). Changes in temperature and precipitation affect the forests of Mozambique, but their production capacity will not be reduced (MICOA, 2009). The threat to forests come more human pressures than climate stress.

Mangroves

Mozambique has the largest cover of mangroves (3,905 km²) in all of East Africa, (Spalding et al, 2001). The largest mangrove stands (1,900 km²) are found in the Save-Zambezi complex (Fatoyinbo et al, 2008) and in the estuaries of Messalo, Pungoé, Limpopo and Maputo (Spalding et al, 1997). In

many areas, they enter 5 to 15 km inland and along the Sava River, up to 50 km (World Bank, 2011).

Mozambique's mangroves are subject to two climate change phenomena. On the one hand, floods will bring large volumes of fresh water and sediment, which will increase the magnitude of flooding of the Save and Limpopo Rivers by up to 25%. On the other hand, salinity intrusion consequent rise in sea level can reach up to 30 km inland to the rivers Zambezi, Save and Limpopo (World Bank, 2011). Thus, areas that are potentially favorable to tidal mangroves will not be restricted, and the vulnerability of these areas to climate change can be considered intermediate.

Coral reefs

Coral reefs in Mozambique cover 1,860 km², 76% of which are exposed to risks (Spalding et al, 2001). The bleaching of 1998 has had significant impacts, particularly in the Northern part of the country. Following the bleaching, the mangroves have started to recover and after ten years, most reefs are in good condition, with large coral cover (Wilkinson, 2008). This suggests that the coral reefs of Mozambique are highly at risk and sensitive, but have a good capacity to adapt. Their level of vulnerability may be considered intermediate.

Vulnerability of livelihoods

Agriculture

Agriculture plays a major role in the economy (MICOA, 2009) and agricultural areas consist of two agro-climatic regions: the coastal area and northern Save, and Southern Save. The climate in Northern Save and the coastal area is favorable to agriculture, but the soils are poor in places. Southern Save is endowed with a relatively fertile soil, but is subject to large fluctuations of the rainy season (MICOA, 2009).

Agriculture is mainly rain-fed and for subsistence. Climate change will affect it negatively, and reduce production by up to 16.33%. This suggests that agriculture's level of vulnerability is high.

Fishing

Industrial development in coastal areas has had serious impacts on marine and coastal ecosystems in Mozambique. This pressure weakens the natural resilience of these ecosystems. Climatic stress will cause other impacts, which will reduce the ability of mangroves and coral reefs to ensure their production function. It is possible to conclude that the vulnerability of fishing in Mozambique is high, so is that of other countries in the region.

Food security

Two recurring climatic events, namely flooding and drought, affect Mozambique and consistently affect food security. These events destroy crops, and under the current climate change scenarios, a reduction in their frequency is not planned. Thus, food security in Mozambique is highly vulnerable.

Health

Systematic flooding and heavy rainfall, coupled with an increase in temperature are favorable conditions for the emergence of vector-borne diseases (malaria) and diseases related to dirty water, including cholera. Climatic phenomena mentioned above will be magnified in the future. Thus, health can be considered highly vulnerable to climate change.

Adaptation and coastal resources management policies

National Action Plan

The following priorities are defined in the Adaptation National Plan:

	Planned actions	Type
Human capital	Agricultural research and technology transfer	Resilience
	Research on and monitoring of coastal ecosystems	Coping
	Improving the management system of water resources (including the monitoring system)	Resilience
	Study on renewable resources	Resilience
Natural capital	Creation of seed banks	Resilience
	Use of appropriate seeds	Coping
	Improvement of the irrigation system	Coping
	Improvement and conservation of soils	Resilience
	Reforestation with indigenous species	Resilience
	Mangroves reforestation	Resilience
	Development of the integrated coastal management	Resilience
	Improvement of the water supply system	Resilience
Physical	Development of new investment norms	Resilience

capital	Improvement of road-building norms	Resilience
	Regulation for dams and waterways	Coping
	Building of sustainable buildings in secured areas	Coping
	Relocation of vulnerable residential and industrial areas	Coping
	Construction of dune barriers and protection walls	Coping
	Cleaning of main channels	Coping
	Promotion of hydro-energy and of alternatives sources of energy	Resilience
	Promotion of bio-energy in rural areas	Resilience

Coastal zones' management policy

In Mozambique, the management of coastal zones is regulated by a set of sectoral laws relating to the environment (impact study and sensitive areas), to fishing, mining, transportation, and agriculture (Gove, 2011). The country lacks specific policies for integrated management, even though a working group is reflecting and operating on the issue. The national priority adaptation activities include the implementation of an integrated coastal zones' management. The management of marine protected areas is included in the outlook of Environmental Management (MICOA, 2009); the reforestation of mangroves is listed among the national priorities for adaptation. Thus, despite the absence of a formal framework, a certain level of integration has been acted upon. Mozambique's marine protected areas cover 8 950 km².

Name	Surface area (km ²)	Year of creation	IUCN Category
National Park of the Bazaruto Archipelago	1,430	2001	II
Ilhas da Inca and dos Portugueses Fauna Reserve	20	1965	VI
Quirimbas National Park	7,500	2002	II

Review of ongoing adaptation activities

The National Plan National has been implemented through country-driven pilot projects: seven projects are presently ongoing.

Project	Type	Focus	Donor	Implementing agency
Disaster risk management and efficient early warning system	Resilience	Capacity-building and institutional strengthening	BMZ	INGC
Sustainable management and use of forests	Resilience	Capacity-building of local communities	Finland	
Adaptation to drought and to climate change	Coping	Capacity-building, policy formulation and field implementation	SCCF	UNEP
Mainstreaming adaptation to climate change in the system of disaster risk management of the Buzi River watershed	Resilience	Policy formulation and capacity-building including an early warning system for thunderstorms and floods	BMZ	UNDP
Adaptation in coastal areas	Coping and resilience	Capacity-building of communities living in the coastal zones, to manage the risks associated with climate change	LDCF	UNDP
Support to adaptation to climate change	Coping	Capacity-building	USAID	Government of Mozambique
Mainstreaming of the environment and of adaptation to climate change	Resilience	Policy formulation and integration, capacity-building, diversification of the sources of revenues	Spain MDG Achievement Fund	UNDP

Seychelles

Overview of the country

The Seychelles archipelago consists of 115 islands, 41 of which are granitic. The main inhabited islands are Mahe, Praslin, La Digue and Silhouette. The archipelago is located between latitudes 4°S and 9°S, covering a total area of 455.3 km². More than 90% of the population, as well as all economic activities are located around Mahe, at an average height of 2m above the sea level (GoS, 2009).

Seychelles has been populated since only 1770 (28 people at the beginning) (GoS, 2000). Currently, the archipelago has 100,000 inhabitants (UNDP, 2011), with a GDP per capita of US\$ 19,587 (UNDP, 2011) and a human development index (HDI) of 0.773 (UNDP, 2011).

Seychelles is characterized by a warm tropical climate, with average temperatures ranging from 26°C to 30°C and humidity reaching 80% (GoS, 2000). The archipelago is hardly ever hit by hurricanes (Chang-Seng, 2007).

Seychelles' annual greenhouse gas emissions are estimated at 0.5 million tCO₂. They are primarily due to agriculture (51.3%) and energy (36.3%).

Climate change: recent trends and predictions

Recent trends

Rise in temperature

Observations over the past 30 years have revealed a rise in the minimal temperature of +0.82°C, and of +0.33°C in the maximum temperature (Chang-Seng, 2007). The rise in the maximum temperature occurs mainly in DJF, and a higher increase, twice the DJF increase, is recorded for JJA. Simultaneously, the number of cold nights has reduced by 4.8 (0.14 per year) (Chang-Seng, 2007).

Change in rainfall

The observation of rainfall over the 1976-2006 period shows an increase of +13.7 mm per year (Chang-Seng, 2007), suggesting that the Seychelles' climate is becoming more wet. Indeed, the rainfall increase observed in JJA is more significant than that observed for DJF. The intensity of annual rainfall on the granitic islands is increasing (Lajoie, 2004)

Sea level rise

The monitoring of the sea level over the period from 1993-2004 has revealed an increase of the sea level of +1.68 mm per annum (Mahongo, 2009).

Frequency of cyclones

The Indian Ocean is the most prolific of all the oceans for the production of tropical cyclones (Acclimate, 2011). Even if the granite islands (located within 50 km around Mahé) are at the end of the tropical zones and are relatively unaffected by tropical cyclones, the outer islands stand in the paths of those that form in the region (Chang-Seng, 2007).

Future climate

Rise in temperature

There is no specific study on the projected temperature change for the Seychelles. Thus, the predictions established by the IPCC for small islands in the Indian Ocean (Mimura et al, 2007) are the reference: the temperature increase will vary between +0.51°C and +0.98°C in 2040, between +0.84°C and +10.2°C in 2070, and between +1.05°C and +3.77°C by 2100.

Rainfall

The change in the rainfall (observed during the year) will be -2.4% to +5.0% in 2025, from -4.8% to +8.5% in 2050, and -8.6% to +16.3% in 2100 (Chang-Seng, 2007). This means that the rainfall will decrease during the dry period and increase during the rainy season, and that heavy rains will become more frequent.

Sea level rise

The rise in sea level will be about 0.5 mm per year in the Seychelles (Church et al, 2006), which is well below the predicted global level of +1.8 mm per year (Bindoff et al, 2006). However, under the scenario of continuity conditions and practices (business as usual), the annual increase in sea level will be between +0.4 and +0.6 m between 2070 and 2100 (Chang-Seng, 2007).

Vulnerability of the natural capital

Water resources

Seychelles' water resources are very limited: the archipelago is experiencing regular water shortages; seawater desalination plants are set up, to supplement inadequate rainfall and storage capacity (Acclimate, 2011). Demand is growing steadily (+6.5% pa); it is fueled by a tourist industry that, although a mainstay of country's the economy (Chang-Seng, 2007), over consumes its resources (Payet, 2009).

The change in rainfall, characterized by less rain and shorter and more intense showers, and a longer dry season, will consequently reduce the flows of rivers, increase runoff to the sea, and the reduce groundwater recharge (Payet, 2009). This suggests that the water resources of the Seychelles are

very vulnerable to climate change. Moreover, the water of the archipelago is recognized as highly vulnerable (Acclimate, 2011).

Land and production

The Seychelles cover 455.3 km², 60 km² of arable land, and 6 km² of cultivated land (Agriculture, 2009). The coastal plateau holds 70% of arable land (Acclimate, 2011); rising sea levels will lead to the salinisation of soils and of surface waters. This suggests that land resources are very vulnerable to climate change, while agriculture is already recognized as being highly vulnerable (Acclimate, 2011).

Forests

The Seychelles' forest cover is 406 km² (Payet et al, 2000), among which 20 km² of natural forests (FAO, 2006), which represent 5% of the archipelago's total surface area. The surface area of natural forests remained stable from 1990 to 2005 (FAO, 2006). Protected forests cover 184 km², and harvesting is limited to 8,000 m³ (Payet et al, 2000)

Climate change could promote the spread of invasive species (Acclimate, 2011). Yet, one can assume that the management methods (45% of forest areas are under protection status) give a strong resilience to forests; their vulnerability can be considered somewhat low.

Mangroves

Seychelles' mangroves cover 29 km² (Spadling et al, 2001), and are mainly located around the islands of Aldabra, Cosmoledo and Astove (Payet et al, 2000). However, mangroves grow on the East coast and West coast of Mahe, in Praslin and in Curieuse, which are the inhabited islands (Jewelry et al, 2008). The population of the granitic islands does not exploit mangroves, and human presence is minimal in the coral islands of Aldabra and Cosmoledo (Bijoux et al, 2008). Thus, anthropogenic pressure on this ecosystem is minimal.

Climatic stress (increased temperature and change in rainfall) will reduce the flow of rivers flow, and therefore the intake of needed fresh water and sediment. The mangroves in the Seychelles are exposed to climate change, are not very sensitive to it (they are currently proliferating), and their ability to adapt is not altered by human activities. Their vulnerability may be considered low.

Coral reefs

Seychelles' coral reefs cover 1,690 km² (Spalding et al, 2008); only 40 km² are spread around the granitic islands (Bijoux et al, 2008). Their level of exposure to risks stands at 17% (Spalding et al, 2001). However, their sensitivity to climate risks is strong: it was estimated that 97% of the coral reefs have been affected by the bleaching of 1998, and that the subsequent bleachings of

2002 and 2003 affected 90% of coral (Wilkinsons, 2008). Following these phenomena, the reefs located around the granitic islands struggled to recover (11% in 2007); higher recovery rates (varying between 18% and 23%), although still low, have been reported for the coral reefs of the outer islands (Wilkinson, 2008). These rates are lower than those of the other countries in the region. The highest recovery rates were recorded at level of the marine protected areas (Wilkinsons, 2008).

Thus, it can be concluded that the coral reefs of the Seychelles are not very exposed to risks, are very sensitive and have weak resilience capacity. Their vulnerability can be considered high.

Vulnerability of livelihoods

Agriculture

Agriculture is relatively able to satisfy the local demand (80% of fruit, vegetables and cereal). However, it is known to be highly vulnerable to climate change (Acclimate, 2011e), due to the rise in the air's temperature, to drought (causing a reduction of pasture and water stress), and to strong rainfall. Moreover, these events are also promoting the proliferation of invasive species.

Fishing

Fisheries are an important part of the country's economy (Lajoie, 2004). Global climate change will be moving schools of fish and shorten the fishing season (Acclimate, 2011th). Moreover, small-scale fisheries will be affected by the deterioration of habitat quality and coral bleaching. Given the sector's weak adaptation capacity, both the artisanal pelagic fishing and industrial fishing are highly vulnerable.

Livestock breeding

Livestock breeding fulfills part of the local demand (60% of demand for meat). The rest is imported. Livestock breeding is also known for being highly vulnerable (Acclimate, 2011e), because of the reduction of water resources, but also because of the conditions, which enable the outbreaks of epidemics.

Food security

Given the fact that foodstuffs are partly imported (mainly cereals), the effects of climate change on local agriculture have limited impact on food. However, the country is exposed to the variations in the cost of food globally, rendering food security highly vulnerable (Acclimate, 2011th).

Drinking water supply

The drinking water supply is highly dependent on the storage systems and on alternative systems for the desalination of seawater. The prolonged drought

and the heavy rains will not facilitate such storage, the capacity of which is already limited (Acclimate, 2011th). For these reasons, the water supply in the Seychelles is considered highly vulnerable.

Health

The increase in temperature and the change in rainfall are factors that can promote the resurgence of vector-borne diseases (including chikungunia). However, the country presents good health indicators (life expectancy, immunization rates, etc.), indicating a good system of disease prevention and of patients' care. The vulnerability of the population's health to climate change can be considered medium (Acclimate, 2011th).

Adaptation and coastal resources management policies

Given their level of economic performance, the Seychelles are not required to submit a National Adaptation Action Plan. The strategic documents dealing with climate change are the national Communication (elaborated in 2000), the National Strategy on Climate Change (elaborated in 2009) and the Environment Management Plan 2000-2010.

Targeted adaptation activities

The following adaptation activities are extracted from the National Strategy:

	Planned actions	Type
Human capital	Review of policies and institutions, to ensure that adaptation issues are accounted for	Resilience
	Identification key sectors dealing with adaptation	Coping
	Evaluation of the resilience of diseases and vectors linked to climate	Resilience
Natural Capital	Identification of adaptation opportunities for fishing activities	Coping
	Identification of priority zones for adaptation activities	Resilience
	Adoption of the ecosystem approach in the management plans of fishing activities, for social and ecological resilience	Resilience
	Adjustment of approaches to protected areas' management	Resilience
Physical capital	Evaluation of potential risks to coastal areas, vulnerability and the level of protection in place	Coping

	Develop a legally-binding plan for the use of coastal areas	Resilience
	Elaboration of references which integrate climate issues, for coastal pipes, protection works, roads and other development infrastructure	Resilience
	Strengthen the importance of impact assessment and of strategic evaluation, for adaptation and the reduction of climate risks	Resilience
	Improvement of waste collection and treatment	Coping
	Improvement of public health infrastructure	Resilience
Financial capital	Mobilize funding for adaptation	Resilience

Coastal zones' management policy

The Seychelles lack an integrated coastal areas management policy (Nageon and Carolus, 2011). Nevertheless, the set of regulations into force, which relate to pollution prevention, coastal development, fisheries and conservation deals with virtually all issues relating to an integrated management of coastal zones. Moreover, the envisaged adaptation to climate change activities includes a focus on marine and coastal ecosystems.

The creation of marine protected areas has begun rather early, in 1968. Today, they cover 1,078.34 km².

Name	Surface area (km ²)	Year of creation	IUCN Category
Special Reserve	350	1981	I
Aldabra World Heritage site	350	1982	I
Arde Island Special Reserve	0.70	1973	I
Baie Ternay Marine National Park	0.80	1979	II
Cousin Island Special Reserve	0.28	1968	I
Curieuse Marine National Park	14.70	1979	II
Port Launay Marine National Park	1.58	1979	II
Silhouette Marine National Park	30.45	1987	II
Sainte Anne Marine National Park	14.23	1973	II
Ile Coco, Ile La Fouche and Ilot Platters	0.01	1997	II

Marine National Park			
African Banks Protected Area	8.20	1987	II
Anse Faure Shell Reserve	1.08	1987	n.a.
North East Point Shell Reserve	2.99	1987	n.a.
La Digue Shell Reserve	1.58	1987	n.a.
Praslin Shell Reserve	1.74	1987	n.a.

Review of ongoing adaptation activities

Only one climate change adaptation project is currently being undertaken:

Project	Type	Focus	Donor	Implementing agency
Ecosystem-based adaptation to climate change	Resilience	Capacity-building and field activities relating to water supply, management of coastal areas et restoration of ecosystems	Adaptation Fund	UNDP 2011-2018

Tanzania

Overview of the country

Tanzania is the largest country in East Africa, with a total surface area of 945,200 km², of which 60,000 km² are hinterland waters and include Lake Victoria and Lake Tanganyika (Mwandosya et al, 2003). Tanzania consists of a mainland part and of the islands of Zanzibar and Pemba, and lies between latitudes 1°S and 12°S (SSN, 2006). The terrain consists of an 800 km² narrow coastal strip within less than 200 m of altitude, of plateau (most of the territory consists of the central plateau, ranging from 900 m to 1,800 meters in altitude) and of mountainous areas (Shemsanga et al, 2010). The highest peaks in Africa are found in Tanzania; Mount Kilimanjaro, for instance, culminates at 5,895 m), so is the lowest point: the depth of Lake Tanganyika, 356 m below sea level) (Mwandosya et al, 2003).

Tanzania is also the most populous country in East Africa, with 46.2 million inhabitants (UNDP, 2011). The annual population growth rate is 3.1%. GDP per capita was US\$ 1,362 in 2010, and the human development index (HDI) 0.466. Agriculture (including livestock) is the leading economic activity: it contributes to 56% of GNP, and provides income and employment for more than 80% of the population (VPO, 2007).

Tanzania's coastal line is 800 km long (SSN, 2006). It reaches 3,400 km if the coasts of the associated islands are included (GCAP, 2011). The width of the coastal belt varies between 20 km and 70 km (SSN, 2006). The coastal areas of Tanzania are heavily populated: about 25% of the population lives in coastal areas (Torell et al, 2004). Coastal economic activities contribute one third of the country's GNP, and 75% of industries are located in coastal urban areas (GACP, 2011).

Given its proximity to the Equator, Tanzania is not subject to significant temperature variability (Shemsanga et al, 2010). The average temperature varies between 20°C and 32°C, and annual rainfall varies between 600 mm and 1,200 mm (SSN, 2006).

Tanzania has annual direct greenhouse gas emissions estimated at 98.1 million teCO₂ (VPO, 2003). These emissions are mainly due to land use change (57.8%), agriculture (29.1%) and energy (11.8%).

Climate change: recent trends and predictions

Recent trends

Rise in ground temperature

In Tanzania, the average temperature has increased by 1.0°C between 1960 and 2003 (McSweeney et al, 2009). This increase was more significant in JF, and lower in JJAS. During this period, the average number of hot days has increased by 30 per year, and the warm nights increased by 50 per year. Meanwhile the number of cold nights has decreased by an average of 34 per year (McSweeney et al, 2009). During the past 30 years, the great lakes (Tanganyika, Jipe in Rukwa) experienced a recession, and between 1912 and 2002, the glaciers of Kilimanjaro have decreased by 80% (VPO, 2007).

Reduction in rainfall

Over the same period, rainfall has decreased across the country; it lost 2.8 mm per month, per decade. This reduction has been more severe in the South of the country (McSweeney et al, 2009).

Sea level rise

The rise in sea level affected Tanzania, even if its extent is less than that observed at the global level (Mahongo, 2009). The sea level reconstruction model, which combines the collected data and the altimetric level recorded by satellites between 1955 and 2003, points to a rising trend: between 1.2 mm / year (observed in the North) and 2.0 mm / year (observed in the south) (Bindoff et al, 2007).

Future climate

Rise in temperature

Current projections envisage a temperature rise ranging between +1.0°C and +1.3°C in 2030, between +1.7 and +2.5°C in 2060, and between +2.1 and 3.9°C in 2090 (McSweeney, 2009). Hot nights will be more frequent than hot days, (up to 30-68% of nights in 2060, and 35-91% of nights in 2090).

Rainfall increase

At the same time, the annual median rainfall will increase by 2 to 3% in 2030, by 5 to 6% in 2060, and by 7 to 14% in 2090 (McSweeney et al, 2009). This tendency will result from the reduction of rainfall during the dry season (-6% in 2030, -6% in 2060, -4% in 2090), and from the increase of rainfall in the rainy season (+13% in 2030, +18% in 2060, and + 30% inn 2090).

Sea level rise

By 2030, the sea level rise will be of around 0.05 m and 0.19 m, and in 2100, it will be between 0.18 m and 1.22 m (GACP, 2011).

Vulnerability of the natural capital

Water resources

Climate change will affect the three main rivers in Tanzania, namely Pangani, Ruvu and Rufuji. Assuming a rise in the temperature, the flow of the Pangani stream will lose between 6 to 9% and those of the Ruvu stream will lose 10% of its flow. By contrast, the flow of the Rufuji stream will increase by 5 to 11%. These variations are significant, and the change in rainfall will have a strong impact on the use of water resources.

Land and production

Land resources will also be exposed to climate change. First, the increase in rainfall during the rainy season will lead to heavy runoff and the loss of soil minerals. Moreover, the reduced rainfall during the dry season will limit groundwater recharge. The country's main crops, corn, coffee, tea, etc., as well as livestock will be strongly affected by climate change; they can be assessed as being vulnerable.

Forests

Tanzania boasts the largest forest cover in the region. It stretches over 352,570 km², which represents 42.8% of the country (FAP, 2006). The rate of deforestation is rather high: (1.0% in 1990-2000 and 1.1% in 200-2005), and increasing. The main threats on the forests are: fuel-wood collection and

uncontrolled fires. Thanks to its surface area, forests in Tanzania have high resilience. Thus, their vulnerability can be considered intermediate.

Mangroves

The mangroves in Tanzania cover 1,642 km² (Spalding et al, 2001) spread along the coast between Tanga and Mtwara (TCMP, 2001). The important concentrations of mangroves are located in the delta of the Rufuji River (530 km²), and in the estuaries of the Pangani, Wami, Ruvu, Mantandu, Mbwemkuru and Ruvuma Rivers (Semesi, 1991). In the islands of Zanzibar, mangroves cover 18,000 ha (Ngoile, 1992). Between 1990 and 2000, mangroves have not significantly decreased. Those of the Rufuji delta seem particularly stable (Wang et al, 2003).

The increase in temperature and rainfall have reduced fresh water supplies to the Pangani (-9%) and Ruvu (-10%) streams, reducing the sediment supply in their delta (Orindi and Murray, 2005); the rising sea level might not be offset. By contrast, the annual flooding of the Rufuji stream contributes to the stability of the delta's mangroves area (Wang et al, 2003). The mangroves of Tanzania were classified as forest reserve early on, and mangrove restoration programs have been launched since 1994 (TCMP, 2001).

Therefore, even if the mangroves of Tanzania are exposed to climate change their adaptation capacity is strong, allowing their vulnerability to be considered intermediate.

Coral reefs

Tanzania has the largest surface area (3,580 km² of coral reefs in the region, 99% of which are exposed to risks (Spalding et al, 2001). The mass bleaching of 1998 has greatly affected the corals, up to 70 to 90% of the stands around the island of Mafia and Zanzibar. The recovery resumed after the mass bleaching of 1998, in a slow but consistent manner: ten years on, it reached 20% to 70% of the initial coverage, depending on the area and access modes (Wilkinson, 2008). In places, the recovery of corals was severely hampered by the resurgence of starfish (COTS), observed in 2004 (Wilkinson, 2008).

It can be said that the coral reefs of Tanzania are very exposed to risks, are very sensitive. They have a weak adaptation capacity in the open-access areas, and a strong one in the protected areas. Their vulnerability can be considered high outside of the non-protected areas, and weak in the protected areas.

Vulnerability of livelihoods

Agriculture

Agriculture in Tanzania consists of food crops and industrial agriculture. Maize cultivation, practiced by 50% of farmers, will be strongly affected by climate change: production could reduce by 20% by 2075 (and could be as

high as 80% in the central area of the country) (VPO, 2003). Industrial agriculture (coffee, cotton, cashew nuts, sisal) will also be strongly affected. Overall, Tanzania's agriculture is highly vulnerable.

Fishing

Small-scale fishing in Tanzania is carried along the coastlines, and coral reefs and the marine vegetation maintains and renews fish stocks. The impact, considered potentially high, of climate change on these ecosystems also weakens fishing activities. Moreover, the rapid population and infrastructure growth in coastal areas result in increasingly high human pressures on these ecosystems. The management system in place moderately mitigates such pressures. Thus, fishing can be considered high.

Livestock breeding

Increased temperature will affect the structural composition of livestock ranges: more drought-resistant vegetation will grow, but livestock will not appreciate it much. Also, the vegetation that will grow during the short rainy season, or in areas where rainfall will increase, will be less rich in proteins (VPO, 2003). Pastures will be more restricted and 60% of them will be infested with the tse-tse fly (NAPA). Consequently, the productivity of livestock will be reduced. Given the fact that farmers' reaction capacity is limited, and that the policy is weak (VPO, 2003), the sector's vulnerability can be considered high.

Food security

All of the food crop production is for domestic consumption. The decrease in production induced by climate change, combined with population growth (the rate is among the highest in the region) will make food security highly vulnerable.

Drinking water supply

The country has major rivers, which provide water supply to almost all regions. However, the majority of the population uses wells, lakes and collected water to meet their water needs. The change in rainfall will directly affect this segment of the population (VPO, 2006). Indeed, a reduction in the annual flows of major rivers is expected, and groundwater supply is threatened by the temperature increase, which favors evapotranspiration); it is also threatened by excessive runoff caused by heavy rains. Thus, the vulnerability of the water supply can be considered medium.

Health

Malaria is by far the main cause of mortality at the country level (16% of declared deaths). The increase in temperature and the rainfall variation will lengthen the season during which the disease strikes, as well as its occurrence area. The disease is already endemic in low altitude areas, and

could stretch to altitude areas around Lake Victoria (VPO, 2006). Moreover, just like in other countries, diseases linked to dirty water are likely to increase with more intense (which will be less spread out over time). Thus, the vulnerability of health to climate change is high.

Adaptation policies

Two strategic documents define the climate change adaptation policies in Tanzania: the national Communication on climate change (submitted in 2003), and the climate change adaptation national action Plan (PANA), developed in 2007.

The National Action Plan

It defines the following activities as priorities:

	Planned activities	Type
Human capital	Raising the population's awareness on major health risks	Resilience
Natural capital	Community-based fire prevention	Coping
	Encourage seed banks	Resilience
	Protection of fauna and flora	Resilience
	Reduction of the fragmentation of habitats	Resilience
	Establish migratory corridors and buffer zones	Resilience
	Afforestation of degraded soils (with relevant species)	Resilience
Physical capital	Management of the coastal channeling systems	Coping
	Construction of protection infrastructure (dikes, sand dikes)	Resilience
	Establishment of a good land-tenure system	Resilience
	Use of substitution products to woods	Coping
	Improvement of the irrigation system	Coping
	Promotion of renewable energy and of energy co-production systems	Resilience
	Promotion of water retention and recycling	Coping

Coastal zones' management policy

Tanzania adopted a national strategy for the integrated management of coastal areas in 2003 (Daffa, 2011). It focuses on the following issues:

- Support to environmental planning and to integrated resource management at the local level, as well as harmonization with national interests.
- Promotion of an approach based on sustainable economic use of coastal resources, which is compatible with the environment Conservation and restoration of critical habitats, to ensure sustainable use of coastal resources by the population.
- Implement an integrated planning and management mechanism for sensitive coastal areas with a strong economic potential.
- Develop research and promote the use of information, to guide decision-making on coastal areas.
- Promote opportunities for stakeholders' involvement in the process of coastal development and in the implementation of coastal management policies.

The implementation of ICZM includes the management of a network of marine protected areas. Currently, the network stretches over 3 907.05 km².

Name	Surface area (km ²)	Year of creation	IUCN Category
Mafia Island Marine Park	822	1996	VI
Mnazi-Bay –Ruvuma Estuary Marine Park	650	2000	VI
Dar es Salaam (Bongoyo, Fungu, Yasini, Mbudya, Pangavini) Marine Reserves	26	1975	II
Boma-Mahandakini (Tanga Complex) Collaboration-based areas	100	2001	VI
Deepsea-Boma (Tanga Complex) Collaboration management areas	400	1999	VI
Mwarongo-Sahare (Tanga Complex) Collaboration management areas	300	1999	VI
Mtanga'ata (Tanga Complex) Collaboration management areas	150	1996	VI
Boza -Sange Collaboration management areas	559	2000	VI

Mkwaja-Sange (Tanga Complex) Collaboration management areas	405	2001	VI
Mwazi Island Marine Reserve	2.60	1981	II
Chumbe Reefs Sanctuary	0.30	1994	II
Menai Bay Conservation area	470	1997	VI
Misali Island Conservation area	22	1998	VI
Mnemba Island Conservation area	0.15	2002	VI

Review of ongoing adaptation activities

There are presently 5 country-driven adaptation actions in Tanzania that address national priorities defined in the NAPA.

Project	Type	Focus	Donors	Implementing agency
Resilient agro-landscapes 2008-2011	Resilience	Evaluation, research and capacity building	BMZ	World Agroforestry Centre
Reduction the vulnerability of households and of the economy of coastal communities 2011-2016	Coping and resilience	Capacity-building, dissemination of knowledge and field activities, integrated coastal zones' management and ecosystem restoration	Adaptation Fund	UNEP
Management of marine and coastal environment	Resilience	Improvement of the legal and institutional framework for the management of marine resources, to determine the level of sustainable use and marketing	GEF	World Bank

Regional activities and assessments relating to climate change

Adaption actions at the regional level

Issues relating to climate change are very similar across the countries of the region. Impacts and vulnerabilities are very similar for East African countries, and the small islands are facing similar issues. Some of Madagascar's issues are like those of East African countries; others are similar to those of the small islands.

Following is a review of the ongoing activities relating to adaptation to climate change at the regional level.

Project	WIO countries involved	Focus	Donors	Implementing agency
Adaptation to Climate Change (Acclimate)	Comoros, Madagascar, Mauritius, Réunion (France), Seychelles	Evaluation, policy formulation	European Union, France, FFEM	COI 2008-2011
Community-based adaptation to climate change	Kenya, Tanzania	Research, capacity-building, field implementation and community-based adaptation	DFID, IDRC	African Centre for Technology Studies 2008-2011
Adaptation to the water stress induced by climate change in the Nile Basin	Kenya, Tanzania	Evaluation, capacity-building, policy formulation and integration	SIDA	UNEP, Nile Basin Initiative 2009-2012
Adaptation of agriculture to climatic variability (Making the Best of Climate)	Kenya, Madagascar	Research, capacity-building, community-based adaptation	World Bank	ICRISTAT 2009-2011
Global Climate Change Alliance	Mauritius, Seychelles, Mozambique	Policy formulation and implementation	European Commission, Czech Republic,	National governments Since 2008

		, dissemination of knowledge	Sweden	
Support to broader approaches for adaptation to climate change	Kenya, Tanzania, Mauritius, Mozambique	Capacity-building, policy formulation and dissemination of knowledge	JICA	UNDP 2008_2011
Participatory development and strategy-testing to reduce climate variability	Kenya	Research, community-based adaptation	BMZ	International Potato Centre 2008-2011
Groundwater in sub-Saharan Africa: implications for food security and livelihoods	Kenya, Tanzania, Mozambique	Research, policy formulation and integration	Alliance for Green Revolution in Africa (AGRA)	International Water Management Institute 2009-2011
Management of risks, reduction of vulnerability and enhancement of productivity	Kenya, Tanzania	Capacity-building and field implementation in the agricultural sector	DFID, IDRC	Sokoine University of Agriculture (Tanzania) 2007-2011
Include resilience to climate change in agriculture research programs	Kenya, Tanzania	Research, policy formulation and integration	Rockefeller Foundation	FANRPAN 2009-2011
Development and adaptation initiative to climate change (CC-DARE)	Seychelles, Tanzania, Mozambique	Capacity-building, dissemination of knowledge and field implementation	Denmark	UNEP, UNDP 2008-2011
Zambezi River Bassin Initiative	Mozambique	Capacity-building, community-based adaptation	International Red Cross and Red Crescent Foundation	Red Cross and Red Crescent national associations 2009-2013

Cities- and-climate-change initiatives	Kenya Mozambique	Dissemination of knowledge and capacity-building	Norwegian government	UNEP, UN-HABITAT Since 2008
Climate-Land Interaction Project (CLIP)	Kenya, Tanzania	Agriculture, Information system on climate	Rockefeller Foundation	University of Michigan Since 2005
Urban-rural interdependence and climate change	Tanzania	Research, capacity-building	DFID, IDRC	University of Dar es Salaam 2009-2012
Linking African researchers to the adaptation policy community	Kenya, Tanzania	Research, policy formulation, integration and capacity-building	DFID, IDRC	IDRC, Institute of Development Studies 2009-2011
Mangroves for the future	Seychelles	Research, dissemination of knowledge, policy formulation and implementation	Norway, Sweden	CARE, FAO, UNEP, Wetlands International Since 2008
Partners in resilience	Kenya	Capacity-building, dissemination of knowledge	Netherlands	Croix Rouge Hollandaise, Red Cross Climate Centre, Cordaid, Wetlands International 2011-2015
Small African farms and resilience	Tanzania, Mozambique	Policy formulation and integration, community-based adaptation	DFID, IDRC	University of Zimbabwe, IFPRI 2007-2011
Control climate change to protect human health	Kenya	Capacity-building, field implementation	SCCF, WHO, UNDP	UNDP, WHO 2009-2014
Preparing for	Madagascar,	Capacity-	Red Cross –	Red Crosses

climate change	Seychelles	building, policy formulation and integration	Red Crescent Climate Centre	and Red Crescents at the national level Since 2006
Adaptation learning Program (ALP)	Kenya, Mozambique	Capacity-building, policy formulation, integration and community-based adaptation	DFID, Denmark, Finland	CARE 2010-2014
Pilot program for climate resilience	Mozambique	Policy formulation and integration	World Bank Climate Fund	World Bank 2008-2013
Regional climate change program in Southern Africa	Madagascar, Mauritius, Seychelles, Tanzania, Mozambique	Research, policy formulation and integration	DFID, SIDA	OneWorld Sustainable Investments 2009-2014
Capacity-building of agro-pastoralists to climate change	Mozambique	Research, community-based adaptation	BMZ	ILRI 2008-2011
Capacity-building to adapt to climate change (ACCA)	Kenya, Tanzania, Madagascar	Evaluation, capacity-building, policy formulation and integration	IDRC, DEFRA, Switzerland, NCAP, European Commission	UNITAR
Strengthening the adaptation capacity to climate change in the Chinyanja Triangle	Mozambique	Evaluation and research	BMZ	WorldFish Center, International Water Management Institute 2010-2013
Strengthening the role of civil society in the governance of water resources in African cities	Kenya, Mozambique	Research et capacity-building	DFID, IDRC	York University 2010-2013
Network of five pioneering	Tanzania,	Capacity-building, policy	DFID, IDRC	International Council for

cities in climate change adaptation in sub-Saharan Africa	Mozambique	formulation and integration		Local Environmental Initiatives 2009-2012
Running Dry (Management of water resources in arid and semi-arid areas)	Kenya, Tanzania	Community-base adaptation	H.G. Buffet Foundation	ACF, CARE, CRS, IUCN Since 2007
Climate change adaptation in seascapes	Tanzania, Kenya, Mozambique	Ecosystem and community vulnerability assessment	Barclays NORAD, DANIDA, SIDA	World Wildlife Fund

Activities at the regional level relating to the management of the marine and coastal environment

Given the potential by natural ecosystems for adaptation to and mitigation of climate change, all efforts to strengthen their management is in fact a battle against climate change. In particular, all activities in research, data collection, basic knowledge construction, and dissemination of information on ecosystems, constitute basic elements to build these ecosystems' resilience.

Following is a summary of principal ongoing collaborative initiatives relating to adaptation to climate change at the regional level.

Name	WIO countries involved	Focus
ASCLME (Aghula and Somali Large Marine Ecosystems)	Comoros, Kenya, Madagascar, Maurice, Mozambique, Seychelles, Tanzania	Evaluation, policy formulation and integration
Clearing House Mechanism of the Nairobi Convention	Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Réunion (France), Tanzania	Network for sharing data, for capacity-building and for the dissemination of knowledge
ODINAFRICA (Ocean Data and Information Network for Africa)	Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles,	Network for data management and for knowledge dissemination

Tanzania		
COAST-MAP-IO	Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Réunion (France), Tanzania	Data collection, evaluation and bathymetric mapping
TRANSMAP (Transboundary Network for Sustainable Marine Protected Areas)	Mozambique, South Africa, Tanzania	Transboundary network of protected marine areas evaluation, integration, field implementation
WIOFish database	Kenya, Mozambique, Seychelles, Tanzania, South Africa	Data collection and capacity-building on fisheries' management
WWF Coastal East Africa Initiative	Kenya, Tanzania, Mozambique	Addressing regional and national Governance failures, community-based natural resources management

Gap analysis at the country level

Gap analysis of the adaptation policies

During the first national communication in the context of the Convention on Climate Change, all countries in the region have performed an analysis of the vulnerabilities. These analyses focused on the vulnerable sectors, and to a certain extent, on the vulnerability of natural resources. However, in the process of prioritizing actions for adaptation to climate change, some aspects of vulnerability have been omitted.

In general, except in the case of the Seychelles, only the terrestrial ecosystems are considered. This mismatch between the aspects of the natural capital's vulnerability and the prioritization of actions could be attributed to a lapse in planning.

Gap analysis in relation to integration issues

Conservation policies and climate change adaptation policies have been developed almost in parallel, both at the country and at the regional level. Conservation policies have been defined quite early, and concrete measures are implemented in coastal areas: for instance, marine protected areas were established in 2001 in the Comoros, in Kenya in 1968, in 1989 in Madagascar,

in 1983 in Mauritius, in 1965 in Mozambique, in 1968 in the Seychelles and in 1981 in Tanzania. In Kenya, mangroves have been under protection status since 1895.

Treating ecosystems as potential tools to adapt to climate change is not yet systematic at the country level. As such, the usefulness of ecosystem conservation for protection services is not always perceived, and is poorly taken into account in potential policies relating to climate change adaptation. Seychelles is the only country where the ecosystem approach to climate change adaptation is one step ahead, despite the fact that all countries in the region are endowed with considerable natural resources (mangroves for Mozambique and Madagascar, coral reefs for all countries). In any case, the conservation of these ecosystems is not integrated into the priority adaptation actions at country level.

The current strategy formulation relating to the integrated management of coastal areas in the countries of the region does not yet take the challenge of climate change into account. Seychelles is the exception.

Gap analysis of the regional interventions

There are numerous interventions relating to climate change at the regional level. Some of them explicitly address climate change issues, and mainly evolve around evaluation and information systems. Similarly, most regional projects relating to the management of marine and coastal ecosystems focus on similar activities. Thus, these issues are often addressed twice. By contrast, activities relating to the capacity building of communities to cope with climate change, or the capacity building of countries to ensure the resilience of their ecosystems are weakly addressed.

Almost all regional projects set out to integrate the challenges relating to the management of marine and coastal resources into the countries' policies. This integration target is initiated through the establishment of an integrated coastal zone management framework, as well as through biodiversity conservation policies. But such integration is not yet included in the adaptation approaches to climate change.

Recommendations from regional evaluations

Two evaluations of climate change and its impacts in the WIO region have recently been carried out. The first evaluation, the Acclimate Project undertaken by the IOC, focused on the islands in the region, while the other evaluation, led by WIOMSA, dealt with all countries in the region. A brief review of the main findings and recommendations of both evaluations is necessary better place this report in proper context.

The IOC Acclimate Project

The IOC Acclimate project is subsequent to the vulnerability analysis of the IOC member countries and aims to draw up a regional strategy for climate change adaptation. Even if all countries are vulnerable to climate change, disparities do exist stemming from land areas, population distribution, the level of economic development and environmental issues at stake. In addition, there are also challenges relating to a regional adaptation strategy, in so much as there is need for a common vision on the issue of climate change, which requires synergy among WIO countries. Moreover, disparities in the use of funding have distorted perceptions and induced reluctance.

Yet, such a regional strategy is of fundamental necessity in order to respond to climate change impacts in the region; to take into account the specificities of the small islands and of their biodiversity; to be able to 'exist' and 'speak for' the region; to attract the interest and the means provided by donors.

The summary results of the Acclimate Project include the outlining of three thematic strategic objectives: structuring, cross-sectoral and sectoral.

- *Structuring objectives* deal with regional climate governance, the improvement of knowledge, the monitoring of public policies, and existence as a regional entity.
- *Cross-sectoral objectives* relate to the common understanding of regional issues, the coordination of actions among all stakeholders, including NGOs and researchers; the performance of technical studies on vulnerability; the acquiring of scientific knowledge and the exchange of data and information; the monitoring of hazards; and a collective advocacy for the mobilization of funding.
- *Common sectoral objectives* include the integrated management of water resources; the preservation of terrestrial, marine and coastal environments; the planning and managing of risks; agriculture and food security; and fisheries and public health.

The WIOMSA assessment

The evaluation performed by WIOMSA stretches beyond the islands, to include Eastern Africa's coastal states. It makes reference to the climate change resolutions adopted on the continent, namely the Bamako (2010) and the Nairobi (2009) Declarations. At this level of analysis, some disparities faced by IOC/Acclimate project are subtler. However, other disparities are exposed that relate to climate change phenomena across the WIO States such as the difference in temperature elevation, differences in rainfall changes, differences in the movement and intensification of extreme weather events.

The WIOMSA assessment emphasizes the need for a broader understanding of system resilience, and of the opportunity provided by an ecosystem-based

approach to acquire such an understanding. Moreover, it calls for the implementation of low-cost solutions to account for the uncertainties related to climate change events and impacts. In addition, the report highlights the need for the adoption, at the country level, of strategies combining mitigation and adaptation and of low emission development strategies.

Through the regional evaluation compiled by WIOMSA, three major issues are identified for a regional climate change adaptation strategy:

- Mobilization of funding dedicated to climate change adaptation, given that the Small Island States, the Least Developed Nations and Africa are granted special international attention in that respect.
- Strengthening of resilience to climate change in coastal areas, which could be implemented for both ecosystems and communities, at local, national, and regional levels. This strengthening includes capacity-building in the management of climatic data; facilitating access to data and information; understanding and apply methods and tools for adaptation; the analysis of vulnerability; and the integration of climate change issues at the government, private sector and civil society levels.
- Drawing up of an action plan at the WIOMSA, regional organizations and NGOs levels. The action plan should include assistance to countries and communities to widen the spectrum of climate change impacts on marine and coastal resources, as well as assistance to planning and implementation of activities to promote coastal and marine resilience. The action plan would include capacity building, the management of knowledge and funding of adaptation measures.

Conclusion

All countries in the region will be severely affected by climate change. The rise in temperature as well as in sea level will affect all countries (without exception). Change in rainfall will be different: the annual average will be higher for Comoros, Kenya, Tanzania and Seychelles, but lower for Madagascar, Mauritius and Mozambique.

This present assessment highlighted the following:

- All countries in the region are experiencing climate change: the temperature has been rising over the last decades.
- Some signs of climate change, namely changes in rainfall patterns and sea level rise measurably visible.
- All countries tries will experience a significant perturbation of the rainfall, which will result in shifting of seasonal rains an likely measureable changes in overall rainfall, particularly during rainy seasons.

- All countries will experience rising sea level, the amplitude of which may reach 56 cm in 2100. For areas of lower altitude to sea level, this increase will be more visible (+2 m for the case of Maputo, in Mozambique).
- Water resources are experiencing different levels of vulnerability, from intermediate to high.
- Land resources experience the same high level of vulnerability in all countries of the region.
- Mangroves experience the same high level of vulnerability in all countries of the region.
- Coral reefs experience the same high level of vulnerability in all countries of the region; for some countries, the levels vary, depending on the management approach.

To cope with this phenomenon, countries have developed adaptation policies implemented through national or regional projects. In one hand, national policies rarely include potentials of marine and coastal ecosystems for the climate change adaptation. In the other hand, coastal area management policies do not always consider climate issues. Finally, most projects currently implemented are focused on research, capacity building and policy elaboration, but very few of them directly address communities.

A review of ongoing country and regional level activities reveals that the adaptation activities targeted by countries include both adaptation activities to climate change, and resilience-oriented activities.

- Adaptation activities initiated by countries are moderate in extent with focus on research, capacity building, and policy formulation.
- By-and-large, activities at the regional level, including environmental management deal with the same issues of research, capacity building, policy formulation and integration.
- The climate change challenge is poorly integrated into coastal areas management policies, except for Mauritius and the Seychelles.
- The only exceptions are the activities on the management of marine protected areas and on the protection of habitats. Once again, research and evaluation are of paramount importance.

Lastly, the formulation of adaptation priorities and the implementation of such priority activities leave room for improvement. However, the biggest gap is the failure to account for natural ecosystems in the analysis of vulnerabilities, and for their potential for adaptation.

CLIMATE CHANGE IN THE WESTERN INDIAN OCEAN: WIO-C INTERVENTIONS AND RECOMMENDATIONS



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Strategy analysis of WIO-C members

The Consortium for the Conservation of Coastal and Marine Ecosystems in the Western Indian Ocean (WIO-C) was officially launched at the Fifth Meeting of the Contracting Parties to the Nairobi Convention held in Johannesburg, South Africa in November 2007. The founding members included a group of like-minded international and regional organizations and agencies who wished to work together to support partnerships that advance marine research, conservation and management in WIO region.

Founding members of the WIO-C include IUCN, WCS, WIOMSA, WWF, EAWLS, CORDIO, IOC, IOC-UNESCO, Nairobi Convention and NEPAD-Cosmar. Other organizations including Birdlife International, Wetlands International, Blue Ventures, Rare Conservation and TNC have since become full members of the Consortium.

The objective of the WIO-C is to align, harmonize, and move forward marine and coastal management activities within the context of a regional and country level framework. WIO-C's vision is that the Western Indian Ocean's unique and globally significant natural resource base provides the essential goods and services that support biodiversity as well as economic development and the livelihoods of present and future generations. WIO-C's Mission is to achieve a healthy marine and coastal environment that sustainably support people's livelihoods in WIO-region.

IUCN

Mission

IUCN (the World Conservation Union) gathers parastatal agencies, governments, and various types of non-governmental organizations. The IUCN counts over 1,000 members, spread over 140 countries, and constitutes a unique worldwide partnership. At the regional level, IUCN is involved in several areas related to the management of ecosystems (terrestrial, marine and coastal). IUCN is one of the first proponents of natural ecosystem-based adaptation (Seimon, 2012). The IUCN's Marine Programme deals with various global challenges, including:

- Marine Protected Areas
- Large marine ecosystems
- Fisheries
- Coral reefs
- Invasive marine species, and
- The protection of high and deep sea

IUCN's objective

The objective of IUCN is to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature, and ensure that any use of natural resources is equitable and ecologically sustainable.

IUCN's strategy on adaptation

It is based on the use of biodiversity and ecosystem services as a component of a set of coping strategies, to help people adapt to the various effects of climate change. Several justifications for this strategy have been proposed by the IUCN at the two relevant conventions (CBD and UNFCCC), including:

- Ecosystem-based adaptation can generate significant social, economic and cultural co-benefits.
- The strategy is based on traditional knowledge and practices of indigenous and local communities.
- A high potential for mitigation through carbon sequestration in forests, wetlands and healthy coastal ecosystems.

The following table lists IUCN interventions within the Western Indian Ocean.

Project	WIO Countries involved	Type	Description
More resilient reefs to climate change	Seychelles	Resilience	Conservation of reefs and mangroves

All non-governmental organizations constituting WIO-C being IUCN members, this strategy can be considered as a common strategy on adaptation to climate change. The following review of institutional strategies will be used to assess the rigor this common option.

CORDIO (Coastal Research and Development in the Indian Ocean)

CORDIO is a research institution, founded in 1999 and based in Kenya. It was initially created to respond to the massive bleaching of coral reefs throughout the region. CORDIO sets out to create and disseminate accepted knowledge, to find solutions to issues relating to the marine and coastal environment and which the populations of the Western Indian Ocean are facing.

CORDIO East Africa's objectives

Gradually much of the research of CORDIO is focusing on mitigation of damage to reefs and on alternative livelihoods for people dependant on reefs

that are being degraded due to climate change and other stress factors. Summary objectives of CORDIO in the Western Indian Ocean include:

- Conduct research on coastal and ocean ecosystems on the conservation, maintenance and restoration of healthy and productive marine environments.
- Strengthen research and economic and social assessment, to support integrated coastal management, poverty reduction and sustainable development.
- Encourage the integration of science, of practices and of policies at local, national and regional levels.
- Educate and build the capacity of coastal communities to improve their living conditions and welfare in the long term.
- Strengthen human and technical capacity, and encourage partnerships and networking for the development of solutions to marine and coastal issues.

CORDIO's adaptation strategy

Adaptation to climate change is not formally described in CORDIO's strategy. However, in its scope of intervention, CORDIO seeks to:

- Define the processes, resource and biodiversity use in the marine ecosystem of the region.
- Assess the ecological and socio-economic impacts of human activities, including fishing and climate change.
- Elaborate environmental indicators in the long term, for the monitoring and assessment of key coastal ecosystems.

The following table lists CORDIO interventions within the Western Indian Ocean.

Project	WIO Countries Involved	Type	Description
Western Indian Ocean Core biodiversity region	Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Tanzania, Réunion (France), South Africa,	Resilience	Research and evaluation on coral biodiversity

Promotion of sustainable and responsible fishing	Kenya	Coping and resilience	Assessment of the impact of artisanal fishing on the Kenyan coast and identification of good practice
Adaptation to climatic vulnerability	Kenya, Tanzania	Coping and resilience	Capacity-building for communities to adapt to climate in the short term, and support to adaptation
Warning against coral bleaching et measure of ecological resilience	Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Tanzania, Réunion (France), South Africa	Coping and resilience	Impact monitoring protocol of climate change on coral reefs, including a bleaching warning system
Marine spatial planning, GIS and ocean databases	Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Tanzania, Réunion (France), South Africa	Resilience	Data and analysis management and application in the planning of marine spaces. In partnership with ORDINAFRICA, ASCLME and SERVIR Africa

The Nature Conservancy (TNC)

TNC's mission

The Nature Conservancy is a leading conservation organization working around the world to protect ecologically important lands and waters for nature and people. TNC's mission is to preserve the plants, animals and natural communities, which represent the diversity of life on Earth, by protecting the lands and waters needed for their survival. In relation to climate change, TNC is involved with climate change mitigation efforts through Reduced Emissions from Deforestation and Degradation (REDD) initiatives. The following table lists TNC's regional activities relating to marine and coastal ecosystems.

TNC's adaptation strategy

TNC strategy's for adaptation is clearly articulated, and focuses on ecosystem-based adaptation. It sets out to:

- o Identify and define overall priorities for ecosystem-based adaptation, through a clear definition of what ecosystem-based adaptation is (and

what is not), and show what the needs and opportunities are, and where they can be found.

- Build expertise and capacity of practitioners and partners, through support to priority demonstration projects, though the facilitation of learning, and the development of tools and methods.
- Maintain the commitment, the funding and the capacity for ecosystem-based adaptation within other institutions such as government agencies, development agencies and humanitarian assistance NGOs.
- Promote public-private partnership for ecosystem-based adaptation, which yields large-scale benefits for people and nature.

The following table lists TNC interventions within the Western Indian Ocean.

Project	WIO Countries involved	Type	Description
Resilience of coral reefs	Mozambique, Seychelles, Kenya, Tanzania	Resilience	Evaluation, policy formulation

Wildlife Conservation Society (WCS)

WCS' mission

WCS was created in 1896. Its mission is to save wildlife and wild places across the globe. Currently manage about 500 conservation projects in more than 60 countries, WCS is committed to protecting 25 percent of the world's biodiversity. Toward this end, WCS addresses four of the biggest issues facing wildlife and wild places: climate change; natural resource exploitation; the connection between wildlife health and human health; and the sustainable development of human livelihoods.

WCS' adaptation intervention framework

WCS' approach to adaptation is "Adaptation for Conservation Targets", which sets out to turn climate change projections into a set of adaptation activities. The components of this strategy are as follows:

- Identify conservation targets (species, ecological processes, ecosystems, etc.) and define the management objectives for each target.
- Develop a conceptual model, with illustrates the climatic, ecological, social and economic drivers, for each target.
- Analyze how conservation targets are affected by various possible climate change scenarios.

- Identify potential interventions and actions for each target, for each scenario.
- Assess feasibility and the impacts of each potential action.
- Implement priority actions and proceed to monitoring.

WCS saves wildlife and wild places across the globe. It acts both on terrestrial and marine ecosystems. WCS is involved in both the REDD (climate change mitigation) and in adaptation to climate change. The following table lists WCS interventions within the Western Indian Ocean.

Project	WIO Countries involved	Type	Description
Impacts Coral reefs of artisanal fishing on the coral reefs	Kenya, Madagascar, Tanzania	Resilience	Performance analysis of different fishing methods and of fishing areas' management
Efficiency of marine protected areas	Kenya, Tanzania, Madagascar, Mozambique	Resilience	Evaluation of the effectiveness of national and community interventions in the management of coral reefs
Ecological research and monitoring of coral reefs	Kenya, Mozambique, Tanzania, Madagascar, Maldives, Mauritius, Mayotte, Seychelles	Resilience	Reef inventory
More resilient reefs to climate change	Kenya	Resilience	Data collection, research, monitoring and mapping of reefs and of resiliencies
Management options for protected areas and fishing areas, in the context of climate change	Kenya, Madagascar, Mozambique, Tanzania	Resilience	Evaluation and research
Awareness-raising and capacity-building	Kenya, Madagascar	Resilience	Research and training
Masoala – Antongil Bay	Madagascar	Resilience	Evaluation, conservation

marine protected area

Ankarea, Ankivonjy, and Soariake marine protected areas

Madagascar

Resilience Evaluation, conservation

WIOMSA

The Western Indian Ocean Marine Science Association (WIOMSA) is a regional professional, non-governmental, non-profit, membership organization, registered in Zanzibar, Tanzania. It includes about 1000 individual members, as well as about 50 institutional members from within and outside the region. The organization is dedicated to promoting the educational, scientific and technological development of all aspects of marine sciences throughout the region of Western Indian Ocean.

Within WIOMSA's regional strategy there can be defined two principal objectives that address climate change:

- To provide countries of the WIO region with strategically relevant and accurate information that will enhance their capacity to plan and implement both adaptation and mitigation response measures required to reduce the detrimental impacts of climate change on communities and coastal and marine resources.
- To lead a scientific process at regional level for marine environmental issues and to promote efficient responses in a resilient sustainable development approach.

The steps that WIOMSA has elaborated to achieve these objectives include:

- Produce data and metadata to better understand and identify the impacts of climate change focusing on marine environment and biological connectivity and littoral interaction.
- Establish a knowledge-sharing platform to enable sharing of information or results on climate change and identify mitigation and adaptation measures.
- Promote standardized information between scientists in order to integrate information at a larger scale.
- Encourage and favor dialogue/discussion between climate scientists and decision makers. This will help in mutual understanding by raising awareness and informing decision /policy makers on climate change issues while helping scientists understand the demand of policy makers and present data accordingly.

- Identify research gaps and needs to better understand the science of climate change and to allow and enable timely scientific responses. Proposed responses/measures need to be assessed by scientists in terms of resilience of the marine environment.
- Carry out cost-benefit analysis on climate change impacts while emphasizing on the consequences of a business as usual (inaction) to climate impacts. This will help decision makers to understand the implication of climate change impacts that of inaction and to move on actions.

In 2009, a WIOMSA-supported round table gathered experts from the countries of the Western Indian Ocean region. The group formulated a wide range of recommendations: 56 relating to research, 30 relating to policies, 24 relating to natural resources management, 17 relating to human and institutional organizations, and 9 recommendations relating to activities that should be implemented by the governments.

In relation to natural resources management, the recommendations can be specifically divided into three topics: ecosystem-based adaptation, mitigation of climate change and sustainable fisheries.

Ecosystem-based adaptation	<p>Reduce human impacts on marine ecosystems (pollution, deforestation, overfishing, construction of infrastructure)</p> <p>Reforest river basins and coastal wetlands</p> <p>Stabilize shorelines through the use of existing vegetation (mangroves and beach vegetation)</p> <p>Ensure the integration of watershed management and coastal management</p> <p>Create a network of marine protected areas, including small protected areas consisting of resilient communities to the impacts of climate change, to be used as buffer zones and spawning</p> <p>Restore marine ecosystems (coral reefs, mangroves, seagrass beds) using climate resilient or stress adapted species</p> <p>Increase natural forests and wetlands that are used for storing water</p> <p>Assess the pollution situation and implement management and impact mitigation strategies for air and water quality</p> <p>Perform an environmental impact study before any development proposal</p> <p>Use co-management and a broad ecosystem-based approach, for healthy marine ecosystems</p>
Mitigation	Reduce emissions and increase carbon sequestration

Sustainable fisheries	relating to the management of marine ecosystems
	Create sources of alternative energy to reduce the pressure on mangroves
	Use low-fuel capture methods
	Set up an adaptive management of fishing capacities, using climatic and environmental warning systems (especially for extreme events).
	Define national catch quotas, to regulate catches in national and international waters
	Reduce the use of fishing gear that destroys corals and herbivorous fish
Build capacity for an ex-situ management of species threatened by extinction	
Maintain fish biomass above critical limits.	

The following table lists WIOMSA interventions within the Western Indian Ocean.

Project	WIO Countries involved	Type	Description
MASMA (Marine Science for Management)	Comoros, Madagascar, Mauritius, Mozambique, Seychelles	Resilience	Evaluation, capacity-building
MARG (Marine Research Grant)	Comoros, Madagascar, Mauritius, Mozambique, Seychelles	Resilience	Research
GEMPA (Group of Experts on Marine Protected Area)	Comores, Madagascar, Mauritius, Mozambique, Seychelles	Coping and Resilience	Collaboration with UNEP (research and expertise)
PUMPSEA	Kenya, Mozambique, Tanzania	Coping and Resilience	Evaluation, research and field implementation of the mangroves' sustainable management activities in the peri-urban areas of Mombassa, Maputo and Dar es Salaam

World Wildlife Fund (WWF)

WWF's mission

WWF was established in 1961 and now operates in over 100 countries across five continents. Its mission is to stop global degradation and to build a future where humans live in harmony with nature.

WWF's adaptation strategy

Within the region, WWF's adaptation strategy is ecosystem-based and evolves around:

- The recognition of the existing vital relationship between ecosystems and human communities.
- Optimizing the role of natural systems in adapting to climate change.
- The notion that sustainable and resilient ecosystems can continue to provide ecological goods and services to natural resources-dependent populations, and help them adapt to climate change.

Within the Western Indian Ocean, WWF addresses issues related to both terrestrial and marine ecosystems. WWF's marine and coastal interventions at the regional level are listed in the table below:

Project	WIO Countries involved	Type	Description
Chumbe Island Coral Park	Tanzania	Resilience	Evaluation, research, conservation
Marine Park of the Mnazi Bay and Ruvuma estuary	Tanzania	Resilience	Evaluation, research, conservation
Rufiji, Mafia and Kilwa Seascape programme	Tanzania	Resilience	Evaluation, research, conservation
Zambezi Delta programme	Mozambique	Resilience, mangrove carbon	Evaluation, research, conservation
Primeiras and Secundas seascape programme	Mozambique	Resilience	Evaluation, research, conservation
Quirimbas National Park seascape	Mozambique	Resilience	Evaluation, research,

programme			adaptation planning
Kwale seascape programme	Kenya	Resilience	Evaluation, research
Kiunga-Lamu seascape programme	Kenya	Resilience	Evaluation, research, adaptation planning
Conservation of mangroves in the West of Madagascar	Madagascar	Resilience	Assessment of the vulnerability of the mangroves
Adaptation in the Diana region	Madagascar	Resilience	Capacity-building, policy formulation and development of replicable models
Nosy Hara Marine Protected Area	Madagascar	Resilience	Evaluation, conservation
Adaptation capacity to climate change	Madagascar	Resilience	Capacity-building and dissemination of knowledge
Integration of climate change in marine and coastal conservation	Madagascar	Resilience	Evaluation, policy formulation and capacity-building
WIOMER (Western Indian Ocean Marine EcoRegion)	Comoros, Réunion, Madagascar, Mauritius, Seychelles	Resilience	Developing the vision for biodiversity and fisheries, marine protected areas' fisheries' adaptation to climate change, species conservation, knowledge-building, planning and implementation of a network of marine protected areas
Coastal East Africa Initiative	Kenya, Tanzania,	Resilience and adaptation	Addressing governance and policy failures,

Mozambique

empowerment of civil society, sustainable trade and investment, biodiversity and fisheries management, community-based natural resources management, climate change adaptation, spatial planning

RAMP (Marine Protected Areas' Network)	Comoros, Réunion, Madagascar, Mauritius, Seychelles	Resilience	Capacity-building and policy formulation
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BirdLife International

BirdLife International is committed to the conservation of the biodiversity of bird life, and of critical areas for conservation, including the migration zones. The following table lists Birdlife interventions within the Western Indian Ocean.

Project	WIO Countries involved	Type	Description
Marine Important Bird Areas	Kenya, Madagascar, Seychelles, Tanzania	Resilience	Evaluation and research

The Indian Ocean Commission (IOC)

The IOC (Indian Ocean Commission) is an intergovernmental organization that joins island states of the Western Indian Ocean (Comoros, Seychelles, Mauritius, Madagascar, and Reunion/France). These states are formed by small islands (except Madagascar which is a large island having itself many small islands). In the last decades, the IOC has greatly invested in the specific issues of climate change in small islands, conforming with the resolutions of Barbados (1994) and Mauritius (2005).

The IOC strategy on climate change

The IOC climate change strategy itself will be formalized in December 2012. However, the technical preparatory work consisting in defining the strategic principles, the priority intervention areas and the strategy support device has been completed. Support devices are proposed to include a regional climate

change observatory and a Resource Centre for Climate Change Adaptation. The IOC priority areas for intervention include: i) integrated management of water resources ii) preservation of the environment, iii) agriculture and food security, iv) fisheries protection, and v) public health. Strategic principles reflected in the preparatory document include:

- Consolidate the process of climate change adaptation in addition to national policies.
- Increase visibility and legitimacy of the IOC countries in international forums.
- Whenever possible reconcile adaptation and mitigation of greenhouse gas emissions.
- Address regional climate change issues with a focus on the most vulnerable populations.
- Create, maintain and develop interactions and exchange networks with the IOC neighboring areas.
- Strengthen solidarity between IOC countries.

The following table lists IOC interventions within the Western Indian Ocean.

Project	WIO Countries involved	Type	Description
Adaptation to climate change (Acclimate)	Comoros, Madagascar, Mauritius, Réunion (France), Seychelles	Resilience	Vulnerability assessment, evaluation, policy formulation, integration
Small Islands Developing States (SIDS)	Comoros, Mauritius, Réunion (France), Seychelles	Resilience and coping	Monitoring and evaluation of Mauritius strategy for SIDS (2005), capacity building and best practices dissemination
RECOMAP (Regional Coastal Management Program)	Comoros, Madagascar, Mauritius, Kenya, Seychelles, Tanzanie	Resilience	Regional program for the sustainable management of coastal areas in the countries of the Indian Ocean
Adaptation by small farms to climate change (IRACC)	Comoros, Madagascar, Mauritius, Réunion (France),	Resilience and coping	Development of agro-ecology and protection and regeneration oriented agriculture, research, capacity-building,

	Seychelles, Zanzibar (Tanzania)		knowledge dissemination, and field implementation
Maritime Highway	Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles	Resilience	Capacity-building and policy formulation
AMESD (African Monitoring of Environmental for Sustainable development)	Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Tanzania	Resilience	Evaluation, capacity- building, climate change effects monitoring and improvement of coastal and marine resources management through oceanographically and satellite data
ISLANDS	Comoros, Madagascar, Maurice, Seychelles, Zanzibar (Tanzania)	Resilience	Evaluation, policy formulation, integration
Network for epidemiologic survey and warning system (RSIE)	Comoros, Madagascar, Mauritius, Réunion (France), Seychelles	Resilience and coping	Capacity building, policy formulation, integration to national responses frame
Disaster and risk preparedness and management	Comoros, Madagascar, Mauritius, R'eunion (France), Seychelles	Resilience and coping	Policy formulation, integration and support for countries in town and country planning

Blue Ventures

Blue Ventures operates in Madagascar to implement the community conservation area of Velondriake, in the South West of the country. Blue Ventures is also piloting Blue Carbon efforts in country. The Blue Carbon programme aims to conserve mangrove and seagrass habitats using a range of innovative management approaches and financing mechanisms. The following table lists Blue Ventures interventions within the Western Indian Ocean.

Project	WIO Countries involved	Type	Description
Velondriake Community conservation area	Madagascar	Resilience	Conservation and sustainable use of fishing areas and mangroves

UNESCO-IOC (Inter-governmental Oceanographic Commission)

UNESCO-IOC is a component of the UNESCO, targeting capacity-building in general.

Project	WIO Countries Involved	Type	Description
Capacity Development Program	Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Tanzania, Réunion	Resilience	Evaluation, capacity-building

The Nairobi Convention

The Nairobi Convention for the protection, the management and the development of the marine and coastal environment became effective in 1996, and involves all countries in the Western Indian Ocean region. The Convention includes two protocols:

- Protected areas and wildlife.
- Cooperation to fight against marine pollution.

Priority issues addressed by the Nairobi Convention include:

- Coral reefs and associated ecosystems.
- Marine protected areas.
- Pollution from land-based sources.
- Coordination with other regional programs and partnership.

Strategy of the Convention on adaptation

Adaptation to climate change is not part of either the Convention's protocols, or the priority areas. However, two areas are intimately linked to ecosystem-

based adaptation, these being coral reefs and its associated ecosystems, and marine protected areas.

Analysis of consistency and gaps

Convergence of policy resolutions

The resolutions of the World Summit for Sustainable Development (Rio, 2012), of the African Ministerial Conference on the Environment (Bamako, 2010), and of the World Ocean Conference (Manado, 2009) strongly converge. These three authorities mainly recommend:

- The adoption of ecosystem-based adaptation, and its inclusion in national programs and ongoing activities.
- The consideration of the potential of natural ecosystems, especially marine and coastal ones, to mitigate greenhouse gases emissions.
- The promotion national research, capacity building and education in climate change adaptation.

Several countries in the region have developed their national adaptation plan prior to the development of these guidelines. Similarly, some jurisdictions (such as the Nairobi Convention) materialize the commitments of the countries at a time when the science relating to climate change and the advocated approaches for adaptation were not at the current level.

Similarly, the potential for carbon sequestration for mitigation by coastal ecosystems are not always taken into account at the country level; they are often only considered as conservation co-benefits (of forest and coastal vegetation). Although these environmental services are recognized, the promotion mechanisms for their conservation, such as REDD, are only very recent.

Thus, although despite the strong convergences in policy at the global or regional level, transformation and integration into the national policies are lagging behind.

Convergence of the strategies of WIO-C members

Complementarily of institutions

Despite its fairly recent creation as a platform for promoting science-based marine and coastal resources management, the WIO-C stands out, insofar as it consists of inter-governmental institutions. Moreover, its members have long, well-established, presence in the region with collective experiences across environmental, governance and well-being sectors. Given the global programs of most WIO-C members, their respective experience and expertise in other geographic locations can also be brought to bear in the region.

Among its member organizations, the WIO-C includes the Nairobi Convention, the Indian Ocean Commission and WIOMSA. The first two institutions have the capacity, and the mission, to influence climate change policies of different countries in the WIO region, as well as policies addressing marine and coastal resources management. For its part, WIOMSA is a platform that improves scientific knowledge of ecosystems and climate change. At the same time, it can catalyze the involvement of international NGOs in the region and provide the necessary scientific frame of reference to better target field interventions. These three institutions are thus complementary in the analysis and integration of coastal and marine science in policies and field interventions.

By their active presence in the region, WIO-C members can influence policy adjustments relating to the management of marine and coastal resources at both national the level, and subsequently work with country representatives to facilitate the harmonization of these policies in the region. Moreover, the institutions represented in the WIO-C often have broader, more global, perspectives and approaches to climate change adaptation. Thus, they can promote both the necessary scaling and the paradigm shift, to ensure the resilience of ecosystems and communities in the region. In concert with the efforts of WIO-C NGO members, WIOMSA and the IOC work in the region with a focus on science-based and policy directed management of the coastal and marine environment, including the issue of climate change. The following table describes their respective objectives and achievements.

	Main objective	Members	Competencies relating to adaptation to climate change
IOC	Harmonization and implementation of policies relating to the management of coastal and marine resources	Western Indian Ocean countries (Comoros, Seychelles, Mauritius, Madagascar, Réunion/France)	Performed an analysis of the vulnerability of member states to climate change.
WIOMSA	Acquisition of scientific knowledge on the region's marine and coastal ecosystems	Research institutions and experts on the management of the marine and coastal environment	Leading- edge knowledge of the vulnerability of ecosystems to climate change.

WIO-C	Fostering capacity and potential synergy, for the sustainable management of marine and coastal resources in the region	NGOs, research institutions and inter-governmental institutions working for the management of the region's marine and coastal environment	Through the NGO members, a knowledge of the on-site realities and of the impacts of climate change on conservation activities.
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The common interest: ecosystems

The preservation of marine and coastal ecosystems, and of the goods and services they provide to populations and communities is an expressed shared priority in the formulation of missions and in the defined strategies of the members of the WIO-C. It is primarily motivated by the preservation of biodiversity and habitats. The environmental services provided by these ecosystems are considered benefits from conservation.

A common approach towards resilience

If preserving ecosystems is part of a management approach vis-à-vis human pressures, climate change relates to another type of stress exerted on ecosystems, which threaten their existence. Moreover, this stress is ongoing, and some of its impacts are inevitable, both for ecosystems and for communities of living things, hence the importance of the concept of resilience (the ability to recover after stress). The missions of all members of the WIO-C and their strategy fall into a *de facto* approach to resilience.

Moving toward the global recommendations at the country level

With the policy recommendations of the World Summit for Sustainable Development (Rio, 2012), of the African Ministerial Conference on the Environment (Bamako, 2010), and of the World Ocean Conference (Manado, 2009) addressing country level change, it is important to acknowledge that the members of the WIO-C are already working toward this end, specifically to:

- o Recognize the dependence of the WIO States' population's resilience on the resilience of ecosystems, and
- o Express the need for a broader concept to address the issue of adaptation.

These interests are confirmed by the recommendations formulated during the WIOMSA roundtable (Seimon et al, 2011), in which an ecosystems-based adaptation and mitigation approach is promoted. Furthermore, the activities carried out by the members of the WIO-C are filling gaps relating to the

prioritization of adaptation actions, and to the implementation of actions at the country level. At the *conceptual level*, the members of the WIO-C provide an additional consideration for various aspects of vulnerability and for options to address climate change, particularly with regards to the marine and coastal environment. At the *operational level*, members of the WIO-C undertake activities that are not systematically planned in the national action plans, but the usefulness of which, in terms of ecosystem resilience and maintenance of ecosystem services is indisputable and assists in advancing the interests of the national action plans.

Limited attention to blue carbon

Certain marine and coastal ecosystems (mangroves, marine seagrass beds and marine vegetation) have a strong potential for storing carbon, and are strongly exposed to human pressures. Currently, blue carbon is poorly mentioned in the objectives and strategies of the WIO-C members (except IUCN and pilot efforts by WWF and Blue Ventures), despite the fact that it is globally recognized as a strong means to mitigate climate change.

Conclusion and recommendations

The coastal and marine ecosystems of the Western Indian Ocean countries are particularly vulnerable to climate change: coral reefs are highly exposed to bleaching, mangroves exposed to sedimentation and sea level rise, and coastal lands to flooding and erosion. Community livelihoods have the same vulnerability scale particularly coastal agriculture, fisheries, human health and industrial activities.

Through complementary expertise, experience and actions WIO-C members address several areas related to climate change such as ecosystem resilience analysis, research, warning system, management of climate refuges through marine protected area and seascape establishment. These elements constitute a good basis for an ecosystem-based approach, which allows for the linkage of biodiversity conservation to climate change adaptation. In addition, WIO-C has the opportunity to facilitate the integration of science and knowledge into marine and coastal resources management decisions, as well as into policies in the countries of the region, through the inter-governmental institutions which are parts of the Consortium, as well as through the expertise of the NGO members and the research leadership of the regional science institution WIOMSA.

The NGOs members of the WIO-C have, with a focus on biodiversity conservation, begun to lay the foundations for adaptation to climate change based on ecosystem resilience; their continued efforts will further promote ecosystems-based initiatives. Toward this effort, the current marine protected areas have been created in light of the ecosystem services they provide (maintenance of diversity, shelter against climate change), but other services, such as protection services, are not given sufficient attention. This is less a

concern in some countries, such as Madagascar and Comoros, where the surface areas of established marine protected areas are still relatively small, however, the importance of protection services is deserved of increased consideration and national prioritization efforts need to be conscious of this. In addition, the potential for carbon sequestration by marine and coastal ecosystems is widely recognized at the global level, but policies at the national level, as well as initiatives among the members of the WIO-C in that field are still limited. With these considerations in mind, WIO-C is certainly the best formed and most appropriate platform for the promotion of the resilience of ecosystems and coastal communities in the region.

The inter-governmental institutions within WIO-C, specifically the IOC and its mission is to harmonize the marine and coastal resources management policies in the region, including climate change, coupled with WIOMSA, which can be considered a knowledge pool on the marine and coastal resources in the region and their sensitivity/vulnerability to climate change provide a necessary policy and science base from which WIO-C NGO members, with their collective expertise - including knowledge of ecosystems, realities of implementation at the local level, and observed impacts of climate change on conservation activities – can engage with national stakeholders. Consequently, the IOC/WIOMSA/WIO-C collective constitutes a coherent system and includes the three necessary components (policy, science, and implementation), to ensure application of a program, both regional and national, that ensures the resilience of ecosystems and communities. The following table identifies Current strength and limitations of these organizations.

	Strength	Current limitations
Policy (IOC)	<p>Inter-governmental institution that addresses development and governance issues across sectors in the countries concerned</p> <p>Strong capacity to mobilize funding</p> <p>Strong alignment on the impacts of climate change on Small Island States</p> <p>Strong influence on policies in the countries of the region</p>	<p>Geographic coverage: restricted to Western Indian Ocean islands</p> <p>Highly dependent on member countries' involvement</p> <p>No official regional strategy for climate change adaptation (regional strategy currently being finalized)</p>

Knowledge (WIOMSA)	<p>Knowledge of ecosystems' dynamics and sensitivities to climate change</p> <p>Knowledge of scientifically-correct solutions for the management of resources and for their resilience</p> <p>Deals with Indian Ocean islands and West Africa's coastal countries</p>	Weak influence on the integration of scientific knowledge (on ecosystems or on climate change) into national policies and action plans
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Implementation (WIO-C)	<p>Knowledge of the on-site realities</p> <p>Experience with implementation of defined policies in the countries of the region</p> <p>Simultaneous experiences in other regions of the world</p> <p>Members' reputation</p> <p>Capacity to mobilize funding from other donors (private foundations, etc.)</p> <p>Various levels of intervention (local, regional, shared between several countries)</p>	Strategy for climate change adaptation still in the process of being drawn up
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Recommendations for potential intervention areas of WIO-C

WIO-C and policy integration

The link between the defined policies at the country and at the region levels, and the implementation of activities to adapt to climate change is not always obvious, as revealed by: (i) a comparison of the countries' national plans (NAPA and NRSCC), (ii) the existing frameworks at the regional level, and the current progress toward country level activities implementation. Thanks to the presence of the IOC and of the Nairobi Convention, WIO-C can fill this gap and address the pending issues relating to climate change adaptation at the regional level. Moreover, WIO-C member countries are currently very active and can influence the adjustment of policies by promoting ecosystem-based adaptation as a key issue for adaptation at the level of the countries. Thus, WIO-C can intervene at the level of the country and the regional levels, to adjust policies.

WIO-C and the integration of knowledge

The connection between the scientific knowledge about ecosystems and their vulnerability to climate change, and the implementation of solutions to redress issues remains ambiguous. However, through the efforts of several WIO-C member organizations, including WWF and WCS, integration can be seen. WIO-C also includes strong research institutions in WIOMSA and CORDIO. Thus, WIO-C constitutes a platform for knowledge-integration in field activities evolving around the resilience of ecosystems and communities to climate change.

WIO-C and knowledge management

Knowledge management includes data collection, the transformation of data into information, which will be used for decision-making, and the transformation of information into knowledge. WIO-C members have the institutional and scientific capacity to promote this process. Moreover, they have the implementation settings, which allow to test knowledge and to provide the necessary feedback for its potential adjustment. Thus, WIO-C can provide knowledge management on marine and coastal resources management, and on adaptation to climate change in the region. It can also provide early warning services (and bleaching alerts, such as those currently provided by CORDIO), and extend the offer for this service to the IOC, the future climate change adaptation strategy of which includes these components.

WIO-C and climate change mitigation

The marine and coastal environment is becoming increasingly important for the mitigation and sequestration of carbon. At the regional level, mitigation and sequestration in marine and coastal environments still attract limited attention. At the international level, the process leading to the creation of a blue carbon fund has just started. A few WIO-C members (WIOMSA, WWF and Blue Ventures) have acquired preliminary field experience in the science of blue carbon. Proposals in the context of international negotiations can be supported through the political position of WIO-C members IOC and Nairobi Convention, by its scientific strength through WIOMSA, and by the NGO members that constitute its implementation capacity.

WIO-C and funding mobilization

Unlike the countries in the region, WIO-C has a capacity to mobilize funding. Indeed, the status of WIO-C members allows them to access multiple sources of private funding for climate change adaptation activities. Conversely, the Western Indian Ocean States (and the IOC) are limited to conventional financing, such as the GEF, the Adjustment funds or assistance Funds.

WIO-C and WIO-CC

WIO-C is ideally positioned to facilitate the implementation of the Western

Indian Ocean Coastal Challenge (WIO-CC). In an effort to promote ecosystem resilience, sustainable lifestyles and human security, WIO-CC strives to be a platform for the promotion of political commitments, of technical and financial resources, and of climate change adaptation activities at the national and regional levels. It commits to this objective through the ability of its members and their impact in the region, as well as through the opportunities it offers to bypass certain barriers - between policy and knowledge, between knowledge and application.

WIO-C and the facilitation of regional adaptation activities

Given the existence of some disparities and reluctance, the implementation of activities on the regional scale is known to be difficult. Being active in several countries all at once, WIO-C is positioned to overcome such barriers. It is able to apply simultaneously in a few countries ecosystem-based adaptation approaches and solutions, which would take longer to implement within the conventional framework.

WIO-C and environmental governance

Environmental governance, as recognized by the IOC report, as well as the involvement of civil society and the private sector, as recognized by the WIOMSA report, are vital for the resilience of ecosystems and communities, and for the sustainable management of resources. Through its participation in policy definition and activities planning, WIO-C improves environmental governance in the region, without substituting for the sovereign of the States for the definition of policies.

WIO-C: to ensure the paradigm change

The strategies of some WIO countries already reflect a change in the conservation paradigm - in terms of habitats, species and ecosystem services - to resilience. A similar change is necessary at the regional level, so as to shift from adaptation to climate change to resilience of ecosystems and of communities. Such a change requires a policy adjustment, the integration of knowledge, and a broad vision of adaptation activities, which would include ecosystem conservation. Given its structure and the specific mission of its members, WIO-C is the most appropriate institution to induce such a paradigm change at the national levels in the region and across the entire region.

Defining a WIO-C strategy

The presence and engagement of the WIO-C is unquestionably a principal component to ensure the resilience of ecosystems and of communities in the region's coastal areas. It holds the appropriate policy framework and the scientific knowledge base. Moreover, WIO-C appears to be the appropriate platform to mobilize additional funding for the sustainable management of the marine and coastal ecosystems of the region, and to internalize new issues

such as ecosystem-based adaptation and the sequestration of blue carbon. Lastly, as it is influential and far-reaching, WIO-C is a cornerstone for governance,

As a consortium of like-minded international and regional organizations and agencies who wished to work together to support partnerships that advance marine research, conservation and management in WIO region, the WIO-C must have a common strategy that should complement, as well as be reinforced by their respective strengths and institutional strategies. To this end, the following recommendations are formulated:

- Consider the preservation of biodiversity and the goods and services they provide the starting point, which is common to all.
- Catalyze the common know-how, i.e. the preservation of ecosystems.
- Target a common issue: the resilience of ecosystems to human pressure and climatic stress.
- Adopt common key concepts such as ecosystem-based adaptation and blue carbon.
- Catalyze a consistent scaling-up, to maintain the relation between the resilience of ecosystems and the resilience of natural resources-dependent communities.

WIO-C's vision is that the Western Indian Ocean's unique and globally significant natural resource base provides the essential goods and services that support biodiversity as well as economic development and the livelihoods of present and future generations. Further, through leveraging of complementary expertise and experiences, the WIO-C – through a strategic orientation – is ideally situated to provide technical support for the development of the WIO- Coastal Challenges. This later will serve as the necessary regional platform to promote the WIO-C vision by mobilizing political, financial, and technical commitments and harmonization of actions of WIO countries for implementing climate change adaptation, promoting resilient ecosystems, and ensuring sustainable livelihoods and human security.

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