ECO 2021/ 02

E€OFISH

Enhancing equitable economic growth by promoting sustainable fisheries in the EA-SA-IO region

The Technical Centre for Agriculture and Rural Cooperation (CTA)

POTENTIAL EFFECTS OF CLIMATE CHANGE AND EXTREME WEATHER EVENTS ON THE SMALL-SCALE FISHERIES OF THE IOC MEMBER STATES

Dr Soobaschand Sweenarain

Fisheries Economist

Promoted and Funded by

EUROPEAN UNION

Implementing partners

INDIAN OCEAN COMMISSION

iotc ctoi

SWIOFC

Acknowledgement & Disclaimers

This study has been commissioned by the Technical Centre for Agriculture and Rural Cooperation (CTA) with the financial support of the European Union.

Special thanks to Dr Y. Zewdie, Dr A. Oluyede and Mrs C. Van Loenen of the CTA and Mr R. Mohabeer of the Secretariat of the Indian Ocean Commission for their most effective collaboration in the accomplishment of this work.

The Technical Centre for Agriculture and Rural Cooperation (CTA)

Reprinted by E€OFISH

E€OFISH INTEGRATED PROGRAMME MANAGEMENT UNIT

Blue Tower | 4th Floor | Rue de L'institut

Ebène 72201 | Mauritius | Tel: +230 402 6100

info@ecofish-programme.org

www.ecofish-programme.org

This publication was produced with the financial support of the European Union. Its contents are the sole responsibility of E€OFISH and do not necessarily reflect the views of the European

POTENTIAL EFFECTS OF CLIMATE CHANGE AND EXTREME WEATHER EVENTS ON THE SMALL-SCALE FISHERIES OF THE INDIAN OCEAN COMMISSION MEMBER STATES

by

Dr Soobaschand Sweenarain

Fisheries Economist

August 2016

ECO 2021/ 02

CONTENTS

ABBREVIATIONS AND ACRONYMS

ACP	Africa-Caribbean- Pacific
ASCLME	Agulhas Somalia Currents Large Marine Ecosystems
CFDP	Catch Per Fisherman Day
COP	Conference of Parties
CTA	Technical Centre for Agriculture and Rural Cooperation
DFWN	Distant Waters Fishing Nation
EEZ	Exclusive Economic Zones
ENSO	El-Nino Southern Oscillation
EWE	Extreme Weather Events
ESA-IO	Eastern Southern Africa – Indian Ocean
EST	Earth Surface temperatures
ENGO	Environmental Non-Governmental Organisations
EU	European Union
FAD	Fish Aggregating Devices
FAO	Food and Allied Organisation
GDP	Gross Domestic Products
GHG	Green House Gases
HP	Horse Power
ICZM	Integrated Coastal Zones Management
IOC	Indian Ocean Commission
IOD	Indian Ocean Dipoles
IOTC	Indian Ocean Tuna Commission
Kg	Kilogramme
Km	Kilometre

Km²	Square Kilometre
LDC	Least Developed Countries
MDG	Millennium Development Goals
MEA	Multilateral Environment Agreements
NCCC	National Communication on Climate Change
MPA	Marine Protected Areas
NAPA	National Adaptation Plan of Actions
RFMB	Regional Fisheries Management Bodies
SDG	Sustainable Development Goals
SIDS	Small Island Developing States
SLR	Sea Level Rise
SST	Sea Surface Temperatures
SWIO	South-West Indian Ocean
t	Metric tonne
TEK	Traditional Ecological Knowledge
UNCBD	United Nations Convention on Biodiversity
UNCDD	United Nations Convention on Deforestation and Desertification
UNCED	United Nations Commission on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
US$	United States Dollars
VAT	Value Added Tax
WIO	Western Indian Ocean
WTO	World Trade Organisation

EXECUTIVE SUMMARY

The Technical Centre for Agriculture and Rural Cooperation (CTA) commissioned this study of the effects of climate change and variability on the artisanal fisheries of the Indian Ocean Commission (IOC) member countries, namely Comoros, Reunion Island (France), Madagascar, Mauritius and Seychelles. The artisanal fisheries play a prominent role in the socio-economic development and cultural diversity of the peoples of these island states of the South-West Indian Ocean (SWIO). The study is meant to provide information on the potential impacts of climate change and extreme weather events on the artisanal fisheries value chains and their trickle-down effects on the fishing communities as well as the local and national economies. The study comprises four main objectives namely: to document the manifestation of climate change and extreme weather events on the coastal marine fisheries ecosystems; to examine their direct and indirect effects on the livelihoods and well-being of the fishers and associated actors in the value chains with due attention to the most vulnerable ones; to assess the possible impacts on intra-regional and international trade of fish products and to examine the current sector-specific climate adaptation and resilience interventions at regional and national levels.

The study was processed by an extensive literature review of the available contextual political, socioeconomic and ecological information on the subject matter. It highlighted the scarcity of the relevant fisheries and scientific data at the various geographical scales within the IOC region, which is inconsistent with the sector-wise objectives and global agenda of those island states. This is a major impediment for undertaking effective adaptation and resilience-building measures in the diverse and dynamic local socio-ecological environments. It is scientifically impossible to quantify the current and potential effects of climate change and extreme weather events on the coastal marine fisheries because they are overwhelmed by multiple climate and non-climate, including anthropogenic and environmental stressors, which are often referred to as "wicked problems" ([1]). Simple extrapolation or scaling down of the global climate impacts to regional, national, sub-national or local marine fisheries ecosystems can be potentially misleading.

The artisanal coastal marine fisheries had been differentiated into two distinct types based on their linkages with the specific coastal fisheries ecosystems, namely sedentary and oceanic fisheries. The sedentary fisheries include the demersal and benthic aquatic marine resources such as the reef and herbivorous fishes, molluscs and crustaceans that live in the coral reef areas, mangroves forests, sea-grass beds

1 A wicked problem is a problem that is difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize. The use of term "wicked" is to express the complex nature of the problems caused by climate change in the artisanal fisheries and to denote resistance to resolution, the effort to solve one aspect of a problem may reveal or create other problems. (Source: Wikipedia)

and shallow waters of the lagoons, estuaries and wetlands. They are mostly over-exploited and polluted by land-based and maritime effluents in the vicinity of densely populated areas across the IOC countries. The coastal oceanic or the pelagic fisheries target tuna and associated large pelagic fishes in the nearshore open sea or around artificial fish aggregating devices. The coastal tuna fisheries are not evenly developed in the region. The artisanal fisheries of Comoros and Reunion Island are overly dependent on their coastal tuna resources due to their limited extent of the lagoon and shallow continental shelves. Mauritius is also engaged in the development of artisanal tuna fisheries as an option to relieve its lagoon from overfishing. Coastal tuna fisheries are still nascent in Madagascar and Seychelles. The study has examined the vulnerability of these two components of the fisheries concerning the potential climate threats.

The Paris COP 21 is committed to limit global warming at +2°C and eventually to +1.5°C to salvage the low laying least developed countries and the small island developing states, including the IOC countries from unavoidable collateral damages by the turn of this century. In the Indian Ocean, during 1998 - 2010, net primary productivity has decreased by 10 % and is predicted to decline further. The average sea surface temperatures (SST) and sea-level rise (SLR) in the SWIO are within the range of global trends. However, they differ significantly across the local coastal marine ecosystems, with diverse consequences on the productivity of the artisanal fisheries. Moreover, the impacts of climate change are still understood as seasonal and an inter-annual climatic variation by the coastal fishing communities. They have developed over time some adaptation strategies to cope with these changes; however, these measures are not adequate to foster proactive adaptation and long-term resilience in the fisheries. Scientific evidence highlights positive interactions and mutually reinforcing mechanisms between ocean warming and climatic variations that would aggravate the conditions of the marine fisheries. The fisher folks should be well informed on the silent threats of climate change. A bottom-up approach is necessary to assess the current effects of climate change and variations in local socio-ecological environments. So, mainstreaming of climate adaptation in the coastal marine fisheries institutional and policy frameworks have also been constrained by a lack of convincing scientific and observational information on the potential climate risks on the fisheries.

In a nutshell, the impacts climate change undermines food chain and prey-predator relationship and will have direct consequences on the productivity of the fisheries ecosystems and fish production. Fish stocks tend to move steadily towards cooler waters and heat tolerant and pH resistant species are driving away from the endogenous fish species from their traditional habitats. The migratory pattern of tuna stocks is also changing across the oceans. In the SWIO, the surface tuna resources are being displaced farther easterly. These climatic changes will have dire socio-economic consequences on coastal as well as the industrial tuna fisheries of the region. It is crucial to building up scientific and techno-economic information on the

climate threats of the fisheries sector to inform proactive policy actions at national and regional levels.

The economic returns of the coastal marine fisheries in the IOC member countries are declining steadily due to the Open access regime; lack of basic socio-economic and fisheries infrastructure; outdated fishing technologies and assets; poorly developed fisheries value chains and supply chain ecosystems as well as weak fisheries governance and management. The climate and non-climate - environmental and anthropogenic - factors are also exacerbating the socioeconomic benefits derived from the fisheries. Under the current business-as-usual scenario, the coastal fisheries will ultimately collapse. The opportunity cost of the disaster would be unbearable by the IOC countries. The direct impacts of climate change and variations are manifested by a decrease in availability and accessibility or catchability of the coastal fish stocks. A decline in the total catch, species mix and spatial distribution of the targeted fish resources affect the fishing costs and revenue of the fisher folks. The operating costs would increase as a result of decreasing in the landings and changes in the traditional catch composition; an increase in the number of non-fishing days due to bad weather at sea; extension of fishing trips as more time is required in cruising to more distant fishing areas, increase in post-harvest losses in the absence of adequate preservation practices and higher cost of repair and maintenance. The market demand is driven by other factors such as the quantity and quality of the landed products, the purchasing power of the consumers and the availability of cheaper substitutes, particularly from inland or farmed fish products. Although it is expected that the prices of food items, including fish, would increase globally, the escalating cost of fishing in the coastal fisheries might not be compensated fully in these developing small island states because of the absence of structured primary markets, the low purchasing power of the consumers, widespread subsistence fishing as a social safety net against poverty and malnutrition, poorly value chains and marketing networks and direct competition with imported wet fish.

The impacts of climate change will also impact exports of seafood from the IOC countries although the involvement of the artisanal fisheries in the regional or international trade insignificant, if not inexistent. With a slight exception of Madagascar, the bulk of the production of the artisanal fisheries in these countries is meant for domestic consumption. It might be viewed as a paradox that ocean economies like Mauritius and Reunion Island are overly dependent on imported seafood to satisfy their local markets. Comoros, Madagascar and Seychelles are self-sufficient in seafood supplies. Seychelles has significant export potential in the artisanal fisheries, but are constrained by the geographic isolation and smallness of its economy. Comoros is about to commission an export-oriented and fully integrated tuna fisheries project without internalising fully the potential climate risks. Up to now, the artisanal fisheries are the main suppliers of affordable fish protein to the local populations and appropriate climate adaptation are not implemented timely in these fisheries; it is most likely that the per capita consumption of fish would decline and

the livelihoods of the fishing communities would be severely affected in the future. Locally harvested marine fish would become a scarce commodity and the coastal countries might resort to imports or systematically restrain exports of fish and fish products to satisfy domestic demands.

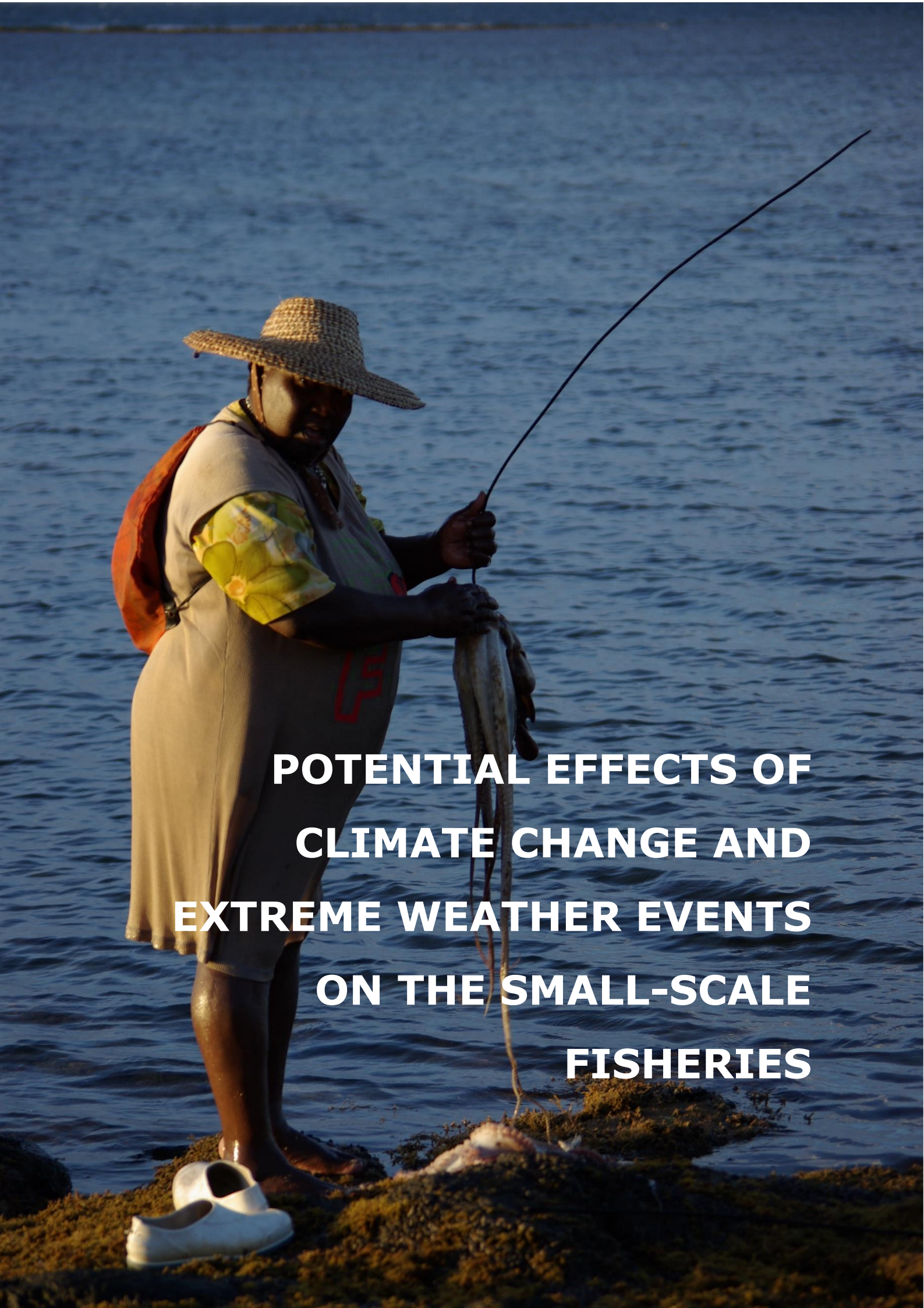
The regional clusters of the export-oriented canned and wet tuna value chains, which is also an extended segment of the European fishing and canning industry are also under threat due to the steady displacement of the surface tuna resources from the SWIO. This would impact negatively the competitiveness of the canned tuna produced in the IOC region at an inappropriate time when the ACP – EU preferential trade agreement is being challenged by the World Trade Organisation. There is a potential risk that the supply of raw tuna from the region would decline constantly. This will eventually affect the future Fisheries Partnership Agreement between the EU and the IOC member countries. As part of the corporate strategy to cut cost, the tuna packers may delocalize their operations closer to emerging fishing grounds. Seafood exporters of the region might also face tougher competition on their traditional markets from exporters from other regions whose fisheries are less affected by ocean warming and/or managed more efficiently. This thought is underway in the seafood hub of Mauritius. The IOC countries should adopt farsighted adaptive strategies to secure their multi-million-dollar tuna industries from the sway of climate change.

Over the past decades, they have participated in over 30 regional and national climate-related programmes with a focus on Research, Evaluation and Policy Formulation; Dissemination of Knowledge and Awareness building; Capacity building and Community-based adaptation. They have performed a vulnerability analysis of the key economic and environmental sectors. The national climate policies have focused more on the land-based sectors than the marine counterparts. The social and environmental challenges in the coastal and marine areas are taken care of by the Ministries of Environment and/or the Integrated Coastal Zones Management. However, these interventions have no direct interest in the socio-economic and ecological aspects of the artisanal fisheries. To cope with this policy gap, the relevant public agencies need to integrate climate-smart strategies into the existing coastal marine fisheries institutional and policy frameworks.

The combined effects of climate and non-climate stressors are wicked problems affecting the socio-ecological sustainability and long-term resilience of the coastal marine fisheries. Some of those stressors are manageable while others of them are unmanageable. It is therefore critical to relieve the coastal marine ecosystems from the human-induced stressors, including overfishing and unsustainable fishing practices, maritime and land-based pollution so that they may uphold their natural resilience to the impacts of ocean warming and extreme weather events. Climate adaptation strategies can be deep-rooted into no regret or triple-win approach, which are more attractive to all stakeholders and may unfold tremendous opportunities for the IOC countries in the process of modernising the artisanal fisheries. The following

areas should be considered in a prospective climate adaptation strategy in the coastal marine fisheries:

- Mainstreaming of climate adaptation and resilience into the current IOC fisheries Strategy 2016-2020;
- Improved communication and coordination among the various environmental and sustainable development policies and programmes at national and regional levels;
- Integration of the fisheries and /or the ocean economy sector into the NCCC and PANA;
- Promotion of participatory ecosystem-based management in the coastal marine fisheries;
- Smart Investments in climate-proofing fisheries infrastructure and fishing assets;
- Development of smart aquaculture and fish farming projects to boost the supply of fish;
- Social security and Insurance Scheme to protect the fishing communities;
- Explore the potential of blue Carbon Projects / Environment stewardship;
- Science-Technology and Innovation leads in promoting climate-resilient fishing operations;
- Review of the MPA and reserves to integrate climate risks.



POTENTIAL EFFECTS OF CLIMATE CHANGE AND EXTREME WEATHER EVENTS ON THE SMALL-SCALE FISHERIES

CHAPTER 1- INTRODUCTION

The Technical Centre for Agriculture and Rural Cooperation (CTA) commissioned the study of the effects of climate change and variability on the artisanal fisheries of the Indian Ocean Commission (IOC) member countries, namely Comoros, Reunion Island (France), Madagascar, Mauritius and Seychelles. This study was meant as part of a series of mapping studies to assist CTA in fine-tuning its interventions on key issues and priority fisheries value chains for the next three years (2016-2018). The study examined the direct and indirect aspects of climate-fisheries issues at sector-specific and macroeconomic levels including fish market and trade, with due emphasis on the vulnerable and informal groups in the fishing communities. It reviews the current regional and national climate-proofing initiatives in coastal marine fisheries. The outcomes of the study should contribute to an inventory of the potential effects of climate change and variability on the coastal marine fisheries ecosystems and the fish production as well as their cascading effects on the fishing communities and the national economy. The IOC is formulating a plan of actions for the operationalisation of its Regional Climate Adaptation Strategy 2016-2020. It is expected that the study would spur national climate compatible development policies and programmes as well as the regional political trust and initiatives to dealing with the wicked challenges of ocean warming in the coastal marine fisheries.

1.1 CLIMATE POTENTIAL IMPACTS ON FISHERIES

Climate change is the world most impactful risks and will remain so for the years to come ([2]). It also acts as a threat multiplier and exacerbates other anthropogenic and environmental risks such as water and energy crises, land-use changes as well as the coastal and marine biodiversity. Various IPCC reports and assessments have established with the highest level of scientific confidence that the accumulation of human-induced GHG emissions into the atmosphere is responsible for the deregulation of the planetary climate system and global warming. The planet has become warmer by 1°C and the sea level has risen by 30 cm over the past 150 years and is expected to warm up by 1°C to 5.5°C and the sea level might rise by 80 cm to 5.5 m by the turn of this century in a business-as-usual scenario. By 2011, the world had already emitted about two-thirds of its GHG quota to stand a 66% chance of keeping the average global temperatures at the +2°C target ([3]). Even if the emissions are stopped immediately, temperatures will remain high for centuries due to the long life of the past emissions in the atmosphere. While +2°C is taken as the global threshold to restrict the global warming, at +1.5°C the low laying least developed

2 Global Risks Report, 2016

3 IPCC 2014, 5th Assessment Report

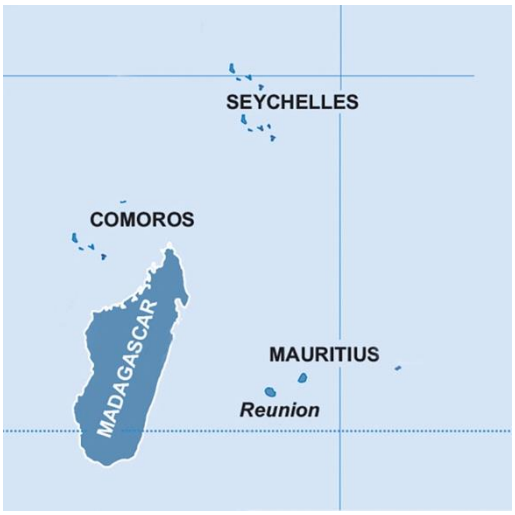
countries and small island developing states (SIDS) would already suffer from unavoidable and irrecoverable damages. The effects of global warming are unevenly distributed across the world and the poorest and small island economies are the most affected although they have the least global carbon footprints.

The fisheries sector, particularly the small-scale fisheries are the mainstay of the coastal economies but are also at the frontline of the impacts of climate change and extreme weather events. The ocean warming, sea-level rise and acidification of the ocean will disrupt the coastal marine fisheries ecosystems and provoke a reduction of fish production of by 40% to 60% in the tropical and subtropical regions ([4]). These fisheries are maintaining food and nutrition security, employment safety nets and the wellbeing to the fishing communities and the coastal populations. Any decline in the productivity of the fisheries will have severe socioeconomic consequences on the local communities and the national economy. The inshore marine fisheries ecosystems such as the coral reefs, mangrove forests, seagrass beds, sand beaches, estuaries and wetlands are already exhausted due to human-induced and environmental pressures, which would be aggravated at an exponential speed by the impacts of climate change and extreme climatic variations.

The fishing communities of the island states are accustomed to seasonal and inter-annual climatic changes as well as EWE such as cyclones, tsunamis, Indian Ocean Dipoles (IOD) and volcano eruptions etc. They have accumulated over time a wealth of traditional ecological knowledge (TEK), observations and some capacities to react to these natural disasters that can be very useful in climate adaptation and resilience planning. However, these coastal communities are not fully aware of the long term and subtle threats of global warming on their livelihoods, safety and wellbeing. Often, there is confusion in the mind of the fishing communities concerning these two distinct, but interconnected climatic phenomena due to the shortfall of awareness building. It is scientifically documented that climate change also influences climate variations to produce more frequent, intense unpredictable EWE. The climate is not uniform across the world; the local weather conditions are determined by several factors, including the latitude and altitude, geographic location, the vegetation and the rotation of the Earth which affects the seasons. The IOC region is influenced by the tropical and sub-tropical climate and oceanographic features of the SWIO. With modern technologies, weather forecasts have been more accurate and useful in the Early Warning System and Preparedness. Nothing can be done to change the weather patterns, but climate science can predict the potential impacts of climate change on biophysical ecosystems. The available scientific knowledge and information can be coupled with the socioeconomic insights to assess the potential vulnerabilities and opportunities for climate adaptation. These EWEs are subtle and yet, vivid manifestations of climate change.

4 Cheung EW & Allison D (2010) – Impacts of Climate Change on the Global Fisheries

1.2 REGIONAL CONTEXT



1.2.1 The Indian Ocean Commission

The Indian Ocean Commission (IOC) is a regional inter-governmental organisation in the South West India Ocean (SWIO) comprising 5 neighbouring island states namely, Comoros, Reunion Island (France), Madagascar, Mauritius and Seychelles. It represents about 25% of the EEZ of the Eastern and Southern African states ([5]). The regional marine productivity is influenced by the Agulhas and Somalia Currents Large Marine Ecosystems (ASCLME), which is reputed for its unique oceanographic features and regional socio-ecological diversities. Besides the shared geo-economic and environment challenges as Small Islands Developing States ([6]), the IOC member countries have their own socio-economic and ecological specificities, including the diverse level of sustainable development. These differences are more apparent in the fisheries sector, particularly the artisanal fisheries through various macroeconomic indicators such as the Gross Domestic Products (GDP), food and nutrition security, level of employment, fisheries governance, hard and soft infrastructure as well as business enabling environment. The vulnerability of the production system to climate and non-climate risks are directly related to its resource-based potential and socioeconomic significance to the local communities and national economy. The fisheries sector in the IOC is overly dominated by the industrial tuna fishing and processing activities, which are an extension of the EU canned tuna value chains. The development of the national industrial fishing activities is at its infancy stage in the region although the process of domestication of the foreign fishing enterprises is underway. The artisanal fisheries consist of the coastal inshore demersal and offshore demersal and pelagic fisheries that supply the domestic markets with fresh fish; while small quantities of high-value reef fishes, molluscs and crustaceans are also exported. Despite its low contribution to the macroeconomic statistics, the artisanal fisheries sub-sector is the primary source of food and nutrition security, employment and wellbeing to the coastal communities, but it is also highly vulnerable to the potential impacts of climate change.

5 IOC Secretariat Annual Report 2014 [Total EEZ of the ESA: 25.5 million Km² and those of the IOC, 5.5 million Km²]

6 As defined by the UN Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States [Yet, there is international accepted definitions for SIDS]

1.2.2 Artisanal fisheries

Defining artisanal fisheries has always been a challenge in a regional context as the terms are used by different stakeholders to represent different political viewpoints and socio-economic perspectives in different national settings ([7]). In this context, the term "artisanal fisheries" will express the same terminology as "small scale fisheries" or "coastal fisheries". These terms are meant to cover all the coastal marine fisheries, including subsistence, traditional or commercial artisanal fishing value chains that supply fresh marine produce for auto-consumption, local and export markets. In the IOC region, this sector is characterized by the use small amount of capital, technology and fossil energies, on-foot, weakly motorized or non-motorized fishing crafts of about 5 to 6 m long, simple fishing gears and techniques undertaking daily fishing trips within the exclusive coastal and territorial waters ([8]). They are **multi-gear** and **multi-species** fishing household units or small commercial enterprises operating mostly in a common pool and open access environment prone to the "Tragedy of the Commons". The available fisheries data are inadequate and underestimated ([9]). The fisheries policies are driven by socio-anthropologic considerations rather than bio-economic or scientific rationale. The fisheries operate primarily as an informal sector and its socioeconomic significance is not fully internalised at the sector and macroeconomic levels.

1.3 METHODOLOGY

The study is performed through an extensive literature review based on the available documentation on the current and future potential impacts of climate change on the coastal marine fisheries ecosystem's productivity and fish production as well as the cascading socioeconomic effects on fishing communities and the national economy. Since the climate change challenges transcend the national boundaries, the study has looked at the current national and regional climate-proofing policies and programmes of the IOC region. The above inputs are complemented with the expertise and field experience of the consultant in the SWIO region.

The study has built on the information from a recent IOC project that has performed a concise environmental vulnerability assessment on the coastal marine ecosystems and the fisheries sector ([10]), the National Communications on Climate Change (NCCC), the National Adaptation Plan of Action (NAPA) and other strategic reports of the beneficiary countries. So far, there have been no socioeconomic studies on the current and future potential impacts of the climate change on the fisheries sector of the IOC

7 FAO Glossary

8 Up 12 – 25 nautical miles (depending on the extent of the continental shelves) from the coastline formally reserved for the domestic artisanal fisheries

9 According to Cochrane et al FAO (2010), the global fisheries statistics are underestimated by at least 30%

10 IOC – Adaptation of Climate Change Project , Acclimate 2008 - 2012

region. This study focuses on sector-specific and national levels because appropriate policies and programmes are generally formulated at this level. The national analytics are then condensed into a regional synthesis to guide future climate actions on coastal marine fisheries at the IOC level.

The study recognises that vulnerability ([11]) of the coastal fisheries in the national economy depends on the interplay of different factors namely:

i)	The future potential climate impacts on the fisheries ecosystems and their productivity;
ii)	The consequential socioeconomic effects on the fishing communities and the economy;
iii)	The existing adaptive capacities to anticipate these threats and opportunities ([12]).

1.3.1 Perspectives informing the Study

The artisanal fisheries have been differentiated into two distinct types based on their linkages to their specific coastal marine ecosystems, namely sedentary fisheries and the oceanic fisheries. The sedentary aquatic resources comprise reef and herbivorous fish, mollusc and crustacean species that are localised in the coral reef's areas, mangroves forests, seagrass beds, beaches, estuaries and wetland habitats. They are vulnerable to overfishing as well as environmental - climate and non-climate - stressors such as sea-level rise, coral bleaching, acidification and extreme weather events. An attempt has been made to highlight some potential climate-driven impacts on the fish production by an analysis of the available historical data of the artisanal fisheries.

The coastal pelagic fishing targets tuna and tuna-like species in the nearshore open sea or around artificial fish aggregating devices. These migratory species appear to be relatively more resistant than the demersal stocks on the impacts of climate change. The coastal tuna fisheries are also less vulnerable to the inshore anthropogenic and environmental forcing but are not completely immune from the biophysical and chemical changes taking place in the oceanic ecosystems. A regional approach is used to assess the impact of ocean warming on the coastal tuna fisheries as all the IOC countries are fishing the same migratory tuna stocks. The study draws on the existing scientific research and observations in the SWIO.

Various pathways and impacts of ocean warming and EWE on the coastal marine fisheries ecosystems of the IOC countries have been examined from existing scientific and peer-reviewed literature. The study evaluates the potential effects of these climate impacts and the EWE on the productivity of the coastal marine ecosystems

11 FAO 2014 – Methodological Approach for the Assessment of the vulnerability of fisheries to CC and variability

12 Allison EH et al. (2009) – Vulnerability of national economies to the impacts of climate change on fisheries

and fish production as well as the cascading socioeconomic consequences on fishing communities, fish market and trade and the national economies. Due emphasis was laid on the most vulnerable or invisible groups and informal stakeholders such as the children, women and elderly people who are engaged regularly in subsistence fishing and other activities in the value chains.

The role of the coastal fisheries as "safety nets" for food and nutrition security and employment of last resort can hardly be underestimated in the least developed islands of the region. A concise and up-to-date profile of the coastal fisheries has been presented for the each of the beneficiary island states, including an overview of the coastal marine environment data: extent and health of the coastal marine ecosystems and potential resource base; key macroeconomic indicators linked to the fisheries sector such as the Gross Domestic Products, Per caput fish consumption, Direct and Indirect employment, Export earnings. The study also highlights the current climate adaptation policy frameworks and programmes related to the fisheries sector at national and regional levels.

1.4 REPORT STRUCTURE

The report comprises 6 chapters, including the first introductory one that rolls out the purpose, regional context, methodology and work-plan of the assignment. The 2nd chapter presents the key features of the artisanal fisheries of the IOC member-states before scrutinizing the potential pathways and impacts of climate change and EWE of the coastal fisheries ecosystems, while the last section deals with the direct and indirect effects of climate change on the fish production, species composition and distribution. The 3rd Chapter examines the socioeconomic impacts of climate change and EWE on the fishing communities and the national economy. This chapter consists of 3 sections. The first section looks at the climate influences on the economics of the coastal marine fisheries by examining the consequences on the fish production, fishing costs and revenue, fisheries infrastructure and onshore facilities, fishing assets and arising resources conservation management issues. The second section provides deeper insights on sociological aspects of the climate impacts on the fishing communities by probing the potential effects on the livelihoods, damage to personal properties, public health hazards, potential socio-psychological traumas and special attention to the most vulnerable groups. The third section investigates on the fisheries climate-induced impacts on the national economy and foreshadows the future potential effects on the GDP, formal and informal employment, food and nutrition security and the potential risks of inaction. The 4th chapter entangles the climate effects on fish market and trade at domestic, regional and international level. This analysis embraces the entire fisheries and fish trade-related services sector. The first section overviews the domestic fish market and trade patterns while the second section reviews regional and international fish trade of the IOC countries. The third section addresses the future potential climate impacts on the fish trade. The 5th chapter presents the current direct and indirect climate adaptation policy frameworks

and programmes implemented by the IOC member-states at national and regional levels. The 6th and the last chapter sum up the key findings in the different areas of this study to raise some pertinent recommendations to advance sustainable climate-friendly development actions in the artisanal fisheries to counter the potential threats arising from climate change and frequent EWE.

1.5 LIMITATIONS OF THE STUDY

The main difficulties encountered in the implementation of this study are:

i)	Unavailability of adequate historical data on the artisanal fisheries at national and sub-national levels.
ii)	The evaluation has been limited to the national level, without covering sufficiently the sub-national regions and inhabited island of the participating archipelagic states;
iii)	Inadequate coastal and marine environment and climate change monitoring data on sea-level rise, sea surface temperature, salinity acidification and primary productivity at national, sub-national and local levels.
iv)	Scarcity of socio-economic data on the artisanal fisheries and climate-fisheries nexus;
v)	No previous studies or monitoring of the effects of climate change on the artisanal fisheries in the IOC countries that could be used as the benchmark.

CHAPTER 2 - CLIMATE IMPACTS ON THE COASTAL FISHERIES ECOSYSTEMS

This chapter describes some pertinent features of the artisanal fisheries of the IOC member-states before investigating the climate pathways and impacts on the coastal marine fisheries ecosystems and assesses their manifestation on the fisheries productivity.

2.1 OVERVIEW OF THE ARTISANAL FISHERIES

This section presents some highlights on the artisanal fisheries of the IOC countries while a more detailed outlay presented in Annexe 2.

In Comoros, the domestic fish production is about 16,000 t per year, which is harvested by the traditional and artisanal fisheries; 25 % of the total catch is landed by the inshore demersal fisheries. The future growth of the fisheries sector depends on the tuna resources endowed in its EEZ, which are estimated roughly at 33,000 t.

The annual landing of the artisanal fisheries in Reunion Island is in the range of 2500 – 3000 t and about 400 t are landed by the inshore traditional demersal fisheries, entirely delivered for local consumption. The remaining catch comprises chilled tuna harvested by the artisanal and extended coastal tuna boats and mostly exported to the EU markets.

Madagascar produces over 100,000 t of demersal fishes, molluscs and crustaceans yearly, almost totally harvested by traditional fishing. The country exports some 20,000t of seafood worth US$ 100 m annually and is made up of canned tuna, wild shrimps, reef fishes, lobsters, crabs etc. The traditional fisheries contribute about 25% of the total export value. The marine resource base is estimated at 200,000t. The development of coastal tuna fishing is still on trial.

The domestic fish production in Mauritius is about 6,000t per year, 80% of which is harvested in the offshore bank fisheries and the remaining, from the coastal fisheries. It also includes 900 t landed by the leisure and sport fisheries. Mauritius imports some 120,000 t of wet fish annually; including 18,500 t for domestic consumption and the balance is intended for processing and re-exports. Some development prospects exist in the demersal fisheries around the distant outer islands as well as offshore seamounts and the coastal tuna fisheries. A nucleus of coast tuna fisheries exists that requires to be sustained.

The artisanal fisheries of Seychelles harvest about 2,875 t of the high-value reef and pelagic fisheries annually. They are meant mainly for the domestic supply. The total catch has decreased by nearly 40 % compared to 2000s. A small export-oriented

semi-industrial tuna fleet is emerging but is currently facing difficulties to take-off. The archipelago is at the heart of the industrial purse seine tuna fisheries of the SWIO. The tuna industry is one of the pillars of the national economy.

2.2 CLIMATE IMPACTS ON THE COASTAL FISHERIES ECOSYSTEMS

The average Earth Surface Temperatures (EST) has increased by 0.85° C from 1880 to 2012. Based on the period 1986-2005, temperatures are likely to increase in the range of 1.15°C – 1.55°C by 2016-2035 and 1.15°C – 5.65 °C by 2081-2100 ([13]). The EST is the main variable used by the IPCC to predict the potential pathways and impacts of climate change on the land and ocean ecosystems. However, these observations are not adequately scaled down to local biophysical levels ([14]). Some climate scientist and fisheries experts have documented the potential impacts of ocean warming and acidification on the global fisheries and have predicted the future potential effects in the regional and national fisheries ([15],[16]). Accordingly, the average sea surface temperature (SST), i.e. the upper layer of the ocean of 0 to 75 m deep has risen at the rate of 0.11°C per decade during 1971-2010 and will continue to rise at a faster rate under different GHG emission scenarios through 2100. The strongest warming is expected in tropical and northern sub-tropical regions. The global average Sea Level Rise (SLR) was 19 cm during 1901-2010 and the rate of increase has accelerated from 1.7 mm per year in the early 20th century to the current rate of 3.2 mm per year. Thus, the total SLR by 2081-2100 based on 1981-2005 data will be in the range of 26 to 98 cm. With these climate metrics on the backdrop and the available climate-fisheries documentation in the SWIO, this section investigates the potential climate impacts on the IOC's coastal fisheries ecosystems.

2.2.1 Rise in Sea Surface Temperature

It is expected that global marine productivity would increase by 0.7 – 8.1 % by 2050, but it would decrease in lower latitudes, including the SWIO due to higher temperatures ([17]). During 1998 - 2010, net primary productivity in the Indian Ocean has decreased by about 10 % and might decline further through the 21st century ([18]). The predicted average temperatures increase in the IOC countries is within the range of the global average temperature rise, however, it is not evenly distributed across

13 IPCC 2014 – 5th Assessment Report

14 Allison EH et al. (2008) – Vulnerabilities of National Economies to the Impacts of Climate Change on Fisheries

15 Macfadyen G et al (2009) – Climate Change, Fisheries and Competitiveness: Understanding Impacts and Formulating Responses for the Commonwealth States

16 IPCC 2014 – 5th Assessment Fisheries Summary

17 IPCC 2014 – 5th Assessment Fisheries Summary

18 Allison EH et al. (2008) – Vulnerabilities of National Economies to the Impacts of Climate Change on Fisheries

the coastal waters of the IOC countries ([19]). For instance, the average SST in Eastern coasts of Madagascar and some parts of Reunion Island has cooled down instead. Marine species are cold-blooded creatures and are sensitive to a slight change in temperatures. A rise in temperature as small as 1°C could have a major incidence of mortality and geographic distributions of most of these aquatic creatures ([20]). Elderly fishers reckon that major biological changes have occurred silently in the coastal marine ecosystems and these would accelerate in the future. Coral bleaching is a vivid example of the impact of the increase in SST on the coral reef ecosystems in the Indian Ocean. The IOC countries have not yet fully recovered from the massive bleaching caused by the ENSO of 1998 and 2004. This explains partly the declining productivity in the coastal demersal fisheries. The geographic coverage of heat-sensitive crustaceans and molluscs such as shrimps, oysters and clams may retreat southward or into deeper waters. For example, despite the strict management and monitoring of the wild shrimp fisheries in Madagascar, the annual production has been declining steadily (ref. to Annexe 2). The pelagic species should be able to adjust their spatial mobility, but the sedentary species: demersal and benthic aquatic resources might not. The distributional changes would result in the new composition of fish species in the region, changes in the food webs and prey-predators relationship across the marine trophic. The heat and pH resistant and invasive species would dominate and the temperature-sensitive ones would perish or move away from the traditional fisheries. There is no scientific research on the interactions between the commercial fish species and their habitats. There is a potential risk of an increased in toxic algal blooms and shellfish poisoning caused by rising temperatures and coral decalcification that might disrupt markets and affect public health. Overall, the impacts of climate change can potentially reduce the aggregate marine fisheries productivity, including the coastal marine fisheries in SWIO by 40 to 60 % at the 2100 horizon ([21]). However detailed scientific information and observation is not available to make more precise spatial and temporal predictions on the different coastal marine demersal and pelagic fisheries in the individual countries of the IOC.

2.2.2 Sea-level Rise

As an induced effect of global warming, it expected that sea level would rise due to thermal expansion and glaciers melt. This would have a direct incidence on the health and productivity of coastal marine ecosystems: coral reef areas, mangrove forests, seagrass meadows, coastal wetland, marshes and estuaries. These habitats are the architecture of the food webs and act as nurseries and refugia for most of the marine aquatic resources. The coral reef may be deprived of sunlight if they do not grow at a faster rate than the expected SLR. The marine biodiversity will be affected by a reduced level of photosynthesis and biological metabolism as some species will thrive

19 Cheung EW et al (2010) – Impacts of Climate Change on Global Fisheries
20 ASCLME & SWIOPF 2012
21 Cheung EW et al (2010) – Impacts of Climate Change on Global Fisheries

while others might adapt or die. The mangrove forests and their biotic universe will be stranded by SLR. They can move inland on sedimentary shores with gentle slopes as sea levels rise, but some coastal development might prevent this inland migration. The changes in salinity will adversely affect the osmotic pressure of marine species that are less tolerant of water salinity variations such as zooplankton living in the lagoon, estuaries and wetlands. This would affect the base of the marine food webs, with serious cascading effects on the coastal fisheries. There is little documentation on the above-mentioned threats to the coastal marine fisheries ecosystems as more emphasis has been laid on the socio-environmental nexus of SLR namely, beach erosion, coastal plan flooding, saltwater intrusion etc.

2.2.3 Change in Rainfall

The predicted rainfall patterns vary significantly among the IOC countries ([22]). By 2090, there would be an increase between 12% and 30% of precipitations in Comoros, 5% in Madagascar, and a relative decrease in rainfall in Reunion Island, Mauritius and Seychelles. Changes in run-off pattern will alter flood risks in coastal plains, low-lying lands, water quality and salinity, fluvial sediment and nutrient supply in coastal water bodies. Decreased precipitation and delivery of freshwater affects food webs in estuaries and alters the amount of time required to flush nutrients and contaminants from the system. Reduced river flows would degrade water quality and will negatively affect coastal marine fisheries and human health through the increased occurrence of harmful algal blooms and accumulation of contaminants in animals and plants. Increased rainfall and resultant freshwater runoff into the inshore waters would carry more land-based effluents, increase stratification of the water columns, leading to depleted oxygen concentrations with excess nutrients. The impacts of the change on rainfall patterns on the coastal marine fisheries ecosystems is mitigated for it can be beneficial in some circumstances and harmful in others.

2.2.4 Change in wind patterns

Wind speed and direction influence production of fish and invertebrate species in regions of upwelling like the SWIO. If upwelling is slowed by changes in wind and temperature, phytoplankton production could be lowered and vice-versa. In some coastal regions, alongshore wind stresses and currents help produce water movements that transport larval fish and invertebrates to coastal nurseries. Climate-related changes in these circulation patterns may hinder such mobility and might alter the species composition of coastal marine ecosystems.

2.2.5 Extreme Weather Events

The most fearful EWE in the IOC region is the seasonal intense tropical cyclones; however other extreme climatic phenomena such as flash flood, torrential rains, strong winds, upwelling etc. are become more frequent and unpredictable.

22 Acclimate Report 2011

Madagascar, Mauritius and Reunion Island are more exposed to intensive cyclones and tropical depressions than Seychelles and Comoros. Increase in EWE would have severe impacts on the coastal fisheries ecosystems and fish production. These ecosystems can recover from the natural shocks, but due to human-induced alteration of coastal habitats, they might take a longer time to bounce back to their original state. It is not technically and scientifically possible to predict the number, frequency and intensity of extreme weather events, in particular, the tropical cyclones although the Indian Ocean is highly productive in cyclone formation ([23]). The major threats of EWE to the fishing communities are the disaster risks to physical infrastructure, personal properties, injuries and loss of lives and post-disaster recovery.

Increased temperature or freshwater input to the upper layers of the ocean results in increased density stratification, which affects ocean productivity. Because productivity varies regionally, simple extrapolation to a particular oceanic region is difficult. Open ocean productivity is also affected by natural inter-annual climate variability such as the El Niño-Southern Oscillation (ENSO), the Indian Ocean Dipoles (IOD) in the Indian Ocean. Climate-driven changes in the intensity or timing of any of these phenomena could lead to marked changes in water column mixing and stratification and, ultimately, a reorganization of the ecosystems involved, for the better or worst. One marked example is the 1998 El-Nino in the Indian Ocean that caused an abrupt decline of 30% in the total catch in the surface tuna fisheries ([24]).

2.2.6 Acidification

Increased in carbon–dioxide concentrations lower ocean pH and alter the ocean chemistry. This would negatively affect a myriad of marine organisms that use calcium carbonate to build their skeletons and shells. Coral reefs, which are already threatened by multiple anthropogenic and environmental stressors in the inshore waters, would also be at risk with the acidification of the ocean. Lower ocean pH would cause decalcification of coral reef materials while increased warming would lead to coral bleaching. Loss of coral reefs would mean a decline of marine biodiversity and setback to the coastal fisheries, tourism and recreational opportunities they provide. There are no previous studies on the socioeconomic impact of acidification on coastal marine fisheries in the SWIO countries ([25]).

23 Acclimate Report a,b,c,d,e , 2011

24 Sweenarain S ACPFiSh II (2014) – Market study of by-catch of the industrial tuna fisheries in the Indian Ocean.

25 Sumalia A R et al. (2010) - Economic Impacts of Ocean Acidification on Fisheries and Aquaculture in the Western Indian Ocean: Current Knowledge and Recommendations

2.3 CLIMATE IMPACTS ON THE IOC ARTISANAL FISHERIES

This section investigates on the cascading effects of the climate change on coastal marine fisheries ecosystems and the productivity of the fisheries.

2.3.1 Climate bio-physical impact on the Coastal fisheries

The following factors are influenced by the impacts of the multiple pathways of climate change that react on the bio-ecological aspects of the fisheries ecosystems and fish production ([26]):

Reproduction processes - All living organisms have a specific range of environmental conditions to which they are adapted and perform optimally. The combined effects of climate change on the coastal marine ecosystem alter the spatial and temporal scale and success of fertilisation, survival and growth of offspring, migration pattern and the food web structure ([27]).

Primary production - Satellite observations suggest 6% reduction in global oceanic primary production between the early 1980s and late 1990s, but with substantial regional disparities. The negative climate–plankton link in the ocean is pronounced in the tropical and sub-tropical regions, where the typically low levels of surface nutrients limit phytoplankton growth. Ocean warming further hampers water mixing, reducing the upward nutrient supply and lowering productivity ([28]). Reduced primary production, at the base of the food webs pyramid, means reduced fish production in the given habitat.

Secondary production – There are no global assessments on the potential impacts of ocean warming and acidification on the productivity of zooplankton in the oceanic food webs because of regional and localised differences. Most commercial fishers, including the large pelagic species such as tunas, depend on zooplankton for food at some stages in their life-cycle and any change in the secondary production could affect the abundance of these fish species.

Changes in fish distribution - Climate change is expected to drive most marine species ranges toward the poles, expanding the range of warmer-water species and contracting that of colder-water species. Such changes have already been experienced in the Pacific and Mediterranean seas. There can also be vertical movements to counteract surface warming. In the Indian Ocean, which is an enclave in the North, it is suggested that tuna stocks could be displaced further Eastward ([29]).

---

26 IPCC 2014 5th Assessment Report – Cambridge University - Fisheries Summary

27 Rebecca A et al. (2015) Climate Change and decadal shifts in the phenology of larval fishes

28 ASCLME & SWIOPF , Report 2012

29 Miller K A (2006) – Climate Variability and Tropical tuna management : Challenges for highly migratory fish stocks

Changes in abundance – Generally, biological production processes occur faster at higher temperatures. But, any increase in the biomass and fish population will only happen when food supply is adequate and when other life-cycle processes like spawning, migrations, fertilization, larval survival rates, disease immunity etc. are not negatively affected by ocean warming. Because of other counteracting effects, it is not expected that ocean warming would increase the abundance of fish stocks in the tropic and sub-tropical regions ([30]).

Change in phenology - More than half the marine species studies have exhibited measurable changes in their phenology over the past 20 to 140 years, in line with climate change. In the oceans, this includes changes in the timing and extent of seasonal phytoplankton blooms which have not been tracked by zooplankton, suggesting an emerging mismatch between food supply and the main intermediary consumer of primary production ([31]).

Species invasions and diseases - Pathogens are spreading to higher latitudes and harmful algal blooms are becoming more common although these may also be caused by land-based effluents. Coastal marine ecosystems may be infested by invasive species as they change conditions from those that may have prevented warmer water species from breeding.

2.3.2 Climate Impact on Coastal dermal fisheries

The inshore demersal fisheries are sensitive to the health and productivity of the coastal marine ecosystems, which are vulnerable to the impacts of ocean warming. However, climate change is not the only culprits for the degradation of these marine habitats as various anthropogenic and environmental stressors are acting in tandem to exacerbate the productivity of these coastal fisheries. The socio-ecological features of the demersal fisheries ecosystems vary considerably at local, sub-national, national and regional levels. Demersal fish species are slow-growing and long life, and take a long period for replenishment, particularly in stressed environments. Many bio-ecological variables of these aquatic species are not fully understood. Various commercial and socio-cultural factors are also responsible for the economic inefficiency of the production systems. Its prime role as safety nets for food security and subsistence income cannot be overlooked in LDC. The resource base of these sedentary resources in the IOC countries is limited but can be managed smartly to enhance sustainable benefits albeit these uncontrollable climate stressors.

2.3.3 Climate impacts on coastal tuna fisheries

Tuna species are fast-swimming top predator whose high metabolic requirements must be supported by ready access and abundance of rich food sources. Their

30 Barange M et al. (2009) – Physical and Ecological impacts of Climate Change relevant to marine and inland fisheries and aquaculture *http://www.fao.org/docrep/012/i0994e/i0994e02a.pdf*

31 Doney S (2006) – Plankton in warmer world

migratory patterns are driven by various biophysical factors: temperatures, oxygen and food. A tuna consumes as much as 15% of its body weight per day ([32]). Climate variations play a major role in determining the short-term, seasonal and inter-annual patterns of change in the location and productivity of the tuna stocks. Tropical tuna, including skipjack, yellow-fin and big-eye tend to be fast-growing and relatively short-lived. The migratory cycle of the tuna stocks changes during the inter-decadal climatic events such the ENSO and IOD in the Indian Ocean. Oceanographic features drive seasonal changes in the location of the fishing grounds. It is indicated that ocean warming in the Indian Ocean might cause a displacement in the migratory path of the tuna stock eastwardly attune of 50 km per decade and it implies that they might move farther offshore of IOC countries. Yet, no scientific research has been undertaken to assess the potential influences of ocean warming on the migratory cycle of the tuna stocks, particular on coastal FAD fisheries in SWIO.

32 Marsac F et al. (1998) – Tropical Tuna – Surface Tuna fisheries in the Indian Ocean – FAO Technical Paper

CHAPTER 3 - SOCIOECONOMIC IMPACTS OF CLIMATE CHANGE

This chapter examines the socioeconomic consequences of climate change and EWE on the artisanal fisheries of the IOC member-states. It is divided into 3 sections; the first one looks at potential changes in the economics of the fishing operations, the second investigates the social dimensions of the impacts on the fishing communities and the last section scrutinizes the potential impacts on the national economy.

3.1 FISHING OPERATIONS

The artisanal fisheries in the IOC member-states are open access and common pool resources which encourage the maximisation of individual benefits at the cost of societal interests ([33],[34]). The fishing operations in the sub-sector suffer from economic inefficiencies and uncertainties as a result of:

i)	Weak fisheries governance and management;
ii)	Lack of basis socioeconomic and onshore fisheries infrastructure;
iii)	Outdated fishing assets and technologies used;
iv)	Poorly developed value chains and supply chain logistics;
v)	Inadequate business enabling environment;
vi	Anthropogenic and environmental externalities from land and ocean-based activities;

It is impossible to assess the impacts of climate change in value terms on the fishing operations because of the interplay of multiple climate and non-climate stressors and also, the lack of adequate time series fisheries data and economic baseline information. Nevertheless, the study attempts to identify some evident impacts of climate change and EWE on the economic returns through an analysis of the various cost and revenue centres.

33 Sweenarain S – Smartfish (2015) – Inventaires des Organisations Professionnelles dans le secteur de la Pêche dans les pays de la COI – Cas d'étude Maurice, Rodrigues incluse et Seychelles.

34 Sweenarain S – Smartfish (2016) Inventaire et Evolution Récentes de la Pêche Thonière Côtière dans les Pays de la Commission de l'Océan Indien – Cas d'étude – Maurice et Rodrigues

3.1.1 Fish Production

Keeping the scientific prediction of the potential decline in the aggregate catches in the SWIO by 40% to 60 % by 2100 on the backdrop of this assessment, it is assumed that the catches of the coastal fisheries might decline steadily, if not exponentially ([35],[36]). The current production patterns of the coastal demersal and pelagic fisheries in the IOC countries are scrutinized briefly.

3.1.1.1 Coastal demersal fisheries

The inshore demersal fisheries in the IOC countries are fully exploited, with limited growth patches around the distant outer islands and offshore continental shelves, which are not accessible to the traditional fishing crafts.

Comoros - The total catch of the inshore demersal fisheries turns around 4,000 t and the fisheries statistics are inconsistent because it does not account for the mass of coastal population indulged regularly in subsistence fishing. The situation in Moheli is slightly different because the inshore fisheries are managed by local community-based associations and there is an MPA of 402 km² that serves as a buffer zone. The productivity of the inshore demersal fisheries is declining, but there are no feasible alternative sources for fish-food and employment safety net on the islands. A decline in fish production will directly undermine the national food and nutrition security and the basic means of livelihoods.

Reunion Island – About 115 traditional fishers harvest about 300 t of demersal fishes per year. The fishery is relatively well managed and monitored, but there is no prospect for any expansion due to the limited extent of the nearshore continent shelves. The climate impacts on the fisheries are moderate.

Madagascar - The annual production of the traditional artisanal fisheries over the past decade is estimated at 107,000 t. The estimation is carried out by a national survey while the fisheries statistics are inadequate. The inshore waters are heavily fished by the traditional and subsistence fisheries. The health of coastal marine fisheries ecosystems is mitigated; the coral reef ecosystems are strained in the vicinity of fishing villages while they are healthier in remote areas. The mangroves forests are relatively healthy. The government is taking actions to rebuild some extinct mangroves forests. On the Eastern coast, it appears that anthropogenic factors are causing more damage to the inshore marine ecosystems than ocean warming. The collapse of the coastal marine fisheries will have severe socioeconomic consequences on the coastal communities. Despite the strict management and monitoring of the wild shrimp fishery, it has decreased from 7,900 t in 2004 to 3,700 t in 2012 and there is still no sign of recovery. This is probably caused by the displacement of the resources due to a change in salinity and the pH of the waters caused by an alteration in the

35 EW Cheung & Allison D (2009) Future impacts of Climate Change on the Global Fisheries
36 IPCC 2014, 5th Assessment Report, Fisheries Summary

water chemistry. Further research is required to identify the cause of this biological decline.

Mauritius - The inshore fishing represents 40% of the total catch of the artisanal fisheries sub-sector. The total catch from the inner and outer lagoon has decreased steadily over the past decade from 850 t to 450 t while the CFDP has remained relatively stable and the number of enrolled fishers has declined slightly. Other factors being more or less stable over this lapse of time; the deficit of the total catch can be attributed cautiously to a significant increase in the number of non-fishing days due to bad weather at sea and the subtle effects of ocean warming. In Rodrigues, the annual catch has nearly doubled over the past decade to reach 2048 t in 2014. The main cause for the frequent shortage of supply of fresh fish on the island is due to the increasing number on non-fishing days provoked by bad weather at sea.

Seychelles - The total catch of the artisanal fisheries in 2011 has declined by about 40% compared to the annual landing before 2000. While the fishing efforts were relatively stable over the period, the decline is attributable to the massive coral bleaching of 1998 and 2004, from which the coral reefs ecosystems have not fully recovered.

3.1.1.2 Coastal tuna fisheries

In Comoros, Reunion Island and Mauritius, there is a growing dependence on the coastal tuna fisheries to maintain the domestic supply of fresh fish. These fishing activities take place around a network of FAD anchored in the nearshore oceanic waters around the islands. About 18,500 t of tuna and tuna-like species are harvested by the coastal tuna fisheries in the IOC (Comoros: 16,000 t, Reunion Island 2,000 t, Mauritius, 300 t ([37]) and Seychelles 200 t). In Mauritius and Comoros, the CPFD in the coastal tuna fisheries is at nearly 2 to 3 times higher than the inshore demersal fisheries. The tuna resources are relatively less vulnerable to ocean warming than the demersal counterparts. The growth potential of this fishery in the IOC region is significant. However, this expansion should be supported by a multidisciplinary research programme to assess the future potential impacts of climate change on socio-ecological factors of the coastal FAD fisheries to inform appropriate techno-economic adaptation.

In a nutshell, the production of the demersal fisheries would be more vulnerable to the combined effects of climate and non-climate stressors in a business-as-usual scenario. The coastal tuna fisheries are relatively more resilient, but they are not fully immune from the impacts of climate change. Altogether, there might be a deficit in local fish production in the region in the long run.

37 This figure does not include 900 t / year harvested by the sport and leisure fishing around the FAD in Mauritius

3.1.2 Effects on fishing costs and Revenue

With unmanaged coastal fisheries and an increasing population – from 25.5 million to nearly 40 million by 2050 – as the regional backdrop, there would be a demand pulled inflation for fresh fish on the local markets. That would not be so simple because the production curve would be inelastic and even, backward bending. It will also depend on the employment opportunities outside the fisheries sector and the income level of the local consumers. It is most likely in some countries more inland population of farmers and agricultural workers who are also suffering from the impacts of environmental degradation in their traditional sectors might move to the inshore marine fisheries. The population displacement is already occurring in the Eastern coast of Madagascar and Comoros.

The coastal fishers are already experiencing decreasing returns due to open access, obsolete fishing technologies, lack of basic infrastructure and poorly developed value chains. The profitability of the fishing operations will be further compromised by climate and non-climates stressors. The development of the artisanal fisheries has evolved from traditional and subsistence fishing operations over time, without adopting the much-needed business skills. The level of entrepreneurship in the commercial artisanal fisheries is low. Profitability might be understood differently in different coastal fishing communities. In the absence of an organised market at landing sites, the primary sale price of the landed catch is not determined by the market forces, but by some speculative or psychological prices. The opportunity cost of labour and time in some fishing villages is insignificant in the absence of alternative livelihood opportunities. The cash flow of the artisanal commercial fisheries is more sensitive to the effects of ocean warming and climatic variation because they have a bearing on the availability and catchability ([38]) of the fish stocks... There is no socio-economic baseline data to allow a viable cost-revenue analysis. The fisheries statistics do not help to differentiate a fisher who is the owner of the fishing assets to a simple fishing worker. Generally, a small fishing enterprise and a fishing worker do not have to same insights over climate risks on their occupation.

3.1.2.1 Revenue factors

Any changes in the total catch, species mix and spatial distribution of the fish stocks will impact the revenue of the fishing unit. Although the fishers are acquainted with the seasonal fluctuation of the catch and market prices, they do not expect a steady decline in fish production in the long term. Logically, a decline in fish production results into the increase in the average fishing cost, which might not be compensated proportionally by an increase in the sale price. Mauritius might be an exceptional case because the local markets of fresh fishes are supply-driven and the fishers tend to command the prices. Over the past 5 years, the primary sale price of fresh fish has increased by 12 % to 15 % annually while the national inflation rate has

38 Catchability is a concept in fishery biology which reflects the efficiency of a particular fishery. Its quantitative magnitude is expressed by the catchability coefficient, which relates the biomass abundance to the capture or fishing mortality.

been less than 5% ([39]). The price signal on the local fish market does not reflect the decline or scarcity of the local production because of the availability and competition of cheap imported of same wild and farmed fish species and other close substitutes. In some of the IOC countries to-date, the price of fish is not determined species wise, rather by a bundle of fish species bearing the same consumers' choice/preference. These examples are worth noting:

i)	In Mauritius, all the commercial fish species landed by the artisanal fisheries are classified in 5 commercial categories and each category includes several fish species;
ii)	In Seychelles, the local catches are not sold by weight, but in a bundle of fishes of different species and sizes.
iii)	In Comoros, tuna is sold in slices or pieces; a weighing scale is never used;

So, in the IOC countries, it is suggested that local consumers are quite indifferent to species-mix as long as the fish is their plates. This is not the case for the local high-value niche and export value chains

3.1.2.2 Cost Factors

The escalating fishing costs are also influenced by availability and catchability of coastal fish stocks and include some of these emerging challenges namely:

i)	Increase in the number of non-fishing days due to bad weather at sea;
ii)	The longer fishing trip as more time is spent on cruising and search of fish shoals;
iii)	Higher repairs and maintenance costs;
iv)	Shortage of fishing workers due to sickness and disabilities or unwillingness to work
v)	Higher prices of fishing inputs etc

The spontaneous reaction of the artisanal fishers to decreasing fish production is to fish more intensely. However, some small fishing enterprises are more professionally organised and have adopted smart business strategies to adapt to changing fishing environments. They are using modern technologies like GPS, fish finders and smartphones to improve their fishing operations. Most of them are vertically integrated into their value chains to maximise resource productivity through value

39 Sweenarain S / SmartFish (2013) – Value Chain Analysis of the Artisanal Fisheries of Mauritius

addition and marketing. Some of these dynamic small-scale enterprises are found in Seychelles, Reunion Island, Mauritius and main coastal cities in Madagascar. The coastal tuna fishing enterprises are more adaptive to climate risks.

3.1.3 Coastal fisheries Infrastructure and onshore facilities

The physical infrastructure such as fishing harbours, onshore facilities, institutional capacities, research and extension services, inputs and outputs marketing networks etc. are necessary for the development of efficient fish value chains. The fishing ports offer shelter to the artisanal fishing assets but are also exposed to the impacts of climate change and EWE. The IOC region has contrasted landscape regarding the availability of dedicated fisheries infrastructure and onshore facilities.

Reunion Island has well-organised and climate-resilient infrastructure dedicated to the small-scale fisheries around the island. They have resisted the past EWE and the local artisanal fleets were adequately protected. These facilities will be useful for coping with the future potential climate impacts in the fisheries at no additional costs. The lessons learnt and best practices in these areas have to be shared with the other IOC countries.

There is virtually no fishing infrastructure and integrated facilities for the artisanal and traditional fisheries in the other IOC countries with an exception of Seychelles, where there are two integrated artisanal fisheries facilities, one at Port Victoria and the other at La Providence; and a small waterfront fisheries facility in Rodrigues. There is a serious dichotomy in Mauritius; it has superb fisheries infrastructure in the Freeport Seafood Hub and basic facilities are absent for the artisanal fisheries around two islands. Reunion Island, being a part of EU territory in the Indian Ocean, has state-of-art fisheries infrastructure around the island, but which are not fully utilised by the local artisanal fisheries.

In Comoros and Madagascar also, there is a lack of a bare minimum of fisheries infrastructures and basic utility services such as tap water and electricity in the coastal fishing villages. Usually, the catch is landed on the beach, where the primary sale takes place. The fishing boats are either anchored in naturally protected areas in the lagoon and/or pulled on the beach. These fishing crafts are often exposed to climate risks. The basic socioeconomic and fisheries infrastructure is the bare minimum requirement for the modernisation of the coastal marine fisheries. The government should improve the overall business enabling environment in the artisanal fisheries by providing adequate fiscal incentives and financial schemes to encourage traditional and artisanal fishers as well as small fishing enterprises to invest more efficient fishing assets and technologies and to provide capacity building services in fishing, fish preservation and processing, quality management, marketing, communication, safety at sea, small business management and entrepreneurial skills. The forthcoming coastal fisheries infrastructure and onshore facilities should climate-resilient to mitigate future potential collateral damages.

The coastal FADs are considered as part of the socio-economic infrastructure of the artisanal tuna fisheries as they ensure the profitability, stability and safety of the fishing operations. These FAD networks in Comoros and Mauritius have been funded by the international development agencies and maintained by the national fisheries administration and/or the fishing communities. FAD engineering is advanced in the IOC region since the average life-time of regularly maintained devices, is about 2 years. They have proven resilience to intensive storms in the past. The average productivity of a FAD in Mauritius is about 50 t / year and its overall cost is approximately US$ 2,500 ([40]). The average cost per kg of fish produced is negligible. It offers feasible prospects for climate adaptation in the coastal tuna fisheries.

3.1.4 Fishing assets

The level of sophistication of the productive assets in the coastal marine fisheries provides a clear representation of the economic efficiency of the existing value chains. It is also an indication of their capacities to resist and to adapt to the potential impacts of climate change and EWE. These fishing assets include fishing boats and the auxiliary business assets such as; boat-yards, repair and maintenance workshops, fishing gears and inputs, including ice and packaging materials suppliers, fish processing units and retails outlets etc. The damage of any of these components of the supply chain ecosystems will interrupt the markets. The major threats to these fishing assets in the IOC countries are the tropical storms, upwelling and sea-level rise. Some countries are more exposed to tropic cyclones than the others. Seychelles is out of the range of the Indian Ocean tropic depressions while Comoros are relatively shielded by the northern part of Madagascar. The North-West of Madagascar is most exposed. Reunion Island and Mauritius are also highly vulnerable.

The fishers and their fishing tools are at the forefront of the bad weather at sea. Likewise, the offshore fishing is more exposed to the oceanic weather risks than inshore fishing. The coastal fisheries are reputed to be multi-gear and multi-species; a coastal offshore fishing unit may retreat technically to inshore fishing, but it is highly hazardous for the inshore fishing unit to venture on the coastal high seas. Unfortunately, this is the main cause of accidents and loss of lives at sea in Comoros and at times, in Mauritius. In Reunion Island, the number of accidents in the coastal fisheries is low because of the mandatory navigation and safety standards. The socio-cultural attitudes of fishers are also an important factor in risk-taking. Some years ago, in Comoros, a FAD fisher was considered a coward by his fellow fishers as he would be thought not having the guts to fish in the open seas. After several mishaps at sea, this social misnomer has disappeared.

Looking at the future potential impacts of climate change and EWE on the coastal demersal marine fisheries, it will be necessary to rethink the fishing technologies. The

40 Sweenarain S – SmartFish (2016) – Evolutions récentes de la Pêche Thonière Côtière à Maurice et Rodrigues

existing artisanal fishing boats and fishing techniques will not be economically viable and safe. The fishing trips tend to be longer and the catch would be exposed to the ambient temperatures if adequate preservation facilities are not available onboard. The poor quality and sanitary conditions of the landed catch will increase post-harvest losses and reduce the market value as well as value addition opportunities. There must be a shift from quantity to quality to maximise resource productivity. The fishing craft will have to be relatively bigger and strong enough to adapt to tougher sea weathers and must be equipped to perform adequate post-harvest treatment on board. This will require an in-depth reorganisation of the fishing operations.

In Mauritius and Comoros, there is an overcapacity of traditional boats in the inshore fisheries; they will have to be removed from the fisheries as they cannot be redeployed in the offshore fisheries. These drastic changes might not be socially acceptable without creating alternative employment opportunities in the coastal communities. The local sustainable development (LSD) approach is very useful in creating linkages between – agriculture-fisheries – tourism – handicraft and services sectors ([41]). The lessons learned in Mauritius on the transfer of fishing efforts from the lagoon to the offshore fisheries are interesting. This transformation is not simple and spontaneous as numerous socio-cultural and techno-economic difficulties in the process must not be overlooked by policymakers and development agencies. Despite the training programme and financial incentives provided by the government, there has been an intensification of fishing efforts within the inshore waters. In Reunion Island and Seychelles, the up-scaling process between the traditional, commercial artisanal and the extended artisanal or semi-industrial fisheries usually takes place in a progressive learning-by-sharing environment because these different types of fishing boats share the same fishing facilities and their peaceful cohabitation is mutually enriching.

The current 5 - 6 m boats operating around the coastal FAD will soon be inefficient and risky as the tuna stocks shift farther. Some small fishing enterprises in the IOC countries are investing in larger coastal tuna fishing boats with a storage capacity of up to 1 tonne and manned by 4 to 5 fishers; with autonomy at sea of 3-4 days. They are adopting new fishing technologies, which are more energy-efficient and respectful of the marine environments. The Japanese mono-filament long line fishing technology that has revolutionised the small-scale tuna fishing operations across the oceans ([42])

3.1.5 Conflict over coastal marine resources

New challenges on coastal marine fish stocks will arise with the escalation of the impacts of climate change and also the EWE. The absence of alternative fish food and employment opportunities, the coastal communities may continue to fish more intensively, causing a collapse of the inshore fisheries and their habitats. Coastal

41Sweenarain S – SmartFish – FAO (2014) – Development of an Alternative Sustainable Livelihood Project for the redundant fisher-women in the South East Marine Parks Authority (SEMPA) of Rodrigues.

42 Beeharry-Panrey S, Fishing Technologist at FiTEC (Mauritius), personal communication

people for whom every day is a struggle, they do not bother about their future and that the future generations. Thus, it is observed that some fishers resort to illegal practices, including pouching in marine reserves and protected areas for survival ([43]). In some circumstances, part-time fishers tend to renounce their fishing activities because they are so attractive any more. It most likely the impact of climate change on the coastal marine fisheries will fuel more conflicts among resource users, especially in an open-access environment.

In the case of Comoros and Madagascar, the women and children in the coastal communities depend on subsistence fishing to obtain their daily fish food and might not have any other feasible options. They might continue to fish down the webs ([44]). The growing food insecurity will lead to potential social conflicts between the types of fishing involved in the inshore waters ([45]). In Madagascar, people are leaving the farming and agricultural sector to join the traditional inshore fisheries and thus aggravating the condition of the coastal fisheries productivity. Overall, the role of the coastal fisheries as a social safety net for the most vulnerable inhabitants of the coastal communities is being eroded.

In Mauritius, Reunion Island and Seychelles, it is relatively easy for the fishers to exit or reduce their dependence on the coastal fisheries because of the existence of alternative livelihood opportunities in these islands. There are social security schemes and re-skilling and vocational training programmes to assist redundant fishers and fish workers to integrate other economic sectors

3.2 CLIMATE IMPACTS ON THE FISHING COMMUNITIES

In this section, the potential impacts of climate change and extreme weather events on the fishing communities are assessed in terms of the probable changes in their livelihoods and well-being. The vulnerability ([46]) the fishing community is the outcome of the interaction of 3 factors:

i)	The sensitivity of the coastal fisheries ecosystems to ocean warming and climate variations;
ii)	The extent of dependence of the community on these ecosystems for their livelihoods and wellbeing;

43 J.Watson, Wildlife Conservation Society, 2015 – in an interview with the Queensland University, Australia on the Tropical Ecosystem Management Challenges with reference to the East coast of Madagascar.

44 Pauly D, (2009) - A century of fish biomass decline in the ocean

45 A Tronel, 2009 – Multi-dimension d'une rélation, entre conflicts et revendication – La pêche traditionnelle à Madagascar

46 Johnson K A, 2014 – Climate Change Vulnerability Assessment for Natural Resources Management

iii)	The adaptive capacities of the community to resist these changes or events.

3.2.1 Livelihoods of the fishing communities

Fishing is not only an economic activity for the fishing communities but also a cultural identity. The level of income of the fishers and fish workers is considered as a major determinant of their standard of living. The impacts of climate change on the coastal fisheries will have negative effects on the livelihoods, well-being and safety of the fishing communities. These effects include:

i)	A decrease in household income;
ii)	Damage of the household fishing assets and personal immovable and movable properties;
iii)	Personal injuries, disabilities and loss of lives;
iv)	Personal health risk, arising from epidemic and vector-borne diseases

The vulnerability of the fishing communities to these risks depends on the adaptive capacities of the fishing communities and the country as a whole. To discuss the current and future potential climate impacts on the livelihoods of the target populations, the IOC member-states can be differentiated into 2 groups. The first group comprises the high and upper-middle-income countries: Reunion Island, Mauritius and Seychelles and the second group, the least developed countries: Comoros and Madagascar.

The first group of countries - In the first group of countries, the concept of traditional fishing communities does not exist anymore because these fishers and fish workers are blended into the socio-economic mainstream of the coastal societies ([47]). However, most of the traditional and artisanal fishers still belong to the low-income or vulnerable groups in these countries. The artisanal fisheries are socioeconomically and culturally important in these countries, but the economy is more diversified and the primary sectors such as agriculture and fisheries contribute less in term of the percentage to the GDP. Alternative livelihood opportunities are available in other economic sectors such as construction, agriculture, tourism and services to allow an easy exit from the coastal marine fisheries. Subsistence fishing is rare although a large number of the coastal populations are engaged in part-time and leisure fishing. Nevertheless, artisanal fishers and small fishing enterprises are coping with declining fish production in various ways. Most of the fisher households have more than one source of income that renders them less vulnerable to climatic vagaries of the coastal

47 There are no fishing villages comprising mainly fisher households as compared to the other least developed countries of the IOC. These households are spread mixed up with other socioeconomic communities across the coastal areas.

fisheries. In Mauritius, the artisanal fishing is emerging into a vertically integrated household business; they have systematically eliminated the fish trader by selling sell their production to end-consumers directly ([48]). The fish traders are also adapting to the changing environment as most of them work seasonally or on a part-time basis and have another income-generating activity as main or secondary occupations. Some local fish distributors have shifted to imported seafood to supply domestic markets.

Artisanal fishing is already considered as a high-risk occupation in these countries. It does not attract the young and educated people although the sector needs young and talented professional to relieve the ageing fishers and to uphold the fishing tradition ([49]). It has to be made attractive in terms of earnings and social status by modernizing artisanal fisheries.

The second group of countries - The picture is not so bright for Madagascar and Comoros because the standard of living is low and is getting worst in the coastal fishing communities. Basic economic infrastructure and utility services such as clean water and electricity are not available in over 80% of the countries. Public safety, health and education and security services are still not available in the enclave and isolated fishing communities. The financial resources of the governments are scarce and the coastal rural communities including the fishing villages are left on their own to cope with their livelihoods and well-being.

In Madagascar particularly on the Eastern coast, there are a large number of people from the agrarian sectors – farming, agriculture and forestry – are moving into the traditional marine fisheries for relatively more secured livelihoods. Traditional fishers from the West coast of the island are also migrating to the East to escape frequent and intense tropical cyclones emerging in the SWIO. The human-induced forcing on the coastal marine fisheries is more visible on than the impact of climate change. The role of 'safety nets' assumed by the traditional marine fisheries is eroding and may aggravate the problems of endemic poverty and food and nutrition insecurity of the country.

Comoros is relatively safe from tropical storms. The inshore demersal fisheries are overfished and rational fisheries management can be useful in sustaining the livelihoods of the existing fishing communities. The impacts of climate change on the fishing communities are moderate. The traditional fishers are also engaged in agriculture that helps to complement their household budgets. The FAD fishers have relatively stable livelihoods, although the increasing number of non-fishing days adversely affects their regular revenue. Safety of the fishers at sea is a major concern because of the increasing number of accidents and loss of lives. The fisher associations

48 Professional fishers are formally authorised to sell directly and deliver their catch to end consumers.

49 See annexe 2 ; the average age of the artisanal fishers in Mauritius, Reunion Island and Seychelles is over 55 years.

and cooperatives are organised at the village level to set common safety regulations and organise rescue operations ([50]).

In Grande Comore, some women are engaged in the sale of fish, but the relationship between the fishers and female fishmongers ([51]) is based on social or family tides and not, commercial. Traditionally, a fisher delivers his daily catch to the women of his extended household so that they can make some profit out the retail sale of the fish to supplement their household income ([52]). There are few cases of inter-island migration of fishers and also, illegal immigration to Mayotte to using fishing crafts ([53]). The adaptive capacities of the fishing communities stem out of the communal solidarity and the external financial supports from the Comorian Diaspora in France. In the absence of the adequate government interventions in the country, the coastal communities have developed over time some adaptive response to the climatic shocks ([54]) even though these actions might potentially undermine the long-term resilience of the marine environments. The future potential degradation of the livelihoods in the coastal fishing communities may provoke political and social unrest in the country ([55]).

3.2.2 Damages to personal properties

Mostly fishing community dwells near shore; sometimes, in high-risk zones and their modest movable and immovable properties are often damaged or ruined by EWE such as cyclones, upwelling, flooding, tsunami etc. Many of them are squatters without any right of tenure on these lands. The IOC assessed the total cost of natural disasters to the regional economy for the past 10 years at US$ 2.7 Bullion ([56]). There is no private insurance scheme to protect these types of risks as they are still considered as "Acts of God". The IOC's ISLANDS programme is working with the UNISDR and World Bank Group to develop a regional inter-governmental parametric insurance scheme to cover certain disaster risks in the region ([57]) based on an existing system in the Caribbean islands. The North Coast of Madagascar, Mauritius and Reunion Island are more vulnerable than Seychelles and Comoros to tropical cyclones. The North-East region of Madagascar is expected to be visited on an average of 10 tropical cyclones per year; one of every three is expected to be an intensive one. These climate-induced

50 E. Ranaivoson et al (Smartfish) 2014 – Inventaire des problèmes dans le secteur de la pêche aux Comores, vue par des pêcheur eux-même ; étude de cas de la Grande Comore.

51 They are called "wachouzi" and its unique in Grande Comore; in the other island of Comoros, women are not involved in the fish trade.

52 Comoros is a matriarchal society, in which women are the head of the family and are supported by the maternal uncles.

53 Sweenarain. S – Conseil Régional de La Réunion (2004) – Etude sur l'écodéveloppement aux Comores pour éviter le flux d'immigration illégale vers Mayotte.

54 Some of the community based practices are: Local fisheries regulations and management, good practices for safety at sea, investments in traditional and artificial fish aggregating devices and onshore refrigeration facilities for the preservation of the catch.

86 FAO – World Fisheries Status Report 2014

56 IOC Annual Report 2014.

57 Sweenarain S – ISLANDS (2014) – Regional Comprehensive Capacity Building Strategy Framework

disasters can potentially push the coastal fishing communities to extreme insecurity and poverty.

3.2.3 Public health issues

The climate impacts have serious consequences on public health by the propagation of water and food-borne diseases such bilharzia, cholera and enteric infections; vector-borne diseases, including Malaria, Chikungunya and Dengue caused by an increase in normal temperatures. Owing to the relatively higher ambient temperatures in the coastal plains, modest public sanitary and health services and the poor living conditions, these infectious diseases turn into an epidemic in the fishing communities. Frequent cases of massive public health issues have been registered in Madagascar and Comoros. The fisher households are affected by the loss of lives and physical disabilities that further affect their livelihoods.

The risks of an increase in post-harvest losses and/or the consumption of contaminated fishes are bound to augment due to the increasing ambient temperatures and the absence of adequate preservation practices. This is a growing public health hazard while the primary role the fish production is to maintain food and nutrition security in the coastal societies. Similarly, the consumption of reef fishes fed on toxic algae causes serious health issues such as ciguatera. This may disrupt the value chain of the reef fishes if the adequate monitoring system is not organised.

3.2.4 Psychological effects

Understanding the potential psychological traumas of climate changes ([58]) on the fishing and coastal communities are as important as the different socioeconomic aspects. There has been a start of research on the socio-psychological impacts of climate change on vulnerable communities, but so far there is no documentation in this field regarding the coastal fishing communities. These mental and emotional impacts on the fishers and their households can be as a result of a life-threatening weather event such as storm, flooding, upwelling etc, deep-rooted anxiety based on an experience of a shocking event or uncertainty about the future, and psychosocial impacts related to a climate event or post-disaster response. Many people, including women, children and elderly persons in the fishing communities are suffering from these traumas silently. The number of cases of mental disorder, depression and other sicknesses is increasing in the coastal populations.

3.2.5 Effects on the vulnerable groups

The SIDS are among the most vulnerable nations of the world due to their geographic, economic and ecological constraints to progress sustainable development and climate resilience. In the least developed countries, the coastal fisheries are considered as 'social safety nets' to maintain food and nutrition security and minimal income to the

58 Doherty et al. (2011) The psychological impacts of global climate change

poorest and most vulnerable segments of the coastal populations. This might explain the persistence of the open access and laissez-faire policy in the coastal marine fisheries in the island states. However, this regime also has its drawbacks and is responsible for the underdevelopment of the fisheries.

None of the stakeholders of the fishing communities, including the fishers, fish processors, and traders and their households are better off in the current production system, but the lack of social mobility, alternative livelihood opportunities and also, redundancies in the other sectors leave them with no feasible options. The fishers are already bearing the economic hardship induced by effects of climate change on their activities such as declining fish production, higher fishing costs and safety issues etc. The vulnerability of the fishers and fish workers depend on the adaptive capacities that they have developed over time. Some are examples are given below.

i)	In the FAD fisheries in Comoros and Mauritius, some artisanal fishers have opted to boat-sharing with other fellow fishers to reduce fishing cost (especially fuel cost). Fishing boats that were previously manned by two fishers currently embark up 4.
ii)	In Grande Comore, fisher associations at the village level are mobilised to oversee safety and rescue operations for the members. Each fishing boat contributes one (1) fish per trip for these communal services. The associations have passed strict safety regulations to be followed by their members; defaulted members are interdicted to go fishing. A fishing boat is not authorized to go out fishing alone. There should be at least two boats. Carrying a mobile phone has become compulsory.
iii)	In Grande Comore, the traditional fishers cooperate to anchor indigenous FAD in the shallow water of the continental shelves near their villages. These devices are useful to continue fishing during bad weather.
iv)	In Comoros and Madagascar, the traditional fishing boats undertake two short trips per day as a strategy to mitigate spoilage of the catch due to extended exposure under rising ambient temperatures. Others have started using insulated containers and ice to preserve their catch.
v)	Some fisher cooperatives in Comoros are engaged in fundraising for financing artificial FAD and cold storage facilities in their respective communities.
vii)	In Mauritius, artisanal fishers operating the inner and outer lagoons tend to use passive fishing gears such as basket traps and hand line instead of line trolling to limit time spent at sea.
viii)	Elder fishers are retreating to the inshore fisheries while younger fishers are found to be more active on the high sea and FAD fisheries.

Some fisher households are better off than others as everyone has its strategy to adapt or to react to its context. The coastal households that depend on subsistence fishing for regular fish food diets will also be in difficulty. The productivity of fish resources is also limited because of the underdeveloped value chains. The actual production system is limited to: **fish - fisher - consumer** and this reduces the potential of indirect employment ([59]). In Comoros, the fishers are overly dependent on the coastal fisheries for their livelihoods and a decline in fish production would negatively affect their livelihoods and those of their extended families. The most vulnerable groups among the coastal populations are the women and children who are engaged regularly in the subsistence fishing. The fading out of this fishery would aggravate the social problems related to food and nutrition security as well as the safety nets for chronic unemployment.

In Madagascar, the traditional fishers in the enclaved and isolated fishing villages are often exploited by the fish traders and collectors as they have no other marketing options. Besides, the coastal fisheries are overwhelmed by inland people who do not have any previous knowledge in coastal marine fishing ([60]). This might lead to potential social conflicts in the future. In Reunion Island and Mauritius, the local production represents only a small fraction of the domestic supply of fish. The fishers are currently at the centre of the social policies of the government ([61]). The fish traders are very few and have diversified their activities to cope with the ongoing changes in the artisanal fisheries.

3.3 POLITICAL ECONOMY

This section examines the cascading effects of the climate impacts on the artisanal fisheries from the political economy perspective...

3.3.1 Contribution to Gross National Products (GDP)

The contribution of the fisheries sector, inclusive of the artisanal in the GDP of the IOC member-states varies significantly. Countries like Madagascar (10 %), Comoros (8%) and Seychelles (5%) are more dependent on the fisheries sector and thus more vulnerable to the future potential impacts of climate change. On the other side, Mauritius (1.3%) and Reunion Island (0.5%) are less dependent on the fisheries sector because the national economy is quite well diversified. Nevertheless, these two island states are realising significant turnover in the fisheries sector and are betting of the development of this sector in their future development. From recent fisheries value chain study on the African continent, including the IOC countries suggests that the small-scale marine fisheries create the highest value (43%) and is followed by

59 According to a recent value chain study in the fisheries of Africa, the ratio is approximately 1 fisher: 3 indirect jobs

60 Ministère des Ressources Halieutiques et de Pêche, - Lettre de Politique Bleue ; Situation de Référence 2014

61 The National fisheries policies of the Government of Seychelles (2014) and of Mauritius (2012).

industrial fisheries (36%) for the national economy. The distribution of the value-added in the artisanal fisheries based on the primary sale price is as follows: marketing 15% and processing 29% while the industrial processing activities create a total value added of 36 % ([62]). So, the economic weight of the artisanal fisheries sub-sector in terms of the creation of national wealth, despite its underdevelopment, it is comparable to the industrial value chains. Apart from the domestic fishing industry, the revenue sources of the Government from the fisheries sector are widely diversified and include sales of fishing rights to the foreign tuna fishing vessels, onshore transhipment and associated services, and processing operations. For instance, the tuna canning plant in Seychelles and Mauritius with an installed capacity of 60,000 t per year each are among the largest canneries in the world. The Seafood hub in Mauritius Freeport handles over 30,000 t of high-value fish annually. Climate change is not only a serious threat to the artisanal fisheries but the entire fisheries sector. Any decrease in the fisheries outputs will have severe consequences on the national economy and public finance of the IOC member-states.

3.3.2 Employment and Safety Nets

The key role of the artisanal fisheries in the provision of direct and indirect employment to the coastal populations in the IOC countries is summarized in the table below:

Table 1: Summary of Number of Artisanal fishers in the IOC countries

Particulars	Comoros	Reunion Is	Madagascar	Mauritius	Seychelles
Registered Fishers	8,000	300	100,000	5,000	1,350
Indirect	24,500	900	300,000	15,000	11,000
% of Total Labour	6%	0.5 %	-	1.5%	11%
Unemployment rate	15 %	35.9 %	-	10 %	-

Source: Fisheries Status data 2012 in SmartFish Report 2014 & Africa Economic Outlook 2014

Owing to the open-access of the coastal fisheries in the IOC member countries, there are a large number of people involved in subsistence, leisure and sport fishing who are included in the above figures. A survey carried out in the coastal fisheries of Mauritius in 2007 identified some 24,500 people involved fishing activities for subsistence or hobby. In Madagascar, it is estimated that more than one million people in the coastal areas are directly or indirectly dependent on the coastal marine fisheries for their livelihoods. The climate change-induced decline on the coast marine fisheries productivity would have a serious repercussion on the livelihoods on those fishing communities as well as the local and national economies.

62 Gertjan de Graft et al., 2014, The Value of African Fisheries and Aquaculture sector.

3.3.3 Food and Nutrition Security

Although the per-caput consumption of fish is not even in the IOC countries, marine fish is the major source of animal protein intake. In 2010, it was 29.5 kg in Comoros, 14.5 kg in Reunion Island, 6.9 kg in Madagascar, 24 kg in Mauritius and 50 kg in Seychelles; while the African average of fish consumption is 9.4 kg. While Comoros, Madagascar and Seychelles are self-sufficient, Mauritius and Reunion import 60% and 90 % respectively of their domestic fish supply annually. The population of IOC countries altogether represented 25.5 million people in 2012 and would be approximately 40 million by 2050. Based on the actual aggregate fish production and marine fish resource potential of the IOC member –states (refer to Section 2.1), it is most likely that per caput fish consumption would decline considerably and the impacts of ocean warming (refer to Section 2.3) would further exacerbate the food and nutrition insecurity ([63]). The region would become a net importer of seafood to satisfy its domestic supply. The progress achieved under the MDG and the 2009 Regional Food Security Strategy might suffer a serious setback if appropriate climate adaptation strategies are not sought urgently.

Table 2: Current and Potential Production of the Artisanal Fisheries of the IOC countries

Particulars	Comoros	Reunion Is	Madagascar	Mauritius	Seychelles
Artisanal fisheries (t)	16,000	2,500	107,000	8,000	2,450
Resource potential (t)	33,000	5,000	300,000	15,000	100,000
Population (2015)	788,744	845,000	24,235,320	1,262,608	92,900
Per caput fish in take (kg)	29.5	24.5	6.9	24	50

Source: Fisheries Status data 2012 in SmartFish Report 2014 & Africa Economic Outlook 2014

3.3.4 Cost of Climate inactions in the Artisanal fisheries

So far, there has not been any direct climate actions in the fisheries sector, particularly in the coastal fisheries in the IOC countries. The national climate policies have focused mainly on the land-based sector such as agriculture, forestry and water resources. The climate threats on coastal and marine environments are looked after by the Integrated Coastal Zones Management (ICZM), where the main emphasis is on coastal erosion, biodiversity conservation and disaster risk management. Marine reserves and protected areas have been established as buffer zones for the conservation of marine ecosystems and aquatic resources. These MPAs were created under the UNCBD with focus on biodiversity conservation without internalising fully the climate risks on these

63 The population growth in the IOC is in the range of 1.5% – 2.8 % per year in the IOC countries (UNDP 2011)

marine reserves and parks. They are also under climate threats and the initial concept has been revisited to make them climate-resilient.

The opportunity cost of inaction is very high in any scenarios. To sustain the flow of benefits from the artisanal fisheries to the local and national economy, the government of the IOC countries must integrate appropriate climate adaption actions into their fisheries policies, strategies and plan, which are usually of "no regret" and "win-win". This is an opportunity for some of these countries to shift from the current business-as-usual approach to promote the artisanal fisheries a vibrant component of their ocean economy.

There is much expectation indeed on the coastal tuna fisheries to sustain its socio-economic functions in the IOC countries; however, this will depend on the impacts of climate change on the migratory pattern of the tuna stocks in the territorial waters of these countries. This is also a major concern for the IOC countries because they derive substantial direct revenues and economic returns from the tuna stocks in the EEZ. The existing scientific literature suggests that the tuna stock in the SWIO has been displacing eastwardly at a speed of 50 km per decade ([64]). If this trend is maintained, the regional countries might lose a multi-million dollars industry. The pressure is already felt on the seafood hub in Mauritius because some major tuna processors are considered to displace their operations to follow the fish. A coastal tuna fishing boat has a limited range of operation, which is roughly about 25 nautical miles. The existing fishing assets will not be techno-economically viable if the tunas and tuna-like fishes are not within their geographic range of operation. Shifting from the inshore fisheries to the coastal oceanic fisheries is a complex enterprise because it requires innovative policy frameworks and enabling environment, business models, human resources, financial mechanisms etc. Please refer to the recommendations made in the concluding chapter for actionable measures.

Ocean warming impacts, through the potential displacement of the fish stocks, will intensify competition and conflicts in both, the coastal fisheries at national and regional levels. In Comoros and Madagascar, the conflicts over resources use and sharing are already seen where traditional customary rights exist in the fishing villages. This can potentially vent social conflicts and hostility among neighbouring fishing villages. Traditional and subsistence fishers may be deprived of the possibilities in operating in other fishing areas except for the marine space in front of their villages. There are some reported cases in Comoros, where fishing assets have been confiscated and fishers held as hostage and released only after payment of some compensation ([65]). A coastal FAD anchored in front of a fishing village can be claimed

64 Marsac F et al. (1998), Miller K (2007) & Cheung EW et al. (2010)

65 Ranaivoson E et al. – SmartFish (2014) – Inventaire socio-économique du secteur de la pêche artisanal aux Comores vue par les pêcheurs eux-mêmes.

by the village as its exclusive fishing areas and fishers from other villagers may not be allowed to fish in its vicinity

The Indian Ocean Tuna Commission ([66]) focuses on the monitoring of the status of the main tuna stocks and the implementation of the FAO International Plan of Actions concerning the protection of marine mammals, endangered marine species, and tuna by-catch etc. This regional fisheries management body has integrated the oceanic bio-diversity issues, but the potential impacts of climate on the tuna fisheries are still not on its agenda.

66 The Indian Ocean Tuna Commission is the Regional Fisheries Management Body in the responsible for providing expert advice and coordination of scientific activities to the its member for the conservation management of the tuna stocks in the Indian Ocean.

CHAPTER 4 - CLIMATE CHANGE AND FISH TRADE

Climate change affects domestic and international fish markets and trade because they are linked to fish production in terms of volume, species mix and size of fish. The potential impacts of climate change are capable of modifying the future fish trade patterns of the IOC member-states. If timely climate adaptation actions are not implemented in the fisheries sector, the flow of benefits from fish trade will be eroded and these countries might ultimately become dependent on imports of fish and seafood to meet domestic supplies. The bulk of the international fish trade of the region consists of canned tuna. This chapter builds on section 2.1 - of the report to examine the current fish markets and trade status of the IOC member-states before discussing the future potential impacts of climate change on fish trade.

4.1 DOMESTIC FISH MARKET AND TRADE

4.1.1 Comoros

Union of Comoros is self-reliant in fish production, which is supplied by the traditional and artisanal fisheries. The country imports approximately 1,000 t of dried salted fish from Madagascar and canned sardines from Europe to satisfy the domestic cultural needs ([67]). It does not export any fish or seafood. The shortage of fish supply on the domestic markets is related to frequent bad weather at sea and the consumers switch on to imported frozen chicken ([68]). The domestic fish production is approximate 16,000 t per year and the per-caput fish consumption is 29.5 kg. A large number of the coastal population fishes regularly in the inshore waters for auto-consumption. Since almost everyone in the coastal villages is a potential fisher, the catch is mostly sold to the coastal cities and inland markets. The post-harvest loss tends to be high. Health and sanitary regulations exist but are not enforced. The consumption of contaminated fish represents a serious public health hazard. The National Competent Authority for the fisheries products is not operational. The fish market is not formally organised and the fish price is often negotiated between the fishers or fish traders and the consumers. Fish prices are relatively stable. The inter-island fish trade is limited. The local markets are adapted to the climatic variations and seasonality of the domestic fisheries. To maintain the same per caput fish consumption in the country, the domestic production will have to increase constantly to cope with the projected population growth. The growth potential is uniquely in the coastal tuna fisheries. Comoros has an FPA with the EU that allows the EU tuna purse-seine fleet to fish in

67 Comoros is an Islamic state with deep rooted French culture and lifestyle, including the Comorian Diaspora in France and also, a significant of population originated from the northern provinces of Madagascar.

68 In 2012, the country imported about 8,000 t of frozen chicken for domestic consumption

its EEZ and the accruing financial contributions complement the public budget and are partly invested in the modernisation of the artisanal fisheries ([69]).

4.1.2 Reunion Island

Reunion Island relies heavily on imports (90%) of fish and seafood for its domestic supply. The island is also an exporter of raw pelagic fishes; in 2012 it has exported a total value of processed fish of EUR 67 million, representing 22% of the island's exports. The European Parliament perceives the fisheries sector in Reunion island as a promising industry for the export of high-quality tropical fisheries to the European markets and as a provider of jobs to the 35.9 % of the unemployed labour force ([70]). The existing onshore fisheries facilities are underutilised. The younger generation does not show interest in the fishing sector. Under the current scenario, Reunion Island will continue to depend on fish imports for local consumption.

4.1.3 Madagascar

Madagascar is auto-sufficient in fish through its inland and inshore marine fisheries supplied by its traditional fisheries. The foreign-owned domestic tuna cannery imports about 25,000t of fish annually for processing and re-export. The fishmeal which is produced as a by-product is also exported due to some intricacies in the customs regulations. Small quantities of by-catch fish (about 750 t per year) are disposed of in Diego Suarez during the seasonal tuna transhipment operations. The tuna by-catch and miscellaneous fishes are sold at a premium retail price within a radius of 300 km from the tuna port ([71]). The industrial shrimp fisheries are owned by locally based foreign enterprises and their total production are exported to EU and Japanese markets. There are a few small-scale fisheries enterprises based in the main cities around the country that are engaged in the export value chains of reef fishes, lobsters, shrimps, octopus, crabs and other high-value seafood. Most of them are cleared to export to the European Markets. Some of the sea products are exported to Reunion Island and Mauritius. The export of wild shrimps is declining steadily over the past five years. The shrimp aquaculture was devastated by the white spot epidemic and will not restart soon.

Due to lack of basic socioeconomic infrastructure, utility services, dedicated fisheries and onshore facilities, it is difficult for the key stakeholders to maximise the flow of benefits from the coastal fisheries resources, which are underutilised. The northern part of the Malagasy waters is rich in tuna resources ([72])but are not harvested by the local fishers. The seafood industry of Madagascar is facing stiff competition on export markets from SE Asian countries. For example, Reunion Island and Mauritius are

69 Breuil C et al – SmartFish/FAO (2014) – Comoros Fisheries Baseline data update

70 INSEE (2012)

71 Sweenarain S et al. ACPFishII (2014) – Market Study of the by-catch of the industrial tuna fisheries in the IO

72 Sweenarain S & Cayré P (1998) – Prospects and Challenges of the tuna fisheries in the IOC countries.

importing more seafood from Vietnam and India than Madagascar. The comparative advantage of the country is undermined by its underdeveloped regional and international supply chains ecosystems. The per-caput fish consumption in Madagascar is lower than the African average. This is not evenly spread between the coastal and inland population. The distribution of marine fish products is limited to the main cities.

4.1.4 Mauritius

The Seafood Hub of Mauritius exports around US$ 185 million of seafood and imports around 120,000 t for processing and re-exports annually. It has a net positive balance of trade in the fisheries sector. It is also a traditional tuna transhipment base for the SE industrial tuna longline fleets. About 30,000 t of sashimi-tuna are handled in Port Louis and some 350 t of tuna by-catch and miscellaneous fishes are offloaded and sold on the local markets every year. There is only one small scale mariculture enterprise with a production capacity of 300 t per year, but the national potential for aqua-farming is estimated at 30,000 t ([73]). In 2014, the aggregate domestic fish production was at 5,884 t, including 717 t harvested by the artisanal demersal fisheries and 300 t, by the coastal FAD (tuna) fisheries. Mauritius imports about 18,500 t of fish and fish products for direct consumption worth US$ 75 million annually. There is no customs duty or value-added tax (VAT) on imported raw fish into Mauritius.

There is a serious dichotomy in the fisheries sector with regards to coastal physical infrastructure and dedicated facilities in Mauritius. There is a one-stop-shop for administrative clearances and the Competent Authority that provides 24/7 services. On the other side, there is virtually no basic infrastructure and onshore facilities for the artisanal fisheries. Health and sanitary regulations exist but are not enforced.

Mauritius has an FPA with the EU. Although it is quite remote from the surface tuna fisheries in the SWIO, it has successfully emerged as a key player in the regional tuna value chains. The government is incentivising the local fishers to harvest more tuna for the domestic markets. Major developments are taking place in the fisheries sector and seafood hub of Mauritius that will also be affected by future potential climate threats.

4.1.5 Seychelles

Seychelles economy is dependent on two sectors, namely tourism and fisheries for its sustainable development and both of them are highly vulnerable to climate change. It is at the heart of the largest surface tuna fisheries that feed the tuna canneries in the Indian Ocean. It is endowed with significant stocks of demersal fishes. With a relatively small population, the archipelago has the highest per caput fish consumption in the IOC. It has one the largest tuna canning plant processing about 60,000 t that feeds the EU markets. Relatively small quantities of raw reef fishes are exported. There is a debut of some small-

73 IDEE 2006, Mauritius Aquaculture Development Plan 2007

scale aquaculture projects on the island with oysters and clams farming. The large-scale shrimp farm at Coëtivy Island was shut down recently due to cumulated financial losses. The physical infrastructure for both, the industrial and extended (semi-industrial) fisheries is well developed. The country has been quite successful in the domestication of foreign tuna fishing and onshore tuna businesses.

The coastal demersal fisheries are reserved for the residents. The tuna by-catch offloaded by the foreign purse-seiners is processed into a variety of value-added product for the local and export markets ([74]). The growth potential in the fisheries sector can be sustained through informed resources conservation management. The emerging cluster of local fishing and processing small scale enterprises are facing structural difficulties to compete in the export markets. As a SIDS, Seychelles is facing geographic and economic hurdles to enhance its comparative advantages in the regional and international fish trade. The government tends to revisit its business enabling policies to boost its seafood export value chains.

4.2 OVERVIEW OF REGIONAL AND INTERNATIONAL FISH TRADE

The international fish trade in the IOC countries relies over 90 % on the tuna resources in the SWIO and accessorily on a limited supply of shrimps, reef fishes and other high-value seafood. Countries like Mauritius and Reunion Island export high market end seafood (tuna) products and import large quantities of basic fish and seafood for mass-consumption from several SE Asian countries. Fish trade among the IOC countries is insignificant for several reasons namely:

i)	The mismatch between the intra-regional demand and supply;
ii)	The countries are bound to export high-value products and import low-cost seafood;
iii)	Inconsistency and irregularity of supply;
iv)	The decline of comparative advantages and competitiveness of the regional exporter;
v)	Inefficient regional transportation and logistics networks.

The financial and economic benefits derived by the IOC member countries from the FPA with the EU and sale of fishing licenses to distant waters fishing nations (DWFN) are non-negligible ([75]). This section will examine some key aspects of regional and international trade and services of the seafood industry in the IOC member-states.

74 Sweenarain S et al. – ACPFish II – Market study for the by-catch of industrial tuna fisheries in the IO.
75 Excluding Reunion Island because the latter is part of the EU in the region

4.2.1 Canned tuna trade and services

The Indian Ocean is the second-largest global tuna fishery, with an annual production of about 1 million tonnes. Over 50% of the aggregate catch is realised by the extended artisanal fisheries of the northern countries of the Indian Ocean. About 450,000 t are harvested annually by the offshore tuna fisheries, namely the EU purse seiner (300,000t) and the SE Asian longlines (150,000 t). It is estimated that some 50,000 t are caught by the coast tuna fisheries of the riparian and coastal countries of the Indian Ocean. The canned tuna trade in the IOC countries, namely Mauritius, Seychelles and Madagascar are part of $ 2 billion industry and is an extension of the European tuna value chains in the SWIO. It stems out the preferential trade agreement under the EU-ACP Convention. About one-third of the total catch of surface tuna fisheries in SWIO is realised in the EEZ of the IOC countries. The financial benefits from the FPA with the EU represent approximately EUR 60 per tonne to the riparian countries ([76]). The direct economic benefits to some of the IOC countries consist of transhipment and associated activities, and processing for re-exports.

Over 80% of purse seine catch is offloaded or transhipped in Port Victoria, Seychelles; the remainder is shared between Madagascar and Mauritius. Each tonne of tuna transiting at a regional fishing port generates gross revenue of about US$ 200 in terms of port dues, stevedoring, bunkering, crew entertainment etc ([77]). There 3 tuna canneries with a total production capacity 150,000t in the IOC (Mauritius and Seychelles 60,000 t each and Madagascar (30,000t). It implies that about half of the annual production is processed outside the SWIO region. Madagascar has lagged in this development due to the persistent political turmoil. The industrial tuna longline base at Port Louis receives over 500 calls and handles about 30,000 of sashimi-grade tuna annually. On average, the vessels spend approximately US$ 25,000 to 40,000 per call. The license vessels have a formal obligation to discharge the by-catch and miscellaneous fishes at Port Louis ([78]).

The canned tuna value chains are characterised by mass production, with a relatively small profit margin. Although most of the tuna is harvested and processed in countries closer to the fishing grounds, there is some doubt on the equitable distribution of the benefits among the different stakeholders in the value chain in the absence of market information and transparency. In some cases, the benefits derived by the host economy are limited to the direct employment as the processing enterprises are beneficiary of the duty-free regime and yet, they have cumulated financial losses ([79]).

---

76 Sweenarain S et al. – ACPFish II – Market study for the by-catch of industrial tuna fisheries in the IO.

77 Sweenarain S (1994) Economic of tuna transhipment in the IOC region

78 Sweenarain S – IOC Regional Tuna Projet II (1996) – Economics of regional tuna transhipment platforms in the IOC

79 Campling L & Doherty M, Regional Trade Facilitation Programme, (2007) – A comparative analysis of Cost Structure and SPS issues in canned tuna production in Mauritius, Seychelles and Thailand: Is there a level Playing field?

These existing business models will have to be revisited in the best interest of all the stakeholders to create more value-added to the coastal economies.

Some game-changing technological revolution is taking place in the purse seine fishery that can potentially upgrade the existing surface tuna fisheries value chains. A few purse seiners have modified the freezing and storage systems onboard to harvest deep-frozen high quality (sashimi) grade tunas, instead of raw material for canneries. The fishing operations are integrated vertically to a high-tech processing plant in the Mauritius Freeport to process raw fish for direct consumption. These products are exported in 'ready-to-cook' and 'ready to eat' packages to niche markets in the EU and USA as well as the emerging economies. Currently, some 15,000 t of tuna are handled through this innovative value chain, but this business model is under trial.

4.2.2 Chilled tuna trade

In the IOC region, much emphasis has been laid on the development of the capital-intensive fishing and processing industries led by the canned tuna value chains in the EU supported by the preferential market access and the FPA. There has been no real interest in promoting small tuna scale (chilled) fisheries that have existed for a long time in many coastal countries in SE Asian and South Pacific countries. The inter-seasonal markets for tropical tunas and fine fishes have always existed in the main European cities. For instance, these small-scale tuna fisheries are a major supplier of high-quality tuna and large pelagic fish to the sashimi markets in Japan and other niche markets worldwide. Recently, Reunion Island and Seychelles have developed a small fleet of extended artisanal tuna longline fleet to target swordfish and tuna for export markets. However, they did not take off because of some indiscriminate EU sanitary standards norms and monitoring procedures that were unrealistic and penalising to the exporters in Reunion Island and Seychelles ([80]). In Mauritius, these industrial tuna fleet are integrating the export value chains through the seafood hub processors and exporters.

4.2.3 Trade in reef fishes, molluscs and other high-value seafood

Madagascar is the only exporter of frozen wild shrimps in the IOC. The industrial segment of this industry is controlled by a few foreign enterprises... Some small-scale fisheries enterprises are also involved in this trade by collecting the daily catch of the traditional fishing units. These frozen products are distributed in the main cities of Madagascar and also exported to Mauritius. These value chains are still unreliable due to irregularity of supply and inconsistency quality management. Some Mauritian seafood importers have opened offices in Madagascar to monitor their regular shipments. Direct flights between the two countries have led to the development of

80 Prévost D – International Centre for Trade and Sustainable Development (2010) – Sanitary, Phyto-sanitary and Technical Barriers to Economic Partnership Agreements between the EU and the ACP Countries.

the trade of live mud crabs, lobsters and chilled reef fishes supplied mainly supermarkets, hotels, restaurants, specialised fish shops in Mauritius. Despite its significant demersal fish resources, Seychelles has not been able to consolidate its export value chains mainly due to its geographic isolation and lack of economies of scale. Like other SIDS, it is a victim of the indiscriminate trade policies of the World Trade Organisation.

4.2.4 Seafood hub of Mauritius

The seafood hub in Freeport has emerged as in international warehouse for a wide range of seafood which is offloaded by the foreign fishing vessels and imported in bulk, processed and packaged for re-export to a large number of countries. The foreign fisheries enterprises in the Freeport are authorised to sell 10% of their products locally. Imported raw fish intended for direct consumption or further processing are exempted from custom duties and VAT. The seafood hub acts as a buffer for the procurement of a wide variety of seafood at competitive prices to the domestic markets.

4.2.5 Supply of foreign labour in the fisheries value chains

There is a growing mismatch between the demand and supply of labour in the fisheries industry in the high and middle-income countries of the IOC. In Mauritius, because of the scarcity or unwillingness of the local professional fishers to work in the offshore bank fisheries, the boat owners are hiring Malagasy fishers to stay in business. Likewise, the tuna canneries and other seafood processing plants in the Mauritius Freeport are recruiting workers from Madagascar, India, Sri Lanka and Bangladesh. Likewise, the tuna cannery in Seychelles is hiring foreign labour to run the plant on a two-shift basis. These expatriate workers are contributing considerably in maintaining the efficiency and competitiveness of the regional fisheries value chains. The Sri-Lankan boat builders and professional fishers are also assisting the Comorian coastal tuna fisheries in boosting their technical capacities of the local fishers.

4.3 POTENTIAL CLIMATE IMPACTS ON FISH TRADE

The damages caused by EWE on the physical and natural infrastructure, fishing and personal assets, safety and health status of the fishing and coastal communities can disrupt the whole economy, including domestic and international supply chain ecosystems. This section investigates the different aspects of the climate-induced changes in fish production on foreign trade. These expected changes might occur in the species composition, regularity and consistency of supply, price structures, and consumer behaviour. It also assesses the potential effects on the comparative advantages and competitiveness of exporters in the IOC member-states. Since the climate effects on fish trade are not uniform in space and time across the world, it may be beneficial to some regions and countries and adversely impact others. On the

backdrop, it is reckoned that the international fish trade in IOC will be knocked down by the future potential impacts of climate change if appropriate adaptation measures are not taken now.

4.3.1 Demersal fishes

The big chunk of international trade in fish and seafood in the IOC countries, namely Madagascar; Mauritius and Seychelles consists of canned tuna and accessorily some high-value marine products such as shrimps, reef fishes and molluscs. Except for Madagascar and Seychelles, the artisanal fisheries in the other IOC countries are not involved in fish export. Their entire local production is meant for domestic consumption. Comoros is self-reliant, while Mauritius and Reunion depend heavily on the import of a wide variety of raw fish and frozen seafood. These exporting countries are farming some of these wild fish species to anticipate consumers' demands in importing countries. A decline in the wild fish production in the exporting countries will also impact the consumers in these importing countries. The demand-pull inflation for fish and fish products on future market prices will be about 6 -10 % per year ([81]). The low participation of the regional small-scale fisheries in international fish trade may help in import substitution and improving per caput consumption of fish protein in these countries. The price signal of the scarcity of some local fish species is flouted by existing market failures since the same species can be imported at relatively cheaper prices. This would be a major challenge for the island countries to implement effective resource conservation management and social policies in the coastal fisheries under the current free trade practices. If appropriate climate change adaptation measures are not taken, the IOC island states might become net importers of raw fish and fish products in the future.

4.3.2 Fresh and frozen tuna

The coastal tuna fisheries are less vulnerable to the effects of climate change than the demersal fisheries. Reunion Island, Mauritius and Seychelles are developing export-oriented coastal and extended (semi-industrial) tuna fisheries. However, these fisheries are not entirely immune to the climate-induced challenges in chilled tuna trade. The regional producers are probably going to face the economics of diminishing returns because of increasing fishing costs:

i)	Reduction in the number of effective fishing days due to bad weather;
ii)	Longer fishing trips because of lengthier cruising and search time;
iii)	The higher cost of operating costs: fishing labour and consumables, repair and

As price takers, the local producers would face tougher competition from other countries, which are less affected or benefit from the impacts of climate change. A Consumer buying decision is rarely based on environment or emotional factors, rather

81 FAO – World Fisheries Report, 2014

on the utility/satisfaction or perceived benefits derived from the consumption of the purchase goods. The small-scale tuna fisheries will have to think of innovative business models and value chain development strategies to uphold their comparative advantage on the competitive markets.

4.3.3 Canned and raw tuna value chains

The displacement of tuna stocks from their traditional fishing grounds in the SWIO should be a matter of serious concern to all the IOC countries because they are the bedrock of a billion-dollar regional tuna industry. The tuna fishing, processing and associated services are important sources of financial and economic benefits to these countries. The industry operates on relatively small margins and is in a financially tight situation. The preferential trade agreement between the EU and ACP countries is eroded under the WTO and the canned tuna producers in the SWIO are already facing serious competition in their traditional markets. In the early 80s, the EU purse seine tuna fleet shifted from the Atlantic to the Indian Ocean because of a decline in the surface tuna fisheries. In 1998, with the decrease in the catches by nearly 30 % caused by the El-Nino, some vessels left the SWIO and others were planning to quit definitely. The same problems arose during the 2000s with Somalia piracy in the region. Currently, tuna shoals have extended eastward to the Chagos archipelago waters. It is most probable that the canned tuna catchers and processors will continue to follow the fish. The FPA with the EU has based a quota of tuna caught in their respective EEZ, it is most likely that the corresponding financial package would also decrease with a decline of the level of catch by the foreign vessels. So, the future challenges of climate change to the canned tuna industry cannot be treated casually by the IOC member countries.

The raw tuna value chains are also not protected from the potential risks of climate change. Some operators in the seafood hub of Mauritius are already considering delocalised their operations to be closer to the fishing grounds to reduce production costs. The Indian Ocean Tuna Commission (IOTC) have not paid considerate attention to the climate threats on the regional tuna fisheries, which is crucial for the effectiveness of the current and future tuna resources conservation management in the SWIO and also, to safeguard the long term interest of the coastal and riparian states in conjunction with the potential displacement of tuna stocks. The collapse of the regional industrial and coastal tuna fisheries would have severe socioeconomic impacts on the IOC member countries although some of the countries would more be affected than the others.

4.3.4 Consumer preference and indifference

Tropical fisheries are characterised by a large variety of species, which are available in relatively smaller quantities. The fishers and consumers are accustomed to some extent to the seasonal changes in the availability of certain commercial fish species. This trend will be further enhanced with the mixing of species from wild marine fisheries, mariculture, inland fisheries and aquaculture etc. Several tropical reef fishes,

crustacean and molluscs, including tuna species that were only found in the wild are now farmed to ensure regular supply. Looking at the declining trend of the coastal fisheries, the IOC countries must promote smart aquaculture project to maintain the supply of fish for the domestic and export markets.

There is a rising opposition of the environmental NGO regarding the air-freight of lived and chilled fish too long-distance destinations because of the relatively high carbon footprint, e.g. the quantity of carbon emission per kilo of fish transported. So far, the Marine Stewardship Council has emphasised on the biodiversity issues of fisheries and marine ecosystems conservation through the society demand for eco-friendly consumption and this is evolving to integrate carbon footprint to ensure long term climate resilience. Awareness building on the effects of climate change on the fish value chains and the consumers is still an explored topic.

4.3.5 Policy shifts

Mainstreaming of climate change adaptation policies will also affect international trade in different ways. Owing to the significance of domestic fish production in food and nutrition security in the IOC countries, it is mostly like that these products will be considered as public goods. There might be some restrictions on the export of raw fish to ascertain adequate supplies for domestic consumption. This was the case in the post-Independence era in Mauritius when the common fish species "emperor" was banned for export. The local retail price was formally fixed and the bank fishing operators were incentivised to increase production for domestic consumption. To compensate for the decline in the production of reef fishes, the government will have to promote the development of herbivorous as well as climate and disease-resistant fish species to increase domestic fish production. The fish meal produced by the tuna canneries from the fish offal and waste might meet with export restricted as the by-product is crucial for the development of domestic aquaculture and cattle farming.

4.4 SUMMING UP

To sustain the flow of benefits from the international trade of fish and seafood, the IOC member-countries will have to undertake proactive climate adaptation actions. The impact of climate change on the marine fisheries will have a cascading effect on fish production and obviously on the domestic, regional and international fish trade.

CHAPTER 5 – CLIMATE CHANGE ADAPTATION MECHANISMS

5.1 INTRODUCTION

This chapter scrutinizes the current climate change adaptation and resilience institutional portfolio, policies and programmes directly and indirectly implicated in the coastal marine fisheries of the IOC countries at both national and regional levels. It is necessary to clarify the terminology of the terms Adaptation and Resilience, which are associated with climate change. Adaptation can be described as an adjustment in natural or human systems, in response to actual or expected climatic pathways or their effects, which moderate potential harm or exploits beneficial opportunities ([82]). Resilience is generally defined as the capacity for a socio-ecological system to absorb stresses and maintain function in the face of external stresses such as climate change and organized or evolve into more desirable configurations that improve the sustainability of the system, leaving it better prepared for future impacts ([83]).

5.2 INTERNATIONAL INSTITUTIONAL FRAMEWORKS AND STRATEGIES

All the IOC member states are signatories to the 1982 United Nations Convention on Law of the Sea (UNCLOS) that enable the coastal nations to establish the exclusive economic zones (EEZ); of the three 1992 Multilateral Environment Agreements ([84]) of the United Nations Commission on Environment and Development (UNCED) as well as the 1995 Code of Conduct for Responsible Fisheries and associated covenants enacted by the Fisheries Department of the FAO, which are enforced by the coastal and DWFN under the coordination Regional Fisheries Management Bodies (RFMB). These international institutional portfolios, as well as numerous mutually enriching conventions, provide comprehensive legal and regulatory frameworks to the nations worldwide to pursue their sustainable and climate-resilient development. Due to the historical development of the UNCLOS, this convention did not incorporate the environmental challenges at the outset as they were not the priorities of that time and later on the international community, through the FAO has tried to catch up on these issues by enacting the Code of Conducts for Responsible Fisheries and several associated mechanisms. These conventions have focused on the continental seas and the EEZ while the international waters have remained as the wealth of humanity or

82 Rampengan M R et al. (2014) - Capacities in Facing Natural Hazards: A Small Island Perspective

83 Folke, C et al. (2006) -Resilience: The emergence of a perspective for social-ecological systems analyses

84 United Nations Framework Convention on Climate Change (UNFCCC); on Bio-Diversity (UNCBD) and on Deforestation and Desertification (UNCDD)

common pool and open access. There is inadequate scientific information on the open oceans.

The 3 MEAs are dealing with overlapping challenges of environmental sustainability in the coastal marine ecosystems by different implementing governmental and international agencies without adequate coordination between them. They mostly focused on coastal marine and land-based sectors such as agriculture, forestry and water; different components of the coastal marine ecosystems such as the coral reefs, mangroves, beaches, estuaries and wetlands have benefited from several conservation management interventions. Although the coastal marine fisheries have been a major economic sector among the other resource users such as tourism, coastal development and maritime transportation, it has not been subject to dedicated climate change adaptation strategy so far. Climate change adaptation policies have been mainstreamed in the core institutional frameworks of the IOC countries and the national climate change strategy has earmarked some prioritized actions to be implemented to build the resilience in the artisanal fisheries, but no concrete action has been seen on the ground. The indirect climate actions from which the artisanal fisheries have benefited include mainly, Early Warning System, Disaster Risk Management, Awareness Building and some dedicated financial mechanism to improve the existing fishing assets. The marine reserves and protected areas have been established in the region under the UNCBD to arrest biodiversity loss in the coastal marine areas provoked by overfishing and environmental forcing. These MPAs are considered as a buffer zone for the coastal fisheries and are also an anchorage for eco-tourism. However, these sites were selected primarily on biodiversity criteria. Most of them will have to be reviewed in light of the potential climatic threats such as ocean warming, sea-level rise and acidification. The integrated coastal zones management (ICZM) is sought as an overarching platform for the implementation of climate actions in the coastal fisheries; however, it is still not fully operational in the IOC countries. Seychelles has not adopted an ICZM framework but has an analogous mechanism to carry out these interventions. At the national level, these conventions are managed by different Ministries or Departments without effective communication and coordination between them. These conventions were locked up in an inter-governmental bureaucracy loaded with mandatory communication and conferences with limited actions on the ground. It is not surprising that global environments have been worsening in the meantime.

The year 2015 has rekindled optimism for a better and safer future for all. Once again in the human history, the international community stood united to promote a world without extreme poverty and hunger albeit a fast-growing global population by endorsing the 17 Sustainable Development Goals (SDG), to marshal the unfinished jobs of the Millennium Development Goals (MDG). Of primary importance to this study is the SDG 13 - Climate Action. The 2015 International Conference on Financing for Development has come up with innovative financial mechanisms to mobilize domestic and external resources to leverage massive investments to finance basic infrastructure

needs in the poor economies. The UNCBD Strategy 2011-20 and the Aichi Targets for biodiversity conservation, particularly Targets 6 & 10 addressing the restoration of the coastal marine ecosystems and the depleted fish stocks, and climate change – Coral Reefs nexus is of primary significance to this study. In December 2015, the Global Climate Agenda (Paris COP 21) was unanimously accepted by the 196 nations of the world. By so doing, the international community has made a firm resolution to keep the global warming below 2°C since pre-industrial times and consider lowering it further to 1.5°C to salvage the SIDS and the low-lying countries. For the first time in the history of COP, climate justice or loss and damage have been subtly integrated into the Paris Climate Accord although the source of financing has not been fully identified. This is crucial for the LDC and SIDS because some collateral damages caused by climate change in coastal communities would be unavoidable. The global force of international community, multilateral development agencies, donor countries, business communities and research and scientific institutions and NGO worldwide is mobilised to advance sustainable and climate-resilient development. The gist of the challenge is still the mobilisation of adequate resources and the mainstreaming of appropriate strategies plan of actions at sector-specific and community levels.

5.3 REGIONAL STRATEGY FRAMEWORKS AND PROGRAMMES

The issues of climate change transcend the national boundaries and thus, require a global and regional approach to capture the possible economy of scale and value-added. The IOC is intertwined into other large regional blocks such as the SIDS Alliance and the African Organisations on sustainable development and climate change challenges. Over the past decade, the IOC member countries have participated altogether in about 30 regional and national climate change adaptation interventions with at least one of the following areas: i) Research and Evaluation and policy formulation, ii) Dissemination of knowledge and Awareness building, iii) Capacity building, iv) community-based adaptation. These initiatives were mostly related to institutional strengthening, rural development and agriculture and were funded by a plethora of multilateral development agencies, donor countries and international NGO. Some of them have addressed the challenges of climate change in the coastal marine ecosystems and the coastal fisheries have benefited indirectly from these projects. So far, none of them has a deal with the specific threats of climate change on the fisheries and fishing communities.

5.3.1 Other Overarching Regional Initiatives

The following table summarizes the regional programmes undertaken in the Western Indian Ocean countries over the past decade that has some linkages with climate change adaptation.

Table 3: Summary of the Environmental interventions in the IOC countries

No.	Programme Title	Participating Countries	Interventions
1	ASCLME	IOC countries + Kenya Mozambique & Tanzania	- Assessment of the socio-ecological features of the ASCLME - Policy formulation and Integration
2.	Clearing House Mechanism (Nairobi Convention)	IOC countries + Kenya Mozambique & Tanzania	- Capacity Building - Networking for data sharing - Dissemination of scientific and socio-economic knowledge
3.	ODINAFRICA ([85])	Same as above (excluding Reunion Island)	- Networking for data management - Knowledge dissemination
4.	RE-CO-MAP – OI ([86])	IOC countries + Kenya Mozambique & Tanzania	- Data Collection & Evaluation - Bathymetric mapping - ICZM Strengthening

Source: Author's compilation from the related project documents

5.3.2 IOC Acclimate Programme (2008-2011)

Adaptation to Climate Change (Acclimate) 2008-2011 is the first IOC programme dedicated to the issues of climate change that was funded jointly by the EU and the French Government. The main objective of this programme was to undertake a vulnerability analysis of the main social, economic and environmental sectors in the participating countries. The vulnerability of the coastal and marine ecosystem and the fisheries sector was also briefly reviewed through national and regional multi-stakeholder workshops. The regional adaptation strategy was technically validated in July 2012 and adopted in January 2013. The Regional Climate Change Adaptation Strategy 2016-2020 will focus on the following four sectors: food security, water, health and the environment. Other sectors will be treated in a second phase, including natural disasters, infrastructure, transport, energy, and tourism (87). The land-based

85 Ocean Data and Information Network for Africa

86 Regional Coastal and Marine Programme – Indian Ocean under the aegis of the IOC funded by the European Union

87*http://climate-l.iisd.org/news/acclimate-project-concludes-ioc-member-states-adopt-regional-adaptation-strategy/*

sector would likely be prioritized over the fisheries sector (88). In 2012, the IOC has developed a Regional Food Security Strategy. One of the main lacunae of the mechanism is that in a region where fish and fisheries are central to the economy and diet, this food security strategic document does not integrate fully the significance the fisheries sector, particularly the coastal fisheries (89).

5.3.3 IOC Current EU-funded Environment programmes

i) SmartFish Programme – The programme for the Implementation of a Regional Fisheries Strategy in the Eastern and Southern Africa and Indian Ocean region (ESA-IO region) started in 2011 and will continue until 2017. The main objective of this programme is to contribute to an increased level of social, economic and environmental development and deeper regional integration in the ESA-IO through the sustainable exploitation of marine and lake fisheries resources and include 5 specific goals: i) sustainable fisheries management, ii) governance, iii) Monitoring, Control and Surveillance, iv) Trade in fish and fisheries by-products and v)Food security, and target marine and inland fisheries, as well as aquaculture. The programme has concluded a side agreement with the FAO to implement fisheries management and food security. From the set goals and objectives, it is clear that the programme does not have an agenda to address the climate adaptation in the fisheries sector of its participating countries.

ii) ISLANDS Programme - The Implementation of the Mauritius Strategy for Small Islands Developing States (SIDS) of the ESA-IO region aims at advancing the sustainable development of the SIDS in the ESA region. Rooted into the Global Mauritius Strategy 2005, the programme started 2011 and will last until 2017 and is helping the beneficiaries in addressing common challenges of sustainable development such Coral reef monitoring, Climate-induced Disaster Risk Management through the development of appropriate national and regional mechanisms, tools and capacity building and partnership ([90]). Even though this programme has a deep interest in the monitoring of the health status of the coral reefs and climate Disaster Risk Reduction and Management and other synergistic actions, it is not involved in any direct aspects for climate adaption in the coastal fisheries.

iii) Biodiversity Programme – This programme aims at strengthening the coastal, marine and island-specific biodiversity management of in the ESA-IO. It started in 2014 for 5 years. In tandem with the Nairobi Convention, the programme aims at improving and harmonising institutional and policy frameworks for sustainable use of biodiversity across the region; promote informed decision making at all levels through improved education, sensitization and awareness building strategies; effective knowledge

88 Information obtained by author from the Consultant working on this Climate Adaptation Strategy framework

89 Kurien J et al. SmartFish (2013) - Updating the Regional Food Security Strategy of the IOC

90 Sweenarain S, ISLANDS (2013) – Regional Comprehensive and Integrated Capacity Building Framework (CICBS)

and information management, improve networking, exchange of ecological and socioeconomic data on biodiversity and a couple of associated activities. It also provides for a call for proposals scheme to the social and business enterprises to implement small biodiversity management and revenue-generating projects such as small-scale fisheries, aquaculture and fish farming. All said this programme is not mandated to plunge into the intricacies of the climate change on the coastal marine fisheries.

iv) Energies Programme – This Renewable Energy (RE) and Energy Efficiency (EE) programme of the IOC aim at advancing low carbon development strategies in the IOC countries by promoting conducive enabling business environment for the development and management of RE and EE. The programme is geared to achieve a significant milestone in climate mitigation through business-friendly approach to carbon footprints reduction. It also has a call for proposal scheme to promote innovative energy-smart ideas in the social and economic sectors. While this programme may potentially contribute to the development of energy-saving technologies in the fisheries sector, it does not have a direct interest in climate adaptation.

5.4 NATIONAL CLIMATE ADAPTATION POLICIES AND PROGRAMMES

So far, climate adaptation has not been mainstreamed in the national fisheries although the importance of this socioeconomic sector has been highlighted in all National Communications on Climate Change (NCCC) and the National Adaptation Plan of Actions (NAPA) of all IOC member-states. However, the climate adaptation in coastal marine environments has been high on the agenda of these island states through the ICZM under various regional and national programmes. This section will track the main features of the current climate adaptation policies and programmes devolved in the coastal fisheries.

5.4.1. Comoros

Climate Adaptation has not yet been integrated into the national fisheries policies. No fisheries-related actions were accepted under PANA 2002 ([91]). The coastal zones management policy has been enacted through sector policies relating to fisheries, environment, tourism and transportation. No specific structure is set in place for the implementation of an ICZM, which is currently deprived of legal status (92). Target 6 of the National Accelerated Growth Strategy for Poverty Reduction 2006-2009 was related to the consequences of climate change on environmental sustainability and national safety. It pointed out that climate change would have significant impacts on major economic sectors, including fisheries. It alerted that climate change could backwash development efforts and specific strategies on food security and poverty

91 Two proposed actions namely, anchorage of FAD around the islands and use of ice for the reduction of post-harvest losses, were rejected under PANA 2002.

92 Acclimate 2011.

reduction. There is only one MPA of 404 km² in Moheli. Climate adaptations are not yet integrated into the coastal marine fisheries.

5.4.2 Reunion Island

Following the Kyoto Protocol, France had its first Climate Plan in 2000. Upon the enactment of the Environment Act 2009 ([93]), a national Climate Adaptation Plan was formulated and is updated periodically. A national agency ([94]) has been established to monitoring the effects of Climate Change was responsible for formulating a National Adaptation Plan and was approved in 2006. This constitutes the framework to scale down climate adaptation measures at the community level. The National Climate Adaptation Plan is mainstreamed in the ultra-peripheral territories through a Regional Climate Adaptation Plan ([95]). Reunion Island, in the process of formulating its regional climate adaption Plan, has organised a regional consultation ([96]) and the following recommendations were made for the fisheries sector:

- Scientific Monitoring of the Effects of Climate Change on the fisheries
- Reduction on overfishing on already overexploited fisheries resources.

Other overarching measures of importance to the fisheries are namely, the Early Warning System issued by Météo-France to alert the population on the occurrence of EWE and a dedicated Disaster Risk Management mechanism to deal with tropical cyclones other natural calamities.

5.4.3. Madagascar

Since 2010, Madagascar has a National Climate Change Policy that encompasses the Disaster Risks Management as well as the national strategic framework for climate change adaptation. A Directorate of Climate Change was created under the Ministry of Environment and Forests. In the same year, a Policy framework for the Sustainable Development of the Coastal and Marine Area was formulated and it constitutes the formal approach for the ICZM. The strategic components are:

i)	Improvement and strengthening of Governance of the Coastal and Marine Areas;
ii)	Improvement of the socio-economic well-being of the coastal communities;
iii)	Protection and conservation of the coastal and marine ecosystems and the natural resources

In 2013, the Ministry of Agriculture, Livestock and Fisheries developed a National Strategy to combat climate change in these economic sectors for the period 2012-

93 Grenelle de l'Environnement (Loi 2009-967 du 3 août 2009, Article 42)
94 Observatoire National pour les Effets du Réchauffement Climatique (ONEREC)
95 Plan Climat Territoriaux (PCT)
96 Conseil Régional (Plan Adaptation Changement Climatique 2010)

2025 and comprises four strategic goals: i) adaptation to climate change; ii) generating socioeconomic benefits through mitigation; iii) developing a suitable financial mechanism for adaptation actions and iv) promoting applied research and technological innovations. These mechanisms are still inactive. No specific adaptation actions have been spelt out for the coastal fisheries. The ICZM framework is not fully operational. Madagascar has MPA of 1715.6 km².

5.4.4 Mauritius

The Mauritius Fisheries Act 1998 provides the legislative portfolio for the development and management of the fisheries in the country. The Government of Mauritius acknowledges the significance of the fisheries sector in the local and national economy. In its 2nd NCCC, Mauritius has earmarked the following measures to adapt to the effects of climate change, ranging from multidisciplinary assessment in the coastal marine ecosystems, strengthening fisheries governance at national and regional levels and strengthening and expansion of capacity of the artisanal fishers. Four strategic areas were established to support the 2012 Draft Baseline Assessment Report for the fisheries sector:

i) Sustainable utilisation of fisheries resources, ii) Sustainable development of aquaculture, iii) Knowledge and information management and iv) protection of critical habitats and plan for future hazards. In 2011, Mauritius has formally adopted an ICZM framework that integrates beach preservation, land-based pollution, and maintenance of the coastal ecosystems. The first MPA was created in 1983 and currently, it covers a total surface of 91 km².

5.4.5. Seychelles

The Seychelles National Strategy 2017, which was adopted in 2007, provides the political vision for the sustainable development of the archipelago. The fisheries sector is one of the 5 overarching goals of the Comprehensive Africa Agriculture Development Programme (CAADP). A National Food Security Strategy 2008-2011 was enacted in 2010 in response to the global food crisis that occurred in Seychelles in 2007-2008 and it has been reviewed for the period 2012-2015. The strategic documents dealing with climate change are the national Communication 2000, the National Strategy on Climate Change 2009 and the Environment Management Plan 2000-2010. Seychelles does not have an integrated coastal areas management policy. Nevertheless, the existing regulations that address pollution prevention, coastal development, fisheries management and conservation encompass all the conventional tasks of the ICZM ([97]). The intended climate adaptation actions cover the marine and coastal ecosystems. Seychelles has total MPA of 1,078.34 km².

[97] Acclimate 2011

5.5 SUMMING UP

During the preparation of the national communication on climate change (NCCC), all the IOC member-states undertook a vulnerability analysis on the key economic and environmental sectors, but they were superficial for the fisheries sector, particularly the artisanal fisheries. Except for Seychelles, the other IOC countries have focused mainly on the land-based sectors. There is a mismatch between the perceived vulnerability of the coastal marine fisheries to climate change and the intended political economy to embark on appropriate adaptive actions. The prospects for Ecosystem-based approach for Disaster Risk Management and resilience building in the coastal and marine environment have not been fully explored in the IOC countries. This can open up to new socioeconomic perspectives such as the blue carbon projects and environmental stewardship projects in the coastal and marine sectors.

Inadequate domestic and external financing mechanisms have been the main hurdle for the implementation of several climate adaptation projects in the coastal marine environments, both at the national and the IOC level ([98]). Improved communication and coordination on cross-cutting issues such as climate change, renewable energies, biodiversity conservation and ICZM can potentially enhance the 'value for money' of the current national and regional programmes ([99]). The combined effects of climate and non-climate stressors are complex issues for the sustainability of the coastal marine fisheries ecosystems; while some of the stressors are manageable, others are not. It is therefore imperative to relieve the coastal marine ecosystem from human-induced stressors such as overfishing and unsustainable fishing practices, maritime and land-based pollution so that it may recover faster from the impacts of climate change and EWE.

98 Acclimate 2012 – Mapping and Inventory of the Access and Use of Climate Change related financing in ESA-IO

99 Sweenarain S – ISLANDS – Regional Comprehensive and Integrated Capacity Building Strategy Framework

6.0 CONCLUSION

The current and predicted ocean warming and sea-level rise in the IOC member states are within the range of the global forecasts but tend to differ significantly across their coastal marine ecosystems, which have varied consequences on the primary and secondary productivity of the coastal marine fisheries ecosystems. Likewise, the impacts of the extreme weather events also differ considerably among these vastly dispersed archipelagic states in the South-West Indian Ocean. Some of them are more exposed to floods and tropical cyclones than the others. It is scientifically acknowledged that in the long-term climate change and the seasonal climatic variations would reinforce each other in the Indian Ocean. The impacts of climate change are often perceived by the local communities as the manifestation of more frequent, intensive and unpredictable climatic events. Over the past two decades, significant variations have been observed within the region to the extent, intensity and rate of recovery from the coral bleaching. Satellite data shows that the primary productivity of the SWIO is relatively low as compared to the other oceanic regions of the Indian Ocean and is predicted to decline further by the turn of the 21st century. It can be safely assumed that the vulnerability of the vast extent of marine fisheries environments as well as the resilience of some hotspots and refugia in the IOC coastal marine fisheries habitats are still not fully understood and adequately monitored. Moreover, a macro or large marine ecosystem or one-size-fits-all approach in planning climate adaptation measures in those diverse coastal marine fisheries might not be effective as these interventions have to be deep-rooted into the local socio-ecological realities.

There is no doubt that ocean warming is modifying the biochemistry of the coastal marine ecosystems and the underlying living aquatic creatures. It is altering the core of the food webs, the prey-predatory relationship, life-cycle and migratory pattern of a wide range of targeted commercial aquatic species. There is a global tendency for marine aquatic resources to move steadily towards the poles to avoid warmer waters. Heat tolerant and pH resistant invasive species are also invading the coastal marine waters. Beside anthropogenic causes responsible for overfishing and degradation of the health of the coastal marine ecosystems and fish stocks, climate and non-climate environmental stressors are also exacerbating these problems, but are not monitored. The seasonal and inter-annual migratory patterns of tuna and tuna-like species are also influenced by ocean warming and climatic variations and it has been observed that these pelagic resources are displacing farther easterly in the SWIO. It is most likely that the impacts of climate change and extreme weather event will adversely affect impact the productivity of coastal marine fisheries and fish production in the IOC member-states.

The artisanal fisheries contribute significantly in the socio-economic development and cultural diversity of the island states of the IOC. However, the countries do not harness the full potential of the socioeconomic and environmental benefits from their coast

marine fisheries resources because of the prevalent open access regime, lack of basic socio-economic and fisheries infrastructure, outdated fishing assets and technologies, inefficient value chains and supply chain ecosystems as well as weak fisheries governance and management. Climate change and extreme weather events will exacerbate the current difficulties in the production system at stake. It is expected that the net revenue of the artisanal fisher household might take a downward turn. The costs of fishing might increase as a result of a decrease in the catch as well as in the catch composition; an increase in the number of non-fishing days; the length of fishing trips as more time is required for cruising and searching of fish shoals and higher cost of repair and maintenance. The revenue of the fishers is related to market factors such as the primary sale prices, the purchasing power of the consumers, consistency of supply, population growth and the availability of other close substitutes. The net revenue of the artisanal fishers will probably decrease as a result of the absence of organised fish markets; limited income of the population; increase in subsistence fishing and access of cheaper imported fishes and fish products, as in the case of Reunion Island and Mauritius. Local fish exporters may also face tougher competition from exporters from other countries that are less affected by the impacts of climate change.

The increase in the frequency and intensity of extreme weather events such as cyclones, upwelling and flooding can potentially damage fishing assets and personal properties of the fishing communities. They are more exposed to the risks of the proliferation of infectious and vector-borne diseases. The safety of the artisanal fishers at sea will be more challenging. Public health concerns may arise from the consumption of contaminated fishes due to rising ambient temperatures without adequate post-harvest conservation practices and reef fishes fed on toxic algae. The existing export value chains may be disrupted if a proper monitoring system is not in place. All the IOC member–states will not be affected evenly by the impacts of climate change and extreme weather events in their coastal marine fisheries because of their diverse socio-ecological features, the existing adaptive capacities of the fishing communities and the resilience of the national economies. There is a fear that the progress achieved by the least developed countries of the IOC in the combat against extreme poverty and food and nutrition security can be potentially undermined.

The IOC member states are signatories to a plethora of multilateral and regional conventions related to the protection of the environment and sustainable development. Over the past decade, they have participated in about 30 regional and national climate adaptation and mitigation programmes with at least one of the following themes: Research, Evaluation and Policy Formulation; Dissemination of knowledge and Awareness building; Capacity building and Community-based adaptation. These countries have undertaken a vulnerability analysis of their key economic and environmental sectors, but they have been superficial concerning the marine fisheries sector. So far, there has been no real climate adaptation initiative in the coastal marine fisheries. The national climate policies have focused mainly on the

land-based sectors: water resources, agriculture and forestry rather than the marine counterparts. Generally, the social and environmental challenges in the coastal and marine areas are dealt with by the Integrated Coastal Zones Management and /or the Ministry of Environment. There has been no initiative to grasp the potential socioeconomic and ecological effects of climate change and the induced extreme weather events on the coastal marine fisheries and the people dependent on them for their livelihoods. It is crucial for the Ministry of Fisheries of the IOC member countries to mainstream proactive climate adaptation measures into their fisheries or ocean economy policies, strategies and development plan.

The combined effects of climate and non-climate stressors are wicked problems affecting the long-term resilience and sustainability of the coastal marine fisheries ecosystems. Some of the stressors are manageable or while others are mere externalities. It is therefore critical to relieve the coastal marine environments from those human-induced stressors, including overfishing and unsustainable fishing practices, maritime and land-based pollution so that the natural environments may strength their intrinsic long-term resilience to cope more effectively to the impacts of global warming and extreme weather events. The climate adaptation mechanism in the coastal marine fisheries can be conceived as opportunity, no-regret or triple-win approach to promote a modernised and climate-resilient coastal marine fisheries sub-sector. The following points are recommended in a forthcoming climate adaptation strategy:

i)	Integration of the climate adaptation in the current IOC fisheries Strategy 2016-2020;
ii)	Improved communication and coordination among the various environmental and sustainable development programmes at national and regional levels;
iii)	Integration of on the fisheries sector in the NCCC and PANA;
iv)	Adoption of participatory ecosystem-based management in the coastal marine fisheries;
v)	Smart Investments in climate-proofing fisheries infrastructure and fishing assets;
vi	Development of smart aquaculture and fish farming projects to boost the supply of fish;
vii)	Promote Social security and Insurance Scheme to protect the fishing communities;
viii)	Explore the potential of blue Carbon Projects / Environment stewardship;
ix)	Science-Technology and Innovation leads in promoting climate-resilient fishing operations;
x)	Review of the concept of MPA and reserves in light of the potential climate risks.

REFERENCES

Acclimate (2011) Etude de vulnérabilité aux changements climatiques. Evaluation qualitative. Seychelles - Commission de l'Océan Indien. 93p

Acclimate (2011a) - Etude de vulnérabilité aux changements climatiques. Evaluation qualitative Comores – Commission de l'océan Indien. 83p

Acclimate (2011b) - Etude de vulnérabilité aux changements climatiques. Evaluation qualitative La Réunion – Commission de l'océan Indien. 81p

Acclimate 2012 – Mapping and Inventory of the access and use of climate change related financing in the ESA-IO region - Indian Ocean Commission109p

Acclimate. (2011c) - Études de vulnérabilité aux changements climatiques. Evaluation qualitative – Madagascar -Commission de l'Océan Indien. 110p

Acclimate. (2011d) - Etude de vulnérabilité aux changements climatiques. Evaluation qualitative. Maurice - Commission de l'Océan Indien. 93p

Allaoui, A (2011) - Rapport de consultation sur les politiques et la gouvernance Comores. Vice-Présidence en charge de l'agriculture, de la pêche, de l'environnement, de l'énergie et de l'artisanat. Projet No. 0004725- ASCLME. 43p.

Allison E H et al., - WorldFish Centre (2008) – Vulnerability of national economies to the impacts of climate change on fisheries. Fish and Fisheries, 10: 173–196. doi:10.1111/j.1467-979.2008. 00310.x

Archive F, WTO (2010) – Trade and Fisheries: Key issues for the World Trade Organisation. 62p

Badjeck MC et al., World Fisher Centre (2009) - Climate Change and Capture Fisheries: Potential Impacts, Adaptation and Mitigation – FAO Fisheries & Aquaculture Technical Paper 530

Béné, C. (2008) - Global Change in African Fish Trade: Engine of Development or Threat to Local Food Security? OECD Food, Agriculture and Fisheries Working Papers, No. 10, OECD publishing, © OECD. doi:10.1787/230215206300

Brueil C et al., SmartFish (2014) – Update of Fisheries Baseline data: Comoros, Madagascar, and Seychelles. Indian Ocean Commission

Campling L & Doherty M, (2007) – A comparative analysis of Cost Structure and SPS issues in canned tuna production in Mauritius, Seychelles and Thailand: Is there a level Playing field? Regional Trade Facilitation Programme 80p

Chang-Seng D et al. (2007) - Climate variability and climate Change Assessment for Seychelles; Prepared for the Seychelles Second National Communication (SNC) Under

the United Nations Frame Work Convention on Climate Change (UNFCCC), and with the Guidance of the National Climate Change Committee (NCCC) 56 p

Chomo V et al (2015) – Towards sustainable fish food and trade in face of climate change *http://www.ictsd.org/bridges-news/biores/news/towards-sustainable-fish-food-and-trade-in-the-face-of-climate-change*

Commission de l'Océan Indien – Rapport Annuel 2014

Constanza R et al. (1997) - The value of the world's ecosystem services and natural capital. Nature #387: 253-260 published by the Ecological Economics Research and Applications Inc., Maryland 20688, USA.

Gertjan DG et al., FAO/NEPAD (2014) – The Value of African Fisheries; FAO Fisheries and Aquaculture Circular No. 1093

Giri, C. et Mulhausen, J. (2008) - Mangrove Forest Distributions and Dynamics in Madagascar (1975-2005). Sensors 2008, USGS - 2104-2117.

Government of Mauritius (2010) - Second National Communication under the United Nations Framework Convention on Climate Change (UNFCCC) - Republic of Mauritius 148p

Government of Seychelles (2009) - Seychelles National Climate Change Strategy 96p

Graham Research Institute on Climate Change and Environment (2015) – Review of Climate change legislations in 99 countries (incl. Comoros, Madagascar, Mauritius and Seychelles); website: *www.lse.ac.uk/GranthamInstitute/legislation/*

Hayine A C et al., ICES (2009) – Why economics matters for understanding the effects of climate change in Fisheries; doi: 10.1093/ices jms/fss021 First published online: February 27, 2012

Holmyard N et al., University of Cambridge (2014) – Climate Change: Implications on Fisheries and Aquaculture, Key findings from the IPCC 5th Assessment Report (Fisheries Summary) *http://www.cisl.cam.ac.uk/Resources/Climate-and-Energy/Climate-Change-Implications-for-fisheries-and-Aquaculture.aspx*

International Conference on Trade and Sustainable Development (2009) – Climate change and Fisheries: Policy, Trade and Sustainable Development Issues 8p *http://www.ictsd.org/downloads/2009/10/climate-change-and-fisheries.pdf*

International Fund for Agricultural Development (2014) – Guidelines for integrating climate change adaptation into Fisheries and Aquaculture projects 55p

International Atomic Energy Agency (2016) – Economics of Ocean Acidification: Impact of fisheries and aquaculture based on the Proceedings of an International Workshop organized in collaboration with Centre Scientifique de Monaco in 2012

IPCC 2014 – 5th Assessment Report – website*: https://www.ipcc.ch/report/ar5/*

IPCC. 2007 - 4th Assessment Report - A report of Working Group I of the Inter-governmental Panel on Climate Change - Summary for Policymakers.

https://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf

Kathiresan, K. (2006) - Importance of mangrove ecosystem. Centre of Advanced Study in Marine Biology. Annamalai University, India 34p

Kirema-Mukasa CT, SmartFish (2012) – Regional Fish Trade in the ESA-OI Region: A Fish Trade Guide, Indian Ocean Commission 58p

Lehodey et al. (1997) – Impact of Climate Change on regional tuna fisheries

Macfadyen G et al. (2009) – Climate Change, Fisheries, Trade and Competitiveness: Understanding impacts and formulation responses for the Commonwealth States – Commonwealth Secretariat 120p

Ministère de l'Agriculture, de la Pêche et de l'Environnement - Union des Comores (2007) - Rapport National sur l'Environnement Marin et Côtier. Nairobi Convention 39p

McSweeney, C. et al. (2009a). UNDP Climate Change profiles. Comoros – United Nations Development Programme 18p

McSweeney, C. et al. (2009c) - UNDP Climate Change profiles. Mauritius. – United Nations Development Programme 18 p

MDRPAE 2006. Union des Comores : Programme d'Action national d'Adaptation aux Changements climatiques (PANA). 92p

MEF Madagascar (2006) - Madagascar : Programme d'Action national d'Adaptation au Changement climatique (PANA). 79p

MEF Madagascar (2010) - Deuxième Communication Nationale dans le cadre de la Convention Cadre sur le Changement climatique.159p

MEF. 2003. Communication Nationale Initiale dans le cadre de la Convention Cadre sur le Changement climatique. 127p

Michigan Sea Grant (2016) – Climate Variability and Climate Change – What is the difference? Michigan University

Mimura, N L et al. (2007) - Small islands Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change 2p

Nageon., E J. et al. (2011) - Seychelles National Level Policy and Governance Assessment for Marine and Coastal resources – ASCLME 68p

Pauly D, Sea Around Us (2009) – If you not like overfishing, you sure won't like Global Warming; University of Columbia, Canada 6p

Payet, R.A. & Agricole W (2006) - Climate Change in Seychelles – Implications for Water and Coral Reefs AMBIO, 35 (4): 182-189p.

Prévost D – International Centre for Trade and Sustainable Development (2010) – Sanitary, Phyto-sanitary and Technical Barriers to Economic Partnership Agreement s between the EU and the ACP Countries; Maastricht University, Institute for Globalisation and International Regulation 107p

Ragoonaden, S (2006). Sea level activities and changes on the islands of Western Indian Ocean J. Mar. Sci. Vol 5, No 2, pp 179-194. WIOMSA.

Raholijao, N. et Ramiandrisoa, V. 2007- Tendances climatiques observée à Madagascar au cours des cinquante dernières années (1955-2005) et changements climatiques futurs. Service des Recherches appliquées. Direction de la Météorologie de Madagascar

Rakotoarison, H., F. 2003.Evaluation économique des bénéfices hydrologiques du Programme Environnement III à Madagascar. Mémoire d''Ingénieur Agronome EESSA, Université d'Antananarivo, 72 p.

Rakotobe T et al. (2012) – Le changement climatique dans l'océan Indien Occidental: Une évaluation de la situation et les considérations politiques

Randrianarisoa, H. 2011. National-level policy and governance assessment for marine and coastal resources Madagascar 70p

Sheppard, C (2002) - Corals of the Indian Ocean; CD Interactive Database; CORDIO, Mombasa, Kenya (consulted at*https://cmsdata.iucn.org/downloads/cordio_status_report_2008_1.pdf*)

Spalding, M.D. et al. Eds. (1997) World Mangroves Atlas - The International Society for Mangrove Ecosystem, Okinawa, Japan 318p

Spalding, M.D. et al. (2001) World atlas of Coral Reefs - UNEP World Conservation Monitoring Centre, University of California Press, Berkeley

Sukhdev, P. Et al. – TEEB (2009) - The Economics of Ecosystems and Biodiversity: Climate Issues Update. UNEP

Sweenarain S – SmartFish (2016) – Evolutions récentes de la pêche thonière côtière dans les pays de la Commission de l'océan Indien – Cas d'étude : Maurice et Rodrigues, Commission de l'Océan Indien 18p

Sweenarain S, ISLANDS (2014) – Regional Comprehensive Capacity Building Strategy Framework – Indian Ocean Commission 78p *http://commissionoceanindien.org/fileadmin/resources/ISLANDSpdf/Regional_Comprehensive_and_Integrated_Capacity_Building_Strategy_Framework.pdf*

Sweenarain S, SmartFish (2013) – Value Chain Analysis of the Artisanal Fisheries of Mauritius – Indian Ocean Commission 84p (*http://www.fao.org/3/a-az114e.pdf*)

Sweenarain S et al. (1998) – Prospects and Challenges for the development of tuna activities in the members-states of the Indian Ocean Commission – IOC/Orstom – Colloques & Séminaires 429p

Sweenarain S et al., Transtec / ACP Fish II (2014) – The market study of the by-catch of the industrial tuna fisheries in the Indian Ocean – Brussels, Belgium 78p

(*http://acpfish2-eu.org/uploads/projects/id279/FTR_Part%201.pdf*)

Sweenarain S, SmartFish/FAO (2013) – Value Chain Analysis of the Fisheries Sector of Rodrigues – Indian Ocean Commission 85p – (*http://www.fao.org/3/a-az388e.pdf*)

Tadross, M. et al. (2008) - Climate Change in Madagascar: Recent past and future Climate Systems Analysis Group under the UNFCCC – A workshop Report, Madagascar 113p

WIOMSA /UNEP (2015) – Science to Policy Workshop: Regional Climate Change Strategy under the Nairobi Convention UNEP 46p

World Resources Institute (2016) – After COP 21: 7 key tasks to implement the Paris Agreement *http://www.wri.org/blog/2016/03/after-cop21-7-key-tasks-implement-paris-agreement*; website consulted on 29/04/2016

ANNEXE 1 - TERMS OF REFERENCE

Terms of Reference for a Study on Effects of Climate Change and Variability on Fisheries in the IOC Member States

1. A brief background of the Study

The Technical Centre for Agricultural and Rural Cooperation (CTA), based in the Netherlands has recently developed six Regional Business Plans (RBPs) that specify the key priority intervention areas (KPIs) for the Centre for the next three years (2016-2018). In the eastern Africa RBP, promotion of policies and programmes that encourage adoption of climate-smart agricultural practices has been identified as one of the key focus areas. CTA also recognises that for agricultural producers to pursue practices that enable them to adapt to the ever-changing climate, the extent to which climate change affects their ability to produce, trade and conserve their resources needs to be clearly understood.

Fisheries contribute significantly to food security and livelihoods. Fish provides essential nutrition for millions of people in the IOC region and fish products are among the most widely traded foods in the region. Small-scale fisheries and aquaculture have contributed comparatively little to the causes of climate change but are amongst one of the first sectors to feel its impacts. Climate change is modifying fish distribution and the productivity of marine and freshwater species. This has impacts, among others, on the sustainability of fisheries. With sea level rising coastal fishing communities are in the front line of climate change while changing rainfall patterns and water use impact on inland (freshwater) fisheries. Coastal and fishing populations and countries dependent on fisheries, such as the IOC member states (namely, Comoros, Reunion, Madagascar, Mauritius and Seychelles) are particularly vulnerable to climate change.

Climate change also engenders resource use competition and triggers conflict over the use of scarce resources and increased risks associated with more extreme climatic events such as hurricanes. These result from direct impacts on fish themselves as well as from impacts on the ecosystems on which they depend, such as coral reefs. In general, the consequences of climate change will be negative for fishers at low latitudes.

The above notwithstanding, the precise and localized impacts of climate change on fisheries especially in the context of developing countries like the IOC region are poorly understood and seldom documented and made available in an accessible manner.

To design effective programmes to assist fisherfolks to adapt to the changing climate, some questions remain: what is the extent of the impact of climate change on the fisher communities in the IOC? Which of the social groups in the fishing community are much more affected than the others, and why? Which point in the fishery VC is more vulnerable to climate change? What is the level of knowledge of the actors of the effect of climate change on their livelihood? What are the various types of impacts

of climate change on the fishery VC? How does climate change impact on the production and supply of fish and the profitability of the VC for smallholder fisherfolks in particular and the actors in general? To what extent has policies and institutional arrangements promoted or constrained the implementation of climate-resilient fishery practices along with the VC? What is responsible for this? What policies have helped to promote profitable VC on fisheries in the region? Answers to these questions will provide insights into identifying appropriate interventions along the fishery VC to promote profitable VC for all the actors.

3. Objectives of the Study

The Study is expected to address the following five interrelated objectives:

a) Document how climate change and variability manifest themselves in the context of the artisanal fisheries sector in the IOC region;
b) Analyse the differential effects (along gender and wealth status lines in particular) of climate change and variability on the livelihoods of fisher's folk and the actors in the entire value chain;
c) Assess the effects of climate change and variability on intra- and inter-regional trade in fisheries resources; and
d) Identify existing major climate-resilient programmes put in place and policies and strategies enacted to address the effects of climate change and variability on the fisheries sector.

4. Study method and mechanisms for monitoring progress of the Study

The study is expected to be informed by a comprehensive desk review on the subject in addition to the expertise of the consultant. This will include a literature review of assessment/evaluation reports, policies/strategies, and projects and programmes on the effects of climate change on the fisheries sector.

To bring about a common understanding of the study process and ensure delivery of the required output, regular interactions are necessary between the consultant and the CTA team in charge of overseeing the study. Thus, interactions between the CTA technical team and the consultant will include teleconferences/Skype calls preferably at the specified times:

i. Kick-off meeting - to agree on method development and detailed work plan;
ii. Second meeting – to review first draft report; and
iii. Third meeting – to review the final draft report.

5. Deliverables

The consultant is expected to submit a substantive report of 35 - 40 pages long, excluding annexes and appendices. The report should also include Annexes that contain

names of key informants interviewed, their institutions and contact information; and

profile of pertinent initiatives in IOC member states and at the IOC Secretariat.

In preparing the report, the following specifications need to be adhered to:

Font type: Cambria;

Font size: 11;

Line spacing: 1

6. Duration of the consultancy and key milestones

The consultancy will cover 27 working days.

The consultant is expected to adhere to the following milestones:

Within a week of the signing of the consultancy contract with CTA, the consultant is required to provide detailed work plan including timeline and draft report outline and a draft protocol for interviews/focus group discussions etc.

Submit a draft study report to the CTA within five weeks after signing the contract by CTA. The consultant should expect consolidated comments from CTA team within two weeks after submission of the first draft.

The consultant is expected to incorporate the comments of the CTA team and submit the **final report** within two weeks after CTA provides comments to the draft.

ANNEXE 2 - A SYNOPSIS OF THE ARTISANAL FISHERIES OF THE IOC MEMBER STATES

1.0 Comoros

The Union of Comoros is located at the northern entrance of the Mozambique Channel and consists of 3 autonomous states, namely Grande Comore, Anjouan and Moheli. Comoros has a total land area of 1869 km², a coastline of 327 km and an EEZ of 600,000 Km². It has limited continental waters that include 430 km² of coral reefs and 10.8 km² of mangrove mostly located in Moheli. It is one of the least developed countries (LDC) in the world. In 2011, the population was 830,000 inhabitants, with a growth rate of 2.8 % per year. The artisanal fisheries contribute about 24% of the agricultural and 8 % of the national GDP ([100]). It provides formally over 8,500 direct and 24,000 indirect jobs. However, it is estimated that 30% of the population is dependent on the fisheries for their livelihoods ([101]). The per-caput fish consumption is 29.5 kg, representing 70 % of the total animal protein intake wholly supplied by the domestic traditional and artisanal fisheries ([102]). The annual fish production is estimated between 16,000t, comprising 75 % of tuna and tuna-like fishes. The artisanal fisheries can be differentiated in 3 broad types:

Subsistence and on-foot fishery: Owing to open access and social "safety nets" character of the fishery, it attracts a large number of the coastal populations, including women and children who fish, hunts and collects fishes, crustacean, mollusc and other eatable aquatic creatures in the inshore shallow waters and on the seafloor during low tides for auto-consumption. These people are often not visible in the fisheries statistics and socioeconomic baseline surveys.

Traditional Artisanal fishery: It consists of some 3660 single-crew non-motorised wooden canoes of 3 – 4 m long, commonly called 'galawas' that operate in the inner and outer lagoon to harvest about 4000 t of the reef and herbivorous fishes, octopus and crustaceans annually ([103]). The fishery is plagued by overfishing and land-based pollution. The fishers developed their strategies to cope with the decline of fish production as there are few alternative livelihood opportunities in the country.

Modern Artisanal fisheries: This fishery involves some 1670 wooden and fibre-glass fishing boat of 6 -7 m long, commonly called 'japawas' propelled by 15-25 Hp

100 UNDP, 2011

101 SmartFish-FAO (2011) – Fisheries and Food Security in the ESA region – Comoros Country Profile

102 Kurien J et al – SmartFish/FAO (2011) – Update of Fisheries and Food Security in IOC member-countries

103 Breuil C et al. – SmartFish/FAO (2014) – Fisheries Baseline Report, Comoros

outboard engines and manned by 3 to 4 fishers. They operate around the coastal FAD at 500 – 2500 m deep at a distance of 5 to 10 nautical miles off-coast. These FAD have been deployed by several regional development programmes in collaboration with the fishing villages and associations.

Except in Moheli, the inshore demersal and benthic resources are fully exploited; the latter has larger continental areas and the resources are managed by community-based organisations supported by some ENGO. It also has an MPA of 404 km² that serves as a buffer zone to the local fisheries. The coastal FAD fisheries have immediate growth potential for Anjouan and Grande Comore as the archipelago is located in the vicinity of the migratory cycle of the tuna stocks in the Mozambique Channel ([104]). This tuna resource potential is estimated at 33,000 t, which is partly exploited by the artisanal fishers of Grande Comore and Anjouan.

The Current productivity of the inshore traditional fisheries is approximately 1 t / Galawa or per fisher per year, whereas it is 7 t per Japawa per year for the coastal tuna fisheries.

2.0 Reunion Island

Reunion Island, an overseas French Department in the SWIO with a relatively higher standard of living than the other IOC member-states, but confronted to the same socioeconomic and environmental challenges, particularly in the artisanal fisheries. It is located in the East of Madagascar at 200 km South-West of Mauritius. The island has a total land surface of 2520 km², a continent fringe of 182 km² and an EEZ of 351,000 km². In 2011, the total population was at 833,500 inhabitants, with an annual growth rate of 1.5 %. The per capita income was EUR 18,284, which is about 60% of the average French mainlander. Per-caput fish consumption is 14.5 kg in 2014.

Over the past 5 years, the artisanal fisheries have landed 2500-3000 t of fresh fish annually, comprising 87 % of large pelagic fishes (swordfish, tuna and tuna-like fishes) and 13% of reef fishes caught in the lagoon. In 2014 the fisheries sector employ some 1200 people, representing 0.5 % of the total labour force. The island exported EUR 58 Million of raw fish and fish products, which is approximately 20% of the total export value. The rate of unemployment on the island is 35.9%, including 60% of a new entrant. The artisanal fisheries can be classified into 2 broad groups:

Traditional fishery: It consists of some 115 fishers operating on-foot from the beach or in the shallow waters of the lagoon and from 5 – 7 m motorised fishing boats targeting the reef fishes in the inner and outer lagoons. The total annual landing is estimated at 300 t; which are meant wholly for the local markets. The fishery is dwarfed by the limited inshore marine ecosystems.

104 Sweenarain S & Cayré P (1998) – Prospects and Challenges for the Development of tuna fisheries in the Indian Ocean Commission member-countries

Modern Artisanal fishery: It comprises some 423 fishers and 183 fibre-glass fishing boats of 7 – 9 m long that targets tuna and tuna-like species around FAD and the open seas in the territorial waters and EEZ of the island.

The island is equipped with state-of-art fisheries infrastructures and onshore facilities. As an ultra–peripheral territory of the EU, they are boosted to become fully compliant with the EU health and sanitary standards. The export value chains of tuna are well organised but limited in the volume of trade and competitiveness. The continental shelves are limited but less affected by coral bleaching ([105]). There is no major aquaculture project on the island. The future development of the coastal fisheries relies fully on the large pelagic resources.

3.0 Madagascar

Madagascar is a large island with significant ecosystem diversities ([106]). It has a land area of 587401 km², coastlines of 5600 km, continental shelves of 117,000 km² and an EEZ of 1.2 million km². It enjoys tropical weather with diverse microclimatic variations across the country ([107]). The inshore ecosystems include a coral reefs area of 2230 km² and 2797 km² of mangrove forests stretching mainly over on the Eastern coast. It is among the least developed countries in the world.

The fisheries and aquaculture sector contributes about 10% of the agricultural and about 3% of the national GDP. The per caput fish consumption is 6.9 kg, which much lower than the African average of 9.4 Kg. The artisanal fisheries consist primarily of traditional fishing units that operate entirely in the inshore waters. The sector officially employs 100,000 people, including 2300 in the industrial fisheries. Informally, it employs over one million people in the coastal communities. The annual landings are estimated at 107,000 t, which are meant mainly for domestic supply. A small part of this production, comprising high-value aquatic species: reef fishes, crabs, octopus sea-cumber etc are linked to export value chains through small scale fisheries enterprises. In 2011 about 19,760 t of seafood were exported, representing an export value of US$ 97 million. These figures include 25% in volume and 12.5% in value of produce harvested by the traditional fisheries. The remainder accounts for the canned tuna, wild shrimps and other high-value seafood.

The shrimp stocks are fully exploited, but formally well managed ([108]). However, the total output has been decreasing steadily, from 7,900 t in 2004 to 3700 t in 2012. The inshore fish resources close habitations are fully exploited, but some demersal fish stocks in remote fishing areas are moderately exploited. The small pelagic fishes

105 Acclimate, 2011c

106 ASCLME & SWIPF (2012) – Trans-boundary Diagnostic Analysis of the LME in the WIO (Madagascar Chapter)

107 Acclimate, 2011c

108 Tandros et al. (2008)- Climate Change in Madagascar: Recent past and future Climate Systems Analysis Group under the UNFCCC

in the lagoon are moderately exploited. The development of coastal tuna fisheries has just started on the East coast but is handicapped by the tough weather conditions. The Northern part of Madagascar is at the centre of a seasonal purse seine tuna fishery ([109]). About 30,000 t of tuna is offloaded or transhipped at Diego-Suarez annually.

4.0 Mauritius

The study focuses on two main inhabited islands of the Republic of Mauritius, namely Mauritius (mainland) and Rodrigues, a semi-autonomous territory. The total land area of Mauritius is 1865 km² and that of Rodrigues, 109 km². Mauritius is a higher middle-income country and ranks among the highest in HDI over Africa. In 2014, the total population of the country was 1.3 million people, with an annual growth rate of 1.8%. The fisheries sector, including the seafood services, contributes 1.2% of the national GDP and employs 15,000 people. The per-caput fish consumption in Mauritius is 24 kg and 50 kg in Rodrigues ([110]).

Although Mauritius has a net positive balance of trade for the fisheries sector, it imports about 18,500 t of raw fish for direct consumption, representing a total value of US$ 75 Million per year ([111]). Rodrigues is self-reliant in fish production and exports about 300 t of frozen and dried octopus and dried salted fish to Mauritius annually ([112]). The artisanal fisheries can be classified into two broad groups:

Coastal demersal fisheries: These fishing activities occur in the inner and outer lagoons of the country. In Mauritius, the total landing of the artisanal demersal fisheries has declined from 1,360 t in 2000 to 459 t in 2014 and about 40% of the production is made in the inner and outer lagoon. Over the past 15 years, the number of canoes has increase from 971 to 2047 and the enrolled fishers, from 1741 to 2038. During the period 2004-2014, the annual catch per fisher day (CPFD) in these fisheries has fluctuated between 6.5 kg and 4.1 Kg, with an inter-annual average of 5.8 Kg. For the same period, CPFD in the inshore waters was 5.2 kg and that of the off-lagoon was 7.2 kg ([113]). In Rodrigues, the small-scale fisheries sector is vital for the socio-economic development of this autonomous island. Over 2005 - 2014, the number of fishing crafts has increased from 1654 to 1974 whereas the number of registered fishers has declined from 1978 to 1221. Total catch has almost doubled, from 1040t to 2028t. The entire production is from inshore waters.

Coastal tuna fisheries: In Mauritius, during 2004-2013, the annual production was estimated at 250 t, with a peak of 330 t in 2010 and ebb of 164 t in 2007 ([114]). The

109 SWIOFP Scientific Committee 2010

110 Sweenarain S - SmartFish (2013) – Value chain Analysis of the fisheries sector of Rodrigues

111 Sweenarain S et al. ACPFishII (2014) – Market Analysis of by-catch in the industrial tuna fisheries in the IO

112 Mauritius Statistics – Rodrigues Statistical Digest 2014

113 Albion Fisheries Research Centre – Fisheries Statistics 2014

114 FiTEC – Coastal tuna (FAD) fisheries data 2014

annual average CPFD recorded for the period 2008-2010 has fluctuated considerably: 21.4 kg in 2008, 32 kg in 2009 and 18 kg in 2010. The highest CPFD registered is 51 kg and the lowest, 10 kg, which is more than double the CPFD of the inshore demersal fisheries. By adding the catches of the leisure and sport fisheries, the total yield of the coastal FADs is estimated at 1100 t per year. The FAD fisheries consist of fifty (50) fishing crafts of about 8 m in length, powered by 15 Hp outboard engines and involve 300 professional FAD fishers.

The development of coastal FAD fisheries has been sought by the government to reduce fishing pressure in the lagoon and to improve the livelihood of the fishing communities ([115]). However, the fishery is still at its infancy stage in Mauritius and inexistent in Rodrigues. The FAD network is mostly used by the sport and leisure fisheries in both islands ([116]). The tuna stocks around Mauritius are healthy and an expansion of the coastal tuna fisheries ([117],[118]) can be envisaged in a sustainable and climate-resilient way.

5.0 Seychelles

The archipelago of Seychelles comprises 115 islands and only four of them, namely Mahé, Praslin, La Digue and Silhouette are inhabited. It has a total land area of 455 km², a coastline of 491 km. The EEZ of Seychelles extends over 1.3 million Km² and encompasses 31,490km² of continental shelves that haven 1690 km² of coral reefs and 29 km² of mangroves. The fisheries sector is the second pillar of the Seychelles economy after the tourism industry; both sectors are highly vulnerable to climate change ([119]). The artisanal fisheries contribute 5 % to the national GDP while the fisheries sector as a whole, including the tuna industry, has a stake of 30% in the national economy. In 2011, The fisheries sector provided direct and indirect employment to approximately 5,000 people, representing about 11% of the national labour force ([120]). This includes 1400 full and part-time fishers. The local tuna cannery is the largest employer on the island with a workforce of over 2,500 workers. The artisanal fisheries of Seychelles consist of two main components:

Traditional and Commercial artisanal fisheries: The fisheries are multi-gear and multi-species, but line fishing is the most popular. They consist of 400 artisanal boats of different types ranging from 5-7m fibre-glass open-deck boats powered by outboard engines to 10-15m decked whalers and schooners equipped with inboard

115 Soondroon V et al. (1998) – Assessment of the MSY of the demersal fish stocks in the lagoon of Mauritius

116 Sweenarain S – SmartFish (2016) – Evolution Récentes de la Pêche Thonière Côtière de Maurice et Rodrigues

117 Rey H et al. SWIOFP (2011) – Socioeconomic study of the Development of coastal FAD fisheries in the WIO

118 Indian Ocean Tuna Commission – Tuna Stock Assessment Meeting Report , Mauritius - 2014

119 Africa Economic Outlook 2013

120 Africa Economic Outlook 2013

engines. Most boats are based on the three main islands: Mahé, Praslin and La Digue ([121]). They harvest high-value demersal fishes such as red snappers, jobfish, groupers, parrotfish, emperors etc mainly for domestic markets, although relatively small quantities are exported. In 2011, some 2,875 t of fish were landed, which is lower than the annual average of 4000-5000 t / year before the 2000s ([122]). The artisanal fisheries are open access, except for sea cucumber and lobster fisheries.

Commercial Artisanal Pelagic fishery: It consists of a small fleet of extended tuna long-line fishing boats of 14 to 22 m long fully owned by the residents, targeting large pelagic species outside the territorial waters of Seychelles. The catch is intended for export markets but the fishing enterprises are facing difficulties to take-off.

The reef fishes in the vicinity of the inhabited islands are fully exploited, while some potential may exist around distant outer islands ([123]). The increasing demand for high-value fishes for local consumption, tourism industry and export markets in recent years are the reasons for more intensive fishing ([124]). Seychelles is located at the centre of the principal surface tuna fisheries in the SWIO. The tuna cannery is the largest manufacturing enterprise and the single largest employ

121 Seychelles Fishing Authority – Annual Report 2011

122 SmartFish (2014) – Fisheries Baseline Data - Seychelles

123 Nageon Z et al - SmartFish (2013) – Formulation of a Fisheries Development Plan for Seychelles

124 SWIOPFC – Scientific Committee on Stock Assessment ,2011

E€OFISH INTEGRATED PROGRAMME MANAGEMENT UNIT

BLUE TOWER | 4th FLOOR | RUE DE L'INSTITUT | EBÈNE 72201 | MAURITIUS | TEL: +230 402 6100

info@ecofish-programme.org

www.ecofish-programme.org