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

IDENTIFICATION OF CLIMATE CHANGE INDICATORS AND EQUIPMENT NEEDS FOR THE MARINE RESEARCH INSTITUTIONS OF THE REGION

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Identification of Climate Change indicators and equipment needs for the Marine Research Institutions of the Region

Countries Covered: Comoros, La Reunion/France, Madagascar, Mauritius, Seychelles, Mozambique, Tanzania and Kenya.

by

Dr. Sandeep S. Beepat

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ABREVIATIONS AND ACRONYMS

EA-SA-IO	Eastern Africa, Southern Africa, and Indian Ocean
GHG	Green House Gas
IGAD	Intergovernmental Authority on Development
IOC	Indian Ocean Commission
IPCC	Intergovernmental Panel on Climate Change
FAO	Food and Agricultural Organization
FCON	Fisheries Climate Outlook Network
GMES	Global Monitoring for Environment and Security
MOI	Mauritius Oceanography Institute
MoU	Memorandum of Understanding
NGO	Non-Governmental Organization
NFP	National Focal Point
SDG	Sustainable Development Goal
SIDS	Small Island Developing States
SST	Sea Surface Temperature
SWIO	South-West Indian Ocean
UNCTAD	Western Indian Ocean Marine Science Association

1 Introduction

Oceans cover over 70% of our planet and are host to important biodiversity and natural resources for mankind. However, human-induced emissions of Green House Gas (GHG) into the atmosphere resulting in climatic change and the occurrence of more frequent extreme weather events have greatly impacted the world's oceans (IPCC, 2014). Of the 350 billion tons of carbon dioxide that has been emitted in the atmosphere, 25% has already been absorbed by the oceans so far (Canadell et al., 2007). As a result, the oceans have been converted into major carbon dioxide sinks over the past century. Continuous GHG emissions have significantly influenced the physio-chemical balance of the ocean, by altering seawater temperature, ocean acidity, water salinity through precipitation and oxygen concentration (Bates et al., 2008). Consequently, these perturbations in the oceanic physico-chemical equilibrium have resulted to decreased ocean productivity, altered food web dynamics, reduced abundance of habitat-forming species, shifting species distributions, and a greater incidence of disease (Hoegh-Guldberg and Bruno, 2010). Impacts of climate change on marine ecosystems can be highly variable (Arnell et al., 2019). While the phenomenon is known to occur globally, the impacts of climate change are not spread evenly across the globe. For example, impacts of climate change on polar regions are significantly superior to those occurring in the tropical regions (Hwang et al., 2017). Likewise, the impacts of climate change will likely vary among the five oceans.

The Indian Ocean is the world's third largest ocean and is home to approximately 2.5 billion people (Ridgway and Sampayo, 2005). It is a major trade route linking Asia to Africa and Europe (Potgieter, 2012). In addition to shipping and cargo, the South-West Indian Ocean (SWIO) basin is an important biodiversity hotspot and is known to host a wide diversity of marine species (Obura et al., 2017). This region is also known for its rich fisheries resources such as tuna (Groeneveld, 2016, van der Elst et al., 2005). However, compared to other regions, such as the Caribbean and Indo-Pacific, the impacts of climate change in the SWIO basin are relatively unknown. While the past two decades have shed some light on the anthropogenic impacts on SWIO marine biodiversity (Turner and Klaus, 2005, McClanahan et al., 2014), the impacts on climate change on the fishery sector, most specifically coastal fisheries (small-scale fisheries) in this region are very poorly understood (Dueri, 2017). For example, the regional assessment of Dueri (2017) clearly demonstrates that tuna stocks in the Western Indian Ocean in future years will be greatly dependent on climate change impacts. Ecosystem degradation due to climate change will most likely result to a decrease in tuna stocks in this region.

According to the Food and Agricultural Organization (FAO), fisheries provide 3 billion people around the world with about 20% of their average animal protein intake and over 500 million people living mostly in the poorest countries in Africa and Asia are dependent on marine fisheries for food and income. The SWIO basin is a major

fishing area (Groeneveld, 2016) and countries found in/bordering this region are highly dependent on this important natural resource. According to Jackson et al. (2001) the increasing population density in this region during the past 50 years has exponentially increase the pressure on SWIO natural resources including fisheries. The SWIO basin is also home to several fragile economies and Small Islands Developing States (SIDS) such as the Comoros, Madagascar, Mozambique, Seychelles, Mauritius, and La Reunion. While some SWIO countries are slowly progressing towards a developing economy, they are greatly dependent on regional small-scale or artisanal fisheries resources (Groeneveld, 2016). As a result, while being naturally susceptible to climate change impacts, countries in the SWIO basin are also running the great risk of losing one their main natural resource (i.e., small-scale, and artisanal fisheries) due to climate change. Indeed, climate change is no more an approximate gamble for the SWIO region.

Given the deep uncertainties surrounding climate change, the SWIO countries are reclined to only two possibilities:

(i) either adapt to the dynamic situation using a sustainable and regional strategy, or

(ii) to perish due to the consequences of climate change.

The use of monitoring practices such as developmental evaluation and participatory social science techniques, centered around learning as described by Dinshaw et al. (2014) could bring a major boost for SWIO countries in the face of climate change and sustainable use of sustainable fishery. According to Ledda et al. (2020), simple sustainable adaptation strategies can be largely beneficial to a whole region. Given the persistence of climate change and the lack of basic background data in the SWIO region, the monitoring of climate change impacts (or parameters) on coastal fisheries *via* a regional Fisheries-Climate outlook network may be a primordial necessity for all SWIO countries (Ruhl et al., 2011, Bastos et al., 2016, Smith et al., 2018). While the concept of Fisheries-Climate outlook network may be uncommon globally, other forms of this concept has successfully been developed and implemented in several regions, such as the Pacific (Hallegraeff, 2010) and North Atlantic (Barnes et al., 2015). However, the implementation of such concepts is deeply reliant on primary *in situ* long term data (i.e., ongoing oceanic climate change and small scale/artisanal fisheries data).

This report aims to build an initial inventory to identify climate change related indicators and investigate the needs for marine research institutions of the region for the successful development of a regional Fisheries-Climate outlook network. The Fisheries-Climate outlook network has been framed in two stages. Stage 1 encompasses a Research and Development phase of the Ecofish Regional Coastal Marine Fisheries Climate Change Biodiversity Outlook Network (see Ecofish Technical

Handbook) and focusses mainly on IOC Member States (Comoros, La Reunion, Madagascar, Mauritius, and Seychelles) and three East African (EA) countries (Kenya, Mozambique, and Tanzania). The final section of this work, which involves countries from the horn of Africa (Somalia, Eritrea, Djibouti, and Sudan) will be conducted separately with the collaboration of Intergovernmental Authority on Development (IGAD). The specific objectives of this report are to:

- Identify main Marine research institutes of the partner countries.
- Identify main existing indicators/Parameters and locations to be used for data collection.
- Collaborate to list the needs of the Research Institutes in terms of equipment & support services
- Examine capacity building needs including training and sharing of lessons learned, use of innovative technologies, and good practices at the regional level.

2 Methodology

This investigation has been conducted *via* an extensive multistakeholder research based on available documentation in the SWIO region and a series of activities, such as one-on-one communication with IOC National Focal Points (NPF), marine research institutions of beneficiary countries and the Mauritius Oceanography Institute (MOI). Since the potential impacts of climate change on the SWIO fishery sector is currently unknown (Sweenarain, 2016), research was focused on existing global/regional databases, such as reports from the Western Indian Ocean Marine Association (WIOMSA), United Nations Development Programme (UNDP) and United Nation Environment Programme (UNEP). Data triangulations were then performed between existing databases, published reports and NFPs of beneficiary countries to identify basic information on oceanic-climate change parameters in the SWIO basin. The Fisheries-Climate outlook network framework was built with the collaboration members of the Ecofish programme.

2.1 Scope and prospects of work

Given the lack of information in the SWIO region on temporal oceanic climate change data, this report aims to identify all regional stakeholders in the region and propose a framework for the Fisheries-Climate outlook network. The present report is solely based on the technical fisheries and climate change aspects of the project i.e., to identify linkages and synergies in the SWIO region. The socio-economic/policy aspects of the project will be coordinated separately by Dr. David Kirugara.

3 Outcomes

3.1 Inventories

3.1.1 MARINE RESEARCH INSTITUTIONS IN THE SWIO REGION

The SWIO region consists mostly of developing economies or Small Island Developing States (SIDS). However, each country is known to host at least one marine research institution as they are greatly dependent on fisheries resources. While these institutions were initially developed for environment, coastal and marine conservation (including fisheries), the emergence of climate change in the late 1990s have compelled them to become more multidisciplinary. Since then, several climate change reports/studies have been conducted in this region (McClanahan et al., 2000, McClanahan et al., 2011, Ainsworth et al., 2021). Furthermore, most countries in the SWIO basin are also host to Non-Governmental Organizations (NGOs), which are actively involved in climate change-related monitoring or research. Both governmental and non-governmental institutions have important roles in the region, regarding marine biodiversity conservation, and regional collaboration between institutions and organizations could pioneer a more efficient and sustainable approach vis a vis the impacts of climate change. While some governmental institutions have participated in regional initiatives, such as the Global Monitoring for Environment and Security (GMES) or African Monitoring of the Environment for Sustainable Development (AMESD) projects, effective regional collaboration from these institutions/organizations have the potential to be a game changer in the region when it comes to the setting up of a Fisheries-Climate outlook network. An inventory of governmental marine research institutions and their potential implication in the current project is listed in Table 1. A non-governmental organization list including regional organizations is also attached in the Annexes (see Table A1) of this report.

Table 1: Governmental marine research institutions and data collection

Region	Country	Marine Research Institution	Climate Change Data	Fisheries Data
Indian Ocean Commission Member States (IOC)	Comoros	Institut National de la Recherche pour l'Agriculture, la Pêche et l'Environnement (INRAPE)		✓
		Direction Generale des Ressources Halieutique (DGRH)		✓
		Centre national de surveillance des pêches		✓
		Agence Nationale de l Aviation Civile et de la Meteorologie (ANACM)	✓	
	La Reunion	Institut de Recherche et du Development (IRD)	✓	
		Universite de la Reunion	✓	
		Ifremer	✓	
		France geological survey	✓	
	Madagascar	Ministere de L'Environnement et du Developpement Durable	✓	
		Institut Halieutique et des Sciences Marines (IHSM)		✓
		Madagascar Research and Conservation Institute	✓	
		University of Toliara- institute of Fisheries and Marine Science		✓
	Mauritius	Mauritius Oceanography Institute (MOI)	✓	
		Albion Fisheries Research Centre (AFRC)	✓	✓
		Mauritius Meteorological Services	✓	
		University of Mauritius, Department of Biological Sciences	✓	
	Seychelles	Seychelles Centre for Marine Research and Technology	✓	

		(SCMRT-MPA)		
		University of Seychelles, Blue Economy Research Institute	✓	
		Seychelles Fishing Authority (SFA)		✓
		Seychelles National Park Authority		✓
		Seychelles Meteorological Services	✓	
East African countries (EA)	Kenya	Kenya Marine and Fisheries Research Institute		✓
		University of Nairobi, Moana Research Station for Marine studies	✓	
		Kenyatta University	✓	
		Kenya Meteorological Department	✓	
	Mozambique	Eduardo Mondlane University, Faculty of Sciences	✓	
		National Institute of Fisheries Research (IIP)		✓
		National Institute for the Development of Small-Scale Artisanal Fisheries and Climate Change		✓
		National Institute for the Development of Aquaculture		✓
		Marine Fisheries Research Institutes, IDPPE		✓
	Tanzania (incl Zanzibar)	University of Dar es Salaam, Centre for Climate Change Studies or Institute of Marine Sciences	✓	
		Tanzania Fisheries Research Institute (TAFIRI) (ZAFIRI in Zanzibar)		✓

3.2 Climate change parameters and Locations

Assessing the impacts of climate change on marine ecosystems, including fisheries is a multidisciplinary task, because climate change-induced alterations are very often multidimensional and involve a suite of physico-chemical parameters or indicators (Herr, 2009, IPCC, 2014, 2018, Sathyendranath et al., 2019). Marine biological organisms are widely dependent on their immediate environment; therefore, they are directly impacted by changes in physico-chemical parameters of their environment (Viitasalo et al., 2015, Hoegh-Guldberg and Bruno, 2010). This is more prominent in tropical waters, where marine organisms are most likely living near their thermal tolerance limits (Saunders et al., 2014, Somero, 2010). The most common climate change parameters considered in the marine environment are temperature (Sea Surface Temperature), CO_2 concentration (ocean acidification or pH) and dissolved oxygen concentration (Garcia-Soto et al., 2021). However, given that climate change can cause excessive precipitation and impact coastal or intertidal communities, ocean salinity (coastal waters) and sea level rise were also taken into consideration for this task. Marine climate change data in the SWIO basin is relatively unknown. While some of these data may be collected during scientific experiments/investigations or from satellite data sources, *in situ* temporal data or season variability data are relatively scarce. The most common marine climate change data currently available in this region is sea Surface Temperature (SST). SST data are generally collected by meteorological service stations and are available upon official request in several countries such as the Seychelles, Mauritius and Kenya. Climate change parameters/indicators that are currently being collected in the SWIO region is listed in Table 2.

Table 2: Climate change parameters currently collected

		Climate Change Parameters/Indicators				
Region	Country	Sea Surface Temperature	Ocean Acidity (pH)	Dissolved Oxygen	Salinity	Sea Level Rise
Indian Ocean Commission Member States (IOC)	Comoros	✓			✓	✓
	La Reunion	✓	✓	✓		✓
	Madagascar	✓			✓	
	Mauritius	✓	✓	✓	✓	✓
	Seychelles	✓	✓	✓		✓
East African countries (EA)	Kenya	✓	✓			✓
	Mozambique	✓		✓	✓	✓
	Tanzania	✓	✓		✓	✓

Note: This table summarizes the parameters that are measured/monitored by Governmental marine research institutions only.

There is a direct correlation between the quality of data that are being used in a model and the result quality (Zhao et al., 2017). Quality climate change predictions (or impacts) are often based on multidisciplinary quantitative and qualitative datasets. For this inventory, a regional data distribution map of climate change parameters that are currently being collected in the SWIO basin was essential to identify potential gaps in climate change data availability among beneficiary states. Fig. 1 demonstrates the distribution of climate-change parameters that are currently being collected across the SWIO region. Specific locations of these parameters in each beneficiary country are listed in Annex (see Table A2).

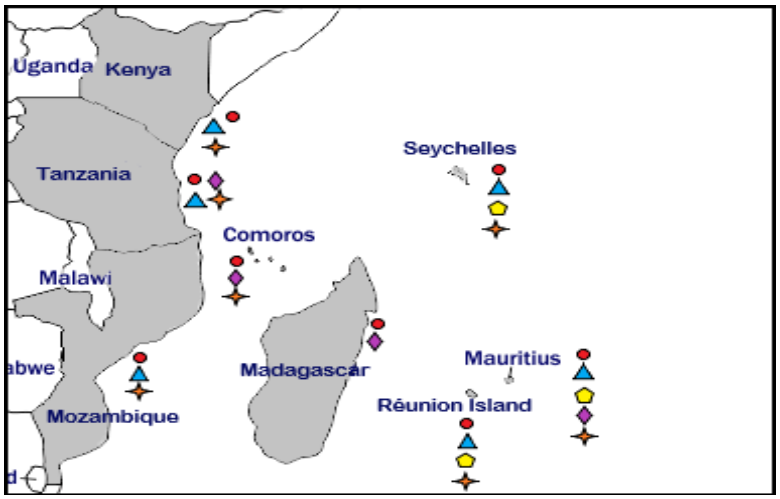

Figure 1: Distribution of climate change parameters that are currently being collected from the SWIO region.

3.3 Existing climate change policies in SWIO region

Since the emergence of the Sustainable Development Goals (SGDs) were adopted by the United Nations in 2015, the global climate change community has been invested to formulate national climate change policies or develop climate change strategies (Sachs et al., 2021). According to the UNCTAD, of the 17 SDGs, the SDG 13 and most specifically SDG 14 are the most important goals for developing states and SIDS. Given that most SWIO countries are directly reliant on fisheries resources, it was of paramount importance that each member state caters for a climate change policy at the national level. While recent scientific studies clearly demonstrate a keen interest of SWIO countries in investigating the impacts of climate change on marine ecosystems, such as coral reefs, not much has been done regarding the fisheries resources. Of the eight beneficiary countries that have been included in this report, seven countries (La Reunion have similar policies to France) have already developed a national climate change policy (Table 3). *However, it will be interesting and more beneficial to all the beneficiary countries that are listed in this report, if they could*

combine their effort and formulate a regional climate change policy for the Western Indian Ocean region.

Table 3: Existing climate change policies from the SWIO region.

Region	Country	Existing policy
Indian Ocean Commission Member States (IOC)	Comoros	-
	La Reunion	Policies related to existing France policies
	Madagascar	National Strategy to face Climate Change in Agriculture-Livestock-Fishery
		National Climate Change Policy
		Nationally Determined Contribution 2015-2030
	Mauritius	National Environment Policy
		The Climate Change Bill
		The Environment Protection Act
	Seychelles	National Climate Change policy
		Blue Economy Strategic Roadmap and Implementation (In preparation)
		Conservation and Climate Adaptation Trust of Seychelles Act
		Energy Act
East African countries (EA)	Kenya	Climate Change Act 2016
		Environmental Management and Coordination (Amendement) Act (EMCA)
		National Climate Change Action Plan 2018 - 2022
		National Policy on Climate Finance
		A Climate Risk Management Framework for Kenya
	Mozambique	Decree No.6/2016 Creating the National Fund For Sustainable Development
		National Strategy for Climate Change - ENMC (2013 - 2025)
	Tanzania (incl Zanzibar)	Environmental Management Act
		National Climate Change Strategy 2012
		Tanzania Agriculture Climate Resilience Plan
		National Climate Change Communication Strategy (2012 - 2017)

3.4 Equipment and needs

Marine climate change data acquisition capabilities in beneficiary countries are highly variable. While some countries may be equipped with the minimum equipment requirements for such a project, other countries are less likely to possess all equipment. The setting up of a regional Fisheries-Climate outlook network require up-to-date, standard, and quality climate change data, which can be monitored and acquired on a long-term basis. For quality outputs and long-term monitoring and predictions, it is imperative that all beneficiary countries are equipped with the standard quality equipment for this project. Based on the inventory from Section 3.2, a list of equipment that are required for this project is listed in Table 4. Equipment for 'Sea Level Rise' was omitted from this table. This is because the most common method of measuring sea level rise globally is *via* satellite data. In parallel to the acquisition of sensors (equipment), each beneficiary is recommended to have sensors at different locations (i.e. locations which correlates to national small-scale/ artisanal fishing zones)

Table 4: Equipment needs of beneficiary countries.

		Climate Change sensors			
Region	Country	Temperature	pH sensors	Dissolved Oxygen	Salinity
Indian Ocean Commission Member States (IOC)	Comoros	-	✓	✓	-
	La Reunion	-	-	-	✓
	Madagascar	-	✓	✓	-
	Mauritius	-	-	-	-
	Seychelles	-	-	-	✓
East African countries (EA)	Kenya	-	-	✓	✓
	Mozambique	-	✓	-	-
	Tanzania	-	-	✓	-

Note: It is expected that purchased equipment are to be delivered to Governmental marine research institutions via their respective National Focal Points.

3.5 Operationalisation of the regional Fisheries-Climate outlook network

During this inventory, NPFs of beneficiary countries were invited to express their opinions and concerns about the setting of a regional Fisheries-Climate outlook network in the Southern Western Indian Ocean (SWIO) region. All beneficiary countries listed in this report have provided positive responses towards the setting up of this network as such a regional tool will be highly beneficial to all stakeholders in the long term. While most member countries may have yearly fisheries data already collected, there was an agreement between NFPs that there is currently no correlation between small-scale fisheries data and marine climate change data in the region. Therefore, it is currently impossible for SWIO countries to monitor the effects and identify the impacts of climate change on small-scale/artisanal fisheries, both at a national and a regional level. It has been proposed that the Fisheries-Climate outlook network would be based at the Mauritius Oceanography Institute (MOI) in Mauritius. This is because the MOI has coordinated similar projects in the past decade (e.g. the GMES and Africa project) and have the logistics to support a project of this scale. It is important to note that the MOI has expertise in the field of satellite data and their input are focused on that field. Information in the SWIO-data from the Sentinel group of satellites could be used for altimetry, Chl a, primary Productivity and potential fishing zone. *Ecofish and the MOI is currently in the process of signing a Memorandum of Understanding (MoU) in this regard.* A technical committee consisting of specialists from all beneficiary countries will be set up to monitor the setting up and implementation of this observatory. NFPs in each member state will be approached to nominate an expert dedicated to the Fisheries-Climate outlook network. A framework of this project is described in the next section of this report. In line with this project, all beneficiary countries must be on a common baseline on the type of data (both fisheries and climate change) that would be required for standardized and quality outputs.

3.5.1 FISHERIES-CLIMATE OUTLOOK NETWORK FRAMEWORK

3.5.1.1 INPUTS

Frameworks are generally essential structures underlying proposed concepts (Potschin-Young et al., 2018). Given that a Fisheries-Climate outlook network is novel concept to the SWIO region, this proposed framework is focused on standardized quality fisheries and climate data from each member states. While small-scale fisheries data could be retrieved/obtained from governmental bodies such as ministries or NGOs from several countries, the availability of precise ocean-related climate change data is currently a challenge for several Member States (see Section 3.2). The Moi for example, has the appropriate equipment to acquire SSH, Current patterns and wave regime around Mauritius. As a result, it is primordial that

activities within this proposed framework is focused on the pre-defined essential ocean climate change variables stated in Table 2. Fig. 2 demonstrates the proposed Fisheries-Climate outlook network framework and a log frame for the project is descripted in Fig. 3. Oceanic climate change indicators will require a combination of existing data that are currently being monitored in each member state (Meteorological services) and specific sensors, such as pH sensors to be purchased and installed in the coastal waters of each member state.

3.5.1.2 PROCESS

Small scale fisheries and oceanic climate data would be acquired from Fisheries-Climate outlook network dedicated national focal points from each member states. The Fisheries-Climate outlook network national focal points (FCON-NFPs) will then transfer the national data to the MOI for processing. It is important that all beneficiary states provide physical oceanic as well as fisheries data to the MOI for analysis. In addition to these national data set, organizations, such as the WIOMSA and Nairobi Convention may also contribute to supplementary fisheries/oceanic climate change data in the SWIO region to the MOI. As a result, the MOI will gather temporal regional data sets for fisheries and oceanic climate change. The MOI will be the 'central processing unit' of the Fisheries-Climate outlook network and will produce the temporal fisheries / climate maps, trend etc. With an inflow of yearly regional data, the MOI will also aim to produce temporal projections of small-scale/artisanal fisheries stocks in the SWIO region and identify the regional impacts of climate change on these resources.

3.5.1.3 REVIEW

To ensure standardized quality outputs and the sustainability of the proposed outlook network, a regional technical committee will be set up to support the Fisheries-Climate outlook network. A regional technical committee consisting of experts from the MOI, national experts from each beneficiary countries as well as observers from regional organizations such as the WIOMSA, Nairobi Convention and the Indian Ocean Commission may be considered for annual technical meetings. Other regional institutions such as the IOTC may also be invited to provide their expertise and inputs. The aim of the annual review sessions will be to ensure transparency, identify potential drawbacks in climate and fisheries data collections to evaluate and enhance the products of the Fisheries-Climate outlook network.

3.5.1.4 OUTPUTS

The primary outcomes of the Fisheries-Climate outlook network would be as follows:

a) Production of temporal small-scale fisheries maps.
b) Production of temporal oceanic climate maps.
c) Projections on the impacts of climate change on small-scale fisheries
d) Monitor the changes of regional small-scale fisheries stocks

While these outcomes would be focused on the SWIO region, the MOI may also be able to produce maps and projections for specific member states. In addition to the expected Fisheries-Climate products (i.e. primary outcomes), the proposed framework also takes into account secondary regional outputs, such as a weather extremes database and *in situ* regional fisheries data, which may be acquired in parallel from the Fisheries-Climate outlook network. The MOI is in the process of developing an application for fishers to locate possible potential fishing areas and sea weather forecast. This application could be adapted regionally as and when appropriate.

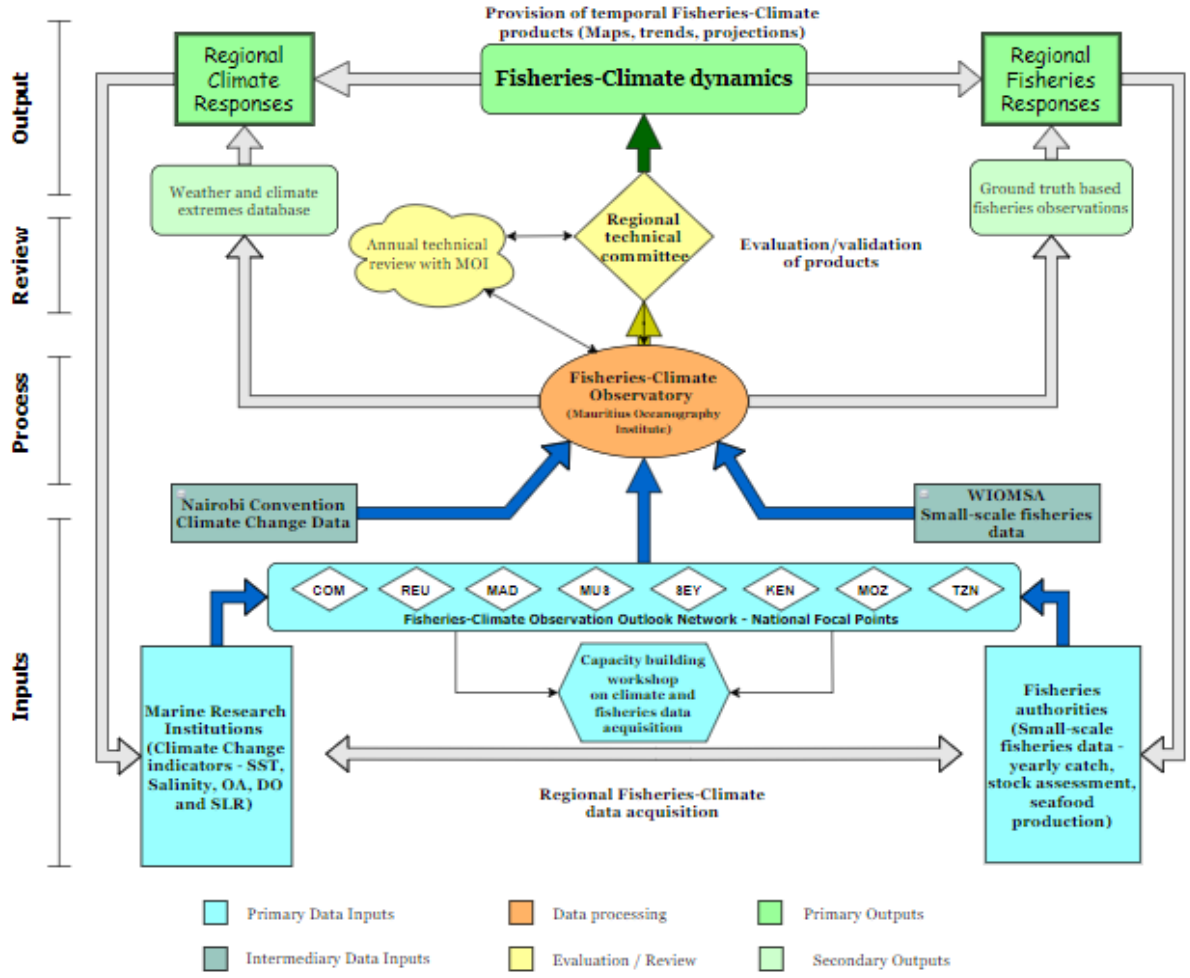

Figure 2: An overview of the Fisheries-Climate outlook network framework in the SWIO region.

3.5.2 FISHERIES-CLIMATE OUTLOOK NETWORK LOG FRAME

	Project Summary	Indicators	Means of verification	Assumptions
Goal	Reaching equitable economic growth by promoting sustainable fisheries in the SWIO region	Understand the impacts of climate change on small-scale fisheries in SWIO region.	Compare fisheries stocks before and after the setting up of the Fisheries-Climate outlook network	Collaboration from governmental, non-governmental and regional stakeholders.
Outcome	Setting up of a regional Fisheries-Climate outlook network for the benefit of all SWIO countries.	Production of temporal maps of fisheries dynamics and precise projections and trends.	Peer-review from international experts (FAO, UNFCCC)	Support from international bodies (FAO, UNFCCC, Nairobi Convention)
Outputs	1. Fisheries-Climate dynamics in terms of maps, trends and future projections.	Number of maps and trend analyses produced *per* year.	Review of maps and projections by regional technical committee.	Regular quality data sent to the MOI.
	2. Monitoring of small-scale fisheries resources for future generations.	*In situ* stock assessments of small-scale fisheries resources.	Yearly small-scale fisheries stock assessment	National control of IUU within territorial waters.
Activities	1. Identify country-specific Fisheries-Climate Outlook Network National Focal Points (FCON-NFPs).	Number of FCON-NFPs nominations	Participation rates of dedicated national focal points	Interest of all member states to have a dedicated FCON-NFPs.

	2. Identify and purchase of equipment for all beneficiary states (potential regional workshop)	Type and number of sensors and data loggers purchased.	Number of data loggers and sensors being deployed	Collaboration between Ecofish NFPs and nominated FCON-NFPs.
	3. Installation of equipment and initial data acquisition (potential regional workshop)	Standardized quality of oceanic climate change data acquisition.	Comparing acquired data with satellite predictions	Quality sensors to acquire standardized data.
	4. Data transfer of small-scale fisheries and oceanic climate change data from member states for processing at the MOI.	Amount of small-scale fisheries data received from Member states.	Regular small-scale fisheries survey in SWIO region	Close collaboration between local government bodies and FCON-NFPs.
	5. Setting up of the regional Fisheries-Climate technical committee.	Number of experts being nominated by beneficiary states.	Outcomes of the annual technical review (Official reports)	At least one expert is nominated by each member state.

Table 5: Log Frame for the SWIO Fisheries-Climate outlook network.

3.5.2.1 PLANNED ACTIVITIES

I. ***Identifying Fisheries-Climate outlook network National focal points (FCON-NFPs)*** It is proposed that all member state nominate a dedicated national focal point for the Fisheries-Climate outlook network. FCON-NFPs will serve as resource/liaison person and will be responsible to provide regular fisheries and oceanic climate change data to the MOI for processing. FCON-NFPs will also be responsible to attend capacity building

programmes/workshops related to the Fisheries-Climate outlook network and provide support to the MOI when required. Human and technical capacities at the MOI shall be discussed with Ecofish to identify any specific needs of MOI for the purpose of this project.

II. ***Identify and purchase of standardized equipment for all beneficiary states*** – It is proposed that a regional workshop is held for FCON-NFPs in collaboration with the MOI and Ecofish representatives to define the necessary equipment (brand, sensitivity, range, etc), that will be required for this project. Given that the needs and marine ecosystems of each member state is country-specific, it is recommended that this activity is conducted with the assistance of FCON-NFPs and with the inputs of all stakeholders.

III. ***Installation of equipment and initial data acquisition –*** This task is expected to be performed as soon as equipment are delivered to member states. FCON-NFPs will be able to provide guidance on the locations where these devices would be installed. Installation of sensors would preferably be positioned near artisanal/small-scale fishing zones in each member state. Initial data acquisition from sensors and data from existing sources, such as, meteorological services, ministries, marine research institutions shall be sent to the MOI for initial trial data processing. A second regional workshop lead by the MOI may be undertaken here to familiarize all FCON-NFPs on the specific type data required and data transfer to and from the MOI.

IV. ***Acquisition and processing of small-scale fisheries and oceanic climate change data*** – Once an initial trial data processing has been conducted, it is expected that *in situ* fisheries and oceanic climate change data are shared with the MOI for a first analysis of fisheries-climate dynamics. This initial complete data processing will serve as a baseline for future data processing at the MOI.

V. ***Setting up of a regional Fisheries-Climate technical committee*** – The setting up of this technical committee will be to assess yearly progress, needs and improvement of the Fisheries-Climate outlook network. Technical experts for this committee may be a combination of a fisheries and climate expert from each member state or the FCON-NFPs themselves if they have the desired expertise in the field. Regular reviews on the Fisheries-Climate outlook network functioning will be necessary to ensure transparency and sustainable regional economic growth of the fisheries sector in the SWIO region.

3.5.2.2 SCOPE AND ORIENTATIONS

I. **Moving toward sustainable small-scale fisheries in the SWIO region. -** The present project analyses the potential of enhancing regional cooperation in the SWIO region to sustain the important small-scale fisheries sub-sector. This sub-sector is country-specific and is highly variable between member states. The proposed concept of a regional Fisheries-Climate outlook network will enable SWIO member states to assess any impacts of climate change on small-scale fisheries. Thus, assist in the improvement of stock management for future generations.

II. **Adaption of the current needs of partner countries.** - The needs and potential of member states in the management of small-scale fisheries stock in the SWIO region significantly differs. This is due to the variability in species/fishing methods/ecosystem approach, human capacities and local common practices. As a result, adaptation or mitigation measures in each partner state can only be defined after identifying the potential impacts of climate on their fisheries stocks. The present project will set a common regional understanding among all member state and will be a baseline for immediate adaptation/mitigation measures.

III. **Potential range of this project.** – This report is currently focused on the SWIO region However, it is expected that the project will be extended to other countries in the Horn of Africa (Somalia, Eritrea, Djibouti, and Sudan) in collaboration with IGAD. This project is also expected to be a multistakeholder initiative, including governmental, non-governmental and regional organisation to ensure equitable economic growth by promoting sustainable fisheries in the EA-SA-IO region.

IV. **Building on past regional achievements.** - East African partner countries have in the past demonstrate exceptional capabilities to collaborate for regional environmental monitoring programmes such as the Global Monitoring for Environment and Security (GMES) or African Monitoring of the Environment for Sustainable Development (AMESD) projects. While these initiatives demonstrate the enthusiasm of partner countries to protect coastal environment, a Fisheries-Climate outlook network would be a game changer in the SWIO region in terms of oceanic climate change and small-scale fisheries monitoring. Given the rising interest of all member states in developing a Blue Economy, this project may be the steppingstone in that direction.

3.5.2.3 PROJECT TIME FRAME

This section describes a provisional time frame in the form of a Gantt chart for the setting up of the SWIO Fisheries-Climate outlook network.

Activities	Time frame (January – September 2022)								
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Assessing technical and human capabilities of the MOI									
Designing a yearly Action Plan for the Fisheries-Climate outlook network (MOI)									
Identify Fisheries-Climate Outlook Network National Focal Points (FCON-NFPs)									
Setting up of the regional Fisheries-Climate technical committee.									
Workshop to identify and purchase of equipment for partner countries									
Identifying the expected outcomes of the Fisheries-Climate outlook network.									
MOI completes technical upgrade and acquire human resource for the project									
Installation of equipment and workshop on initial data acquisition									
Start feeding small-scale fisheries and oceanic climate change data to the MOI.									

4 Recommendations

This section discusses the recommendations and highlights the importance and implications of a Fisheries-Climate outlook network in the SWIO region. The report of Sweenarain (2016) demonstrates that while the economic status and priorities of partner countries may differ significantly in the Western Indian Ocean region, all SWIO countries are still highly dependent on the small-scale fisheries sub-sector. In addition to their dependence on coastal fisheries resources, all partner countries are known to be vulnerable to the impacts of climate change and extreme weather events. To date, the impacts of climate change on the small-scale fisheries sub-sector in the SWIO region is relatively undescribed. As a result, this initiative paves the way for all member states to pioneer a regional project, which will be beneficial to current and most importantly future generations. This project has the potential to tackle four aspects of the Blue Economy concept:

I. Understanding oceanic climate change occurring in the SWIO basin;
II. Identify the dynamics of *in situ* small-scale fisheries stocks;
III. Monitor the impacts of climate change on the small-scale fisheries sub-sector; and
IV. Enhancing sustainable seafood production for future generations.

While this initiative of the Ecofish programme has a solid conceptual backbone and is a unique opportunity for all partner states, the following recommendations are to be considered during the implementation of this project:

4.1 Technical and human capabilities of the MOI

It is recommended that there is a mutual understanding between the MOI and the Ecofish programme on the technicalities and human resources required for the smooth running of the Fisheries-Climate outlook network at the MOI. While the MOI has been involved in major regional projects such as AMESD and GMES in the past decade, these projects were focused on satellite data and modelling. In contrast to these past projects, *the proposed SWIO Fisheries-Climate outlook network is more demanding in terms of* in situ *data and therefore may necessitate additional technical support, logistics and equipment as well as specific human expertise in the field*.

4.2 Regional cooperation

This project is a unique opportunity for all partner states to tackle major issues. As goes the saying 'Strength through unity', *the main component of this project is based on regional cooperation between partner states as well as close collaboration between FCON-NFPs and the MOI. Therefore, it is primordial that all beneficiary*

states actively contribute to feeding the MOI with reliable and standard oceanic climate change and fisheries data for analysis. It would be a milestone for all stakeholders that this outlook network remains into operation and gradually becomes self-sustaining well beyond the span of the Ecofish programme (approximately 36 months). If successfully sustained this initiative has the potential to be extended to other common regional sectors related to the Blue Economy concept, such as aquaculture development and sustainable tourism. *Furthermore, the expansion of this project to encompass regional bodies such as the WIOMSA, UNFCCC, SADC and the Nairobi Convention may also provide an excellent platform for the equitable development of the EA-SA-IO region*.

4.3 Technical expertise

The SWIO region may have multiple technical expertise in terms of climate change, ocean dynamics and fisheries experts. However, it is potentially rare for partner countries to have a technical expert who combines both fisheries and climate change expertise. *It is therefore recommended that partner countries support their FCON-NFPs in both aspects. It will also be an asset for this project to have specific technical experts in the Fisheries-Climate technical committee, as a combination of both climate change and fisheries expertise may be required for evaluation and reviewing processes*.

4.4 Implications for implementing of a regional Blue Economy

The past decade has experienced a major enthusiasm around the concept of the Blue Economy. While this concept has a futurist sustainable approach, it has the potential to be a great powerhouse for developing economies and SIDS from the SWIO region. Countries such as Mauritius and Seychelles have already started working on this concept. However, the implementation of the different sub-sectors of the Blue Economy, such as tourism, seafood production and maritime safety may be more profitable and viable using a regional approach. Should the SWIO Fisheries-Climate outlook network proved to be beneficial and self-sustainable, the concept could also be extrapolated to other Blue Economy sectors for the benefit of all partner countries.

5 Conclusion

Climate change is currently one of the major threats of mankind. Ocean warming, ocean acidification, sea level rise is now within the doorsteps of all countries. However, developing economies and SIDS are reported to be more vulnerable to these impacts. Countries from the SWIO region are already experiencing the impacts of climate change with more frequent climatic events such as flash floods, droughts, and powerful tropical cyclones. In addition to physical impacts, climate change also has major unseen impacts on marine ecosystems, which could lead to mass mortalities of coral reefs and alteration in aquatic population dynamics. As climate change exacerbate its effects on coastal zones, it is expected that the impacts will be extrapolated to artisanal/small-scale fishers. As a result, this would fuel a decrease in fish catch, reduction in daily income, which could lead to the stagnation of the ever-dependent small-scale fisheries sub-sector in the SWIO region. Given that the SWIO countries are significantly reliant on coastal fisheries, most specifically small-scale fisheries, it is thus a priority to identify and monitor the impacts of climate change on this important sub-sector in the region. Therefore, this proposed project has the potential to be a game changer for all partner countries in the SWIO region.

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7 ANNEXES

Table A1: Non-governmental and regional organizations involved in climate change-related research/monitoring in the IOC-EA-IO region.

Region	Country	Institution	Contact	Email
Indian Ocean Commission Member States (IOC)	Comoros	Moheli Marine Park	Mr. Said Youssouf Mbechezi	youssouf.mbechezi@undp.org
		"Association d'Intervention pour le Développement et l'Environnement (AIDE)"	-	-
	La Reunion	-	-	-
	Madagascar	World Wildlife Foundation Madagascar	Mrs. Nanie Ratsifandrihamanana	wwfmadagascar@wwf.mg
	Mauritius	Reef Conservation (Mauritius)	Mrs. Kathy Young	admin@reefconservation.mu
	Seychelles	Living Oceans Foundation	Dr. Sarah Hamylton	smh61@cam.ac.uk
		Marine Conservation Society Seychelles		mcssoffice@gmail.com
		Nature Seychelles	Dr. Nirmal Jivan Shah	nature@seychelles.net
		Seychelles Conservation and Climate Adaptation Trust (SeyCCAT)	Mrs. Elke Talma	elke.talma@gmail.com
East African countries (EA)	Kenya	Kenya Arocha Conservation and Hope	Mr. Stanley Baya	stanley.baya@arocha.org
	Mozambique	Bazaruto Center for Scientific Studies	Dr. Mario Lebrato	Mario.Lebrato@bcssmz.org
		African Impact – Marine research and Conservation	-	-
		Sealife Station	Dr. Yara Tibiriçá	yara@zavoralab.com
	Tanzania	Zanzibar Climate Change Alliance (ZACCA)	Mahfoudh Shaaban Haji	zacca.zanzibar@gmail.com

	Zanzibar	Zanzibar Fisheries Research Institute	Dr. Zakaria Ali Khamis-	zakaria.khamis@suza.ac.tz
Regional Marine Organizations				
Western Indian Ocean Marine Science Association (WIOMSA)			Dr. Jacqueline Uku	juku@kmfri.co.ke
Indian Ocean Tuna Commission (IOTC)			Dr. Paul de Bruyn	paul.debruyn@fao.org
IGAD Climate Change Unit			-	-
The Global Climate Change Alliance Plus (GCCC+)			-	-
The Nairobi Convention			Dr. Jared Bosire	jared.bosire@un.org
Indian Ocean Research Group (IORG)			Mr. Sanjay Chaturvedi	sanjaychaturvedi@sau.ac.in
Coastal Oceans Research and Development in the Indian Ocean			Dr. David Obura	dobura@cordioea.net

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