AFRICAN UNION
INTERAFRICAN BUREAU
FOR ANIMAL RESOURCES

Sweden
Sverige

Impact of Climate Change on Africa Aquatic Ecosystems and Biodiversity and Proposed Mitigation Measures

Prepared by: Giorgio Brandolini

Edited by: Joel Mokenya, Mohamed Seisay, Alberta Sagoe and Eric Nadiope

Disclaimer: The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the African Union Interafrican Bureau for Animal Resources.

Citation: AU-IBAR, 2022. Impact of climate change on African aquatic ecosystems and biodiversity and proposed mitigation measures

Published by AU-IBAR, Nairobi, Kenya

ISBN 978-9966-1659-5-4

Requests for such permission should be addressed to:

The Director
African Union – Interafrican Bureau for Animal Resources (AU-IBAR)
Kenindia Business Park
Museum Hill, Westlands Road
P.O. Box 30786
00100, Nairobi, KENYA
Or by e-mail to: ibar.office@au-ibar.org

Acknowledgements: The Director of AU-IBAR wishes to acknowledge the consultancy services by the consultant, Mr. Giorgio Brandolini who carried out the studies and prepared the report on the Impact of Climate Change on Africa Aquaca Ecosystems and Biodiversity. The Director also extends appreciation to all stakeholders and partners (RECs, other specialized regional institutions, AU member states, Partners, Experts NSAs etc) that contributed immensely to improving the quality of the report.

Special thanks go to the Swedish International Development cooperation Agency (SIDA) for the ongoing cooperation and the team at AU-IBAR for the editorial work. ***This work was done with financial support by the Government of Sweden , through the Embassy of Sweden to the African union***.

Executive Summary

The impact of Climate change on the African aquatic ecosystems and biodiversity is affecting the livelihoods and welfare of the population depending on their services. The projects concerning the aquatic resources are trying to link conservation to local development to ensure the engagement of the local population in performing innovative mitigation and adaptation measures. The aquatic ecosystems and biodiversity already stressed by human impacts are the most vulnerable to the impact of Climate change.

Several practices have been successfully tested to reduce the impact of Climate change including, among others, its mitigation through the adoption of circular economy short value chain solutions, the adaptation of economic activities to the changes in the biology of the aquatic organisms, the sustainable intensification of aquaculture production to reduce the extent of the fishery extraction areas.

The progress made in this field is little known and insufficiently disseminated to produce the large-scale changes needed to systematically improve the conditions of the aquatic ecosystems and biodiversity.

The AU-IBAR can contribute to filling in such gap by exploiting the existing multi-level dialogue tools and strengthening the interactive services provided by the existing knowledge management platforms to link the building of capacities and testing of best practices in this field to their dissemination at a larger scale. At the same, time, the evidence of the benefits of mitigation and adaptation measure disseminated across the continent should stimulate the engagement of African decisions makers. They can dialogue and join forces to mainstream mitigation and adaptation measures in planning development, transboundary initiatives, etc. and in view of their participation to international fora, thus of promoting the common objectives and priorities enshrined in the Policy framework and reform strategy for fisheries and aquaculture in Africa (PFRS) and African Blue Economy Strategy (ABES).

The elaboration of such initiative should integrate the contribution of the regional, subregional and national actors in the transfer of knowledge and technology.

The Studies on the impact of climate change on the aquatic ecosystems and biodiversity and proposal of mitigation measures analyses the impact of climate change on the aquatic ecosystems and biodiversity, the ongoing initiatives and best practices to address it and proposes mitigation, adaptation and resilience measures for an African strategy in this sector.

Table of Contents

Acronyms

ABES	African Blue Economy Strategy
AFOLU	Agriculture, Forestry, and Other Land Use
ACLME	Agulhas Current Large Marine Ecosystem
AU	African Union
AU-IBAR	African Union - InterAfrican Bureau for Animal Resources
BCLME	Benguela Current Large Marine Ecosystem
CBD	Convention for Biological Diversity
CCLME	Canary Current Large Marine Ecosystem
CFI	Coastal Fisheries Initiative
CO2	Carbon Dioxide
CRB	Congo River Basin
GAL	Great African Lakes
GCLME	Guinea Current Large Marine Ecosystem
GHG	GreenHouse Gasses
HCLME	Humboldt Current Large Marine Ecosystem
IAE	Inland Aquatic Ecosystems
IPCC	International Panel on Climate Change
LME	Large Marine Ecosystem
NRB	Niger River Basin
NRB	Nile River Basin
OID	Okavango Internal Delta
PFRS	Policy framework and reform strategy for fisheries and aquaculture in Africa
SCCLME	Somali Coastal Current Large Marine Ecosystem
UN	United Nations
VRB	Volta River Basin
WIO	Western Indian Ocean

1. Introduction

Africa, with 14% of the world's population, contributes to 3.8% of total Greenhouse gasses (GHG) emissions, or about 1.6% for Sub-Saharan Africa alone[1]. Although Africa emits far less Carbon dioxide (CO2) than any other continent, this continent that contains the majority of the world's poor countries and communities, is expected to face severe Climate change impacts sooner and more severely than other regions due to its lower resiliency, lower adaptive capacity, and greater reliance on climate-sensitive sectors such as agriculture, fisheries and aquaculture for food and nutrition and income. A temperature increase of 2°C could result in a loss of 4.7% of the Gross national product across the continent[2] . The vast majority of this would be the result of agricultural losses due to drought or floods causing damages and failure of yields. A temperature rise of 2.5°C - 5°C would be even worse, causing a 15-95 cm rise in sea level, flooding affecting 108 million and hunger 128 million people[3].

The African Union (AU) has passed several conventions and protocols and recognizes a number of sub-regional and global agreements on the conservation, development and management of aquatic biodiversity in relation to the mitigation of the impact of Climate change on aquatic ecosystems and biodiversity and the promotion of adaptation practices[4]. Most of these practices involve or are linked the performance of activities that preserves the aquatic ecosystems. These programmatic and regulatory instruments include measures to maintain water-based essential ecological processes as well as to protect human health against pollutants and water-borne diseases; prevention of damage that could affect human health or transboundary natural resources by the discharge of pollutants and preventing of excessive abstraction or exploitation of which could reduce the benefits for downstream communities and adjacent States. The AU has elaborated the Policy framework and reform strategy for fisheries and aquaculture in Africa (PFRS, 2014) and Africa Blue Economy Strategy (ABES, 2019) to shape the continental approach to the development of an inclusive and sustainable blue economy and anchor it to the continent transformation and growth processes. The ABES focusses on five critical thematic sectors:

- Fisheries, aquaculture, conservation and sustainable aquatic ecosystems, including the strengthening of resilience and reduction of vulnerability to climate change
- Shipping, transportation, trade, ports, maritime security, safety and enforcement
- Coastal and marine tourism, climate resilience, environment and infrastructure, including the Development of capacity for climate resilient economies and communities
- Sustainable energy, mineral resources and innovative industries
- Polices, institutional and governance, employment, job creation and poverty eradication, Innovative financing, including the integration of blue carbon and ecosystem services into the Climate change policies and Coastal and Aquatic policies to ensure environmentally sustainable and climate resilient economies and communities

[1] *Spore, 2008*
[2] *ClimDev-Africa, 2008*
[3] *UNECA, 2011*
[4] *Convention on the Conservation of Migratory Species of Wild Animals, 1979; Regional Convention for the Conservation of the Red Sea and of the Gulf of Aden Environment, 1982; Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, 1984; Nairobi Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region, 1985; Convention of Biological Diversity (CBD), 1993; United Nations Convention on the Law of the Sea, 1994; Convention for the Protection of Marine Environment and the Coastal Region of the Mediterranean, 1995; United Nations Agreement on Straddling Fish Stocks, 1995; Regional Sea Conventions; African Convention on the Conservation of Nature and Natural Resources, 2003, etc.*

The ABES guides the formulation, updating and implementing of the national, subregional and regional policies for the development of aquatic resources in African marine, brackish waters, open freshwaters, wetlands, and underground waters. Specifically, it acknowledges that climate change and climate variability are already impacting on Africa's aquatic systems and food production and urges Member states to:

- integrate ecosystem services into their National action plan for adaptation
- collaborate with regional and international partners and specialised institutions to establish synergies and complementarity in their climatic actions

The mitigation of the Climate change impact on aquatic ecosystems and biodiversity has been prioritised in the PFRSS and mainstreamed into the ABES where the conservation, sustainable use and equitable access to aquatic resources acts as a booster of the other aspects of sector development. The ABES seeks to guide the enhancement of the capacities of public and private actors across the continent to enhance the blue economy potential and protect the environment. The execution of mitigation measures requires the mobilisation of huge investments to enhance the absorption capacity of Greenhouse Gasses (GHG) emissions through the CO2 sink function of the watersheds and water catchments as well as the control of chemical effluents, disposal of plastic materials and in general of water pollutants. Such actions along with adaptation measures contribute to maintain healthy blue ecosystems whose biological resources are the basis of the blue economy.

2. Drivers of Climate change

Emission of Greenhouse Gasses (GHGs). The emissions of GHGs are on the rise despite the intervention of a wide range of multilateral institutions and national policies pursuing the mitigation of Climate change. The World Resources Institute notes that the increase of the GHG emissions has steadily grown to reach 50 gigatonnes CO2-equivalents per year over the last decades. The emissions from the energy sector accounted for 73% of total emissions, those from Agriculture, Forestry, and Other Land Use (AFOLU) 18% (of which agriculture accounted for 12%)[5], those from industrial processes 6%, and those from waste management activities 3%[6]. For African countries, the largest part of GHG emissions comes from AFOLU; for high-income countries, GHG emissions are dominated by sources related to energy supply and industry.

Human and natural factors. Carbon dioxide is the most significant anthropogenic greenhouse gas, with concentrations in the atmosphere increasing rapidly since pre-industrial times. The use of fossil fuels is the primary cause of the increased CO2 concentration in the atmosphere since the pre-industrial period, with land-use change playing a significant but smaller role. Likewise, the other GHGs have been increasing at faster rate since the pre-industrial era. Methane concentrations in the atmosphere increased from near three times by the 1990' and currently is about four times the pre-industrial levels. According to the analysis of ice cores, methane concentrations in the atmosphere far exceeded the natural range over the six and half centuries. The observed increase in atmospheric methane concentration is very likely due to anthropogenic activities, primarily agriculture and the use of fossil fuels, but the relative contributions from different source types are not well established.

The global atmospheric nitrous oxide concentration has increased from the pre-industrial times, agriculture

[5] *Over this period, AFOLU sectors decreased significantly in relevance by falling from 27%.*
[6] *Osman-Elasha and Fernández de Velasco – AfDB, 2020*

accounting for more than a third of all nitrous oxide emissions. The total radiative forcing due to increases in CO2, methane, and nitrous oxide has increased by 20% between 1995 and 2005 with a steady growth in the most recent years. Other anthropogenic sources of radiative forcing making significant contributions include changes in tropospheric ozone caused by ozone-forming chemical emissions (nitrogen oxides, carbon monoxide, and hydrocarbons).

Marine and inland water are important elements of the atmospheric CO2 balance. The global annual emissions of CO2 from inland waters to the atmosphere are comparable to the oceans CO2 uptake, and global burial of organic carbon in inland water sediments exceeds organic carbon sequestration on the ocean floor. Human activities, such as the construction of impoundments, which accumulate large amounts of carbon in sediments and emit methane to the atmosphere, can change the role of inland waters in global carbon cycling and climate forcing. Lakes with thawing permafrost are also expected to emit methane.

Atmospheric Greenhouses Gasses concentration. The more perceived effect of the impact of Climate change is the temperature increase observed in all continents and oceans has a direct impact on the natural ecosystems. Many scientists recognise the spatial correspondence between regions of significant warming and locations of changes in biodiversity dynamics[7]. Here below we present the main drivers of Climate change and their more prominent physical manifestations.

The rapidly rising atmospheric GHG concentrations are pushing aquatic systems into conditions not seen in millions of years, posing the risk of fundamental and irreversible ecological transformation. Over the last decades, the growing greenhouse gas concentrations in the atmosphere have increased global average atmospheric temperatures by 0.2°C per decade, with most of the extra energy being absorbed by the oceans[8]. The heat content of the oceans upper 700 meters layer has steadily increased over the recent year, while the average temperature of the ocean's upper layers has increased by 0.6°C over the last century[9]. In addition to acting as a heat sink for the planet, the oceans have absorbed roughly one-third of the CO2 produced by human activities.

Atmospheric Black Carbon concentration. Black carbon in soot is the most effective absorber of visible solar radiation in the atmosphere. Although anthropogenic black carbon sources can be found all over the world, they are most concentrated in the tropics, where solar irradiance is highest. Black carbon is frequently transported over long distances, mixing with other aerosols. The aerosol mix can produce transcontinental plumes of atmospheric brown clouds with vertical extents of 3 to 5 km. Black carbon emissions are the second most significant contributor to current global warming, after CO2 dioxide emissions, due to their high absorption, regional distribution roughly aligned with solar irradiance, and ability to form widespread atmospheric brown clouds when mixed with other aerosols[10]. High altitude solar heating from black carbon in the dispersion of heat from the atmosphere directly impacting on global warming.

Carbon sequestration. The CO2 is removed from the air and stored as organic matter through photosynthesis of the plant mass of the organisms that live on the land and in the water including mangrove, marshes and

[7] *Change IPOC 2007*
[8] *Ove Hoegh-Guldberg and John F. Bruno 2010. The Impact of Climate Change on the World's Marine Ecosystems. Science 328(5985):1523-8*
[9] *+14*1022 Jules from 1975 to 2005*
[10] *Ramanathan and Carmichael, 2008*

seagrass. The organic carbon sequestered and retained in both plant mass and sediments beneath coastal and marine ecosystems is known as blue carbon. The ocean carbon sequestration potential is estimated as more than 80 % of global carbon stock, and half of this is sequestered in ocean sediments. The CO2 gaseous exchange between the ocean and the atmosphere is considered the most important ecosystem service provided by marine ecosystems as it mitigates the emission of GHG. The combination of seagrasses and a low amount of herbivore predation leads to the accumulation of high amounts of carbonaceous organic matter that is stored in marine sediments through detritus. Fish produce carbon in form of carbonates during their lifetime, which are then excreted by osmoregulatory reactions. This flow has a remarkable impact on the inorganic carbon cycle, constituting up to 15 % of all ocean carbonate produced[11].

The combined effects of the natural and anthropic factors change the physical parameters of the atmospheric, land ad aquatic habitats thus directly impacting on the consistency and distribution of the marine and freshwater living resources. Here below we analyse the changes induced in the aquatic ecosystems and biodiversity in Africa.

3. Impacts of Climate change on aquatic ecosystems and biodiversity in Africa

Aquatic ecosystems are significant source of food that comprise white meat, seaweed and other food that account for over 20% of the global human food intake by weight. aquatic wild animals (game), seaweed, other aquatic wild aquatic plants, and cultured animals and plants that account for over 20% of the global human food intake by weight. There indeed an important staple for many coastal communities. The extremely low cost of some these seafoods as the minnow-like tiny pelagic growing in the Great African Lakes (GALs) and artificial basins provide low cost and low carbon footprint sources of protein that contribute to reduce malnutrition and support the development of human organisms in the early stages of life.

The impact of Climate change sums to that of other anthropological factors, as the increased disposal of plastic waste that ends up in the water ways, in disrupting the aquatic biological cycles. Small-sized freshwater and marine pelagic fish play an important role in the nutrition of the poor as an affordable and much needed source of high-quality animal protein and essential amino acids, omega-3 fatty acids, vitamins, minerals, and trace elements, in addition to their superior nutritional profile and benefits. Global wild fish catches have been at or near the limits of what aquatic ecosystems can naturally provide for some time. Meeting the world's demand for fish has thus relied on aquaculture's exponential growth[12].

Within the seas, climate warming is affecting the reproduction of several species. Shifts in latitude of fish species have already been noted. Species that need more cold temperatures migrate poleward of the ocean with warming oceans. The ecological situation could be very different for each species or species group and location. It is therefore important to analyse every specific geographical and ecosystem and related species involved. Climate change has an impact on fisheries production by influencing primary production, food web interactions, and target species life history and distribution. The changes in physical and chemical environment influence changes in primary production, while changes in the food web are also influenced

[11] *E. Entrena-Barbero et al. 2022*
[12] *FAO-FISHSTAT, 2012*

by primary production availability[13].

Climate change is also expected to reduce the water flow of coastal rivers thus impacting on the evolution of wetlands and estuaries. Riparian, endorheic, and floodplain wetlands are already being degraded due to urbanization, infrastructure development and agricultural activities. As their water supply will be depleted, they will suffer increased degradation due to desiccation. Estuaries are particularly vulnerable to warming and drying because they are at the end of river flows and thus the final recipients of increasingly scarce water. Nonetheless, estuaries are highly productive and important fish nurseries. They have specific requirements for fresh water to maintain salinity profiles and flush sediment and contribute significantly to the national economy through fisheries alone. Special care is required to maintain their ecological functioning in the face of increased anthropogenic competition for the water resource in coastal areas.

Overall, the impact of Climate change can be clustered in (a) Chronic climate hazards that refers to the incremental climate changes, such as raise in seawater temperature and acidification, change in rainfall patterns and rise in sea level; and (b) Acute climate hazards that refers to extreme weather events such as drought, heatwaves and extreme rainfall. These include (i) sea level rise, as the most prominent effect; (ii) irregular rainfall patterns and shorter rainy season, which is likely to affect the agricultural sector; (iii) shorter cool season, which could negatively impact coastal and marine ecology; and (iv) more frequent occurrence of extreme weather, including longer drought spells, heat waves and not least also storms and storm surges, all of which are disaster events likely to increase the severity and frequency.

Their combined effects on coastal areas are especially relevant as they impact on the livelihood and welfare of an extensive population of fishers and farmers[14] through: (a) coastal erosion; (b) coastal flooding; (c) inland flooding; (d) saltwater intrusion, affecting both surface and groundwater, and by extension the low-lying paddy rice fields. The highest impact is forecast to affect the fishery and aquaculture producers that operate in the open seas. In fact, the rising sea temperatures and changes in the oceans' water currents and other dynamics, such as acidification and loss of nursery areas, are going to reduce fish populations and prompt the adoption of short-term exploitative practices that further erode the aquatic ecosystems and biodiversity and, in practice, curtail their sources of income.

3.1 Impacts on the marine and freshwater biological processes

The climate change drivers combine their effects on the biological parameters of the aquatic ecosystems. For example, they influence the volumes of fine sediment delivered to river channels, thus changing their shape as well as the direction and speed of the water currents and hence the composition of the bioma. Such feedbacks must be considered when attempting to predict the potential effects of climate change on aquatic ecosystems and biodiversity[15].

Climate change is primarily driven by precipitation, air temperature, and evaporative demand. Its ecological effects on freshwater ecosystems can be classified as effects on water quantity, water quality, habitat, and

[13] *Blanchard et al., 2012*
[14] *L. Canevari's definition, 2021*
[15] *Dallas and Rivers-Moore, 2014*

biological assemblages. Stressors frequently act synergistically, with the interaction of two or more effects, such as the combined effect of reduced run-off and elevated water temperature, exacerbating the effects. Aside from the direct effects caused by rising atmospheric temperatures and changes in the pH of oceanic waters, the rise of CO2 concentration is also likely to directly impact on biological parameters[16]. The CO2 concentration in the atmosphere is correlated to photosynthetic rate and plant growth. For many plants, doubling the current atmospheric CO2 level is likely to increase yields by about 30% on average. Almost all marine plant species are classified as C3-plants, which are expected to respond more vigorously to rising CO2 levels than C4-plants and other plant groups[17]. However, the effects of the increase of the atmospheric CO2 levels on marine, coastal and estuarine flora, where mangroves play an important role, are more difficult to forecast as they depend also on the change of the physical and chemical parameters of the water.

The absorption of anthropogenic CO2 has acidified the ocean's surface layers, with a consistent decrease of 0.02 pH units in the last decades and a total decrease of 0.1 pH units since the pre-industrial era. Although these pH increases appear relatively small, they are associated with a significant decrease in carbonate ion concentrations and represent a significant departure from the geochemical conditions that have prevailed in the global ocean in the recent geological eras.

The increase in the heat content of the ocean is associated to several processes that impact on the aquatic ecosystems and biodiversity. The thermal expansion of the oceans, combined with increased meltwater and discharged ice from terrestrial glaciers and ice sheets, has increased the ocean volume and thus the sea level. Warmer oceans cause more intense storm systems and other changes in the hydrological cycle. Warming in the upper layers of the ocean causes greater stratification of the water column, which reduces mixing in some areas of the ocean and affects nutrient availability and primary production. These changes have increased the size of the Pacific and Atlantic's nutrient-poor ocean deserts by km2 6.6 million.

Ocean acidification alters the metabolism of calcium by the calcifying organisms (molluscs, etc.) thus slowing the growth of their calcium carbonate structures as shellfish and the formation of coral reefs. Such change in the patterns of the aquatic biology along with the change in the other physical parameters results in the reduction of shellfish production and bleaching and increased susceptibility to diseases of coral reefs, that are fundamental component of many marine and coastal ecosystems.

3.2 Impacts on the aquatic ecosystems and biodiversity

Freshwater ecosystems are among the most vulnerable to global climate change. Many GALs have experienced the growth of alien species as the water hyacinth, predatory fishes, pelagic fish that are substituting the local biodiversity. Observational data and climate projections show that climate change has the potential to severely impact freshwater resources, with far-reaching consequences for human societies and ecosystems. Global trends in precipitation, humidity, drought, and run-off indicate that southern Africa is on a downward trend in terms of climate change-related changes. Natural and human activities exacerbate

[16] *Clark, 2006*

[17] *The CO2 fixation pathway of the C4 plants is more efficient than that of the C3 plans under conditions of drought, high temperatures and limited availability of nitrogen and CO2. In practice, their metabolic processes require less molecules of water per atom of carbon fixed, thus limiting the depletion of the soil moisture and ensuring a longer growth in arid climates.*

the impact of Climate change on large marine and freshwater ecosystems[18] where small changes in water and air temperature can cause a delay or anticipate seasonal events such as upwelling currents[19] that create the conditions for the productivity of marine and freshwater organisms.

The empirical evidence about the effects of Climate change on marine ecosystems and their constituent species is increasing[20]. Over the last decades, the waters of the northeast Atlantic have warmed affecting the distributions and relative abundance of fish on local and regional scales. Climate change impacts have led to an increase in the presence of tropical fish species in estuaries along South Africa's southeast coast, and are expected to change precipitation patterns, affecting the quality, rate, magnitude, and timing of freshwater delivery to estuaries, as well as potentially exacerbating existing human modifications to these flows. This pattern is likely to have a significant impact on the structure and functioning of fish communities in South African estuaries[21]. The predicted increase in the frequency of extreme weather events, combined with sea level rise, may result in even the loss of estuarine habitat, affecting estuarine fish communities and having implications for estuary-associated fisheries.

Climate change has serious negative impacts on habitat-forming species such as corals, sea grass, mangroves, salt marsh grasses, and oysters are among the most obvious and profound, with expected loss of these species and habitats. These organisms collectively provide habitat for thousands of other species. Although some resident species may not have absolute requirements for these habitats, many do, and if the habitat is removed, they become extinct. For example, as temperatures rise, mass coral bleaching and mortality are reducing coral richness and density. Notably, coral reefs have a symbiotic relation with the algae and cannot survive without them. The increasing in bleaching of corals with rising water temperatures cause the death of microscopic algae living inside corals, as shown by the greater resilience of the Mauritius reefs that escaped the bleaching that has affected those of Kenya in particularly hot years as it happened in 1998.

A warmer and drier climate is likely to result in a progressive loss of species richness in the internationally recognized biodiversity hotspots, as the Fynbos and Succulent Karoo Biomes. However, projections of the impact of Climate change are limited by high levels of uncertainty due to a lack of understanding of species tolerance limits[22]. These regions are climate change hotspots from a biophysical viewpoint. Its effects are most likely and potentially severe, overlapping and thus constraining the response measures. Parts of West Africa, including the western and eastern Sahel, the region around Lake Victoria, and portions of the large rivers Congo, Niger, Nile, Okavango, and Zambezi, present a combination of relatively high likelihood of negative impacts in all biosphere properties with the possibility that extreme impacts occur. Multiple vulnerabilities also concern the East African rift rivers and lakes.

Species losses, estimated to be as high as 30% under worst-case scenario assumptions, may occur both directly as a result of warming and drying, as well as indirectly as a result of changing fire regimes and interactions with invasive alien species. High altitude marshes, which are home to some highly endemic and isolated species (for example, the ghost frog), are especially vulnerable to desiccation. Overall, the

---

[18] Large marine ecosystems, or LMEs, are areas defined by their unique hydrography, community food webs, bathymetry and productivity.
[19] As the Equatorial and the Benguela current.
[20] For example, the disappearance of tigerfish (Balsites capricus) in the Gulf of Guinea was recorded in the years 1980' - 1990'
[21] James et al., 2013
[22] Tadross et al., 2005

large natural phenomena induced by Climate change have a significant impact on coral reef formation and ecosystem productivity throughout the entire value chain, from the smallest phytoplankton organism to the largest predator fish and mammals at the top of the alimentation pyramid, and, of course, the human being at the very top of the alimentation pyramid.

3.3 Socio-economic impacts

Climate change greatly influences the aquatic ecosystem thus changing all the previous variables including the pattern of production and seasonality and socioeconomics of these aquatic ecosystems. An example of marine aquatic biodiversity hotspot facing significant decline in biodiversity is the GLCME region. This decline is the result of anthropogenic and natural causes. The limitation of reliable data on these changes and insufficient coordination among the countries of the region challenge the effective management and protection of the aquatic organisms.

In Angola the distribution of numerous pelagic species including Sardinella and Trachurus has changed with the rise of the water temperature in recent years. The higher depth of colder water and increased oxygen concentration create problems in the small-scale fishers' communities using dugout canoes without engine. They lack the resources to catch fish moving deeper. The change of fish seasonality also affects artisanal fishers that share this activity with agriculture.

The complementarity of these activities means that their traditional food security patterns are under threat. Just this creates problems for the fishers whose livelihood depends on marine and freshwater natural resources. There are several consequences for the resident fisher as their activities concentrate in the most favourable fishing periods, a situation that can harm the fish reproduction and migration.

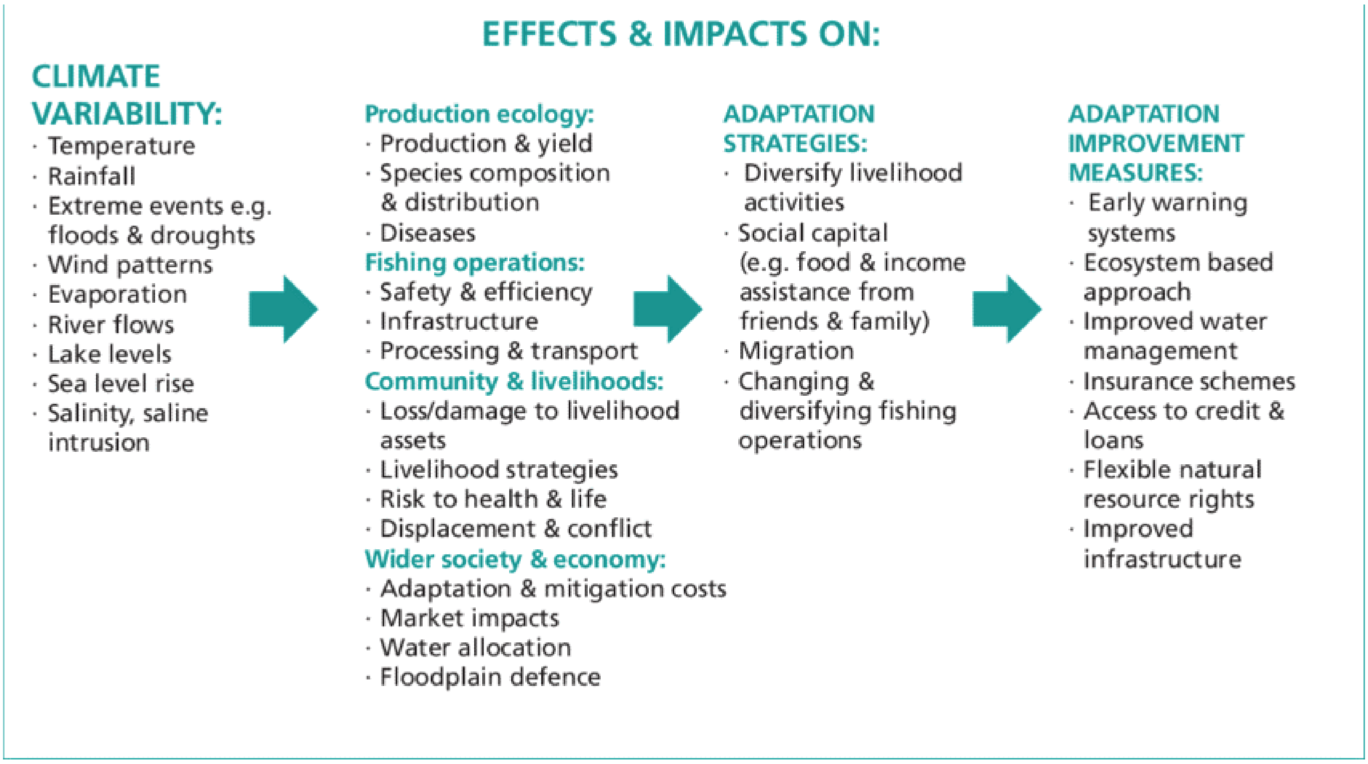
In Mali, the part-time fishers catch only immediately after flood, or they need to travel a long distance to follow the water and the fish.

There are also nomadic fishers but are a small part of the fishers' population as the migrant fishery resources are limited. Some marine artisanal fishers do not fish during high waves periods as the canoes are too small and it is too dangerous to fish in some seasons.

In Sierra Leone, the marine and lagoon fishermen operate inside Bonthe lagoons during the energetic ocean period. Finally, most artisanal fishers can be considered opportunistic as they have other sources of revenue such as agriculture and small fish processing to live on if fish become scarce as it can happen as a consequence of the impact of Climate change induced events.

Climate change directly impact on the livelihoods of the people settled close to the aquatic systems and indirectly on the population that lives in the surrounding regions.

In Lake Chad, the main threats of Climate change are the growing scarcity of freshwater, increased levels of salinity for coastal communities, possibility of worsening health from air pollution concentration (the projected increase in the number of inversions will trap pollutants in the atmosphere close to the ground), heat stress (the number of extremely hot days may increase), and increased flooding (rainfall events may become fewer but heavier).



Source: Alejandro Ramírez, 2018

Figure 1: *Effects and impacts of Climate change on coastal and inland fisheries*

The combination of increasing water scarcity and rising temperatures will also have a regular impact on industries that rely heavily on ecosystem goods and services, such as agriculture, forestry, and fishing. Insurance, banks (via underlying secured assets), transportation and communication infrastructure, and construction are all possible economic sectors likely to suffer from damages and losses resulting from effects of climate change. People whose asset bases (homes, household items, money, pensions, savings, natural assets, social assets [e.g., support networks], and food security) are damaged or destroyed may have the most severe economic consequences. The poor, who are often forced to live in marginal areas, are the first to suffer the consequences due to low capacity and inability to resist effects of climate change. Climate change impacts on people's livelihoods in a variety of, often overlapping ways. Changes in water temperature, precipitation, and oceanographic variables such as wind velocity, wave action, and sea level rise can cause significant ecological and biological changes in marine and freshwater ecosystems and their resident fish populations. Such processes affect the welfare of the people whose livelihoods rely on the aquatic ecosystems. Extreme weather events can also disrupt fishing operations and land-based infrastructure, and fluctuations in fishery production and other natural resources, can have an impact on fishing communities' livelihood strategies and outcomes by inducing seasonal or permanent migrations[23] .

[23] *Badjeck, et al., 2010*

3.4 Impacts on human livelihoods

Climate change is impacting in several ways on the blue economy, with fisheries and aquaculture production that are inextricably linked to the shrinking of the degradation of the aquatic ecosystems. Changes in weather patterns are having dramatic impacts on productivity and in turn having a direct impact on human well-being. The main documented areas of climate change impacts are extreme events such as floods/ droughts and cyclones, which cause damages to aquaculture systems, fishery structures, marine and freshwater ecosystems, erode the settlements of riparian and coastal communities, displace economic activities and destroy equipment and infrastructure; climate impacts in general; and changes in aquaculture-related systems such as mangroves, livelihoods and landscape, and supply chains.

Tropical storms may have a variety of effects on marine aquaculture, including sea-level rise, floods, the progression of the low water line, and coastal erosion. For example, ocean warming has already destroyed parts of the East Africa coral reefs where certain species live and reduced fish stocks. Rising sea levels have caused coastal flooding in Sierra Leone, increasing the vulnerability of coastal populations. The cyclones Ida and Kenneth have caused significant direct and indirect damage to coastal fishing and fish farming communities in Mozambique, in relation to the destruction of fishing boats, fishing gear, boat engines in Sofala province and fishpond and aquaculture equipment in Zambesia province.

In 2001, Africa accounted for more than 20% of the global mangrove extent with the northernmost being found in Mauritania and Egypt and the southernmost mangroves in Angola and South Africa. Potential decline in mangrove forest habitat in coastal zones due to sea level rise, changes in sediment and pollutant loading from river and lake basins, land reclamation for agriculture, or overexploitation can also impact on fisheries by reducing or degrading critical coastal habitats. In 2000, a major flood caused by Tropical Cyclone Eline destroyed about half of the mangrove forest around the estuary of Limpopo River in Mozambique after five weeks of intense rainfall. The construction of the harbour of Durban bay had already destroyed one large mangrove area (ha 440) in South Africa. Mangroves no more exist in ten small KwaZulu-Natal estuaries due of catchment and mouth disturbance. In Cameroon, sea level rise and mangrove areas shrinking are linked through the growth of the sediment deficit. On the contrary, in Central Africa, the mangroves areas are expected to little change or also expand as this region is expected to have an increase in precipitation. Such changes in the coastal ecosystems directly impact on the livelihood of the fishers' communities living there.

Mangrove forest loss has a negative impact on the diversity of benthic invertebrates like tiger prawns and mud crabs, which are exploited or managed for profits worth more than US$ 4 billion per year. Fishers may seek alternative livelihoods in response to declining yields, income, and food security, putting pressure on other sectors or resources such as hunting for wild animals in the nearby game reserves. Indirect effects from different sectors' adaptive strategies may be significant, compounding the effects of direct climate impacts on fish production and dependent livelihoods.

Impact predictions become more difficult and uncertain as a result of these potential interactions. For example, changing precipitation patterns and the increasing frequency of extreme flooding events in river basins may prompt agricultural sector adaptive strategies that focus on the construction of more flood control, drainage, and irrigation schemes. However, these structures are likely to exacerbate the direct negative effects of climate change on fisheries.

Sea-level rise and increased storm and flood frequency are already reported to be having severe impacts on the physical capital of households or entire communities, resulting in not only decreased harvesting capacity but also disruption of public infrastructure and services that support livelihoods. Storm and severe weather events severely damaging productive assets and infrastructure including landing sites, boats, and equipment. Damage to fisherfolks' non-productive physical assets such as housing and community infrastructure (hospitals, schools, sewage system etc.) are also important consequences of extreme climatic events. Physical capital loss, combined with a deteriorating financial asset base, results in reduced fishing capacity, with significant consequences for fishers' livelihoods. This leaves the fishers without a safety net or access to financial resources to deal with the difficult economic situation.

Most fishers do not work in the low catch season and its prolongation due to the impact of climate change can put them out of business. The nomadic fishers move along the coast (e.g., between Mauritania and Senegal) or inland (e.g., in the Niger internal delta in Mali) with their families or in group. At a larger scale the Senegalese fishers migrate in all Atlantic coast of Africa with their canoes with outboard engine and operate as expatriate fishers on industrial vessel all over Africa, North Atlantic and Mediterranean fishery vessels too. Thus, the impact of climate change modifies their calculation of the rentability of fishing change and push them to new fishing areas – with the risk of over-exploitation or at least of practicing not regulated fishing – or to perform their alternative occupations.

The human capital, ranging from maritime safety to food security, is indirectly affected by Climate change. The loss of life can be the most dramatic impact of extreme climatic events on human capital, affecting not only surviving household members but also potentially disrupting economic and social activities and systems outside the immediate family. Safety at sea and injuries are frequently associated with natural disasters linked to climatic stresses such as floods and hurricanes, reducing the physical capabilities of fisherfolk to pursue their livelihoods, as it has happened in Mozambique following the Gombe cyclone. Changes in safety while pursuing fishing activities due to changes in weather and storm events against storminess and strong current posing are operational challenges to fishing. Furthermore, revenue loss can occur as a result of fisheries closures or reductions during weather anomalies.

These impacts are likely to lead to health challenges with increased incidence of exposure to disease causing agents such as bilharzia carrying snails, mosquitos, red tide algae, and others. This increased exposure to health hazards, combined with a health-sector shortage, puts fisherfolk's ability to recover from health impacts and pursue their livelihoods in jeopardy. Indeed, small coastal and riparian rural communities are often vulnerable due to a lack of adequate health systems, potable water, sewage, and drainage.

Changes in food availability and affordability caused by climatic disturbances impose an additional health burden on households and communities. In the event of decreased catches due to climate change events, the risk of malnutrition and under-nutrition for communities that rely heavily on fish for protein, combined with dietary changes (reduction of protein from a fisheries source), are some of the possible consequences. This is especially important for Sub-Saharan African, which rely heavily on fish as a source of animal protein. Reductions in fishery-dependent income can also reduce the ability to purchase store-bought food during times of natural resource scarcity. Similarly, infrastructure damage caused by extreme events or flooding can reduce access to local services.

Climate variability and change can also have an impact on the local institutions that underpin resource management, particularly property rights. It could be argued that changes in abundance patterns and stock displacement in fisheries could lead to conflicts over property rights and resource access at the local level. Conflicts between fishers targeting different species and using different gears in the same fishing grounds, between fishers and fish farmers, and between migrant fisherfolk and local fishers are likely to increase under restricted access conditions and increased climate variability.

Droughts are expected to become more common in Southern Africa, causing greater variability in lake levels and river flows, affecting lakeshore and river floodplain livelihoods that include fishing[24]. Fishers may need to become more mobile and responsive to fishing opportunities as landings vary more spatially and temporally. Such opportunistic behaviour increases displacement and migration, putting strain on communal-level management and resource access systems, while decreasing commitment to stable settlement has an impact on investment in community-level institutions and services.

3.5 Impacts on fishery and aquaculture

About 60% of wild fish stocks are harvested at their maximum sustainable levels while another 33% are overfished. As a result, wild capture production directed to human consumption is 72.5 million MT, with the aquaculture production that has steadily expanded growing 5.8 times by volumes in the last 25 years overcoming the wild capture[25]. Aquaculture's market value per unit is 180% greater than that of wild-capture, reflecting aquaculture's relative focus on higher-value products[26].

The fishery sector (excluding post-harvest activities) is estimated to contribute to about 20 billion dollars or 1% to the African economy. Inland fisheries constitute 55% and marine fisheries 45% by weight of fresh and processed fish, following inland fish[27]. Aquaculture account for 17% of total fish production of the continent. The sale of fresh fish creates 70% of the postharvest value. Post-harvest losses are estimated at 20-25% of fisheries and aquaculture extraction with deterioration of quality accounting for more than 70% of the loss[28].

Africa is a net importer of fishery and aquaculture products in volume terms but a net exporter in value terms, a situation that reflects the higher unit value of exports, which are primarily destined to Europe and other developed markets. African imports have relatively low value, consisting largely of cheaper small pelagic species such as mackerel, which represent an important source of dietary diversification[29]. The

[24] *Badjeck et al., 2010*
[25] *FAO 2018, The state of world fisheries and aquaculture 2018 - meeting the sustainable development goals*
[26] *OECD-FAO 2018. Agricultural Outlook 2018-2027. The nature conservancy 2019. Catalysing private investment in aquaculture sustainable production systems*
[27] *NDF et al. 2019. Climate change and marine fisheries in Africa: assessing vulnerability and strengthening adaptation capacity.*
[28] *Akande and Diei-Ouadi, 2010*
[29] *OECD-FAO 2018. Agricultural Outlook 2018-2027*

Africa population engaged in the fisheries and aquaculture sectors is 10% of the global one.[30] The sale of fresh fish creates the majority of postharvest value (70 percent), followed by artisanal fish processing (20%) and finally by industrial fish processing (10 percent). African aquaculture production is forecasted a steady increase over the next decades due to its flexibility in responding to the market demand, in terms of diversity and quantity of products.

3.5.1 Fisheries

Key effects of Climate change on fisheries include reduced productivity, loss of fishery habitats, displacement of stocks and or species, interference with reproduction and migratory patterns of fish species, and loss of species among others. These impacts on the fisheries have been linked to changes in average water temperature, erratic rainfall variability, and increased occurrence of extreme weather events[31]. Socio-economically, the climate change has been reported to affect coastal physical and technological infrastructure by corroding some, inundating others, and making others exposed with receding waters. The impacts have affected the livelihoods of those dependent water-based enterprises such as fishing.

Warming is diminishing productivity in Lake Tanganyika in East Africa due to the emergence of a regional decrease in wind velocity which has contributed to reduced mixing, reducing deep-water nutrient upwelling and entrainment into sub-surface waters. Primary productivity may have decreased by about 20%, implying a 30% decrease in fish yields. In this case, the regional effects of global Climate change on aquatic ecosystem functions and services can be greater than the impact of local anthropogenic activity or overfishing[32]. In Sub-Saharan African fishers employ a variety of strategies to safeguard their livelihoods and food security in the face of Climate change as the use of new fishing gear, migration, targeting new species, and increasing fishing grounds and time spent fishing are some of the adaptation strategies used by fishers to deal with the effects of climate change.

In West Africa, climate change impacts on fisheries have been projected to be mainly negative with the potential adaptation strategies adopted by both the artisanal and industrial fishing sectors being diverse. For artisanal fishery, generally is a passive adaptation just changing the fishery species target. Large industrial vessels can change place and target species relatively more easily. Overall climate change and over-exploitation have altered the species composition of fisheries catches in West Africa and other freshwater and marine large ecosystem (e.g., the BCLME and Mozambique channel region). In certain areas, the effect of ocean warming on fisheries is indicated by the increase in the dominance of warmer water species in the landing shown by an increase in the Mean Temperature of Catch, in the region. Climate-induced changes in potential catch and species composition, which inherently have similar symptoms as over-exploitation, are expected to have repercussions on the economic and social performance of fisheries. Both artisanal and industrial sectors may adapt to these changes mainly through the expansion of fishing grounds and increased operating costs. Sometimes the warming adapting species can increase the fishery productivity, according to the ecological situation.

---

[30] *FAO 2018. The state of world fisheries and aquaculture 2018 - meeting the sustainable development goals*
[31] *Muringai, et al., 2021*
[32] *O'Reilly et al., 2003*

3.5.2 Aquaculture

The large majority of aquaculture exploitation in Africa consist of freshwater farming of Tilapia and some catfish, followed by crustaceans, shellfish and algae. Industrial aquaculture is a relatively small part of this sector. Small scale aquaculture farmers that practice this activity part-time prevail. They usually lack the resources to cope with the increased production costs and lack of resources to change harvesting practices compared to larger producers. But they are more elastic than the large-scale producers as they share the employment of their family workforce among several activities. Normal constraints to aquaculture production include limited credit, inadequate awareness of climate change, inadequate access to land, inadequate supply of seed improved fish for pond stocking, inadequate supply of fish farming feed and equipment, inappropriate stocking period, and inadequate fish feeding. Aquaculture faces some specific risks induced by Climate change that can appear more dramatic than in the case of fishery due to its more intensive and timebound exploitation of the aquatic resources:

High water temperature during the summer	decreases the pond's overall oxygen content with death of fish especially early morning when the plankton adsorb oxygen.
Low water temperature during the winter	slows the appetite and grow rate and leads to poor growth, and therefore requires the farmer to extend the rearing period
Floods during the rainy season	whose surplus rainwater could cause the ponds to become flooded
Droughts during dry season	make difficult and more expensive of how to replenish water in the ponds
Low oxygen content in ponds during the rainy season	reduces solar light and plankton production of oxygen
Water acidification	Highly influences the ocean chain productivity and the fish reproduction.
Disease and harmful algal bloom, such as bacterial, parasitic, viral, and fungal diseases	are likely to be affected by a changing temperature regime, but in a largely unpredictable manner. What is certain, however, is that when cultured species are exposed to thermal stress conditions, they become more susceptible to diseases and have less reproductive pattern
Sea level, lake level and flood rise	floods the ponds and damages the cage mooring network
Uncertainty of External input supply	decreases fish grow rate: change in sea salinity and other chemical parameters decreases the grow rate as the fish use part of the energy to balance the increased water salinity or can decrease/increase the reproduction attitude; changes in chemical parameters also impact on freshwater ecosystems
Severe climatic events	physically destroy human settlements, production sites and their facilities

3.6 Impacts on the equitable access to aquatic ecosystem services

The role of aquatic ecosystem services in reducing livelihoods vulnerability and in contributing to adaptation is particularly important in the face of the impact of Climate change. Wetlands can improve water quality and help to mitigate drought and flooding. Seagrasses, saltmarsh vegetation, and mangroves can reduce the height and force of waves while also helping to protect against flooding. Furthermore, preserving biodiversity protects genetic libraries and future opportunities for the discovery of valuable biological compounds. Wetlands are critical for several ecosystem services and have a high and long-term capacity for improving water quality if they are not degraded or encroached upon. They are particularly effective at removing nutrients from flowing water, owing to sedimentation, soil adsorption, denitrification (in the soil), and nutrient uptake by vegetation. Coastal wetlands and estuaries particularly play an important role in water quality regulation by capturing and filtering sediments and organic wastes as they travel from inland regions to the ocean. Indeed, wetlands are so effective at removing suspended solids, phosphorus, and nitrogen from wastewater that they have been integrated into wastewater treatment plants in many countries in Africa.

Several field studies and modelling have concluded that the impact of Climate change is directly affecting the aquatic ecosystem services in both saltwater and freshwater systems and thus on the access to the aquatic ecosystem services by vulnerable people, as the artisanal fishers of coastal communities. However, in Africa, these impacts are usually more severe due to lower capacity in mitigating such effects. The effects are felt through limiting ecosystem service supplies, limiting people's access to services, and influencing service quality. Critical Aquatic ecosystem services (AES) in Africa include supply of potable for domestic, agricultural and industrial use; maintenance of the hydrological cycles; natural water supply for production, removal and recycling of wastes; maintenance of atmospheric ambient conditions, among others. The main AES services include (see Annex 3 for more details):

Provisioning Services	that include fish, crustacea, mollusc, algae and other organisms for food and industry but also fibres in the case of coastal and inland waters as well as direct use of freshwater for drinking and water in general for consumptive and no-consumption purposes (cooling, cleaning, etc.)
Biological self-purification	that regulates of local hydrology, and climate are typical examples of these services
Cultural services	that are non-material values include recreation and tourism as well as educational, ethical, and aesthetic values
Supporting services	that include indirect benefits and aspects of long-term stability such as soil formation, nutrient cycling, and carbon sequestration. Expansion of the ocean waters with rise in temperature has led to increased intrusion of saltwater further inland causing freshwater salinisation, reducing access to safe drinking water in coastal areas, interfering with food production, weaking physical and production infrastructure through corrosion, and making ecosystems health and biodiversity in vulnerable.

The rise in temperature to certain threshold can directly impact the services of aquatic ecosystems such as survival of certain contained biodiversity, while physical threshold that can be attained through wind-driven water circulation can lead to significant changes in the biological processes within open saltwater and freshwater bodies tied triggered by the increased primary production. The combination of temperature increase and change in water circulation can lead to a shift in the ecological behaviour of migratory fish.

4. African Aquatic Ecosystems

Nearly all African countries have national agencies in charge of and / or are part of bilateral or regional management body responsible for governance of aquatic resources especially fisheries and water resources. Multi-country mechanisms are being put in place to deal with the challenges of management aquatic resources. Thirty-three African states and 600 million people share the African LMEs that represent natural points of aggregation of the action of the stakeholders of the aquatic resources. The Large Marine Ecosystems (LMEs) and Inland Aquatic Ecosystems (IAE) are endowed with a wealth of both living and non-living resources, ranging from vast oil and gas reserves to abundant fisheries and unrivalled natural beauty. The predicated increase of dry and hot climate across Africa, will affect every aspect of peoples' lives and ecosystem services delivery. Different countries are already facing the impact of Climate change that is producing erratic weather and extreme weather. Key aquatic hotspots threatened by the impact of Climate change are:

Marine ecosystems	the mangroves of Guinea Bissau, the Gambia, Tanzania, Mozambique (erosion and biodiversity loss); Madagascar, Tanzania and Kenya coral reefs (growing bleaching); Mauritius seagrass (degradation and biodiversity loss), Banc d'Arguin off Mauritania coast (migratory bird route degradation)
Freshwater ecosystems	the Madagascar freshwater (endemic fish biodiversity loss); the Zaire River basin (degradation and biodiversity loss), Africa's Great Lakes Tanganyika, Malawi, and Victoria – (cichlid and other fishes biodiversity loss), the Sudd swamp in South Sudan and Zambezi valley (migrating bird routes degradation), the Chad lake basin and Okavango Delta (desertification and biodiversity loss)

Examples of the impact of Climate change on African aquatic hotspots are presented here below.

Senegal	Seawater seeping into underground freshwater aquifers is slowly increasing soil salinity, wreaking havoc on farming communities living near biodiversity-rich wetlands. Siné Saloum delta in Senegal is a biodiversity hotspot and UNESCO world heritage site encompassing wetlands, lakes, lagoons, and marshes, as well as sandy coasts and dunes, terrestrial savannah areas, and dry, open forest. It is home to endemic species and plays an important role in flood control and regulating the distribution of rainwater for the local people and wildlife. Drought, climate change, and uncontrolled logging of mangrove forests are increasing the salinity of the ground threatening the livelihoods of the people that live there. Over the last decades, the water extracted from the wells has gradually turned salty.
Egypt	This country faces significant challenges as a result of its limited water resources and rapidly growing population. Climate change is expected to raise even more concerns across the country, with serious environmental, social, and economic consequences. Where transboundary water agreement commitments exist, Egypt's current water availability is insufficient to meet the required water demand for agriculture, industry, domestic use, and others. Furthermore, concerns for the Egypt's Nile water share is linked to the economic development of the upper basin. It is worth noting that Climate change can present both challenges and opportunities for the countries that partake the waters of the Nile River Basin to collaborate to reduce the impact of Climate change.

Uganda	Climate variability and change since the 1970' have been accompanied by changes in the hydrology and water balance of inland aquatic systems. Small shallow lakes like Kawi in eastern Uganda and Wamala in central Uganda are extremely vulnerable to the effects of climate change. In the last decades, the average air temperature around Lake Wamala has increased as well as rainfall. In case of Lake Kawi, the air temperature has increased and rainfall decreased. Fishers from Lake Kawi reported that the lakeshore has receded. In practice, the precipitations are no longer sufficient to maintain normal lake water levels and lake surface area as temperature and wind speed, which increase evaporation, continue to rise. This change has serious consequences for lake productivity processes. Presently, the Lake Victoria has an higher level than normal despite the climate change.
Kenya	Climate change affects coral reefs by altering long-term mean environmental conditions, inter-annual cycles, seasonality, and the frequency of extreme climate events. Coral communities in Kenya (as well as in the Seychelles and Maldives islands) have been assessed to be generally less rich and diverse, with fewer bleaching-tolerant coral taxa, with evidence of continued declines in the abundance of temperature-sensitive taxa and community change. The rise in temperature has been found to be the leading cause of bleaching of corals in Kenya waters.
Mozambique	This country shorelines host large mangroves ecosystems that are mostly found in sheltered shorelines and river estuaries. Mangrove concentrations are highest in central Mozambique, in river deltas and estuaries. Overexploitation for construction and firewood and clearing for solar salt production are major threats to mangroves, along with pollution and expansion of human settlements. Although evidence of the impact of Climate change on mangrove ecosystems are reported, anthropic activities are the leading cause for degradation of mangroves in Mozambique.
South Africa	Some parts of this country will face more severe water shortages, other parts, especially those that are currently water stressed, are predicted to face increased occurrence of extreme flooding events Several small towns in South Africa's Northern and Eastern Cape provinces have been threatened by total water supply failures, and livestock farmers have faced financial ruin as a result of multi-year droughts. Heatwaves and late rains have caused local supply failures in other parts of the country. Although the dams that supply most of the major urban areas are still at safe levels, there are growing concerns that the country is about to enter a major drought. Recent devastating floods in Durban, combined with low rainfall in the Cape Town region, add to the contradictory events. Weather forecasters appear to be incapable of making accurate predictions more than a few weeks in advance. The problems encountered differ greatly from place to place.
Mauritius	The degradation of seagrasses in Mauritius, as in the rest of the WIO has been assessed to be due to a range of causes ranging from local physical disturbance to the impact of Climate change. These causes include deliberate clearance for tourism-related activity, anchor damage, pollution, and sediment inflows, pollution, and sediment inflows, sea urchin herbivory, and climate related extreme weather events. The assessment also established that although seagrasses appear to be able to tolerate gradual changes in climatic conditions, Climate change induced extreme events such as heat waves or severe storms may pose a significant threat[33].
Seychelles	Climate change-induced shoaling of the mixed layer in the Western Indian Ocean (WIO)[34] between Seychelles, Madagascar and the Mozambique channel may result in significant decreases in surface and subsurface temperatures in the WIO between Seychelles, Madagascar, and the Mozambique Channel. This would imply that they would be less vulnerable to warm seawater temperature anomalies.

[33] *Short et al., 2016*

[34] *Evidence indicates that the WIO is warming as a result of climate change*

4.1 The Large marine ecosystems

The Large marine ecosystems (LME) are regions that include coastal areas from river basins and estuaries to the seawater boundaries of the continental shelves and the outer margins of the ocean current systems. Their productivity is higher than that of the deep oceans: the world sixty-six LME produce about 80% of the global annual marine fishery biomass[35]. The African LME play an important role in the environmental balance and fisheries of the continent. The Canary and Benguela currents define important ecosystems that move cool water towards the equator and generate permanent areas of upwelling off the Southern coast of Mauritania, Senegal, the Democratic Republic of the Congo, Angola and Namibia. The Benguela Current also causes strong upwelling along the southern coast in winter (August), with weaker upwelling in summer (November to February). These areas are highly productive fishing grounds, particularly along the coast of southern Angola and Namibia. The cool waters from these two currents preclude formation of any true coral reefs or extensive seagrasses along the west coast. The Somalia Coastal Current has an annually reversing monsoon cycle: from November to March, the northeast monsoon generates a fast, southward flowing current, resulting in nutrient-rich upwelling in Somalia and northern Kenya. The Agulhas current is responsible for the southward larval dispersal of a variety of fish species along the South-East coast of the continent[36].

The Benguela Current Large Marine Ecosystem (BCLME) and Canary Current Large Marine Ecosystem (CCLME) are ranked second and third in the world in terms of primary productivity after the Humboldt Current Large Marine Ecosystem (HCLME) that crosses the Pacific Ocean. The Guinea Current Large Marine Ecosystem (GCLME) has some of the world's largest mangrove vegetation[37] while the coastal areas of the Agulhas Current Large Marine Ecosystem (ACLME) and Somali Coastal Current Large Marine Ecosystem (ACCLME) are renowned for their beauty, diversity, and sensitivity, and they support a thriving tourist industry[38] The total economic value of environmental goods and services produced by African LMEs is estimated to be US$139 billion per year: the ACLME and SCCLME contribute US$22 billion, while BCLME contributes $54.3 billion, CCLME contributes US$ 11.7 billion, and GCLME contributes US$ 51 billion annually[39]. While the total production of capture fisheries was about 6 million tonnes in 2013. With the establishment of the LME Commissions that spearhead multi-country collaboration, the African countries are adopting joint approaches in the fields of regional policies and institutional harmonization, science and capacity building through the implementation of science projects, the conduct of environmental monitoring and offshore research cruises; economic valuation of the goods and services in the respective LMEs and training scientists and technicians on the key transboundary concerns.

The BCLME is one of the first LME initiatives that were established and represents the interests of three countries of Angola, Namibia, and South Africa. It focuses on traditional approaches to fisheries management, focusing on target species, and management has been largely centralized. Although management capability varies across countries, scientific capacity has been generally good, and scientific advice plays an important role in management decisions. All have sufficient capacity to ensure sustainable fisheries, but there are skill

[35] National Oceanic and Atmospheric Administration.
[36] National Oceanic and Atmospheric Administration.
[37] FAO, 2007, UNEP, 2007
[38] Lutjeharms and Bornman, 2010
[39] Hamukuaya, 2011

shortages in some areas.

In the mid-1990s, the GCLME program pioneered the application of the ecosystem approach in the coastal waters of six African countries stretching from Côte d'Ivoire to Cameroon. Its activities were expanded to include the sixteen coastal states that share the GCLME, stretching from Guinea Bissau to Angola. The application of ecosystem approach to ocean governance was introduced in the BCLME in 2002, in the ACLME and SCCLME in 2008 and in the CCLME in 2010.

Figure 2: *The African Large Marine Ecosystems*

Map numbers in parentheses are those of the World Map of LME. 27: Canary Current LME), 28 Guinea Current LME, 29: Benguela Current LME, 30: Agulhas Current and 31: Somali Coastal Current LME. Source: Satia, 2016.

Examples of the impacts of Climate change by Large marine ecosystems are provided here below:

Canary Current Large Marine Ecosystem (CCLME)	The CCLME along the Northwest African coast is a highly productive ecosystem with significant socioeconomic impact because it supports a large and diverse marine population. Because the CCLME's high productivity is primarily driven by trade winds that flow parallel to the coastline, the actual global warming scenario may affect the CCLME by warming the upper ocean waters, but also by intensifying upwelling and thus cooling the upper ocean waters. It is expected that the increased GHG emissions will increase the temperature gradient between land and ocean, intensifying the continental-oceanic pressure gradient and, as a result, increasing the alongshore wind stress that forces coastal upwelling. Upwelling favourable wind intensification could benefit marine populations by increasing nutrient supply to the euphotic layer, but it could also have a negative impact by transporting plankton out of the shelf or interfering with trophic interactions. However, the overall, the CCLME region's yearly averaged sub surface temperature is warming. the Madagascar freshwater (endemic fish biodiversity loss); the Zaire River basin (degradation and biodiversity loss), Africa's Great Lakes Tanganyika, Malawi, and Victoria – (cichlid and other fishes biodiversity loss), the Sudd swamp in South Sudan and Zambezi valley (migrating bird routes degradation), the Chad lake basin and Okavango Delta (desertification and biodiversity loss)
Guinea Current Large Marine Ecosystem (GCLME)	The GCLME stretches from Bissagos islands in Guinea Bissau to Cabinda in Angola. It contains some of the world's major coastal upwelling sub-ecosystems and is an important centre of marine biodiversity and marine food production. The GCLME is distinguished by distinctive bathymetry, hydrography, chemistry, and trophodynamics that are being impacted by overfishing, pollution from domestic and industrial sources as well as the increase of the atmospheric temperature. The poorly planned and managed coastal and near-shore activities contribute to the depletion of the rich fisheries resources and degradation of vulnerable coastal and offshore habitats, threatening the economies, productivity, and health of the population.
Benguela Current Large Marine Ecosystem (BCLME)	There is evidence of a general increase in upwelling favourable winds throughout the system during the summer, but little evidence that this has resulted in large-scale changes in primary production. There is also some evidence of an increase in the frequency of anomalous intrusions of warm, nutrient and oxygen poor water from southern Angola, which can severely impact marine life in northern Benguela, but it is unclear whether this trend is continuing. Copepod abundance has increased by at least an order of magnitude in both the northern and southern Benguela over the last decades, accompanied by a change in size structure, possibly due to a change in predation pressure rather than a change in primary production. A significant eastward shift in sardine and anchovy distribution in the southern Benguela in the early 2000' appears to be reversing. The impact of Agulhas current water leakage into the Southeast Atlantic appears to be a particularly important question. Recent evidence suggests that anthropogenic global warming is increasing leakage, which could have a significant impact on the BCLME's upwelling regime[40].
Agulhas and Somali Coastal Current Large Marine Ecosystem	This is a combination of two LMEs, the Agulhas Current Large Marine Ecosystem (ACLME) and the Somali Coastal Current Large Marine Ecosystem (SCCLME). The ACLME and the SCC LME are both part of the WIO. Evidence exists that climate change and/or variability are currently impacting ocean-atmosphere dynamics and the operation of the ACLME and SCCLME by influencing the atmospheric and oceanic circulation in the WIO region. As a result, sea surface is warming and subsequent air-sea heat flux impacts on the SCCLME water flow and broadens and weakens the Agulhas Current, with potential negative implications for Agulhas leakage.

[40] *Hampton and Willemse, 2012*

Red sea	This sea harbours one of the world's most diverse marine ecosystems, but it is fragile and vulnerable to oceanic warming. The Red Sea temperature increase is one of the highest recorded in the world. Such change is steadily rising sub-superficial temperatures are already driving dramatic changes in the growth of an important reef-building coral in the central Red Sea and, in some areas, have reduced calcification and consequently produced coral bleaching (zooxanthellae loss) and mortality. Because oceanic warming may have a direct or indirect impact on marine entities and ecosystems, there is a need to evaluate additional available past biological data (e.g., coral, fisheries, plankton) for potential responses to the new thermal state, as well as closely monitor the relatively unexplored and fragile Red Sea ecosystem.
Mediterranean sea	The sea temperatures recorded in the Mediterranean over the 2015-2019 period were the highest since recording began in 1982. Of almost there is evidence of the widespread mortality of marine life, tightly linked to periods of extreme heat. Marine environments with a depth of 0–25 metres are subject to particularly intense warming and are home to some of the most biodiverse ecosystems in the Mediterranean, formed by coral-like organisms. More than two-thirds of the deaths of marine organisms occurring on the hard sea floor were in the shallowest waters[41]. Change in the water temperature is contributing to the spread of alien invasive species. The Suez canal is a major entry point of aliens marine species in the Mediterranean where there is an high density of mariculture and shipping activities. The alien thermophilic species as like barracuda (Sphyraena viridensis) easily adapt to the growing sub-superficial temperatures of this sea. On the other hand, the Mediterranean species that need more cold water try to go north wide and will have a limiting spawning as soon the Mediterranean water temperature is rising. Consequently, endemic fish species has lost and are projected to lose suitable habitat in coastal Mediterranean due to climate changes. Anthropogenic activities and climate change are the main contributors of alien species invasions, including harmful algal blooms, mostly phytoplankton blooms, which have detrimental environmental and socioeconomic impacts. Their increase in frequency, intensity, and distribution is associated to eutrophication, habitat modification, and human-mediated introduction of no indigenous species. They form high-biomass or toxic proliferations of cells or blooms that modify the aquatic ecosystems fauna and flora as well as humans being exposed to water-borne toxins or by toxic seafood consumption. Also associated to the increase of surface water warming anomalies is the growing frequency of the coalescence of marine snow into the formation of marine mucilage. These contain a large microbial biodiversity and host pathogenic species that were absent in surrounding seawater and characterize aquatic systems with altered environmental conditions. The climate induced acidification of this sea is also negatively impacting on the coralline algae due to the solubility of their high-magnesium calcine skeleton.

The Global Environmental Facility (GEF) / World Bank (WB) are the primary sources of funding for the LME programs, as are appropriations of general tax revenues by coastal governments and contributions from donors to specific LMEs. These programs are implemented in collaboration with the FAO, UNDP, UNEP and UNIDO agencies of the United Nations.

4.2 The Inland aquatic ecosystems

The Internal aquatic ecosystems (IAE) wholly contained in a particular country are managed through national agencies while those that are transboundary are largely governed through regional management bodies or under agreed regional or subregional protocols. Examples of those managed regionally include Lake Victoria, managed under the Lake Victoria Basin Commission and Lake Victoria Fisheries Organization;

[41] *J. Spicer, 2022.*

the Zambezi River Commission; the Lake Tanganyika Authority; the Nile Basin Initiative; the Lake Chad Commission; and others. Regional bodies were set up to harmonize management measures and regulate socioeconomic and development activities of member states. These national and regional management systems for aquatic ecosystems are funded by appropriations of general tax revenues by concerned governments and contributions from donors to specific water bodies. Most often the management is carried out with technical assistance and in collaboration with regional economic bodies/centres, and international development agencies especially those of United Nations agencies.

Examples of the impacts of Climate change by freshwater ecosystems are provided here below:

Niger River Basin (NRB) and Volta River Basin (VRB)	These are the two largest river basins in West Africa. They play important roles in the regional socioeconomic sustainability. Any negative impact of climatic change on the water systems will take a toll on the livelihoods of the people. The Inner Niger Delta is home to a million people, including fishers, livestock breeders, and farmers who rely on the water and soil. Inflows of water to the delta have decreased with climate change and dam construction has modified the water flow and reduced the inundated areas thus negatively affecting the livelihood by nomadic fishery and livestock population. There is less rainfall and less water in the delta, thus a smaller surface area flooded. Drought intensity and frequency are expected to increase over NRB, and the Middle Sub-basin is expected to be the most affected in the future, while the Upper Niger is expected to be the least affected. The VRB spans across Ghana, Burkina Faso Bénin, Côte d'Ivoire, Mali, and Togo. Agriculture accounts for 40% of the basin's economic activity. Researchers and policymakers have been looking into switching to groundwater or other types of irrigation as rains become less reliable in a changing climate. Hydroelectric power plants, on the other hand, are thought to be crucial to sustaining industrial development and expanding economic opportunities. Climate models predict the temperatures in the Volta Basin will rise by up to 3.6oC over the next century, potentially increasing water loss due to evaporation. They also predict a 20% decrease in average annual rainfall. Water flows in the VRB could fall by 24% by 2050 and by 45% by 2100, depriving the basin of water that countries rely on to power turbines and feed farms. The dams built to produce electricity can create problems on the environmental balance of the region if badly managed.

Congo River Basin (CRB)	This basin spans between Cameroon, the Central African Republic, the Democratic Republic of the Congo, the Republic of the Congo, Equatorial Guinea, and Gabon. The region contains the world's second largest tropical rainforest, as well as rivers, swamps, and savannas teeming with wildlife. The area is home to thousands of bird species, 700 species of fish, 400 species of mammal, and 10,000 species of tropical plants, 80 percent of which are indigenous to the region. The basin stretches from the Atlantic Ocean in the West to the Nile-Congo watershed in the East, and roughly the same distance from the north to the interior plateau of Angola, beginning at the Lake Chad watershed and reaching south to Angola. The CRB has two seasons: rainy season from March to November and dry season from December to February. The CRB is critical both globally and locally. Throughout the basin, approximately 75 million people from nearly 150 different ethnic groups live and rely on the forest for food, fresh water, and shelter. Natural resources found in the ecosystem include diamonds, gold, cobalt, copper, timber, petroleum, and uranium. However, the extraction of these resources places enormous strain on the Congo Basin and its inhabitants. Under high emissions scenarios, average temperatures in the region are expected to rise by 2.5°C by 2050, rising by 3-5°C by 2100[42]. Furthermore, regions of the Congo Basin with semi-arid climates are expected to see much higher average temperature increases than tropical climates. The amounts and distribution of the CRB precipitation are also expected to change. The region's precipitation is expected to increase by 20-30% by 2100. Most of the increase is expected to occur in the central and western parts of the Basin, with projections in other parts of the region being more uncertain. Precipitation is also expected to change seasonally as the dry season becomes drier and the wet season becomes wetter. Furthermore, projections for changes in river discharge volume due to climate change vary across the Congo Basin region, but they generally correspond to precipitation projections. Volumes of discharge are expected to increase during the wet season while decreasing during the dry season. The current and projected changes in temperature and precipitation will have a significant impact on the livelihoods of CRB residents. The vast majority of people in this region live off of natural resources and agricultural cultivation. Erratic and extreme weather events are already posing challenges to the traditional crop-growing practises of these populations. Many crop production factors will change as temperatures rise, including reproductive viability and plant disease dynamics. Farmers will be more vulnerable to early/late rains and flooding as seasons become less defined. Given its rich biodiversity, the effects of climate change on vegetation and soil in the Congo Basin are also a source of concern. According to climate change simulations and models, the CBR will see an increase in vegetative production on average as the effects progress through the first half of the twenty-first century. Vegetative production, on the other hand, is expected to decline as weather becomes more erratic and temperatures rise. It should be noted that most of the projected increase is due to higher levels of atmospheric CO2 and the CO2-fertilisation effect. Soil organic matter is expected to increase in most areas of the Congo Basin due to increased vegetation. However, increasing temperatures are expected to cause a steep decline in soil organic matter stocks after 2050. Furthermore, advanced stages of the effects of climate change on these forests are expected to result in decreased vegetative productivity. The decline of these critical forests will put pressure on the habitats of local species such as bonobos, chimps, mountain gorillas, and forest elephants. Overcrowding and a decline in resource availability will almost certainly be exacerbated as climate change progresses, threatening the survival of these wild species.

[42] *UNEP-CMS, 2022*

Great African Lakes (GAL) region	This region includes the Victoria, Tanganyika, Malawi, Turkana, Albert, Kivu, Edward, etc. lakes. The lakes are spread across ten countries: the Democratic Republic of the Congo, Burundi, Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Tanzania, Uganda, and Zambia. These lakes contain approximately 25% of the world's unfrozen freshwater. Temperatures in the GAL region have already risen as a result of climate change. This has an impact on lake processes as well as fish yields. As regards to rainfall, taken together, the models predict more intense wet seasons, increased intensity of high rainfall events, and less severe droughts[43], but significant increases are not expected to occur for several decades. Significant seasonality changes are evident in model results focused on the Albertine Rift in the Lake Tanganyika and Malawi / Niassa / Nyasa basins, which project the majority of the annual rainfall increase to occur as a lengthening of the end-of-year short rains[44]. The most recent forecasts are consistent with the multi-model projections elaborated by the International Panel on Climate Change (IPCC)[45]: precipitation intensity will increase as temperatures rise due to the exponential increase in the atmosphere's water vapor carrying capacity as a function of temperature; and precipitation seasonality will shift, particularly in the southern basins, with significant increases in late-year rainfall.
Lake Chad Basin (LCB)	This basin coves about 8% of the African continent surface. Its surface has decreased from 25,000 km2 in 1960 to 4,800 km2 in 2014. The impact of climate change explains half of this reduction in surface[46]. The other half is due to increased use of tributary inflows into Lake Chad for irrigation and meeting the needs of a constantly growing population, particularly in Nigeria, Cameroon, and Chad. The multi-ethnic population of the Lake Chad Basin has grown from 17 million in 2005 to around 38 million today. A changing climate, specifically more variable rainfall, has caused the lake's water levels to fluctuate more unpredictably. Future annual rains are projected to increase 2.5%-5% by 2050 according to most climatic projection models. Despite the increase in projected annual precipitation in the LCB, most models project a decrease of the monsoon season precipitation[47].
Okavango Internal Delta (OID)	This delta, located in Northern Botswana, is one of the world's inland deltas and also one of the world’s richest biodiversity hotspots with remarkable wetland flora and fauna, has an estimated surface area of 160 km2. The basin is vulnerable to the effects of climate change and local development and has seen the active cells shrinking to 90,000 km2 in the recent decades[48]. Simulations of the impact of Climate change predict that the OID will dry up, resulting in deeper groundwater levels and lower inundation frequencies. These effects are expected to be far greater than the side effects of economic developments, as the deforestation along the Okavango river valley that is already increasing the inflow into the delta, mitigating the local effects of Climate change. The challenge is that the area covered by vegetation types that require relatively wet conditions is expected to decrease as hydrology changes due to climate change. Changes in groundwater level will affect the distribution of ecoregions since the groundwater depth defines vegetation types; and that the greatest change in vegetation is expected in the delta itself. This is because logically it is in the delta where the greatest changes in groundwater depth are projected. As such, a shift from vegetation types that require and tolerate water to drought-tolerant vegetation types is expected. As there are fewer ecoregions that prefer dryness to wetness, and that because drought tolerant ecoregions are already more prevalent in the OID, the drying of the delta will cause significant biodiversity loss[49]. Socioeconomically, Climate change is projected to have a probable negative impact on tourism as well as livelihood opportunities for the people’s residing in the basin while the prevalence of rain-fed agriculture in most of the region will make its food systems highly sensitive and vulnerable to the changing rainfall patterns caused by climate change.

[43] *Shongwe et al., 2011*
[44] *Seimon and Picton Phillipps, 2012*
[45] *IPCC, 2007*
[46] *UN Environment Programme*
[47] *Nkiaka et al., 2018*
[48] *Burg, 2007*
[49] *Burg, 2007*

Nile River Basin (NRB)	The Nile river with its delta and swamp areas is the source of livelihoods to over 300 million people. The negative impact of Climate change on the availability and quality of water in the NRB is largely recognised[50]. The flow of the basin is estimated to be reduced in the coming decades due to the increasing withdrawal of water for irrigation, evapotranspiration, and declining precipitation in response to effects of climate change[51]. In the Blue Nile, the streamflow is projected to decline after 2050 because of declining rainfall and increased evaporation. The outflow from Lake Tana is expected to decline by 2080[52] which in turn reduces the streamflow from the main river as Lake Tana is the main source of water for the whole basin. Climate change has a significant impact on the basin's water resources system and hydrology. Extreme hydrological events such as floods and droughts are projected to be common in the basin on a local and basin wide scale[53]. Because all natural and socioeconomic systems rely on water, the effects of climate change on water resources will be extremely significant[54]. Climate change is project to have a direct impact on hydrology of the RNB by altering the pattern and variation of the hydrologic cycle, resulting in increased and prolonged droughts and floods. It also has an indirect impact on energy, food, and agricultural production. This impact may be exacerbated on transboundary rivers such as the Blue Nile River, where riparian countries are increasingly competing for water. The rainfall in the Nile basin is projected to become highly seasonal and increasingly erratic while the construction of new dams is expected to stabilise the water flow and reduce the floods and afflux of lime on downriver inundated land[55].
Other deltas and swamp areas	The deltas are highly vulnerable to the impact of climate change, particularly sea-level rise and changes in runoff, as well as being subject to stresses imposed by human modification of catchment and delta plain land use. Most deltas are already undergoing natural subsidence that results in accelerated rates of relative sea-level rise above the global average. The effects of water extraction and diversion and declining sediment inputs due to the entrapment in dams sum to the impact of Climate change in disrupting the livelihood of the population. For example, the agro-ecological production systems of the Tana river delta in Kenya have been adapted to its flooding regime with farming, fishery, and livestock-rearing as the main sources of wealth, each blooming at appropriate times of the seasonal flooding events. The decrease in water availability due to Climate change is affecting the agricultural production since the 1990' . The Senegal River delta is an example of a low capacity for adaptation efforts. Changes in temperature, relative humidity, precipitation, and evaporation, combined with the current water resource allocation pattern to agriculture, have accelerated land degradation and increased water salinity, thus affecting the access of the population to underground freshwater.

[50] *Gebre and Ludwig, 2015*
[51] *McCartney et al., 2013*
[52] *Abdo et al., 2009*
[53] *Taye et al., 2015*
[54] *Mekonnen and Disse, 2018*
[55] *Barhane et al., 2014*

5. Mapping of ongoing initiatives and of ecosystem-based solutions for mitigating climate change

5.1 Areas of intervention of the ongoing projects

The information gathered on the projects that concern the aquatic marine and freshwater resources in Africa concern 70 current projects in the African region (see Annex 4). The Southern, Eastern and Western African regions are those with the highest number of the mapped aquatic ecosystems and biodiversity projects (over 20 each), followed by Indian Ocean and Northern African region (about 10 each) and the Central African region scores the lowest number (5 of which only one is not a part of a continental actions)[56].

Table 2: *Marine and freshwater projects in Africa by priority topics*

Category	Number of projects			% inside the OC and MC groups		
	OC	MC	Total	OC	MC	Total
Ecosystems and biodiversity	19	32	51	66	78	73
Fishery and aquaculture	19	29	48	66	71	69
Climate change smart, resilient and sustainable solutions	10	11	21	34	27	30
Policies and governance	20	30	59	69	73	71
Research	1	5	6	3	12	9
Freshwater	3	6	9	28	22	24
Total	29	41	70			
%	37	63	100	100	100	100

OC = One country. MC = Multi-country. Source: elaboration of the Annex 4 data

The 51 projects that prioritise aquatic ecosystems and biodiversity also address policy and governance (42 projects or 82%), fishery and aquaculture (30 or 59%), climate change, smart, resilient and sustainable solutions (14 or 27%), research (5 or 10%), freshwater (9 or 18%); while 20 of these projects (39%) target one country, 31 are multi-country (61%). The preferred strategy of these project is to jointly address aquatic ecosystems and biodiversity policies, fishery and aquaculture and governance (24 projects or 47%). Overall, the mapping of the current projects shows that the aquatic ecosystems and biodiversity is a central element in the management of the aquatic resource and that it is usually articulated in relation to its main economic use (fishery and aquaculture) in the frame of systemic approaches that tackle the policies and governance factors that are critical for its management. The importance of the ecosystem and biodiversity dimension is crosscutting the sector approach as it is considered a critical element of the sustainable, resilient and smart use of the aquatic resources.

[56] *The EU-funded NaturAfrica programme is replacing the Ecosystèmes Forestiers d'Afrique Centrale (ECOFAC, 1992-2022) programme.*

Table 3: *Marine and freshwater ecosystem and biodiversity projects in Africa by priority topics*

Category	Number of projects			% inside the OC and MC groups		
	OC	MC	Total	OC	MC	Total
Fishery and aquaculture	11	19	30	55	61	59
Climate change smart, resilient and sustainable solutions	7	7	14	35	23	27
Policies and governance	18	24	42	90	77	82
Research	1	4	5	5	13	10
Freshwater	3	6	9	15	19	18
Total	20	31	51			
%	39	61	100	100	100	100

OC = One country. MC = Multi-country. Source: elaboration of the Annex 4 data

A further important element of the mapping concern the prevailing multi-country dimension of the identified project. Of course, this also depends on the sources examined as the recording / indexing of the national and especially sub-national projects is less systematic in the examined bibliography, that is mostly covering internationally funded actions. Notwithstanding such bias, it can be considered that the negotiation between the funding institutions and African countries is strongly influenced by the concerns on the degradation of the aquatic ecosystems and biodiversity. At the same time, the commitment to research and to developing and adopting innovative solutions is less relevant, a fact that show that most initiatives represent the initial stages of a behavioural change that is at odds in developing and adopting new approaches, knowledge and tools. The projects that concern the freshwater aquatic resource are well represented in the current projects concerning ecosystems and biodiversity, as such or as part of the broader scope of the whole aquatic resource. Overall, the mapping exercise reveals that all African countries are individually or as part of multi-country interventions addressing the critical issue of the conservation, sustainable use and equitable access to the aquatic resources.A more in-depth analysis of the identified project shows that most of them link the aquatic ecosystems and biodiversity management to the socio-economic welfare the life of the local population by proposing the sustainable exploitation of the coastal, marine and freshwater resources as an approach to diversify the sources of revenues and ensure the delivery of environmental services.

The widespread concern for the strengthening of policies, regulations and governance of the ecosystems confirms that the proposed solutions are framed in broader visions linked to the spatial planning, preservation of the fishery and aquaculture production potential and socio-economic development trends. The global nature of some of these initiatives shows that international donors are concerned about the contribution of Africa to the management of the aquatic ecosystems and biodiversity worldwide. The overall picture emerging from the mapping is of the search for solutions to the socio-economic development of the population depending on the aquatic resource for its livelihood that are rooted on its conservation and that try to ensure its compatibility with that of the broader context – the interests of external actors for whom the aquatic resource is not a vital element and that are less concerned with its spoiling -.

5.2 Complementarities and gaps at the national and regional level

The fields of action of the regional and national interventions identified are quite similar. The major differences concern the prevalence of research projects that concern aquatic ecosystems and biodiversity and the larger role played by the promotion of sustainable, resilient and smart solutions in the actions concerning only one country. It should be noted that different kinds of multi-country interventions are being implemented. Some concern regional or continental groups of states, but there are also numerous actions targeting the peculiar problems of small groups of countries, as those related to the Large marine ecosystems or that share interconnected coastal ecosystems (marine and freshwater alike). The multi-country projects include mechanisms that relate the national to the regional strategies and interventions. In practice, they adopt multi-level approaches that are make possible the sharing of experience and customisation of solutions. Indeed, a gap felt by most stakeholders concern the gaps in knowledge on the aquatic ecosystems and biodiversity.

Many development projects are designed on the basis of a circumscribed study or general fact-finding that is expected to be completed or refined during the implementation. indeed, such data are appropriate to perform short term interventions but lack the detail and reliability needed to frame long term solutions. Another critical element emerging from the mapping is that projects that are complementary are seldom connected. Thus, they often address the same problems at different scale or in different countries and sub-regions, without make use of the reciprocal experience or without joining forces to converge in the achievement of the common goals or in the assistance to the same beneficiaries. This situation is made clear by the existence of sub-regional initiatives that mostly concern the same countries and deal with the same topics and that have minimal operational connections. Such weakness is reflected in the fact that most current projects include a component on policies and governance that overlap in filling such structural gaps. Thus, the mapping exercise has identified as main gaps spotted at the regional and national level: the insufficient development of new knowledge, the weak linkages among initiatives with overlapping scope and the difficulty to transform the experience of previous initiatives in solutions that are customised to the exigencies of the people whose livelihood depends on the aquatic ecosystems and biodiversity.

These weaknesses have produced the concentration of projects in fields that are preliminary to the development and adaptation of sustainable, resilient and smart solutions for the preservation, sustainable use and equitable access to the aquatic ecosystems and biodiversity. At the same time, the numerous regional and subregional projects show the growing consciousness of the stakeholders for the need to join forces in addressing the challenges that face the management of the African aquatic resources. While many ongoing initiatives produce new knowledge and skills, these are tested at small scale in absence of structured dissemination approach to make the best use of the scarce resources devoted to knowledge management.

5.3 National climate adaptation plans

The African governments have elaborated and adopted national adaptation strategies and plans to contain the impact of Climate change on their environment, society and economy. For example, the Egyptian

National Adaptation Strategy (2011) aims to increase this country flexibility in dealing with the impact of Climate change. This plan expects to raise climate finance through multilateral, bilateral, public, and private initiatives that supplement the locally raised resources. Benin is drafting the National adaptation plan that prioritises the build-up of the institutional capacities to integrate Climate change adaptation into the main fields of the national development strategy. For example, the Mozambique National adaptation plan focuses on the strengthening of the early warning systems and the capacity to prepare and respond to climate risks; improving capacity for integrated water resources management including building climate resilient hydraulic infrastructures; increasing the effectiveness of land use and spatial planning for the protection of floodplains, coastal and other areas vulnerable to floods; increasing the resilience of agriculture, livestock and fisheries; and increasing the adaptive capacity of the most vulnerable groups.

The national adaptation plans tackle the conservation, sustainable use and equitable access to the aquatic ecosystems and biodiversity services but usually their implementation is challenged by the existence of weak capacities and financial resources to implement them as well as the lack of engagement of the population (primary producers) and limited inclusion of vulnerable people. Thus, the protection of the marine and freshwater ecosystems and biodiversity is usually operationalised in the mandate of the marine conventions and basin authorities mentioned above.

6. Mechanisms for integrating and enhancing ecosystem-based solutions

The key synergic mechanisms for the mitigation of and adaptation to the impact of Climate change on aquatic ecosystems and biodiversity are presented here below:

Mitigation mechanisms. While it has been argued that fisheries are not a suitable focus for mitigation because they emit a small fraction of anthropogenic CO2 output, there are opportunities to reduce the sources of emissions, which when combined with the enhancement of carbon sinks such as mangroves, could make the sector's contribution to mitigation efforts significant. Payment for ecosystem services such as carbon credits for mangrove conservation could benefit fisherfolk livelihoods while also promoting ecosystem restoration and conservation. The enhancement of the natural resources and ecological services of the aquatic ecosystems makes possible the adoption of mitigation measures in fish farming systems through the improvement of stocking density to make the best use of the natural trophic resources and the creation of economic linkages with agricultural production aimed at the intensification and sustainable use of biodiversity and other natural resources.

Adaptation mechanisms. Interventions in this field are very diversified. They include adaptation planning, community-based management, adaptive management, and government support.

Adaptation planning considers the different aspects of and expectation from the water and other natural resource management in their management. The innovative approach of Coastal spatcial planning, incorporating participatory modalities, is intended to represent the interests of the coastal population living of the aquatic resources with those of other socio-economic sectors. This approach builds the capacities of the local stakeholders to ensure their participation to coordination, planning, monitoring activities. It the adoption of digital technologies to integrate information from several sources such as reporting from fishers, censuses, satellite and aerial imagery, that require the partnership of public and private entities.

Community based management or adaptation reduces the effects of Climate change impacts on the coastal populations' livelihoods such as ocean acidification, more frequent and intense precipitation floods, droughts, and sea-level rise[57] . During extreme events, a lack of social cohesion and community ties, as well as disaster awareness, can result in the loss and damage of material assets such as boats and dwellings. Investing in social relationships and communities for support during difficult times, as well as building social relations and networks to increase cooperation, sharing of ideas, and technological innovation, can increase the adaptive capacity of fisherfolk households. Adaptation is embedded in complex social and cultural contexts. This emphasizes the importance of understanding how social capital shapes the adaptive capacity of fishers in order to design appropriate adaptation strategies. Gender equality plays an important role in adaptation as women are especially active in the post-catchment activities from processing to storage and trade and have a strong influence on the behavioural change that ensures the adaptation and adoption of innovation.

[57] *Bunting et al. 2017*

Adaptive management is made of a broad range of activities that improve the efficiency of the use of the aquatic ecosystems and biodiversity. The capacity to quickly adapt to changing natural capital through new harvesting techniques and tools plays a role in the evolution of aquatic systems-dependent livelihoods. Individuals, families, and communities benefit from education and skills development to the delivery of technical assistance services[58]. External services can play an important role in this area. Private or public insurance schemes could be put into place to avoid livelihood disruption arising from limited access to credit and loans to re-build the asset base in the aftermath of climatic disturbances. Diversification through occupational multiplicity reduces risk and cope with future uncertainty. The inability of fishing households to adapt to environmental change is linked not only to poverty, but also to the specialization trap, in which fishers rely primarily on one species or activity. Improving fisherfolk resilience through existing livelihood strategies and enabling diverse and flexible fisheries addresses the impacts of Climate change by diversifying fisheries thus reducing their vulnerability to extreme events.

Government support fosters the sustainability of socio-ecological systems that provide the environmental services supporting resilient livelihoods. The enhancement of resilient fisheries can absorb disturbances and reorganize after the perturbation. While some specific investments are required (e.g., risk reduction and transfer initiatives such as early warning systems, storm shelters, managed retreat, and insurance), adapting to climate change becomes a matter of addressing the fundamental problems of fisheries management and the underlying factors that cause vulnerability. Policies and regulatory measures that reduce fishing effort, overcapacity, and promote sector sustainability make fisheries and aquaculture-based livelihoods more resilient in face of climate change impacts, while policies that increase sector fuel efficiency will contribute to global climate change mitigation efforts. Funding of these actions should be done by progressively shifting to the mobilisation of financial instruments tailored for the exigencies of the artisanal producers (e.g., microfinance schemes, community banking) to ensure the sustainability of Government support.

Surveillance of marine and freshwater resources. Technologies are now available to perform the remote surveillance of the fishing and protected areas. Progress in their adoption faces the problem that the staff of most agencies in charge of repression are not acquainted with the practices and infractions spotted by environmental and economic surveillance bodies. Such situation limits the opportunities of collaboration among these organisations and among different countries. Such lack of understanding along with the scarcity of resources are big hurdles to the effective use of promissory technologies as the use of tele-detection / remote sensing devices and involvement of the local communities in the surveillance of the aquatic resources.

Transboundary aquatic ecosystems regulations and indicators. African states have established bilateral and multilateral agreements to join forces and coordinate their action in the management of the shared transboundary aquatic ecosystems. Basin management authorities and marine conventions of countries that share the inland or sea water resource have been established but they have little influence on the enforcement of regulations on fisheries or ecosystem conservation due their limited mandate and lack

[58] Higher educational attainment may allow fishermen to make a broader range of decisions, such as engaging in safe construction practices and assessing potential risk, resulting in fewer deaths when an extreme event occurs. Increasing access to climate information and forecasting with early warning systems reduce the fishing sector's vulnerability as an anticipatory adaptive measure. Recognizing and utilizing traditional knowledge for the development of adaptation strategies is also an important determinant of communities' ability to respond to the impacts of climate variability and change, for example, by providing additional forecasting abilities and observing local environmental changes.

of resources but also to the absence of a common appreciation of the issues they deal with. The planning and coordination of common or harmonised actions often depends on the lack of compatibility of the indicators used to monitor the aquatic resource. Statistics on aquatic marine ecosystems are a relatively new tool and are calculated on the basis of collection and measurement method that are not statistically compatible. These synergic mechanisms that can play an important role in the mitigation of and adaptation to establishing and enforcing regulations on the management of the aquatic ecosystems and biodiversity provided their actions are based on a reliable and mutually agreed knowledge basis, typically compatible national statistics.

7. Mitigation of and adaptation to Climate change in marine and freshwater aquatic ecosystems in Africa

The analysis of the impact of Climate change, ongoing initiatives and best practices on the aquatic ecosystems and biodiversity in Africa shows that a growing number of actions is being tested and knowledge produced with the ais of improving their conservation, sustainable use and equitable access to their services. A cross-cutting gap of the current initiatives concern the knowledge on the aquatic ecosystem dynamics, their interaction with the anthropic factor and replicability of best practices. The elaboration of an action at the African level should adopt the subsidiary principle by complementing ongoing initiatives and concentrating the resources where they make a difference thus filling in gaps instead of repeating ongoing experiences. The following sections present the key elements that should be considered in framing a continental initiative based on these assumptions.

7.1 Knowledge management

The incorporation of natural capital and ecosystem services into national planning processes and decision-making, especially in the face of climate change should be achieved by raising awareness of their interdependence with human well-being, by advancing the interdisciplinary approach of the ecosystem studies and by making available their outputs for decision making. This knowledge management approach should include:

Establishing the evidence about the modalities in which the aquatic ecosystems and biodiversity contribute to the livelihoods well-being of specific groups of people (knowledge base).
Raising of the awareness of policy makers, businesses and civil society on how to integrate such practices and tools into concrete action plans (advocacy).
Elaborating cost recovery mechanisms that link the mitigation and adaptation measures to the creation of the economic resources that ensure their continuation and expansion.
Calculating the comparative advantages of different modalities of payment for accessing to the ecosystem services.
Exchanging experiences that involve a growing number of people in the awareness about and implementation of such mitigation and adaptation measures.

Due to the limited resources available for research and development of innovative solutions, the sub-regional organisations in charge of the LME and IAE can play an important role in testing and disseminating the outputs of research in their areas of reach, thus prompting the partnerships and exchanges of experience that make possible the expansion and replication of the best practices.

7.2 Mitigation measures

The mitigation of the impact of Climate change on the aquatic ecosystems, biodiversity and equitable access to their services has to engage the African stakeholders whose livelihoods are directly and indirectly linked to such resources. Linkages with external initiatives are essential because the African countries contribution to Climate change is marginal with respect to that of other continents. Thus, mitigation measures should leverage the provisions of the Multinational environmental and economic agreements by advocating the reduction of the harmful effects of external actors on the African seawaters.

Local mitigation measures are especially related to the improvement of the efficiency of fishery and aquaculture production and protection of the aquatic ecosystems and biodiversity. Here below we present specific and systemic mitigation actions that have been tested in aquatic resources projects in the frame of the circular economy and short value chain production:

Ecological intensification of fishing areas, e.g., by net fencing of aquaculture production areas
Poli-culture, e.g., coexistence of aquatic species and / or agricultural crops
Short value chain, e.g., by recycling fishery and agriculture residues and by products to produce fish stock feed for aquaculture

Adoption of energy efficient technologies to contain the extraction of mangroves and other coastal species wood (e.g., for fish drying):

Fish drying on racks
Solar water pumps and cooling systems
On-site water storage and logistic facilities
Fishery boat repair and parking
Protection of aquaculture pond and cages
Recycling of fish-stock and agricultural waste to produce energy
Increasing carbon sinks through reducing the global energy use and developing low or no-carbon fuel and sequestering emissions in aquatic ecosystems. The action of the population of the inland and coastal wetlands ecosystems is especially critical to the success of these processes as well as the fishery production in the LMEs high seas

The adoption of these mitigation measures improves the rentability of the local livelihoods thus enticing the fishers and farmers commitment to the preservation of aquatic ecosystems and biodiversity and reducing the CO_2 footprint of their economy. The preservation of the aquatic ecosystems and efficient use of their resources associated to ecological intensive productions is also ensuring the maintenance of their CO_2 sinking capacities of these habitats.

Coastal spatial planning is especially indicated for engaging local communities in the conservation of the mangroves, vegetation covered zones and coral reefs increase the CO_2 sinking capacities of these multifunctional natural habitats and provides the ideal conditions for pilot mitigation initiatives. The improvement of the physical and biological factors that contribute to their health and expansion directly impact on the reduction of CO_2 emissions and its sequestration. The engagement of local stakeholders in environmental protection and makes possible the adoption of eco-friendly practices by the artisanal fishers and smallholder farmers of the coastal communities. Positive results in this field is also important as it creates the condition for the local participation to the elaboration of sustainable development policies, strategies and plans at the national level.

Protected and fishing areas surveillance in the territorial waters. The more important contribution of the African aquatic ecosystems to the mitigation of Climate change concern the conservation of their CO2 sinking capacities. The protection of the ecosystems and biodiversity of the national waters and coastal areas opportunistically exploitation by external economic actors requires that the mitigation and adaptation measures be associated to the strengthening of the surveillance of protected and fishing areas in the national waters. This can be performed through the strengthening of the sub-regional capacities of monitoring the relevant areas (protected areas, local fishing reserves, ecosystems sensitive to pollution). Complementary approaches include:

The development and adoption of sub-regional surveillance mechanisms based on digital technologies, as in the case of the overlapping of the signals emitted by commercial boats transponders (expected access to protected areas and reserved fishing areas) with the situation revealed by satellite images (real access to the sensitive areas) to facilitate targeted interventions by the relevant authorities. The effective use of such information requires the collaboration with local enforcement agencies and international agreements
The raising of awareness on the topics of common interest for the African countries to make them cooperative and proactive in advocating for the continent aquatic ecosystems and biodiversity in the multi-country environmental and economic agreements. By raising the awareness on the linkages between mitigation and adaptation measures it is possible to engage the coastal population support to the negotiations on the targets of the indicators of the international and maritime conferences
The sharing of successful experiences and building of capacities of enforcement agencies on harmful practices and infractions, to create the conditions for their collaboration with environmental agencies
The strengthening of regional collaboration for the surveillance of the marine and freshwater resources

The success of these action requires that the setup of cost recovery mechanisms that ensure the exploitation of the production gains to fund the mitigation measures. In practice, these actions should include the elaboration of business plans that ensure their reinvestment to their benefits to keep them going.

7.3 Adaptation measures

7.3.1 Fishery

The key mechanisms and actions that can contribute to the adaptation of the fishery production to the impact of Climate change are listed here below.

Marine and coastal environmental management. With most of coastal and marine ecosystems – such as mangroves, seagrasses, and tidal marshes having higher carbon stocking capacity than other ecosystems like tropical forests, there is need to mobilize all stakeholders, especially the attendant or affected communities, in the conservation and management of the marine and coastal environments in different countries with appropriate financing and policy support from the respective governments and development partners.

Inland and coastal wetlands restoration and protection. There is need to rehabilitate the inland and coastal wetlands as key areas of GHG emission, sequestration and tampering of climate change impacts such as flooding and prolonged or frequent droughts, as well as acting as buffer zones against other non-climatic stressors especially pollution.

Maintenance of free-flowing rivers. A free-flowing river is a large river that has not been dammed. It flows undisturbed from its source to the confluence with another large river or to the sea. Today there are very few large rivers that remain dam-free, or free-flowing in Africa. Free-flowing rivers are rare features although an important part of the natural heritage. They offer considerable social, economic and conservation value, supporting the livelihoods of people in the catchment. Poor rural populations with close livelihood links to the river are likely to be impacted most and benefit least from dams.

Protection and maintenance of deltas and estuaries. The flow of fresh water to estuaries and the sea supports important ecological processes that keep our marine resources healthy. Healthy marine and coastal ecosystems support commercial and recreational fish stocks while also providing food for poor coastal communities that rely solely on marine resources for survival. Most estuaries require a certain amount of water to scour the mouth; without this scouring effect, sediments build up at the mouth, increasing the risk of back-flooding during storms. Artificial breaching of an estuary mouth to reduce this risk is costly and harmful to estuarine ecosystems. This is why running water into the sea should not be considered waste.

Sustenance of groundwater linkage to river flows. Groundwater sustains river flows particularly in dry seasons and plays major role in containing the negative effects of climate change.

The adoption of the adaptation measures should be preceded by the raising of awareness of the fishery and aquaculture entrepreneurs and their partners and accompanied by capacity building events. Promising solutions for the adaptation to impact of Climate change on aquatic animal geographic distributional change, productivity change and species composition, include:

Changing the timing and areas of fishing and / or adopting variable catches strategies
Closing fishery during climate-driven events to support resistance and recovery
Relocating landing and processing practices
Relocating fish species to compensate for changes in productivity
Enhancing fishing and protected areas monitoring through community-based approaches
Establishing early warning systems to master climatic events
Ensuring the participation of artisanal fishers and coastal communities to the monitoring of fishery and aquatic ecosystems
Developing insurance schemes that protect fishers against loss and damage after climate events or due to forced practice changes or exit from the industry

The Annex 5 provides more details on these measures. They have been originally designed to act at the large scale. The coastal communities and artisanal fishers[59] face operational challenges to adapt to the impact of Climate change that often put them out of business as most of them do not live only of fishery activities and are very sensitive to cost-opportunity calculation. Thus, these measures have to be tested in different ecosystems through the approach presented in section 7.5.

7.3.2 Aquaculture

Water availability is the key point in solving the climate change stress for aquaculture and any effort to provide quality and quantity of water is important for the fish farm. Efforts aimed at circumvention of these socio-economic and technical bottlenecks is often a complex task. The recirculation aquaculture system and aquaponics techniques save water but in Africa face the great challenges due to the dependence on

[59] Artisanal fishers include: the small canoe, the sail canoe, the small canoe with engine, the walking fishermen, the collectors, the recreational fishermen that anyway integrate their diet with their catches. Their value chains could be very simple as they produce their simple long line and net and the material are available along the fishery areas marine and inland. Some of their catches are auto consumed and sold as fresh and if there is a marketing problem they dry/salt/smoke their catches.

external sources of technology and cost of energy. As in the case of fisheries, the small scale aquaculturists adapt to Climate change by diversifying their livelihoods (crops, livestock, off-farm and not-farm activities). The large scale, commercial companies are well organized and access to human and financial resources that small producers lack. Thus, the former can be elastic in stopping and resuming production while the latter can be obliged to stop activities and change occupation. Such practical constraints have to be considered in testing innovation with artisanal fishers as they impact on the sustainability of innovation. A mechanism promoting the testing and exchange of experiences between different countries and ecosystems will make possible to multiply the effects of successful solutions (see section 7.5).

Environmental and socio-economic constraints are especially important in orientating aquaculture, as in the case of artisanal aquaculturalists that should maximise the use of the locally available resources and limit the delocalisation of production to contain energy costs. The commercial producers' access to technology, equipment and operate scale economies that reduce the impact of such factors on the e energy costs. Indeed, they can source external production inputs and establish their farms where these are available, instead of opting for nature-based solutions. In their case, the enforcement of environmental regulations is essential to ensure the adoption of climate mitigation measures. In such case, the regulatory measures alone could be inadequate to achieve the intended impact as enforcement capacities are often scarce in Africa. The same problem is experienced in relation to the opportunity to prevent the regulatory measures through the transboundary delocalisation of part of the aquaculture production.

Most African countries are unable to enforce the provision of international environmental conventions in this field. Joint actions, regional and sub-regional conventions are expected to fill in the weaknesses of the national actions. Inside each country, a mix of incentives and checks has to be established to change consolidated positions and preferences that makes the whole community or country to pay the frays of individual decisions. These policies have notably to remove the macro-economic constraints (as de facto monopolies) that prevent these producers from adopting environmentally friendly practices to adapt to the impact of Climate change. These practices include:

Improving water economy and quality management, pond perimeter trenching and netting, changing the time of the first stocking / breeding, rack drying and other smart production practices
Selecting and introducing less vulnerable or more resilient species.
Changing stocking time and diversify livelihoods
Developing communication networks and social group's membership to foster exchanges of information and experiences
Rehabilitating mangroves and expanding climate resilient species (e.g., coconut tree)
Promoting gender equality and women participation to the aquaculture value chain governance. It is remarkable the fact that in many fishers' communities, women are active in the post-extraction activities (processing, storage, trade) and that their influence on the decisions and practices of fishermen is underestimated in many development projects[60]
Using local by products for producing aquaculture feed, including green water practices and rice cum fish farming system

[60] *The shift from subsistence to market-oriented production creates the opportunity for a more active role of women in the governance of the fishery and aquaculture value chains.*

7.4 Protection of aquatic ecosystem and biodiversity

Priorities for the protection of aquatic ecosystem and biodiversity should include:

Freshwater resources protection. Improved demand management, particularly in agriculture, combined with a careful review of urbanization rates and urban planning make sense for both managing the current water crisis and preparing for future increased competition for freshwater. In a drying scenario, the development of new water sources, including the careful and considered use of aquifers and desalination, appears to be prudent. To ensure the sustainability of wetland and river ecosystems, a strong emphasis on ecological reserve protection should be emphasized.

Wetlands and coastal zones protection. Protecting the ecological water reserves for estuaries, and protecting wetlands, will be critical for mitigating the impact of climate change on aquatic ecosystems. This should include regular monitoring and assessment of key sites and assessment of any planned developments in and around such sites.

Strategic priority actions are listed here below.

Marine ecosystems restoration (mangroves, seagrass, etc.):

Review, improve, or create legal, policy, and financial frameworks for aquatic ecosystem restoration. This may include, as appropriate, laws, regulations, policies, and other requirements for protecting and restoring habitats, as well as improving ecosystem functions. It may be necessary to keep a certain proportion of land, coast, or sea in its natural state
Recognise local and indigenous people's livelihoods rights and land tenure protection
Strengthen formal and informal education and vocational training systems at all levels by including freshwater, inland and coastal wetlands, and marine ecosystem restoration content, and raise awareness about the benefits of aquatic ecosystem restoration for the economy and societal well-being, including through the dissemination of scientifically sound information
Review, improve, or establish terrestrial and marine spatial planning processes and zoning activities at the local, national, regional, and continental levels as part of integrated aquatic ecosystem management
Review, improve, or create targets, policies, and strategies for aquatic ecosystem restoration. These activities are typically reflected in national biodiversity strategies and action plans, as well as national plans for sustainable development, climate change mitigation and adaptation, and water resources management. Setting goals can demonstrate political commitment while also increasing public awareness, support, and engagement. Existing targets established under other relevant processes may also be considered
Create accounting processes that consider the values of natural and semi-natural freshwater and inland and coastal wetlands aquatic ecosystems, and marine ecosystems as well as the functions and services they provide
Encourage economic and financial incentives and eliminate, phase out, or reform incentives that are harmful to aquatic biodiversity in order to reduce the drivers of aquatic ecosystem loss and degradation and to foster aquatic ecosystem restoration, including through sustainable productive activities
Make resource mobilization plans. Create a framework for mobilizing resources to support ecosystem restoration from national, bilateral, and multilateral sources, such as the Global Environment Facility, by leveraging national budgets, donors, and partners, including the private sector, indigenous peoples and local communities, and non-governmental organizations, to implement action plans and fill gaps identified in step A assessments. Public funds and instruments, for example, risk guarantees, payment for ecosystem services, green bonds, and other innovative financial approaches can be used to leverage private funding
Promote and support capacity-building, training, and technology transfer for aquatic ecosystem restoration planning, implementation, and monitoring to improve the effectiveness of restoration programs

Conservation of coral reefs:

Produce digital maps of all coral reefs that address locally identified conservation and management needs.
Identify and regularly monitor reef habitats of high value and reefs in the vicinity of offshore cays and banks.
Comprehensive report and a scorecard on reef health is to be produced every five years.
Develop a resilience/ coral bleaching monitoring and response plan.
Economic valuations of coral reef ecosystems.
Site specific socioeconomic studies in order to resolve user conflicts.
Evaluating examples of best practices and lessons.
Adopt and draw a co-management plan of action for restoration of coral reefs, coral rich countries.

Biodiversity surveillance. Regular and periodic monitoring of aquatic biodiversity in both marine and freshwater ecosystems is important in guiding development of requisite policies to mitigate climate change impacts. Selected hotspots and key ecological and economic areas should serve as indicators. The monitoring of invasive and alien species in and around water bodies makes possible to control the impacts on the ecological health and long-term survival of indigenous ecosystems and biodiversity.

The monitoring of flagship indicator species and populations will be critical for improving understanding of species responses to climate variability and change, as well as detecting emerging signs of impacts. Careful assessment of the protected area system and expansion where possible, combined with reduction of other human-induced stresses on ecosystems and involvement of commercial land managers in reducing impacts, will increase the adaptive capacity of natural landscapes and ecosystems. In extreme cases, ex situ conservation or transfer of key threatened species to new wild locations may be required, possibly guided by focused monitoring programs.

These key strategic actions should be prioritized in the surveillance of aquatic biodiversity:

Fisheries. Increase the coverage and enforcement of Marine Protected Areas
Alien invasive species. Enhance protection against marine invasive species
Pollution. Intensify surveillance of dredging activities and enhance preparedness for marine oil spills
Tourism. Conduct carrying capacity assessment of sensitive ecosystems such as coral reefs, rivers, mangroves, forests and other sensitive natural ecosystems

Fisheries and aquaculture management. Promising responses to the impact of Climate change can be anticipatory or reactive. Key solutions include:

Management approaches and policies that build the livelihood asset base, reducing vulnerability to multiple stressors, including climate change
Understanding of current response mechanisms to climate variability and other shocks in order to inform planned adaptation
Recognition of the opportunities that climate change could bring to the sector
Adaptive strategies designed with a multi-sector perspective
Recognition of fisheries potential contribution to mitigation efforts

Livelihoods preservation. Climate extremes affect all aspects of society, but the poor communities living in low-cost housing are likely to be disproportionately affected by any increase in the frequency of extreme climate events such as floods and heat waves. The projected increase in the frequency of extreme events will be exacerbated by the vulnerability of communities with limited resources to avoid or adapt to the consequences. Climate change has an impact on people's livelihoods across the economic spectrum, but not everyone feels the same way, so it is critical to identify and address the needs of the most vulnerable. An assessment of livelihoods underpinned by threatened aquatic ecosystems will be crucial in developing and implementation of appropriate policies to improve their adaptive capacity. Improved housing and physical infrastructure in informal settlements, electrification and improved public transport in urban areas close to aquatic ecosystems will reduce vulnerability to extreme climate events of those living in close proximity, especially the poor.

Coastal spatial planning. This approach is intended to leverage the contribution of the local communities in the protection of ecosystems. Its implementation requires some caveats as the behaviour of the external stakeholders of the coastal ecosystems is less predictable as their livelihoods are not univocally linked to the ecosystems and they have the capacities and resources to bypass environmental regulations. The local dwellers' commitment to coastal spatial planning can face limitation in relation to the adoption of technologies as digital apps to communicate catches, etc. (e.g., risks incurred in carrying digital equipment in small boats and lack of WiFi connection in extraction areas) and reliability of the data transmitted to the entities in charge of monitoring the protected areas. Artisanal fishers balance the advantages of alternative livelihoods in making their economic choices as they are not bound to practice fishery only. For such reasons, the reliability of their reporting, etc. should be the object of quality control. Continuous improvement in the delivery of the ecosystem services of the protected areas to produce concrete economic results for the local dwellers is essential for their engagement in the protection of the natural resources of the coastal areas.

Harmonisation of the indicators on aquatic ecosystems. The national statistical systems should develop compatible sets of indicators to support the implementation of the bilateral, sub-regional and regional agreements and conventions that concern the aquatic ecosystems surveillance and sustainable management. This action can exploit the experience of the AU statistical services in promoting the collaboration of the Member states in developing compatible statistics. The statistical officers in charge of these indicators have to be convened to discuss the information gaps and methods to develop compatible indicators for monitoring the aquatic ecosystems and biodiversity. Such initiative can be articulated through the inland basin authorities and LME conventions and at the continental level to facilitate the dialogue and integration of compatible indicators.

7.5. Mainstreaming policies on mitigation measures

The analysis of the ongoing projects shows that African countries are piloting joint actions for the integrated development of coastal areas through the participation of women, youth, minorities and vulnerable groups, e.g., by adopting the Coastal special planning approach. Gender equality is an explicit objective of the ABES whose thematic area Fisheries, aquaculture, conservation and aquatic ecosystems includes the objective:

Empower women and youth in fisheries and aquaculture in order to take full advantage for blue growth. Gender is especially important because women are indispensable although not often recognised actors of the fishery and aquaculture value chains, being in charge of post-catchment storage, processing and trade, and strongly influence the production choices although they not always harvest the economic fruits of their contribution. The benefits produced by such actions for the people depending on the aquatic ecosystems and biodiversity for their living strengthen the fishers' community support to the objectives and priorities of the PFRS and ABES in relation to the mitigation of the impact of Climate change. The AU-IBAR can contribute to such process by mobilising the technical resources and by promoting the consultations and supporting the coordination of initiatives that multiply the results of pilot action across Africa thus prompting the mobilisation of the resources needed to advance in this field at the continental level.

The role that AU-IBAR can play in catalysing the action of the African institutions in this field is especially relevant because the Regional economic communities and conventions and the national decision makers are little aware of the solutions that have been successfully tested in other countries and sub-regions. The AU-IBAR can provide the knowledge and expertise that they need to produce and disseminate best practices whose concrete benefits will stimulate the African institutions in replicating them and commit to joint actions to systematically exploit such breakthrough.

The identification of fields for the concentration of resources and production of early successes are expected to catalyse the interest of decision makers and multiply the mobilisation of resources where they make the difference, thus prompting multiplication effects locally and across the continent. The success of this approach depends on AU-IBAR collaboration with regional and subregional organisations that understand the context and are acquainted with national actors in order to test and disseminate the knowledge generated locally across the region. The production of positive results at a larger scale is expected to strengthen the engagement of the policy makers to mainstreaming the objectives and priorities of the PFRS and ABES in their countries. By supporting such process from behind, AU-IBAR also positively contributes to the dialogue and mutual understanding required to push the AU agenda at international level, e.g., in the negotiation and implementation of international agreements as the SDG, multinational environmental agreements and maritime conventions as well as of inter-African transboundary initiatives.

7.6 Strategic priority actions

The testing of mitigation actions should prioritize the establishment of intervention mechanisms that concentrate resources on pilot actions that can be replicated, in order to produce systemic effects. The topics object of such action should be identified by their direct beneficiaries to produce concrete results. The following strategic priority actions should be considered to mainstream the PFRS objectives and ABES priorities in Africa.

- ***Knowledge-based solutions:*** strengthening the value chain of aquatic ecosystems and biodiversity innovation and dissemination of its results. The objective is to promote knowledge-based solutions resulting from the linkage of research to the exigencies of the users of innovation in Climate change mitigation. They include:

The contribution of the civil society to the orientation of research and creation of knowledge on the resilience of aquatic ecosystems to the impact of Climate change
The creation and dissemination of knowledge on the factors that contribute to the mitigation, adaptation and resilience to Climate change

- ***Development perspective:*** establishment of linkages between the conservation of hotspot of aquatic ecosystems and biodiversity to socio-economic development. The objective is to strengthen and expand the consensus on the objectives and priorities of mitigation and adaptation policies. They include:

The adoption of circular economy short value chain solutions that enhance the sinking and reduce the emission of CO2 and other GHGs
The adaptation of economic activities to the changes in the biology of the aquatic organisms (reproduction areas and seasons, migration patterns, etc.)
The intensification of aquaculture production to reduce the extent of the fishery extraction areas
The elaboration of cost-recovery mechanisms that ensure the delivery of environmental services in a sustainable, inclusive and resilient way
The participation of the stakeholders of the aquatic ecosystems and biodiversity in their surveillance and their contribution to the elaboration of mitigation and adaptation policies and national plans

7.7 Intervention mechanisms

The collaboration of and exchange of information among ongoing initiatives that deal with the local stakeholders of the aquatic ecosystems and biodiversity ensures that the strategic priority actions be customized to the local context and exigencies of the local stakeholders. The following interventions mechanisms should be considered in the design of regional initiatives that contribute to the achievement of the PFRS objectives and ABES priorities.

- ***Networking approach:*** exploitation of the knowledge management capacities of regional, sub-regional and national organisations. The objective is to test and disseminate best practices across the continent. It should focus on:

The exploitation of the existing multi-level dialogue tools by prioritizing synergies in the organization of regional meetings, communication and awareness events, training sessions, etc.
The strengthening of the interactive services provided by the existing knowledge management platforms to link the performance of field actions to regional objectives and priorities

- ***International advocacy coordination:*** promotion of the mutual understanding of the AU Member states on their position on aquatic ecosystems and biodiversity in in view of the harmonisation of their participation to international fora, e.g., the Conference of parties to the Convention of Biodiversity. It should focus on:

The elaboration and sharing of the profiles that synthesize the challenges, priorities and strategic actions of (ten) AU Member states in relation to the impact of the Climate change on aquatic ecosystems and biodiversity
The systematization of the evidence of the benefits of mitigation and adaptation measure disseminated across the continent to stimulate the engagement of African decisions makers in dialoguing and joining forces to mainstream mitigation and adaptation measures in planning development, transboundary initiatives, etc.
The organization of information exchanges / remote meetings of institutions, private sector, civil society organisations dealing aquatic ecosystems and biodiversity in view of the participation of the AU Member states to international fora thus promoting the common objectives and priorities enshrined in the PFRS and ABES

7.8 Framing a regional approach to mitigate and adapt to the impact of Climate change on aquatic ecosystems and biodiversity

The analysis of the ongoing projects provides insights on the modalities and themes of the collaboration of AU-IBAR with the regional and sub-regional institutions active in the mitigation of the impact of Climate change on the aquatic ecosystems and biodiversity. AU-IBAR should establish synergies with ongoing initiatives to produce multiplication effects and avoid duplications rather than develop a self-contained project.

The elaboration of an initiative mainstreaming mitigation and adaptation measures across the continent has to integrate the contribution of the regional, subregional and national actors in the transfer of knowledge and technology.

The coastal marine and freshwater areas are a growing field of concern for their fragility and the multiplication effects produced by the disruption of the livelihoods and welfare of the local population on the aquatic ecosystems and biodiversity. Thus, coastal areas should be prioritised in testing and adopting mitigation and adaptation measures. The main features of this initiative should be:

Enhancing the online platforms of two sub-regional organisations (LME, RECs, inland water basin commissions, etc.) to perform interactive services, as the exchange of experience and performance of remote training on mitigation and adaptation measures
Sensitising the local actors (producers' cooperatives, community-based organisations, fishers' association, research centres, institutions, NGOs, etc.) through these platforms and organising information and training sessions on the impacts of climate change and mitigation practices
Tendering of grants supporting the testing of community-based mitigation and adaptation measures enhancing the conservation, sustainable use and equitable access to aquatic ecosystem services,
Mobilising the expertise of the sub-regional organisations and local actors to assist the pilot communities in building capacities, elaborating cost recovery mechanisms;
Organising events for the presentation and exchange of experiences among the participants to the pilot projects to with the participation of national and regional groups of stakeholders.
Disseminating through the online platforms the experience developed for their replication across the continent

The selected grants should:

Be relevant to the object of the tender (inclusive community-based mitigation and adaptation measures enhancing the conservation, sustainable use and equitable access to aquatic ecosystem services)
Include the capacity building of the beneficiaries, including women's empowerment, on the proposed the mitigation and adaptation measures, to be performed by the sub-regional organisation / local actors
Include the elaboration of cost recovery mechanisms (i.e., revenue generating activities) that ensures the sustainability of the proposed mitigation and adaptation measures

This approach stimulates the dialogue and mobilises the experience and resources of ongoing initiatives thus avoiding the creation of new structures or mechanisms. Its implementation should be promoted through the consultation of the regional and sub-regional organisations active in this field to discuss their expectations and contribution to framing a regional approach to mitigating the impact of Climate change on the aquatic ecosystems and biodiversity in Africa.

This initiative can be implemented in collaboration with sub-regional organisations, such as the Abidjan Convention Secretariat and Benguela Current Large Marine Ecosystem Commission, that are:

Endowed with the technical and operational capacities to assist national and sub-national actors in implementing field actions
Currently executing actions in the field of aquatic ecosystems and biodiversity
Networked with and committed to exchange experiences in this field other sub-regional initiatives

8. Conclusions

The impact of Climate change on the African aquatic ecosystems and biodiversity is affecting the livelihoods and welfare of the population depending on their services. The projects concerning the aquatic resources are trying to link conservation to local development to ensure the engagement of the local population in performing innovative mitigation and adaptation measures. The aquatic ecosystems and biodiversity already stressed by human impacts are the most vulnerable to the impact of Climate change. The impact of Climate change is already affecting African development through the degradation of the environmental services provided by the more fragile aquatic ecosystems, as mangroves and coral reefs, to the artisanal fishers, aquaculturalists and residents of the marine and freshwater coastal areas.

Several practices - mixing tradition and innovation, local knowledge and research results - have been successfully tested to reduce the impact of Climate change including, among others, its mitigation through the adoption of circular economy short value chain solutions, the adaptation of economic activities to the changes in the biology of the aquatic organisms, the sustainable intensification of aquaculture production to reduce the extent of the fishery extraction areas. The sustainability of these practices depends on the establishment of cost-recovery mechanisms and the strengthening the participation of their stakeholders to the surveillance and protection of the aquatic ecosystems and biodiversity.

The progress made in this field is little known and insufficiently disseminated to produce the large-scale changes needed to systematically improve the conditions of the aquatic ecosystems and biodiversity. The projects promoting innovation in this field should be framed in or linked to organisations and initiatives that ensure the exchange of information and experiences to exploit best practices at a larger scale, if they want to have a significant impact on the resilience of the continent.

The coastal marine and freshwater areas are a growing field of concern for their fragility and the multiplication effects produced by the disruption of the livelihoods and welfare of the local population on the aquatic ecosystems and biodiversity. Thus, coastal areas should be prioritised in testing and adopting mitigation and adaptation solutions.

The AU-IBAR can contribute to filling in such gap by exploiting the existing multi-level dialogue tools and strengthening the interactive services provided by the existing knowledge management platforms to link the building of capacities and testing of best practices in this field to their dissemination at a larger scale. At the same, time, the evidence of the benefits of mitigation and adaptation measure disseminated across the continent should stimulate the engagement of African decisions makers. They can dialogue and join forces to mainstream mitigation and adaptation measures in planning development, transboundary initiatives, etc. and in view of their participation to international for a, thus of promoting the common objectives and priorities enshrined in the PFRS and ABES.

The elaboration of an initiative mainstreaming mitigation and adaptation measures across the continent should integrate the contribution of the regional, sub-regional and national actors already active in the transfer of knowledge and technology. In this way, this action can stimulate the dialogue, mobilise the experience and resources of ongoing initiatives while avoiding the creation of new structures that overlap with other projects. Its identification should start with the consultation of regional, sub-regional and national organisations active in this field and discussion of their expectations and contribution to the framing of a regional approach to technology transfer in this field.

Sub-regional organisations that have accumulated a large experience in this field, are endowed with technical and operational capacities and are acquainted with the key actors in the respective regions of intervention, as the Abidjan Convention Secretariat and Benguela Current Large Marine Ecosystem Commission, should be considered as priority partners in the implementation of this initiative.

Annexes

Annex 1: Bibliography

1. ***Y. S. Wong 1997.*** Mangrove wetlands as wastewater treatment facility: a field trial. Hydrobiologia 352: 49–59.
2. ***C. A. Shumway 1999.*** Forgotten waters: freshwater and marine ecosystems in Africa. USAID 168 p.
3. ***E. W. Dungumaro, N. F. Madulu 2003.*** Public participation in integrated water resources management: the case of Tanzania. Physics and Chemistry of the Earth, Parts a/b/c, 28(20-27), 1009-1014.
4. ***C. O'Reilly et al. 2003.*** Climate change decreases aquatic ecosystem productivity of Lake Tanganyika, Africa. Nature 424, 766–768
5. ***A. Nyong 2005.*** The economic developmental and livelihood implications of climate change induced depletion of ecosystems and biodiversity in Africa. WWF. Presented at the Scientific Symposium on Stabilization of Greenhouse Gases Met Office
6. ***P. Mukhelbir et al. 2005.*** A status quo, vulnerability and adaptation assessment of the physical and socio-economic effects of climate change in the Western Cape. OpenUCT.
7. ***M. Case 2006.*** Climate change impacts in East Africa a scientific literature review. WWF.
8. ***B. Worm 2006.*** Impacts of biodiversity loss on ocean ecosystem services. Science 314: 787–790.
9. ***V. Burg 2007.*** Climate change affecting the Okavango delta. SFIT. Master thesis
10. ***IPCC 2007.*** Climate change: Impacts, adaptation and vulnerability. Geneva, Switzerland
11. ***FAO 2007.*** The World Mangroves 1980–2005. A thematic Study Prepared in the Framework of the Global Forest Resources Assessment 2005, 77p. Google Scholar.
12. ***UNEP 2007.*** Mangroves of Western and Central Africa. UNEP—Regional Seas Programme/UNEP-WCMC, 88 p. Google Scholar.
13. ***C. N. Ukwe et al 2006.*** A sixteen-country mobilization for sustainable fisheries in the Guinea Current Large Marine Ecosystem. Ocean & coastal management, 49(7-8), 385-412.
14. ***AfDB 2008.*** Climate for Development in Africa (ClimDEV-Africa). Framework Programme Document, pp. 15-16.
15. ***M. J. Novacek 2008.*** Engaging the public in biodiversity issues. Proceedings of the National Academy of Sciences, 105 (supplement 1), 11571-11578.
16. ***V. Ramanathan, G. Carmichael 2008.*** Global and regional climate changes due to black carbon. Nature geoscience
17. ***K. L. Cochrane et al. 2009.*** Benguela current large marine ecosystem—governance and management for an ecosystem approach to fisheries in the region. Coastal Management, 37(3-4), 235-254.
18. ***L. J. Tranvik et al. 2009.*** Lakes and reservoirs as regulators of carbon cycling and climate. Limnology and oceanography, 54(6part2), 2298-2314.
19. ***D. Tadesse 2009.*** Climate change impact on Africa. ISS paper 220. 20 p.
20. ***D. Coumou et al. 2009.*** Climate change impacts in Sub Saharan Africa: from physical changes to their social repercussions. Regional environmental change. Springer. 19 p.
21. ***P. Dill. J. Zhang 2009.*** Impact of climate change on freshwater ecosystems: a global scale analysis of relevant river flow alternations. Hydrology and earth science sciences. 14, 783–799

22. ***M. Boko et al. 2009.*** Africa. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. CUP. 433-467

23. ***E. Odzemir, A. Altindag 2009.*** The impact of climate change on aquatic life. Ankara University. 9 pages

24. ***A. Eissa, M. Zaki 2009.*** The impact of global climatic change on aquatic environment. Procedia Environmental Sciences 4 (2011) 251–259. Elsevier.

25. ***J.R.E. Lutjeharms, T.G. Bornman 2009.*** The importance of the greater Agulhas Current is increasingly being recognized. S. Afr. J. Sci., 106 (3/4) (2010), p. 4

26. ***P. M. Davies 2010.*** Climate change implications for river restoration in global biodiversity hotspots. Restoration Ecology, 18(3), 261-268.

27. ***H. Hamukuaya 2011.*** An Overview of Management of Large Marine Ecosystems and Evidence of Impacts of Climate Change. Paper presented COP 17 Oceans Day on behalf of African LME Caucus. Durban, South. Google Scholar

28. ***FAO 2011.*** Climate change implication for fishing communities in the Lake Chad basin. 95 p.

29. ***C. E. Giri et al. 2011.*** Status and distribution of mangrove forests of the world using earth observation satellite data. Global Ecology and Biogeography 20: 154– 159

30. ***UNEP 2012.*** Climate change challenges for Africa evidence from selected EU-Funded Research projects. 22 p.

31. ***UNDP 2012.*** UNDP and climate change in Africa. Fact sheet. 2 p.

32. ***J. L. Blanchard et al. 2012.*** Potential consequences of climate change for primary production and fish production in large marine ecosystems Phil. Trans. R. Soc.

33. ***S. Humphrey, C. Gordon 2012.*** Terminal Evaluation of the UNDP-UNEP GEF Project: Combatting Living Resources Depletion and Coastal Area Degradation in the Guinea Current LME through Ecosystem-based Regional Actions (GCLME). Evaluation Office, United Nations Environment Programme, 129 p. Google Scholar

34. ***J. Ellison, I. Zouh 2012.*** Vulnerability to climate change of mangroves: assessment from Cameroon, Central Africa. Biology 1: 617– 638.

35. ***I. Hampton, N. Willemse 2012.*** Potential Effects of Climate Change and Environmental Variability on the 16 Resources of the Benguela Current Large Marine Ecosystem. In K. Sherman, G. McGovern. Frontline Observations on Climate Change and Sustainability of Large Marine Ecosystems. UNDP.

36. ***E. Y. Mohammed, Z. B. Uraguchi 2013.*** impact of climate change on fisheries: implications for food security in Sub-Saharan Africa. Global food science. 113.135.

37. ***N. C. James et al.2013.*** Effects of climate change on South African estuaries and associated fish species. Climate research. 32 p.

38. ***AU-IBAR 2013.*** Climate change and Fisheries - Strengthening the fishery communities. 36 p.

39. ***H. F. Dallas, N. Rivers-Moore 2014.*** Ecological consequences of global climate change for freshwater ecosystems in South Africa. South African Journal of Science, 110(5-6), 1-11

40. ***AU-IBAR 2014.*** The Policy Framework and Reform Strategy for Fisheries and Aquaculture in Africa. 62 p.

41. ***S. T. Yang et al 2014.*** Predicting the spatial distribution of mangroves in a South African estuary in response to sea level rise, substrate elevation change and a sea storm event. Journal of Coastal Conservation 18: 459– 469.

42. ***M. Ndebele-Murisa 2015.*** Climate change and management of ecosystems in Africa. The African climate change fellowship program. 30 p.
43. ***I.Thiaw 2015.*** Is the changing climate changing African ecosystems. Ecosystem health and sustainability, 2015:1-3
44. ***A. D. Guerry et al. 2015.*** Natural capital and ecosystem services informing decisions: From promise to practice. PNAS 112(34) 7348-7355
45. ***P. Descombes et al 2015.*** Forecasted coral reef decline in marine biodiversity hotspots under climate change. Global Change Biology, 21(7), 2479-2487.
46. ***P. Vélez-Belchí et al. 2015.*** Open ocean Temperature and salinity trends in the Canary Current Large Marine Ecosystem. IOC Technical Series, N. 115: 299-308
47. ***A. S. Cohen et al. 2016.*** Climate warming reduces fish production and bentic habitat in lake Tanganyika, one of the most biodiverse freshwater systems. PNAS. 113(34) 9563-9568
48. ***The African Development Bank Climate Change Action Plan 2016-2020***
49. ***B. P. Satia 2016.*** An overview of the large marine ecosystem programs at work in Africa today. Environmental Development, 17, 11-19
50. ***C. M. Roberts et al. 2017.*** Marine reserves can mitigate and promote adaptation to climate change. PNAS 114 (24) 6167-6175
51. ***M. Lovei 2017.*** Climate Impacts on African Fisheries: The Imperative to Understand and Act. World Bank
52. ***E. Nkiaka et al. 2018.*** Assessing the reliability and uncertainties of projected changes in precipitation and temperature in Coupled Model Intercomparison Project phase 5 models over the Lake Chad basin. International Journal of Climatology, 38(14), 5136–5152
53. ***P. G. Oguntunde et al. 2018.*** Impacts of climate variability and change on drought characteristics in the Niger River Basin, West Africa. Stoc. Env. Res. and Risk Ass., 32(4), 1017–1034
54. ***A. Ramírez, A. 2018.*** Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options. FAO Fisheries and Aquaculture Technical Paper N. 627. Pontificia Universidad Católica de Chile.
55. ***L. Pettinotti et al. 2018.*** Benefits from water related ecosystem services in Africa and climate change. Ecological Economics, 149, 294-305.
56. ***World Bank 2019.*** At the Nexus of Climate Change and Marine Fisheries: Assessing Vulnerability and Strengthening Adaptation Capacity in Africa. WB. 65 p.
57. ***T. O'Shea et al. 2019.*** Towards a Blue Revolution: Catalyzing Private Investment in Sustainable Aquaculture Production Systems. The Nature Conservancy and Encourage Capital. 163 p.
58. ***N. Gueye 2019.*** Africa's inland aquatic ecosystems. FAO-ROA. 108 p.
59. World Bank 2019. Climate change and fisheries in Africa. Assessing vulnerability and strengthening adaptation capacity. WB. 76 p.
60. ***ECOWAS 2019.*** Comprehensive Strategic Framework for Sustainable Fisheries and Aquaculture Development. 56 p.
61. ***V. Chomo, A. Seggel 2020.*** Climate smart fisheries and aquaculture. FAO. 31 p.
62. ***African Union 2020.*** Africa blue economy strategy. 48 p.
63. ***B. Osman-Elasha, D. Fernández de Velasco 2020.*** AfDB Drivers of Greenhouse Gas emissions in Africa: Focus on agriculture, forestry and other land use. AfDB. 4 p.

64. ***ACPC 2021.*** Climate change and water resources in Africa: challenges, opportunities and impacts. UNECA. 33 p.

65. ***S. A. Ofori et al. 2021.*** Climate Change land water and food security perspectives from Sub Saharan Africa. 16 p.

66. ***Z. L. Jacobs et al. 2021.*** Key climate change stressors of marine ecosystems along the path of the East African coastal current. Ocean and coastal management. 208:105627

67. ***AU-IBAR 2021.*** Biodiversity workshop. SIDA funded project. 54 p.

68. ***A. Kapuka, T. Hyasni 2021.*** Climate change impacts on ecosystems and adaptation options in nine countries in southern Africa: what we know? 17 p.

69. ***CBD 2021.*** The Nairobi convention COP10 Approved Work Programme 2022-2024

70. ***L. Cavenari 2021.*** Assessment of the aquaculture value chain incorporating sensitivity to climate change. Itaca solutions. Kingston. 52 p.

71. ***UNFCCC 2021.*** Blue Nature Alliance to Expand and improve the conservation of 1.24 billion hectares of ocean ecosystems. Nairobi Work Programme. 46 p. GEF. Enhancing resilience of oceans coastal areas and ecosystems through collaborative partnerships. WB. 307 p.

72. ***I. Åhlén et al. 2021.*** Hydro-climatic changes of wetland-scapes across the world. Scientific Reports, 11(1), 1–11

73. ***R. Muringai et al. 2021.*** Climate change and variability impacts on sub-Saharan African fisheries: A Review. Reviews in Fisheries Science & Aquaculture, 29(4), 706-720.

74. ***AU-IBAR 2021.*** Policy brief Climate Change and the Ocean Economy. AGNES. 8 p.

75. ***EU 2021.*** Naturafrica. The Green Deal approach for EU support to biodiversity conservation in Africa. 10 p.

76. ***C. Nolan, et al. 2022.*** Double exposure to capitalist expansion and climatic change: a study of vulnerability on the Ghanaian coastal commodity frontier. Ecology and Society 27(1):1

77. ***E. Entrena-Barbero et al. 2022.*** Blue carbon accounting as metrics to be taken into account towards the target of GHG emissions mitigation in fisheries. Science of the Total Environment 847 (2022) 157558

78. ***IPCC 2022.*** The IPCC 6th assessment report. Impacts adaptation options and investment areas for a climate-resilient Southern Africa. CDKN-ACDI. 18 p.

79. ***R. T. Mulingai et al. 2022.*** Sub-Saharan Africa freshwater fisheries under climate change impact: a review of impacts, adaptation and mitigation measures. Fishes 7:131. MPI

80. ***UNDP 2022.*** The United Nations World Water Development Report 2022: groundwater making the invisible visible.

81. ***John Spicer 2022.*** The Mediterranean has experienced record sea temperatures this summer: this could devastate marine life. Google Scholar

82. ***R. le Gouvello et al. 2022.*** Aquaculture and nature based solutions. IUCN. 68 p.

83. ***USAID-SA.*** Water secure future for Southern Africa. USAID. 3 p.

84. ***A. Sidibe, P. Anton 2022.*** Selected FAO Fisheries projects on related initiatives to FishGov-2in Africa. 18 p.

85. ***GEF 2022.*** Protection of the Canary current large marine ecosystem. Project document. 65 p.

86. ***EU 2022.*** The EU blue economy report. 232 p.

87. ***D. Lethimonnier et al. 2022.*** Case study of innovations in commercial West African family fish farming that led to ecological intensification

88. ***G. Negroni 2022.*** Promoting community-based climate resilience in the fishery sector in Jamaica. Alveo. 15 p.

89. ***UNEP-CMS 2022.*** The Congo basin and climate change. UNEP and Convention on Conservation of Migratory Species of Wild Animals

Annex 2: Informants

Date	Name	Organisation	Country	Email
4/7	Dr Aboubacar Sidibe	Coordinator, FAO Canary Current Large Marine Ecosystems project	Senegal	*Aboubacar.Sidibe@fao.org*
4/7	Mr George Kanyerere	Department of Environment and Aquaculture	Malawi	*geoffreykanyerere@gmail.com*
5/7	Mr Ahmed Taleb Moussa	Directeur de Amenagement et des Resources	Mauritanie	*talebmoussaa@yahoo.fr*
6/7	Mr Xolela Wellem	Benguela Current Commission	Namibia	*xolela@benguelacc.org*
6/7	Mr Nico Willemse	Benguela Current Commission		*nico@benguelacc.org*
6/7	Mr Elethu Duna	Benguela Current Commission		*elethu@benguelacc.org*
6/7	Ms Katrina Hilndwa	Benguela Current Commission		*Katrina@benguelacc.org*
7/7	Mr Aminu Magaji Bala	Environment and Climate Change Expert, Lake Chad Basin Commission (LCBC)	Chad	*alaminmb@yahoo.com*
12/7	Ms Paule Bana	Abidjan Convention	Cote d'Ivoire	*paule.bana@un.org,*
12/7	Mr Mika Odido	IOC Coordinator in Africa, IOC's Sub Commission for Africa & the Adjacent Island States (IOCAFRICA), UNESCO Regional Office for Eastern Africa	Kenya	*m.odido@unesco.org*
12/7	Mr Jacques Abe	Abidjan Convention	Cote d'Ivoire	*jacques.abe@un.org*
12/7	Mr Yacoub Issola	Abidjan Convention	Cote d'Ivoire	*yacoub.issola@un.org*
14/7	MrMohamed Seisay	AU-IBAR	Kenya	*mohamed.seisay@au-ibar.org*
14/7	Mr Rodrick Kundu	Director of Fisheries & Aquaculture	Kenya	*rodkundu@yahoo.com*
29/7	Mr Anthony Taabu Munyaho	Lake Victoria Fishery Organisation	Kenya	*ataabum@vlfo.org*
29/7	Mr Robert Kayanda	Lake Victoria Fishery Organisation	Kenya	*rkayanda@vlfo.org*
3/8	Mr Moussa Demsa Baschirou	Economic Community of Central African states	Gabon	*Moussademsa.baschirou@gmail.com*
5/8	Aomar Bourhim	COMAFHAT	Morocco	*Bourhim12@gmail.com*
23/8	Mr Emmanuel Sabuni	Fisheries Commission for the Gulf of Guinea	Gabon	*issaske@yahoo.fr*

Annex 3: Aquatic ecosystem services

Aquatic Ecosystem Services	Description of service	Climate change impact on aquatic ecosystem service
Economic services		
Food	Fisheries products (e.g. fish, crustaceans), wild game and vegetables	Reduced productivity and production with rising water temperatures.
Domestic water use	Drinking water production and other domestic uses	Freshwater salinization, reduced access to safe drinking water, increased cost of desalinization, increased wastewater and effluents from homes and industries with raised water and atmospheric temperatures.
Industrial water use	Process water in industries and cooling water	Higher water scarcity and increased wastewater with raised temperatures.
Agricultural water use	Irrigation water for production of agricultural goods in arid regions	Reduced water sources and impact on water for production supply infrastructure.
Non-consumptive water use	Hydropower generation and transportation/navigation	Reduced power generation and physical impact on established infrastructure for hydropower generation.
Fiber, fodder, peat	Reed production, animal fodder, peat as energy source	Loss of material due to dying off, and disappearance as a result of dominance of invasive alien species with rising water temperatures.
Regulating services		
Self-purification	Maintenance of water quality, detoxification, natural filtration, nutrient retention. Great importance of benthic communities (biofilms, particle feeders)	Reduction in self-purification capacity due to increased water levels and alteration of lake mixing regimes and availability of fish habitat
Flood buffering	Retention capacities of riparian zones, wetlands, and lakes, buffering of flash floods	Reduced flood buffering due risen water levels that require unavailable large inundation areas and expansive wetlands to contain the higher volumes of water. Changed magnitude and seasonality of runoff regimes that alter nutrient loading and limit habitat availability at low flow
Land-water-interactions	Groundwater recharge from inland waters, transition zones between terrestrial and aquatic ecosystems	Intact flood plains and riparian zones are required. Loss of riparian zones and melioration of wetlands reduce interactions
Climate regulation	Buffering of air temperature and humidity variations by evapotranspiration	Large areas of inland waters are required, loss of wetlands reduce regulating capacity
Cultural services		
Recreation and tourism	Recreational activities and features; local economy through tourism is of high importance at the regional scale	Loss of incomes with loss and flooding out of recreational and touristic sites and features with rising water levels and temperatures.
Aesthetic/spiritual values	Sacred lakes, ethical heritages, aesthetic landscape elements	Quickly lost with rising water levels, as most times such sites are not protected.
Educational values	Education in Ecology, schools, universities and stakeholders (farmers, water managers, etc.)	More academic inquest and interest in the effect of climate change on aquatic resources.

Aquatic Ecosystem Services	Description of service	Climate change impact on aquatic ecosystem service
Supporting services		
Soil formation	Soil formation and fertilization by sedimentation in riparian zones	Reduced soil formation processes due to loss of quasi-natural flood dynamics
Nutrient retention and cycling	Nutrient storage in rivers and riparian zones, nutrient spiralling in rivers	Reduced nutrient retention and cycling capacity with increased water temperatures.
Biodiversity and food web dynamics	High habitat diversity and species richness mediate resilience (“insurance”)	Loss of habitats, disruption of interaction among species; and trigger of shifts and or migration stocks, species.

Annex 4: Ongoing projects on aquatic resources in Africa

Acronym	Project	Objectives	Countries	Duration	curr.	Budget	Donor	Implementer
	Climate change - Enhancing Climate Change Resilience in the Benguela Current Fisheries System	To increase the resilience of the marine fisheries and mariculture sectors in the Benguela Current Large Marine Ecosystem and reduce their vulnerability to climate change through the implementation of adaptation techniques in order to ensure food and livelihood security: To ensure that climate change and variability are recognised as drivers of change in fishery social-ecological systems and that their effects are included in strategic and tactical governance and management; raise the profile of fisheries and mariculture in development and climate change policies and programmes at the local, national and regional policies levels, so that the sector can make its contribution and receive the necessary attention and resources it needs to maintain and improve it; To identify the most vulnerable small-scale fisheries, communities and national fisheries through a structured vulnerability assessment and improve the climate resilience of selected cases of these; strengthen national and regional services for early warnings of extreme weather events and other climate-induced risks to fisheries; and strengthen capacity across the region and amongst all stakeholder groups to assess the risks that climate change poses to their livelihoods and security, and to be able to ensure adaptation to address those risks.	Angola, Namibia, South Africa	2016-2023	USD	4,725,000	WB GEF	FAO, BCC secretariat
CP	Coastal Project	To strengthen the adaptive capacity and climate resilience of vulnerable coastal communities to climate risks in Guinea-Bissau: Governance frameworks for climate risk management in the coastal zone which focuses on supporting the establishment of an enabling political, institutional and administrative environment for advancing the management of the climate risk in the coastal zone. Coastal protection investments which aims to finance additional investments in hard and soft coastal protection measures to help maintain critical economic and natural infrastructures in the face of sea level rise and coastal degradation. This includes interventions in the agricultural and fisheries sectors, as well as those related to nature protection and ecosystem restoration. Diffusion of technologies to strengthen coastal communities' climate resilience: this entails contributing to strengthen climatic resilience through livelihood options for the coastal communities with emphasis on the most vulnerable groups such as women and youths	Guiné Bissau	2019-2024	USD	12,000,000	WB GEF	UNDP, MdA
	Lake Malawi national park fish conservation project	To improve the state of conservation of the Lake Malawi National Park: Sustainable co-management of the fish resources as a key livelihood and heritage asset, in partnership with the local communities Enhanced capacity of the management authorities, community-based Beach Village Committees and Village Natural Resource Committee to support effective conservation. Communities are empowered to enforce bylaws that support conservation of fish breeding areas and sustainable fishing practices in the region. Fish monitoring is improved and capacity of the management authority to conduct ecological monitoring is enhanced with the support of research institutions. Improved working relationships among partners, including the Malawi Department of Parks and Wildlife, Department of Fisheries, non-governmental and community-based organisations and research institutions	Malawi	2019-2024	NOK		Government of Norway	Malawi Department of Parks and Wildlife, Malawi Department of Fisheries, Malawi National Commission for UNESCO and University of Malawi, Chancellor College, Ripple Africa

Acronym	Project	Objectives	Countries	Duration	curr.	Budget	Donor	Implementer
CECAF-PESCAO	Programme for improved regional fisheries governance in Western Africa	To enhance the contribution of fisheries resources to sustainable development, food security and poverty alleviation in west Africa: to improve regional fisheries governance in the region through better coordination of national fisheries policies: 1: A west African fisheries and aquaculture policy is developed and coordination of regional stakeholders is improved. 2: Prevention of and responses to IUU fishing are strengthened through improved monitoring, control and surveillance (MCS) at national and regional levels. 3: Marine resources management at the regional level is improved, building resilience of marine and coastal ecosystems to perturbations	Benin, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mauritania, Nigeria, Senegal, Sierra Leone, Togo	2018-2022	EURO	15,000,000	EU	FAO, ECOWAS/ PMU (GOPA); SRFC (Senegal), FCWC (Ghana), EFCA (Senegal)
RWP	Resilient Waters Program	To build more resilient and water-secure Southern African communities and ecosystems by improving management of transboundary natural resources and increasing access to safe drinking water and sanitation services, with a specific focus at three levels (local, national and transboundary)	Angola, Botswana, Namibia, Mozambique, South Africa, Zimbabwe	2018-2023	USD	32,391,266	USAID	Chemonics inc.
	Scaling Community-Based Fisheries Management in Mozambique	To build and strengthen community-based fisheries management of Mozambique's coastal waters: - Establish managed access areas that provide fishing communities clear rights to fish in certain areas; - Create networks of fully-protected and community-led no-take marine reserves to replenish and sustain fish populations and protect critical habitat; - Build community engagement and effective management bodies to support local decision-making - Collect, disseminate and help fishing communities use data for decision-making - Enact national policy to promote and sustain a community-based management approach to small-scale fisheries; - Enable fishers to adopt more sustainable and better-regulated fishing behaviors (e.g., become a registered fisher; record fish catch; respect fishing regulations; and participate in fisheries management); - Advance coastal fishing communities' inclusion in financial and market opportunities to increase household resilience	Mozambique	2020-2023	USD		Ocean 5	RFF
SWIOFish3	South West Indian Ocean Fisheries Governance and Shared Growth Program 3	To improve management of marine areas and fisheries in targeted zones and strengthen fisheries value chains in Seychelles: expanded sustainable use of marine protected areas, improve governance of priority fisheries, sustainable development of the blue economy,	Seychelles	2018-2023	USD	100,000,000	AfDB	
ASTRAL	All Atlantic Ocean Sustainable, ProfiTable and Resilient AquacuLture	To contribute to the implementation of the Belém Statement and other trans-Atlantic agreements to develop a strategic partnership on marine research, and it participates in building the All-Atlantic Ocean Research Community: to increase the value and sustainability of Integrated Multi-Trophic Aquaculture (IMTA) production by developing new, resilient and profitable value chains	Nigeria, South Africa	2020-2024	euro	7,939,355	EU	NORCE

Acronym	Project	Objectives	Countries	Duration	curr.	Budget	Donor	Implementer
OCEAN FRONT CHANGE	Managing ocean front ecosystems for climate change	To develop scientific and management techniques that allow effective fisheries and conservation management at ocean fronts in low- to medium-data settings in tropical oceans, using the Mozambique Channel as a test case: 1 Engage conservation and fisheries stakeholders along the central Mozambique Channel in co-design of transdisciplinary analyses of Ocean Front ecosystems and climate change. 2 Assess fisheries and marine life use of Ocean Fronts in the Mozambique Channel through expert working groups, stakeholder working groups and historical compilation of remote sensed, modelled and in-situ data sets on Fronts. 3 Produce estimates of Ocean Front variability under climate change and consider these in the context of scenarios for national and regional progress toward sustainable development goals related to fisheries and life under water. 4 Derive conservation and management solutions with Mozambique Channel partners that can be applied locally and estimate the global applicability of these solutions for Ocean Fronts in other locations	Kenya, Mozambique	2020-2022	euro		NSF, SIDA, NRA, FMER	CORDIO, CI, IRD, UH
ECOFISH	Contribution of Sustainable Fisheries to the Blue Economy of the Eastern Africa, Southern Africa and the Indian Ocean Region	To enhance equitable economic growth by promoting sustainable fisheries in the East African-South African-Indian Ocean (EA-SA-IO) region: to support sustainable management and development of fisheries, while addressing climate change resilience and enhancing marine biodiversity.	East Africa, Southern Africa, Indian Ocean	2018-	euro	2,000,000		LVFO
	Establishing an MPA Network in South Africa	To create awareness of the Marine Protected Areas value for provision of ecosystem services, ocean risk mitigation, food security, ecotourism benefits, moderation of climate change and improving resilience to impacts of other global stressors	South Africa	2020-2023	USD	1,191,000	Ocean 5	Wildlands conservation trust
CCLME	Canary current Large marine ecosystem	To reverse the degradation of the Canary Current Large Marine Ecosystem caused by over-fishing, habitat modification and changes in water quality by adoption of an ecosystem-based management approach: Multi-country agreement on priority transboundary issues; Multi-country agreement on governance reforms and investments to address priority transboundary issues; A sustainable legal/institutional framework for the CCLME Strengthened existing transboundary waters institutions Stakeholder involvement in transboundary waterbody priority setting and strategic planning 7 functioning National Inter-ministerial Committees 3 multi-country policy proposals (as annexes to the SAP) 5 management instruments for maintaining fish stocks, associated biodiversity and water quality (as annexes to the SAP) 5 demonstrations implemented and costs/benefits evaluated	Cape Verde, Guinea, Guinea-Bissau, Mauritania, Morocco, Senegal, The Gambia	5 years	USD	27,541,250	WB GEF	FAO, UNEP
	Cape Verde Marine Protected Areas Network	To strengthen the national network of marine protected areas and propose the creation of new areas with larger dimensions and innovative management forms that include local populations in a participatory and inclusive management	Capo Verte	2020-2023	USD	810,000	Ocean 5	Biosfera

Acronym	Project	Objectives	Countries	Duration	curr.	Budget	Donor	Implementer
CFI	Coastal fisheries initiative - Programme for improved regional fisheries governance in Western Africa	To strengthen fisheries governance, management and value chains, through the implementation of an ecosystem approach to fisheries, relevant international instruments and innovative governance partnerships Cabo Verde, Cote d'Ivoire and Senegal.	Cabo Verte, Cote d'Ivoire, Senegal	5 years	USD	6,500,000	WB GEF	FAO, UNDP, UNEP, WB, CI
CFI-WA	Delivering sustainable environmental, social and economic benefits in West Africa through good governance, correct incentives and innovation	To strengthen fisheries governance, management and value chains, through the implementation of an ecosystem approach to fisheries, of relevant international instruments and of innovative governance partnerships in three countries in West Africa (Cabo Verde, Cote d'Ivoire and Senegal).	Cabo Verde, Cote d'Ivoire, Senegal	2018-2023	USD	6,400,000	WB GEF	FAO, UNEP (Abidjan convention)
FishGov 2	Enhancing sustainable fisheries management and aquaculture development in Africa: A programme for accelerated reform of the sector	To provide accelerated reform to the sector: i. AU decisions on sustainable fisheries and aquaculture policies are evidence-based ii. Fisheries and aquaculture policies in Africa are coherent with the PFRS and other AU priorities and coordinated at continental, regional and national levels iii. Africa is adequately represented and effectively participates in international fisheries and aquaculture fora and ably domesticates relevant global instruments.	Africa	2021-2025	euro		EU	FAO
	Improving Fisheries Governance in Ghana and the Wider Sub-Region	To strengthen government and industry commitment to improve fisheries governance in the key policy areas of enhanced transparency, law enforcement, collaborative management and capacity of key stakeholders in Ghana and the West African region	Ghana, West Africa	2020-2023	USD	750,000	Ocean 5	Hen Mpoano
	Improving fishery management and stopping IUU fishing in Cameroon	To combat IUU fishing in Cameroon through supporting the Government's efforts to enhance the fishery governance, legal framework, and control systems, and to contribute to the sustainable management of aquatic resources: 1) enable Cameroon to meet the global transparency requirements and higher international fisheries governance standards and revise the current fishery and aquaculture legislation; 2) reinforce the fishery monitoring and control system and elaborate a fishery management plan.	Cameroon	2022-2025	USD	701,400	Ocean 5	AMMCO, EJF and MINEPIA
LEAF II	Multinational Lakes Edward and Albert integrated fisheries and water resources management project	To sustainably utilize the fisheries and allied natural resources of the Lakes Edward and Albert Basin through harmonized legal framework and policies: Updated and harmonized fisheries and aquaculture policies and legislation jointly adopted by both countries Joint fisheries monitoring, control and surveillance activities supported on both lakes Joint fisheries monitoring, control and surveillance activities supported on both lakes capacities and skills strengthened for fishing communities in improved fishing practices, modern processing techniques, alternative livelihoods Landing sites constructed with fish processing facilities, ancillary feeder roads, potable safe water supply and sanitation facilities. 10 pilot fish cage farms constructed for aquaculture promotion (5 per country) Other alternative economic activities promoted (e.g., horticulture, apiculture, poultry, etc	RDC, Uganda	2016-2021	USD	24,200,000	AfDB, WB GEF	NELSAP-CU

Acronym	Project	Objectives	Countries	Duration	curr.	Budget	Donor	Implementer
RFGG	Reinforcing Fisheries' Governance In Guinea	To improve fisheries governance and policy reforms within the project's timeframe: targeting technical capacity support in combating IUU, national fisheries legal and regulatory framework reforms and fisheries transparency improvement	Guinea	2021-2024	USD	995,000	Ocean 5	GRID Arendal
	Reinforcing the Fight Against IUU Fishing in Senegal	To improve Senegal's capacity to fight IUU fishing through better fisheries governance, in particular by increasing the transparency of the activities of fisheries policy bodies, through enforcement of fisheries legislation and by building capacities of stakeholders in Senegal	Senegal	2021-2024	USD	993,000	Ocean 5	Regional partnership for the conservation of the coastal and marine zone of West Africa
CLIMALG-SN	Seaweed for climate change resilient blue economies, biodiversity and ecosystem services	To enhance biodiversity and ecosystem services in Senegal and neighbouring countries by providing a road map to policy makers to encourage both exploitation (cultivation and harvest) of seaweed and preservation of natural seaweeds habitats as a tool for fisheries management and as refuge and habitat for exploited fish	West Africa, Senegal	2020-2022	euro			Meer-Wissen
MWRD2	Senegal River Basin Multi-Purpose Water Resources Development	To enhance regional integration among the countries of the Senegal River Basin for multi-purpose water resources development, to foster improved community livelihoods to enhance regional integration among the countries of the Senegal River Basin for multi-purpose water resources development, to foster improved community livelihoods: Institutional development, Multi-purpose water resources development, Infrastructure management and planning	Guinea, Mali, Mauritania, Senegal	2013-2023	USD	228,500,000	WB	OMVS
LME-AF	Strategic Partnership for Sustainable Fisheries Management in the Large Marine Ecosystems in Africa	To assist in the development, adoption and implementation of governance reforms supporting environmentally, economically and socially sustainable marine fisheries in the large marine ecosystems (LMEs) of Africa	Comoros, Mauritania, Mozambique, Tanzania	2019-	USD	500,000	WB GEF	FAO, WWF, AUEC-AU
	Strengthen regional mechanisms of coordination to combat IUU fishing in West Africa	To strengthen the coordination among the relevant regional actors: ECOWAS and both RFBs (SRFC and FCWC) and discuss a regional approach for an effective implementation of the PSMA to combat IUU fishing in West Africa	West Africa					ECOWAS
CCLME	Sustainable Management of the Canary Current Large Marine Ecosystem (CCLME) - Initial Support to the Implementation of the Strategic Action Program (SAP)	To create favourable conditions for the effective implementation of the SAP of CCCLME: 1: Strengthening partnerships and fostering investment for CCLME SAP implementation 2: Strengthening knowledge, management and capacity of fisheries institutions and communities for the sustainable use of transboundary fisheries resources and associated ecosystems 3: Communication, monitoring and evaluation	Senegal, Guinea, Cabo Verte, Mauritania, Morocco, Gambia, Guiné Bissau	2022-	USD	1,826,000	WB GEF	FAO
WASP	West African Biodiversity under Pressure	To facilitate the mainstreaming of biodiversity protection, into the management of the fisheries sector, the Oil & Gas industry and Protected Areas policies.	West Africa	2020-2022	euro			Meer-Wissen

Acronym	Project	Objectives	Countries	Duration	curr.	Budget	Donor	Implementer
SOLSTICE-WIO	Sustainable Oceans, Livelihoods and food Security Through Increased Capacity in Ecosystem research in the Western Indian Ocean	To undertake novel and collaborative research to understand selected WIO fisheries and the impacts of current and future changes: grow marine environmental research capability to address challenges facing the WIO region in a cost-effective way via state-of-the-art technology transfer, collaborative environmental and socio-economic research, and hands-on training, To strengthen the capacity of UK marine scientists to apply leading-edge technologies in developing countries, and work with regional and local experts to ensure that their research addresses local and regional needs, strengthen the ability of WIO scientists to effectively deliver evidence-based environmental and socio-economic information to support policy development and implementation at national and regional levels, ensure future sustainability of marine research capability in the region by training and mentoring early career scientists and post-graduate students from the WIO and by developing on-line resources for use in distance learning and hands-on training of marine scientists outside the partner organisations and beyond the duration of the project, ensure on-going support for an Ecosystem Approach to Fisheries in the WIO by building lasting strategic research partnerships between UK marine science and regional centres of excellence, between these centres and other WIO research organisations, and between marine scientist and government agencies and NGOs mandated to deliver sustainable development and exploitation of marine living resources in the WIO.	Tanzania, Kenya, South Africa	2017-2022	pound	3,911,197	UK GCRF	NOC
EAF-Nansen	EAF-Nansen programme	To improve food and nutrition security for people in partner countries through sustainable fisheries: 1. Knowledge on marine resources and ecosystems. 2. Capacity development, Gender, Knowledge exchange	Morocco, Mauritania, Senegal, The Gambia	(1974) 2017-2022	NOK		Norad	IMR, FAO
	Marine Biodiversity Conservation in Africa	To support projects that contribute to strengthening marine biodiversity conservation in sustainable blue economy approaches in Africa	Algeria, Cameroon, Côte d'Ivoire, Democratic Republic of Congo, Egypt, Guinea, Liberia, Libya, Mauritania, Mozambique, Namibia, Senegal, Sierra Leone, Somalia, South Africa, Tanzania	2019-	euro			Meer-Wissen
SWIOFC	A Partnership for Marine and Coastal Governance and Fisheries Management for Sustainable Blue Growth in the Western Indian Ocean	To improve coordination between fisheries and environmental management to maintain the health of the WIO's fisheries resources and the ecosystems that support them	Comoros, France, Kenya, Mauritius, Madagascar, Mozambique, Seychelles, Somalia, United Tanzania, South Africa	2019-2023	USD	8,600,000	SIDA	NC Secretariat, SWIOCC, FAO

Acronym	Project	Objectives	Countries	Duration	curr.	Budget	Donor	Implementer
	Water secure future for Southern Africa	To build governance capacity by mainstreaming the Ecosystem Approach (EA) into Integrated Water Resource Management (IWRM) in the Orange-Senqu River Basin: - Increase knowledge and awareness resulting in the inclusion of ecosystem issues in IWRM thereby improving biodiversity conservation - Demonstrate enhanced social and ecological resilience in hotspots in the Basin by integrating the Ecosystem Approach in transboundary water management - Enhance capacity of key actors to engage effectively in multi-stakeholder processes and negotiate and dialogue towards improved water resources management.	South Africa, Lesotho, Botswana, Namibia	2013-	USD	2,200,000	USAID	IUCN, KCS, SDA, DRFN, EWT
	Who Stole Our Oceans? Empowering Local Communities To Protect Our Oceans	To empower the coastal communities with skills and social capital in order to achieve long-term protection for the ocean: the communities will be capacitated to build networks and solidarity along the entire coastline, in a way that enables people to come together to call for further protection, for example, through increasing MPAs and withstand the current oil and gas threat and any further threat to the ocean.	South Africa		USD	750,000	Ocean 5	
AQUAHUB II	Education and research hubs for the sustainable management of freshwater ecosystems in East Africa	To foster the sustainable management of freshwater ecosystems and to contribute towards the achievement of the SDG's: to support capacity development processes at the individual and institutional level towards the sustainable management of freshwater ecosystems in Eastern Africa, to strengthen HEST institutions in Eastern Africa, which educate professionals, carry-out relevant research/extension activities, contribute to the development of evidence-based policies and enhance regional and international networking	East Africa	2021-2024	euro	1,690,100	Austrian development agency	BOKU
	Increased sustainability in the aquaculture sector in Sub-Saharan Africa through improved aquatic animal health management	To improve: - Research capacity on aquatic animal health management in Sub-Saharan Africa countries - Institutional capacity and learners' knowledge and practical skills on aquatic animal health to improve the aquaculture related education services and enhance extension capacity in Sub-Saharan Africa countries - New knowledge on aquatic animal health in aquatic food systems in the framework of one health and one food systems widely to share in SAA through sustainable networking	Egypt, Ghana, Kenya	2020-2024	NOK	27,000,000	Norad	WorldFish, NVI
	A Ridge-to-Reef Approach for the Integrated Management of Marine, Coastal and Terrestrial Ecosystems in the Seychelles	To manage and conserve the flow of marine, coastal and terrestrial ecosystem services in targeted islands of the Seychelles for multiple benefits through the Ridge-to-Reef approach: 1. Creation and execution of a pre-TDA stage, the Marine Ecosystem Diagnostic Analysis (MEDA). The production of the nine MEDA reports represents an early delivery to the Project countries of information which is immediately useful to researchers and particularly resource managers. 2. The ASCLME Project has undertaken a Policy and Governance process which has resulted in the creation of a Policy and Governance Coordinator post within the Project. 3. ASCLME Project has built regional and international support for a "Western Indian Ocean Sustainable Ecosystem Alliance"	Seychelles	2019-	USD	3,898,914	WB GEF	UNDP

Acronym	Project	Objectives	Countries	Duration	curr.	Budget	Donor	Implementer
	African, Caribbean, and Pacific (ACP) Countries Capacity Building of Multilateral Environmental Agreements (MEAs) project: Effective implementation of the Nairobi Convention	To improve international environmental governance and better management of coasts and oceans	Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, South Africa, Tanzania	2019-2024	USD	2,140,638	EU	NC Secretariat
	Blue Nature Alliance to Expand and Improve the Conservation of 1.25 Billion Hectares of Ocean Ecosystems	To catalyse the conservation of 1.25 billion hectares of ocean ecosystems, to safeguard biodiversity, help build resilience to climate change, promote human well-being and enhance ecosystem connectivity and function: Creation or Expansion of Ocean Conservation Areas, Improved Management or Upgraded Protections	Global	2021-2026	USD	22,635,780	WB GEF	CI, BNA
	Conserving Aquatic Biodiversity in African Blue Economy Project	To Enhance institutional capacity of African Union Member States and Regional Economic Communities on the utilization, conservation and protection of aquatic biodiversity in the context of the Africa Blue Economy Strategy	Africa	2021-2024	USD	10,000,000	SIDA	AU-IBAR
	Effective Management Of The Marine Protected Areas Of The Comoros Archipelago, Africa, Western Indian Ocean	To strengthen the management of and increase protection in the existing four coastal Marine Protected Areas of Comoros	Comoro	2021-2024	USD	998,000	Ocean 5	Wildlands Conservation Trust
LEAP	Enhancing coastal and marine socio-ecological resilience and biodiversity conservation in the Western Indian Ocean	To achieve long-term effective, equitable and inclusive co-management of Locally Managed Marine Protected Areas (LMMAs) in four countries – Kenya, Tanzania, Mozambique and Seychelles through adoption of locally relevant protected or conservation area governance frameworks by national governments and non-state actors	Kenya, Tanzania, Mozambique, Seychelles	2020-2023	euro		BMUV-IKI	IUCN, CORDIO, AIMA, Nature Seychelles
WIOSAP	Implementation of the Strategic Action Programme for the protection of the Western Indian Ocean from land-based sources and activities	To reduce these land-based stresses by protecting critical habitats, improving water quality, and managing river flows: 1 Protecting, restoring and managing critical coastal habitats 2 Ensuring water quality 3 Managing river flows wisely 4 Strengthening governance and awareness	Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, South Africa, Tanzania, France	2016-2021	USD	10,867,000	WB GEF	UNEP
BCLME PROJECT III	Improving Ocean Governance in the Benguela Large Marine Ecosystem	To realize a coordinated regional approach to the long-term conservation, protection, rehabilitation, enhancement and sustainable use of the Benguela Current Large Marine Ecosystem in order to provide economic, environmental and social benefits and well-being to the region through the domestication and implementation of the Benguela Current Convention and accompanying Strategic Action Programme: 1. Improved Ocean and Coastal Governance, 2. Stakeholder Engagement and Partnership Collaborations, 3. Capacity Development and Training	Angola, Namibia, South Africa	2017-2022	USD	10,000,000	WB GEF	BCC Secretariat
	Nile basin Regional Hydromet Project	To provide real time data and more reliable information to improve water resources planning and management both at national and regional levels	Burundi, DR Congo, Egypt, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania, Uganda	2018-2022	euro	5,500,000	EU, BMZ	NELSAP-CU

Acronym	Project	Objectives	Countries	Duration	curr.	Budget	Donor	Implementer
	Strengthening the effective management of the Namibian Islands Marine Protected Area (NIMPA) and expansion of MPA network in Namibia	To establish and resource a formal management plan to effectively manage the NIMPA	Namibia	3 years	USD	900	Ocean 5	NNF
	Support to Trans boundary Water Cooperation in the Nile River Basin (EU-BMZ Wetlands Project)	To strengthen the knowledge base on wetlands of transboundary importance in the Nile Basin to support basin-wide conservation, management, planning and restoration efforts; Raise awareness and undertake advocacy efforts on the important role of wetlands and their ecosystem functions for the basin's development; Develop and promote a basin-wide approach for the sustainable and cooperative management of wetlands taking into account the full range of wetland uses; and to Strengthen national policies and institutional capacities for the effective management of wetlands with basin-wide importance	RDC, Tanzania, Burundi, Rwanda, Uganda, Kenya, Ethiopia, Eritrea, South Sudan, South Sudan, Egypt	2017-	euro	13,500,000	EU, BMZ	GIZ
	Technical Assistance for Capacity Building for River Basin Planning Project	To strengthen the institutional framework and capacity of the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) to manage and develop the region's water resources, within the context of the Nile River Basin: i. strengthening strategic planning and organizational development; ii. strengthening the NELSAP Knowledge Systems iii. strengthening investment finance mobilisation; iv. strengthening the regulation of dam safety	Democratic RDC, Tanzania, Burundi, Rwanda, Uganda, Kenya, Ethiopia, Eritrea, South Sudan, South Sudan, Egypt	2017-	euro	1,000,000	AFD	NELSAP-CU
SAPPHIRE	The Western Indian Ocean Large Marine Ecosystems Strategic Action Programme Policy Harmonisation and Institutional Reforms	To promote policy and institutional reform to help improve the management of the Western Indian Ocean LME	Comoros, France, Kenya, Mauritius, Madagascar, Mozambique, Seychelles, Somalia, United Tanzania, South Africa	2017-2023	USD	8,766,500	WB GEF	UNDP
WaSAf	Water Sources in Africa project	To implement a process for inspecting and assessing the quality of water in three of the continent's lakes used to supply three large cities (Abidjan, Dakar and Kampala), and to pave the way for the first measures to be taken for the sustainable management of these ecosystems and preserving and/or restoring them	Cote d'Ivoire, Senegal, Uganda	2016-2022	euro		FFEM	INRAE
NoCaMo	Integrated Management of the Marine and Coastal Resources of the Northern Mozambique Channel (NoCaMo) Project	To ensure that the high biodiversity value of the Northern Mozambique Channel's (NMC) coral reefs, seagrass, and mangrove ecosystems are maintained by 2025	Réunion (France), Madagascar, Mozambique, Tanzania, Comoros, Seychelles	2019-2022	euro	1,500,000	FFEM	NC Secretariat, WCS, CORDIO, WWF
	Protect the Protected Area of Baía do Inferno, Cabo Verde	To protect and reinforce marine biodiversity, and to ensure the long-term survival of the key marine species (seabirds, sea turtles, dolphins, whales, threatened fish species, etc)	Cabo Verte		USD	35	Ocean 5	Associação Lantuna

Acronym	Project	Objectives	Countries	Duration	curr.	Budget	Donor	Implementer
AFAP	Artisanal Fisheries and Aquaculture Project	To reduce poverty in artisanal inland fishing and small-scale fish-farming households in target communities in view of improving food security and nutrition among artisanal inland fishing and fish-farming households while addressing climate change issues that affect fisheries and aquaculture sectors: To strengthen institutional capacity (national, provincial, local/extension services) To improve community participation in economic and wider local development processes To increase the quantity and quality of fish produced and sold on a sustainable basis	Angola	2015-2022	USD	12,140,000	IFAD	IFAD
FIRST	Food and Nutrition Security Impact, Resilience, Sustainability and Transformation	To create an enabling environment for the development and implementation of the Integrated and Coordinated Regional Fisheries and Aquaculture Strategy to enhance the contribution of the sector to food security and nutrition and poverty reduction in West Africa	West Africa	2019-	euro	40,000,000	EU	FAO
FISH4ACP	Unlocking the potential of sustainable fisheries and aquaculture in Africa, the Caribbean and the Pacific	To contribute to food and nutrition security, economic prosperity and jobs creation by ensuring the economic, social and environmental sustainability of fisheries and aquaculture value chains in Africa, the Caribbean and the Pacific countries.	Nigeria, Tanzania, São Tomé and Príncipe, Cameroon, Côte d'Ivoire, Gambia, Senegal, Zambia, Zimbabwe	2020-2025	euro	40,000,000	EU	FAO
AfriMAQUA	Sustainable marine aquaculture in Africa	To bring together research teams in the field of marine aquaculture in West Africa (Senegal, Ivory Coast), Southern Africa (Namibia, South Africa), East Africa (Tanzania, Kenya, Mauritius) and actors from UMR MARBEC (France) in order to exchange knowledge, pool research efforts and strengthen research capacity: Control of the biological cycles of species of aquaculture interest Establishment of a healthy and sustainable diet for the species produced Development of ecosystem-friendly livestock farming systems Improvement of the welfare and health of organisms and livestock systems	Senegal, Cote d'Ivoire, Namibia, South Africa, Tanzania, Kenya, Mauritius	2019-2024	euro		GDRI-Sud, IRD	GDRI-Sud
KCSFSC	Kenya Climate-Smart Fish Culture Systems	To increase aquaculture productivity and improve livelihoods in a sustainable environment through validation of climate-smart fish culture systems: To validate sustainable biofloc fish farming systems to increase fish larval survival and productivity and reduce production cost. To promote the use of high-density polyethylene (HDPE) fish cages to increase fish productivity while enhancing food safety and of aquatic biodiversity. To promote finger-pond technology to increase fish production, reduce fishing pressure in lakes and GHG emissions To validate integrated fish-poultry culture system to increase food productivity while conserving nutrients.	Kenya	2019-	USD		WB	KMFRI
SFU	Sustainable fisheries in Uganda	To have more fish products available for the food insecure population in Uganda and East Africa as well as an increased income from sustainable and resource-conserving Nile perch fisheries	Uganda	2016-2023	euro	10,950,000	GIZ	GIZ, LVFO, DIFR,

Acronym	Project	Objectives	Countries	Duration	curr.	Budget	Donor	Implementer
POSCAWA	Promoting sustainable cage aquaculture in West Africa	To promote cage culture in West Africa through Sino-Afro exchange of knowledge and public-private partnership: i. Empower rural communities through sustainable cage culture ii. Enhanced employment, incomes and nutritional status of rural households through productive and sustainable cage farming in water bodies iii. Establish linkages and partnerships for improved rural entrepreneurship and livelihoods	Ghana, Nigeria	2020-2022	USD	500,000	IFAD-SSTC	WorldFish
ACLISAT	Advancing climate smart aquaculture technologies	To improve rural livelihood and resilience of fish farmers in Egypt, Eritrea, Ethiopia: to increase adoption of efficient aquaculture technologies in arid areas, improve engagement of women and youth in productive aquaculture and enhance collaboration between IFAD, WorldFish and regional/national partners in the field of aquaculture; strengthen capacity of national aquaculture institutions in Egypt, Eritrea and Ethiopia and promote the adoption of such technologies by fish farming communities.	Egypt, Eritrea, Ethiopia	2018-2022	USD	1,254,000	IFAD	WorldFish
	Ending Destructive Industrial Fishing in Madagascar and the Western Indian Ocean	To end destructive and illegal industrial fishing--its impact on fish stocks, the marine environment and vulnerable traditional fishers--and protect the rights of coastal communities in Madagascar: to collaborate with and support the fisheries authorities in Madagascar to monitor their fisheries, improve transparency and management in the fisheries sector, and empower small-scale fishers	Madagascar	2021-2024	USD	750,000	Ocean 5	Blue ventures conservation
	Marine Biodiversity Protection in Mozambique and Tanzania	To ensure Marine Protected Areas design and management is equitable, effective, and sustainably financed for improved conservation and socioeconomic outcomes	Mozambique, Tanzania	2020-2023	USD	999,000	Ocean 5	Wildlife Conservation Society
SAEK	Strengthening the aquaculture system in Kenya	To build a resilient and inclusive policy environment for the deployment of Kenya's aquaculture sector	Kenya	2019-2022	USD		OSF	Farm Africa
AWFISHNET	African Women's Fish Processors and Traders Network	To enhance the economic empowerment of women in fisheries and aquaculture	Africa: 32 African Union countries	2017-				AWFISHNET
	Aquaculture enterprise development project	To stimulate a viable aquaculture sub-sector in Zambia to promote economic diversification, food security, and sustainable employment generation: support and promotion of reliable access to quality input and output markets; competitively priced risk-sharing access to finance, creation of an enabling infrastructure environment, which in turn is expected to facilitate the entry of new actors and expansion of business opportunities by the existing players in the industry.	Zambia	2016-2022	USD	2,630,000	AfDB	Worldfish
	Empowering women in small-scale fisheries for sustainable food systems	To support small-scale fishers and fish workers in Ghana, Malawi, Tanzania, Sierra Leone and Uganda, with a special focus on women in the post-harvest sector	Ghana, Malawi, Tanzania, Sierra Leone, Uganda	2015-2022	USD	2,500,000	Norad	FAO
FSSP2	Fisheries sector support project 2	To minimize post-harvest fish losses, increase the value of fish traded and enhance safety at sea for artisanal fishers living in four coastal communities (Egipto Praia, Gilco, Sumbe and Yembe) in Angola	Angola	2019-2022	USD	1,100,000	AfDB	MARDAF

Acronym	Project	Objectives	Countries	Duration	curr.	Budget	Donor	Implementer
RFBCP	Responsible Fisheries Business Chains on Lake Victoria Project	To adopt new approaches to fisheries management that are based on economics, wealth creation, value chains, business enterprises and a proactive private sector, adoption of a business approach linked to resource management and a move from open to controlled fisheries access using licensing as management tools only in Uganda	Uganda	2018-	euro	8,000,000	BMZ	LVFO, GIZ
	Sustainable Fisheries, Aquaculture Development and Watershed Development Project	To promote diversification from capture fisheries to aquaculture ventures, and hence increased production and incomes: Sustainable capture fisheries and watershed management, Aquaculture development, Fish value chain strengthening	Malawi	2020-2024	USD	1,500,000	Worldfish	WorldFish
TRUE-FISH	TRUEFISH Farming Story in the Lake Victoria Basin	To contribute to the development of competitive, gender equitable and sustainable commercial aquaculture in order to support economic development and sustainable management of natural resources in the Lake Victoria basin: Remove impediments to growth faced by investors to ensure a more rapid transition to a more efficient and sustainable sector. - Address challenges and threats that could undermine the sustainability of aquaculture development or could impact negatively on the environment, food security, or livelihoods. - Promote harmonized aquaculture development in the region; e.g., through mechanisms for shared experiences, examples, and lesson learning	Kenya, Uganda, Tanzania	2019-2024	euro	10,150,000	EU	WorldFish, LVFO
MARISMA	Marine Spatial Planning	To use the Marine Spatial Planning process to organise the development of the marine area by ordering multiple claims in space and time, based on the best available evidence and arrived at through political prioritisation	Namibia, South Africa	2014-2022	euro	10,088,000	BMUV-IKI	BCC Secretariat

Annex 5: Measures of adaptation to Climate change in fisheries

Threats			**Good practices**	**Level of implementation capacities needed**
Changes in species distribution	**Changes in species composition**	**Changes in fish productivity**		
X	X	X	1. Enhance monitoring programs through community-based approaches	Low
X		X	2. Incorporate environmental variables and risk into fisheries assessment and management advice	High
X			3. Adjust spatial scale of monitoring to be responsive to shifting stocks	Medium
X	X	X	4. Establish early warning systems for extreme events	Medium
X			5. Apply flexible and adaptable fishing seasons	Low
X			6. Apply tradable fishing rights/allocations to allow flexibility in response to stocks shifting across international borders	High
X			7. Close fishery during climate-driven events to support resistance and recovery	Low – High
X	X	X	8. Apply in-season management systems that are responsive to rapid climate-driven stock changes	Low – High
X			9. Relocate fishery species to compensate for changes in productivity	High
X	X	X	10. Conserve keystone species complexes to avoid ecological tipping points and related changes in target species abundance	Low - Medium
X	X	X	11. Relocate landing and processing practices	Low - High
X	X	X	12. Develop new fishery opportunities to capitalise on distribution shifts or enhances productivity (including for 'new' species)	Low - Medium
X	x		13. Source more diverse supplies of seafood for processing facilities	High
X	X	X	14. Develop new products and markets to maximise fishery value as catches decline	Medium
X	X	X	15. Develop insurance schemes that protect fishers against loss and damage after climate events or due to 'forced' practice changes or exit from the industry	High

African Union
Inter-African Bureau for Animal Resources (AU-IBAR)
Kenindia Business Park
Museum Hill, Westlands Road
P.O. Box 30786
00100, Nairobi, KENYA
Telephone: +254 (20) 3674 000 / 201
Fax: +254 (20) 3674 341 / 342
Website: www.au.ibar.org
Email address: ibar.office@au-ibar.org