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Synthesis of current knowledge, adaptation and mitigation options

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Chapter 8: Climate change impacts, vulnerabilities and adaptations: Eastern Central Atlantic marine fisheries

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KEY MESSAGES

- **Significance of fisheries.** The FAO major fishing area 34 currently represents about 3 percent of world marine capture production and 80 percent of the catches are made by 21 African coastal states that derive various benefits from their fishing sectors including, at varying levels, employment, livelihoods, food for local and international consumption and foreign income. The artisanal sector and specifically the small pelagic resources play a pivotal role for food and nutrition security and poverty alleviation.
- **Main threats to fisheries sustainability.** Overfishing, among other anthropogenic pressures on ecosystems, threatens the marine resources of this area. Many of the bordering states have limited capacities to manage their fishing sector sustainably. The area is characterized by the presence of many transboundary fish stocks; more than a third of the monitored stocks are currently exploited at biologically unsustainable levels. Climate change may exacerbate this situation, and could be a potential additional threat to the sustainability of the fishing sector and to its contribution to national economies and to poverty and food insecurity alleviation.
- **Nature of climate change threat.** Climate change is expected to result in an increase in the occurrence of extreme events (swells, storms, extreme rainfall, rising temperatures, rising sea levels, etc.) affecting mainly the artisanal sector fishing communities along the coast. Marine ecosystems are likely to continue to experience warming, changes in ocean current patterns, nutrient inputs and oxygen concentration, potentially resulting in a changed regime of ecosystem productivity and a possible subsequent geographical readjustment of catch potential towards the higher latitudes of FAO major fishing area 34 and towards the more favouurable habitats inside the area.
- **Vulnerability and the need to adapt.** Climate change is already affecting some of the main small pelagic fish (SPF), tuna and tuna-like fish, with potentially heavy implications for tropical nations, given the role of SPF and the artisanal sector in many sub-Saharan countries. It is also very likely that in the short-term, non-climate issues will have a greater effect on fisheries than climate change. Weak governance, weak development of knowledge including in relation to climate change impacts, and persistent poverty in many countries will very likely limit the capacity of fisheries-dependent populations to adapt, which may increase their vulnerability.

- **Short-term priorities to increase socio-ecological resilience** should be to 1) promote mainstreaming of socio-ecological resilience in public policies; 2) ensure, through improved management planning, that fisheries and ecosystem governance improve in such a way to mitigate and prevent further degradation of the quality of marine ecosystems of the region; 3) build or further develop the institutional research and management capacities; and 4) take concrete actions to protect assets and fishing communities against potential impacts of climate change and increase socio-ecological resilience.

8.1 MAIN FISHERIES OF THE EASTERN CENTRAL ATLANTIC AREA (FAO MAJOR FISHING AREA 34)

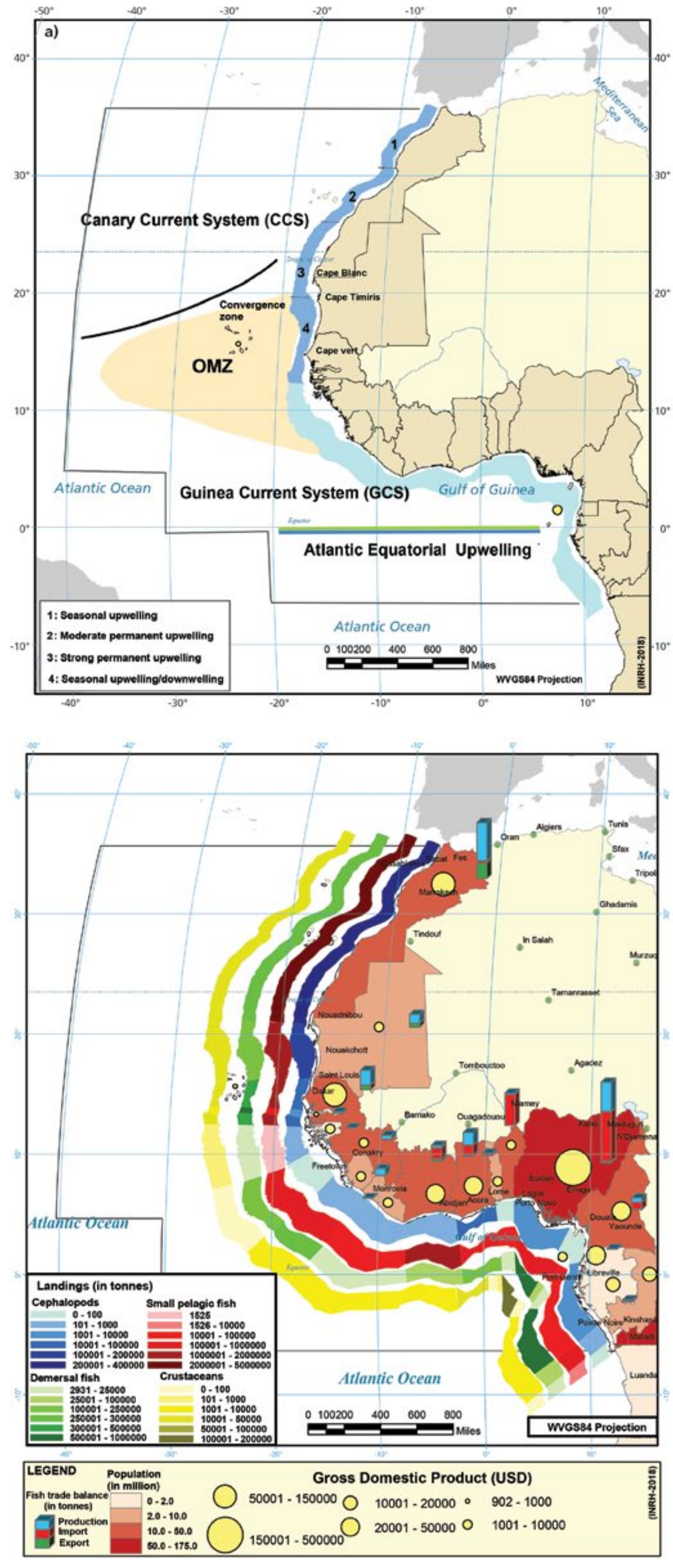
Most of the area (35°47’ north latitude, 5°55’ west longitude/6°07’ south latitude, 12°16’ east longitude; Figure 8.1) lies in tropical and subtropical latitudes and encompasses several marine biogeochemical provinces (Longhurst, 1998) that determine the nature of marine species assemblages and the potential for fishery production at a subregional scale.

FAO estimated the maximum production potential for the whole region at 4.3 megatonnes (Grainger and Garcia, 1996). After a steady increase in the late-1970s, marine catches have fluctuated around 4 megatonnes since the 1990s. Catches originate mainly from coastal stocks in the exclusive economic zones (EEZs) of the West African countries (WACs), whereas catches in areas beyond national jurisdiction on species other than tuna and tuna-like species are limited (FAO Fishstat, 2017). WACs’ catches accounted for 80 percent of the catches reported in the area in 2015 (FAO Fishstat, 2017). Domestic industrial fishing fleets were developed by several African countries after independence. These fleets remained stable until the 1990s, but gradually declined since then to near extinction in almost all the important fishing countries apart from Morocco (especially in Senegal, Ghana and Côte d’Ivoire). Nowadays, the industrial sector in almost all the WACs is comprised almost exclusively by foreign industrial fishing fleets operating under joint ventures or flags of convenience. These fleets’ catches are often quasi-exclusively directed towards the international market. On the other hand, the artisanal fishing effort has strongly increased in the area, especially in some countries of the sub-Saharan region such as Senegal and Ghana. Its level in 2010 had increased tenfold compared to 1950 according to Belhabib, Lam and Cheung (2016). It is important to note that this subsector absorbs a non-negligible part of the total national workforce in some sub-Saharan countries (e.g. Ghana). In Morocco, the largest marine capture fisheries country of the area, the industrial and semi-industrial domestic fleets are the main sectors harvesting fishery resources, even though the artisanal sector is of importance in terms of provision of some supply-chains and for the creation of jobs in some enclaved coastal regions. Many foreign vessels, operating under fishing agreements, are also harvesting living marine resources in several countries’ EEZs.

SPF are the most abundant resources of the area, providing more than 60 percent of the region’s marine catches. These species are mainly composed of European sardine (*Sardina pilchardus)*, round sardinella (*Sardinella aurita*), flat sardinella (*Sardinella maderensis*), bonga shad (*Ethmalosa fimbriata*), anchovy (*Engraulis encrasicolus*), Atlantic chub mackerel (*Scomber colias*), Atlantic horse mackerel (*Trachurus trachurus*), Cunene horse mackerel (*Trachurus trecae)* and false scad (*Caranx rhonchus*). Some other coastal and oceanic groups of high commercial value (cephalopods, shrimps, croakers, grunts, groupers, sparidae, and large migratory pelagic fishes such as tunas and billfishes), provide the main national fish supply chains, on which rely the economies of a large number of WACs as a source of income, creating jobs for 7 million West and Central Africans (de Graaf and Garibaldi, 2014).

FIGURE 8.1

Maps of the Eastern Central Atlantic area summarizing a) major current systems, upwelling sectors and oxygen minimum zone (OMZ) position; b) main fishery production regions, coastal states, declared landings of main fish groups, and national fish trade flows



Data source: FAO Fishstat, (2017); gross domestic product and human population per country (World Bank, 2017).

Fish also constitutes the staple food of the majority of the 400 million inhabitants of the area, who overall consume 7 million tons of fish annually (FAO Fishstat, 2017). Consumption of fish varies greatly between countries, however. SPF in particular contribute to animal protein accessible to the most vulnerable communities in sub-Saharan countries (i.e. nearly 200 million Africans; World Bank, 2017). SPF play a significant role in the food systems and greatly contribute to the supply of small-scale processing industries in almost all sub-Saharan countries (de Graaf and Garibaldi, 2014).

8.2 OBSERVED AND ANTICIPATED IMPACTS OF CLIMATE CHANGE ON MARINE ENVIRONMENTS RELEVANT TO FISHERIES

8.2.1 Physical and chemical impacts

The West African climate has evolved in recent decades according to the latest Intergovernmental Panel on Climate Change report, recognizing with high certainty the atmospheric and oceanic warming in all FAO major fishing area 34 subregions and on the contiguous continent (Niang *et al.*, 2014; Pörtner *et al.*, 2014).

Observed impacts

A cooling, resulting from the intensification of wind-driven upwelling under climate change, has been predicted for the Canary Current System (CCS), which extends from the Strait of Gibraltar to the south of Guinea-Bissau (Bakun, 1990). The CCS has, however, globally warmed over the permanent thermocline during the last three decades (Pörtner *et al.*, 2014; Vélez-Belchí *et al.*, 2015), and the seasonal warming occurs earlier in the subtropical and extratropical upwelling sectors (deCastro *et al.*, 2014). However, the more marked and significant warming trends are observed in the oceanic sector and near the coast in the Senegalo-Mauritanian tropical sector (Vélez-Belchí *et al.*, 2015). Changes in the occurrence of extreme sea surface temperature (SST) events, in parallel with warming, are also hypothesized to be related to climate change in this region (Lima and Wethey, 2012). Extreme hot and cold events have increased and decreased respectively in frequency in the area during the most recent decades (deCastro *et al.*, 2014; Lima and Wethey, 2012). The warming of the Senegalo-Mauritanian upwelling sector has been linked, on another hand, to the recovery of the downwelling favourable winds in the subtropics (Cropper, Hanna and Bigg, 2014). The southwesterly monsoon circulation that drives downwelling-favourable winds is likely strengthening in the subtropics (Cropper, Hanna and Bigg, 2014) and upwelling-favourable winds are likely enhancing in the extratropical sector (Bakun, 1990; Cropper, Hanna and Bigg, 2014; Rykaczewski *et al.*, 2015; Sydeman *et al.*, 2014). The low latitude regions, comprising the Guinea Current System (GCS) and the Atlantic Equatorial Upwelling System (AEUS) also experienced a marked sea surface warming, a relaxation of the AEUS activity, and an increase of tropical rainfall, which have resulted from a weakening of the southeasterly trade winds during the past six decades (Pörtner *et al.*, 2014; Tokinaga and Xie, 2011).

There is lack of knowledge on acidification and oxygen depletion in the low latitude sectors of FAO major fishing area 34 (i.e. GCS and AEUS), but in the CCS, the North Atlantic oxygen minimum zone (NAOMZ) associated with this upwelling system shows a tendency towards deoxygenation since the 1960s (Stramma *et al.*, 2008), probably as a result of a combination of anthropogenic impacts and natural climate variability (Hahn *et al.*, 2017). The OMZ core is extending towards the surface and northwards. Upwelling waters are typically low in pH and high in CO_2 and are likely to continue to show changes in pH and CO_2 resulting from rising atmospheric CO_2 (Pörtner *et al.*, 2014). The surface pH of seawater shows a decreasing trend since 1995 at the ESTOC[1] site in the Canary Islands (Pörtner *et al.*, 2014; González-Dávila and Santana-Casiano, 2015).

Predicted impacts

Although there is low agreement on the statement of a future intensification of the CCS upwelling (Pörtner *et al.*, 2014), global climate model predictions indicate that the ongoing strengthening trend of the upwelling activity in the extratropical CCS, will be maintained by the end of the twenty-first century under the representative concentration pathway (RCP)8.5 scenario (Rykaczewski *et al.*, 2015; Wang *et al.*, 2015). A considerable expansion of the upwelling season of several days per decade, between 1950 and 2099, will likely occur at higher latitudes of the CCS (Wang *et al.*, 2015). Rainfall will likely decrease concomitantly over Northern Africa by the end of the twenty-first century (medium to high confidence; Niang *et al.*, 2014). A continuation of the warming is predicted in the equatorial region by the end of the century under an RCP8.5 scenario (Figure 8.2); it is to be noted that there is also no consensus on this statement because of a lack of reliable data in the region (Niang *et al.*, 2014). It is also unclear how rainfall in the Gulf of Guinea and the Sahel subregions will evolve. Many studies attempting precipitation forecasting for the West African subregion allude to tropical Atlantic SST accounting for the largest proportion of variability observed in rainfall, particularly in the Gulf of Guinea (e.g. Agumagu, 2016). Agumagu (2016) further asserted that anomalously warm SSTs in the Gulf of Guinea generate copious rainfall in the Guinea coast region but drier conditions over the Sahel zone. Many model results suggest an increase in rainfall by the end of the twenty-first century, with a small delay of the rainy season, an increase in the number of extreme rainfall days over West Africa and the Sahel, and more intense and a more frequent occurrence of extreme rainfall over the Guinea Highlands and Cameroon Mountains (Niang *et al.*, 2014). These predictions, however, remain uncertain according to Niang *et al.* (2014). Thus, a decrease in mean precipitation would possibly lead to increased risk of drought while an increase in mean precipitation would lead to increased flooding (Agumagu, 2016).

Coastal systems and low-lying areas in many WACs are also facing increasing risks of erosion, inundation, and salinization of land and coastal waters because of the rise of sea level (IPCC, 2007). A one metre sea level rise (SLR) would lead to inundation and erosion, for example of 1 800 km^2 of lowland in Côte d'Ivoire, and more than 6 000 km^2 and 2 600 km^2 of land respectively in Senegal and Nigeria, most of which are wetlands (IPCC, 2007).

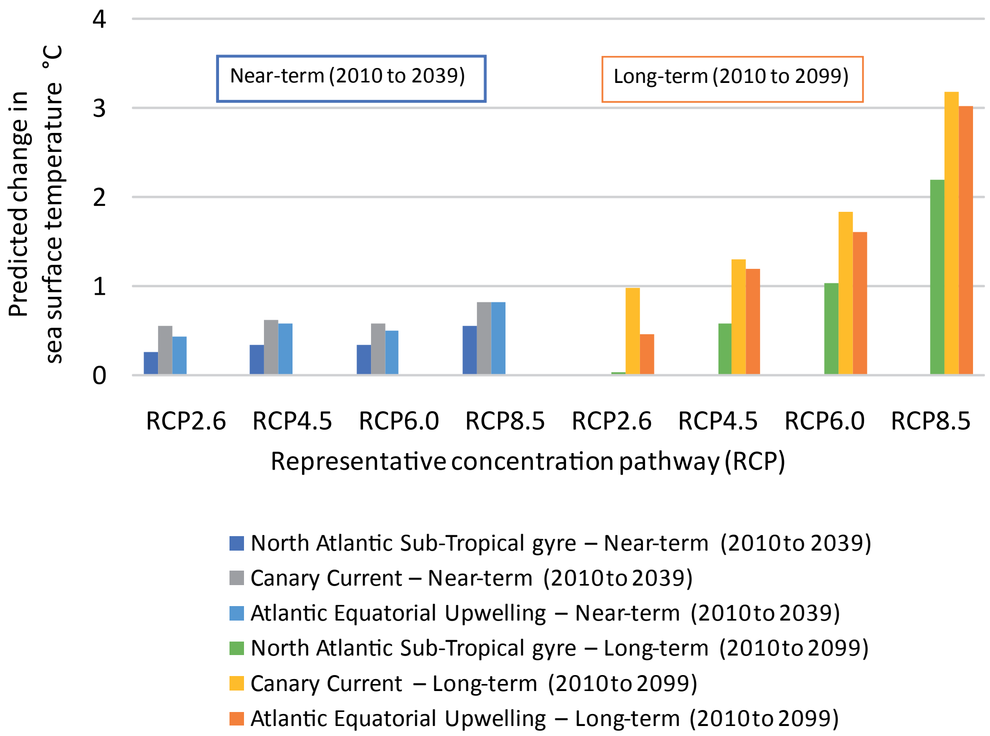
Because of large uncertainties in potential biogeochemical effects and in the evolution of tropical ocean dynamics, there is a lack of consensus on the future volume of low oxygen waters in the NAOMZ. Modelling simulations in the CCS suggest also that although future ocean acidification in this upwelling system will likely be primarily driven by the rise of atmospheric CO_2, changes in local winds and conditions might accentuate or dampen this large-scale trend owing to the nutrient utilization efficiency in the system (Lachkar, 2014).

The pattern and magnitude of changes reported and their future long-term evolution remain a matter of debate. They likely could be a result of greenhouse gas effects, but the likelihood of significant natural climate-related interactions, such as natural low-frequency (interannual to multi-decadal) variability in the ocean-atmosphere system cannot be dismissed (Brandt *et al.*, 2015; Di Lorenzo, 2015). Additionally, the existing global climate models have no consensus on how these large-scale climatic modes will evolve in the future, so their impacts remain unclear. Limited spatial and temporal extent of observations, and changes in wind measurement methodologies during the

[1] European Station for Time series in the Ocean Canary Islands.

mid-twentieth century also hamper somewhat robust conclusions on the causes and direction of change of the upwelling systems' activity.

FIGURE 8.2
Projections of sea surface water temperature rise during the twenty-first century in different regions of the FAO major fishing area 34 under RCP2.6, RCP4.5, RCP6.0, and RCP8.5 scenarios



Source: Pörtner *et al.*, 2014.

8.2.2 Biological and ecological impacts

Changes in the biological components of ecosystems in FAO major fishing area 34 and their eventual attribution to climate change are poorly documented. For the components at the base of the marine food chain, satellite observations over the last three decades in the CCS show that primary production displays an upward trend in the subtropics and mid-latitudes sectors, north of 23°26'13.0"N, and a downward trend in the tropical sector (Demarcq and Benazzouz, 2015). Data from the continuous plankton recorder in the Gulf of Guinea prior to 2008 also display a significant decline in abundance of phytoplankton and zooplankton as SST increases (Wiafe *et al.*, 2008). According to (Wiafe *et al.*, op. cit.), this could have serious implications of rippling effects on productivity of especially SPF species such as *Sardinella aurita* and *S. maderensis* in the region. However, the lack of continuous zooplankton observations in the area and also of empirical data examining the potential biological and ecological consequences of climate change on lower parts of the food chain, make it difficult to draw any sound conclusion on the direction of change at these trophic levels and also on knock-on effects through food webs and into fisheries. Existing model projections for the CCS (Lachkar and Gruber, 2013) suggest, for example, that a doubling of the wind stress will double net primary production (NPP) in central and northern CCS whereas the NPP increase will be less than 50 percent in the Senegalo-Mauritanian sector (south of 21 °N). According to Lachkar and Gruber (2013), these differential biological responses to wind stress may have implications for ecosystem food web structure and biogeochemical features in both sectors that would require a further study.

The effects of climate change on fish spawning habitat and larval connectivity patterns are poorly explored. Nevertheless, several studies conducted essentially on the main SPF of the area, concluded that, overall, the reproduction strategies and spawning habitat of these species are related to specific ranges of environmental conditions (e.g. Tiedemann *et al.*, 2017). Changes in meteorological and oceanographic conditions such as precipitation regime, alteration of current patterns, alteration of winds, and changes in nearshore biophysical processes under the anticipated climate change scenario, may affect these species' spatio-temporal reproduction patterns as well as adult distribution and abundance. Additionally, early life stages of many marine organisms of the area are being challenged by ocean warming, acidification and hypoxia, but their physiological responses to these environmental changes still remain poorly studied. Several studies, conducted mainly in Portugal, demonstrate that predictions of change in the ocean temperature, pH and ventilation may compromise the development of early life stages of some commercial fish such as *Sardina pilchardus* (Faleiro *et al.*, 2016), *Solea senegalensis*, *Sparus aurata* and *Argyrosomus regius* (Pimentel, 2016). Preliminary studies on impacts of ocean acidification on fish diversity in Ghana by Nunoo, Quansah and Ofori-Danson (2016) showed also possible impacts of this phenomenon on diversity and abundance of fish species such as *Sardinella aurita*, *S. maderensis* and *Chloroscombrus chrysurus*. Larvae of some species of the family Peneaidae and Portunidae such as *Peneaus notialis* and *Callinectes sapidus* were also identified to be susceptible to ocean acidification.

The tropical subregion in this area has one of the world's most important mangrove forests. Mangroves exist in semi-arid tropics, which probably makes them especially vulnerable to changes in hydrology and thus salinity, as well as deposits of desert dust from the northeasterly trade wind. Mangroves play an important role in West Africa's coastal fisheries and coastlines, providing some protection among other services. Mangroves are, however, recolonizing many areas in Guinea, the Gambia, and Senegal since 2000 (CILSS, 2016), after decades of loss resulting partly from prolonged and damaging drought in the 1970s and 1980s. According to Andrello *et al.* (2017), field observation in Senegal seems to demonstrate that natural regeneration of mangroves is more important than reforestation and has likely resulted from the recovery of rainfall in the mid-1990s that has enabled the mangrove regrowth.

The effects of relative SLR are also reported as a threat to the survival of mangroves (IPCC, 2007). Given the rates of SLR and the predicted future shoreline calculations, the West African mangroves face the threat of being completely inundated should sea levels rise beyond levels they are able to cope with. For example, in Ghana, SLR is expected to cause the shoreline of the Keta coastal zone to migrate about 8 km inland in the next 100 years (Boatemaa, Kwasi and Mensah, 2013). The muddy coastal regions of Cameroon face being flooded and eroded. The finfish and shellfish of Cameroon make use of these muddy coastal regions as breeding grounds and nurseries, and these regions are also critical for Cameroon's main fisheries production.

The advancement of tropical planktonic species poleward, presumably because of global climate warming, has been recently documented for the tropical dinoflagellate *Gambierdiscus* spp. These harmful algae began to be reported during the last decade in the subtropical upwelling sector of the CCS off Morocco, Canary Islands and Madeira Islands archipelagos, providing evidence of the biogeographical expansion of this genus towards higher latitudes with increasing sea temperatures in the region (Pitcher and Fraga, 2015). An unprecedented massive accumulation of pelagic seaweed, sargassum, also occurred recently on the coasts of several tropical countries in West Africa, suggesting that this phenomenon, linked to climate change, may potentially result in the formation of hydrogen sulphide (toxic), oxygen depletion, and eutrophication (Pfaff, 2015).

8.3 CLIMATE CHANGE EFFECTS ON STOCKS SUSTAINING THE MAIN FISHERIES

8.3.1 Impacts of climate change on fishery resources

Several changes in abundance and distribution have been reported for some of the main fishery resources over the last decades. The European sardine and round sardinella, the main species in terms of volume of catches in FAO major fishing area 34, have experienced a readjustment in their distribution and abundance since the 1990s. In the CCS, the most important European sardine stock, located principally off the Sahara, have experienced large fluctuations in abundance and distribution from the mid-1990s. A northward shift of sardine distribution in the southern limit was noticed during the intermittent extreme warming events that occurred off Northwest Africa. For the period 1982 to 2011, six warm events (1983, 1984, 1997, 1998, 2008 and 2010) have occurred (Oettli, Morioka and Yamagata, 2016), resulting in some years (e.g. 1997, see Strømme, Burgos and Kada, 1997) in a drastic decline of the stock abundance and/or the southern limit moving north by two to three degrees. These warm events, generally coincident with a displacement of the thermal front further north, and a decrease in upwelling and intensities of southward currents, likely induce a northward contraction of favourable habitat for the European sardine, which is tightly associated with the North Atlantic Central Water (NACW). At the same time these conditions seem to have benefitted the round sardinella (Zeeberg *et al.*, 2008), the abundance of which has increased several times in the subtropical sector to the north of Cape Blanc, even though the overall abundance of this tropical species has decreased in the CCS during the last decade (CECAF, 2015b, 2016). The bulk of the stock was located on Sahara Bank during some warm episodes, representing more than 50 percent of the regional stock (Braham and Corten, 2015; Strømme, Burgos and Kada, 1997). At the same time, round sardinella abundance has shown a decline in the Western Gulf of Guinea where its catches display a relatively steady decrease since 1999 and its stock is now considered as over-exploited (CECAF, 2015a). It remains, however, difficult to disentangle the relative contributions of climate change, natural variability and exploitation to the dynamics of these species during the last decades. It is worth noting that the period following the mid-1990s is also marked by an expansion of the sardine habitat to the North Sea, linked to ocean warming and to some climate natural oscillation modes (e.g. Alheit *et al.*, 2014). According to Thiaw *et al.* (2017), in a scenario of future decrease of upwelling-favourable winds in the equatorward region of CCS, in terms of both duration and intensity, a decrease in abundance of both round sardinella and flat sardinella in Senegal may occur as a result of this weakening of upwelling-favourable winds. In addition, a northward shift of upwelling may increase the northward migrations of round sardinella during summer, while flat sardinella may stay in Senegalese waters because of its higher tolerance to environmental fluctuations and less migratory behaviour.

The bonga shad is another important SPF of the tropical inshore waters and one of the most targeted species by artisanal fisheries from Mauritania to Angola. Unlike sardinella (especially round sardinella), bonga shad is physiologically adapted to cope with a wide range of environmental conditions and represents an example for clupeid fishes reproducing under extreme conditions in habitats such as estuaries. As a result of its high adaptive potential and euryhaline physiology, bonga shad will be less likely to suffer from the impacts of climate change on its spawning habitat. Nevertheless, in a scenario of further decrease in precipitation, inversion of estuaries, and a concomitant rise of ambient salinities (e.g. in estuaries of the semi-arid tropic), its reproductive potential is likely to be limited inside many habitats (Döring *et al.*, 2017).

Warming and expansion of the NAOMZ has been shown to affect the distribution of some highly migratory species of tunas and billfish by compressing their vertical habitat towards the surface water and increasing, consequently, their vulnerability to surface fishing gear (Prince *et al.*, 2010). The warming trend of the Atlantic subtropical regions (20 °N to 30 °N and 20 °S to 30 °S) during the past decades may also have resulted in a large-scale "tropicalization" of tuna populations and an increasing dominance of catches of warmer water species at higher latitudes (Monllor-Hurtado *et al.*, 2017).

Pörtner *et al.* (2014) anticipated that global warming will lead to changes in the biogeographical distribution of species resulting in a large-scale redistribution of overall catch potential towards the high latitudes to the detriment of the tropics (see also Chapter 4). The projections obtained by ensemble studies from global models, predict that the Guinea Current subregion will suffer a substantial decrease in marine catch potential by 2050 (Cheung *et al.,* 2010; Lam *et al.*, 2012; Chapter 4 of this volume). Another study (Barange *et al.*, 2014) predicted, contrariwise, an increase in the catch potential in Northern and Western Guinea Current subareas by 2050, which in turn will decrease in the Canary Current and in Central and Southern Gulf of Guinea as well.

8.3.2 Other non-climate stressors

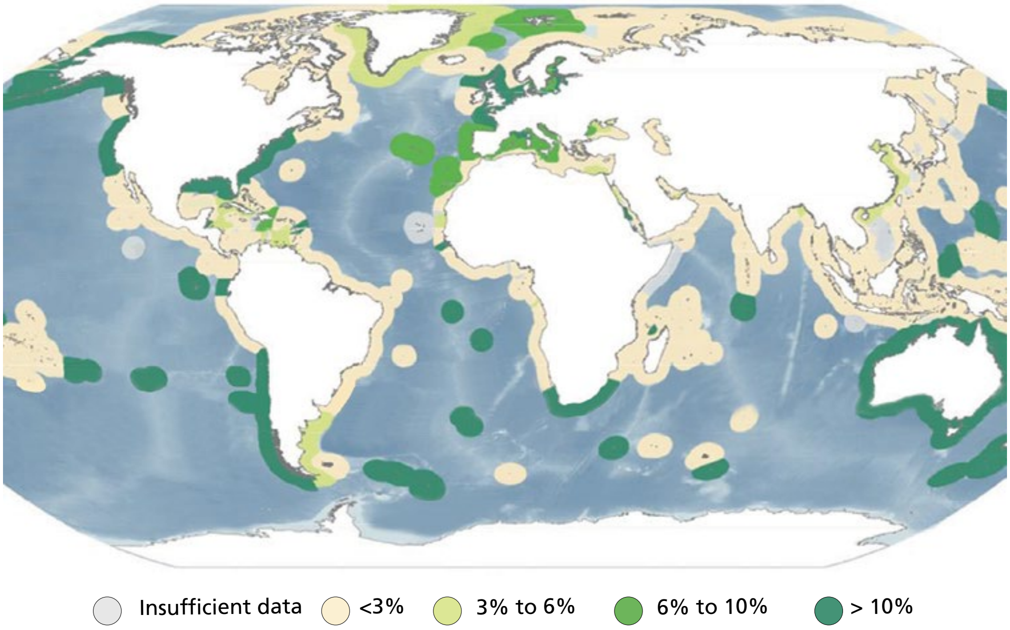
Fishing activities

Ecosystems and natural resources have been intensively exploited in the last decades for development purposes, food security, and as an alternative to loss of arable lands (Binet, Failler and Aggosah, 2015; Morand, Sy and Breuil, 2005). The expansion of the fishing activities during the last decades has driven negative impacts on many fish-food production systems. These factors, amplified in many countries by weak fisheries management, regulation and control systems, have led to overexploitation of many fish stocks. Overall, the Eastern Central Atlantic coastal area has 46.5 percent of its assessed stocks fished at biologically unsustainable levels, and 53.5 percent within sustainable levels (CECAF, 2016). Although the FAO Fishery Committee for the Eastern Central Atlantic (CECAF) regularly made recommendations on fisheries management measures (total catch, fishing capacities, etc.), implementation remains voluntary and weak in many member states. Some recent worldwide surveys show that the FAO major fishing area 34 is one of the most impacted by illegal foreign fishing fleets (Greenpeace, 2017).

Other sources of threats

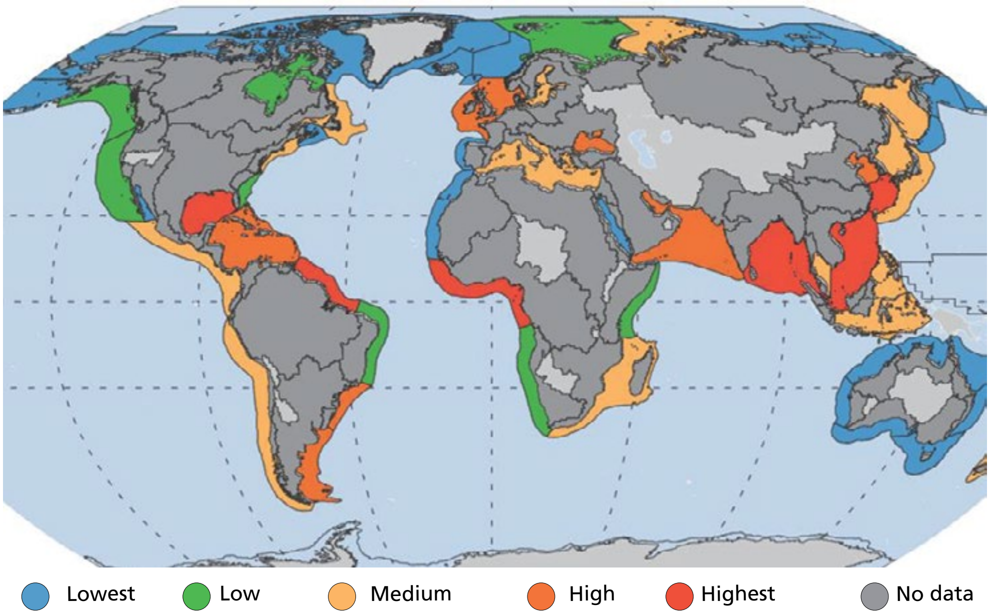
Other anthropogenic pressures on marine, inshore and wetland ecosystems come from adjacent land uses. The growing coastal populations have led to unplanned urbanization with consequences for many natural habitats. Mangroves have suffered losses from conversion into agricultural uses and wood harvesting (including for post-harvest artisanal activities of smoking of fish). About 30 percent to nearly 70 percent of the original mangrove vegetation is estimated to have been lost in many countries of the area (UNEP, 2007). The proportion of marine areas within national EEZs covered by protected areas remains under 10 percent (UN, 2017; Figure 8.3). Pollution from sewage, chemicals (including fertilizers and pesticides) and waste, dam construction, sand mining, and hydrocarbon exploitation in several EEZs, especially in the Gulf of Guinea, are some of the many threats to many ecosystems. Eutrophication is a major concern for the Guinea Current large marine ecosystem (Figure 8.4) where human-induced eutrophication has resulted in several dead zones (e.g. Korle lagoon in Ghana). Additionally, these stressors are often transboundary issues, resulting from ineffective management in most countries of the region (CCLME, 2016a; UNEP, 2016).

FIGURE 8.3
Proportion of marine areas within national jurisdiction (0 to 200 nautical miles) covered by protected areas, 2017 (percentage)



Source: UN (2017).

FIGURE 8.4
Merged nutrient risk indicator of large marine ecosystems projected to 2050



Source: UN (2017).

8.4 IMPLICATIONS FOR FOOD SECURITY, LIVELIHOODS AND ECONOMIC DEVELOPMENT

8.4.1 Implications for fishing and post-harvesting operations

Fishing will likely become an even more dangerous activity, especially for the artisanal sector. West African coasts are regularly buffeted by storm surges and are currently at risk of extreme storm events and tidal waves that may increase (IPCC, 2007). This will likely affect human safety, in particular artisanal fisher folks (Westlund *et al.*, 2007), and increase the risk of losing the means of fishing (canoes and fishing gear). Moreover, a gradual scarcity of resources in productive areas will have an impact on the profitability of artisanal fishing operations because of the increase in the time spent searching for fish, fuel expenditure and irregular catches. Overall, the quantities of fish caught per kWday by artisanal fisheries has dropped from 5 kg per kWday in the 1950s to 1.5 kg per kWday in the 2000s, which is 11 times less than industrial catches per unit effort (Belhabib, Lam and Cheung, 2016). Hundreds of thousands of artisanal fisher folks are trapped into a vicious cycle of increasing fishing effort, with many using subsidized fuel (e.g. in Ghana; Nunoo *et al.*, 2015) while fishing is becoming unsustainable.

Despite recent improvements in some countries, value chains still suffer from underdevelopment of cold chains in many sub-Saharan countries. The absence of cold storage facilities in many landing sites makes the labour-intensive traditional processing methods very important in the value chains. In Senegal for example, this post-harvest activity transforms more than 30 percent of landings. Whilst this activity plays an important role in reducing fish waste, losses still account for nearly a quarter of fish production in sub-Saharan Africa (FAO, 2016). Unchanged conditions in processing, handling for trade, and hygiene practices combined with an anticipated increase of temperatures, precipitation, moisture, and inundation in tropical areas will likely increase post-harvest losses and will likely result in a further decrease of the efficiency of artisanal value-chains.

8.4.2 Implications for communities and livelihoods

The most productive coastal zones (upwelling areas, mangrove swamps, lagoons and estuaries) attract the bulk of the fishing and processing activities conducted by communities representing about 7 million people (Ndiaye, 2016), two thirds of whom are found in sub-Saharan countries, who are mostly engaged in artisanal activities. Artisanal fisher folks and fishing communities, particularly in sub-Saharan countries, have developed different livelihood strategies to cope with natural resource fluctuations on seasonal and interannual scales, including the diversification of income sources, the exploitation of marine and terrestrial natural resources, and “seasonal” or “circular”[2] fishing migration depending on the resources’ distributions (Morand, Sy and Breuil, 2005; Nunoo *et al.*, 2015).

It is also important to highlight the switch in micro-economic strategies that followed the Sahel drought of the 1970s and 1980s and other structural difficulties of the agricultural sector in this part of Africa. The switch was from a traditional model of multi-active artisanal fishers combining fishing and agriculture occupations (e.g. rice farming) to a model of full-time fishers making “seasonal” or “circular” fishing migrations. According to Morand, Sy and Breuil (2005), this historical switch in micro-economic strategies, combined with other factors such as the increase and generalization of motorization of the canoes and the widespread use of destructive fishing gears, has likely contributed to increase the fishing effort and to a degradation in fishing productivity and incomes.

[2] i.e. between African countries.

With the depletion of fish stocks, that could be further exacerbated by the anticipated climate change-driven effects on fishery production, and the enforcement of policy actions by neighbouring countries that limit migration opportunities, migrant fisheries might reach their limits, and see their territories reshaped, with some conflicts resulting from this situation (Binet, Failler and Aggosah, 2015). In the southern CCS for example, Senegalese canoes and fishers have become so numerous since the latter decades of the twentieth century that the fishing effort they are deploying goes far beyond the country's EEZ, extending as far as Mauritanian and Guinean waters (UEMOA, 2014), generating many problems as a result. Some of these problems have been partly solved by international agreements (e.g. agreement between Senegal and Mauritania giving access to 200 artisanal purse seiners of Saint Louis, Senegal to the Mauritanian EEZ during the season of northward migration of sardinella), but others remain a source of concern.

The phenomenon of "seasonal" and "circular" fisher folk migrations is thus becoming a challenge for fisheries management at the regional scale (Binet, Failler and Aggosah, 2015). This issue is all the more important given the anticipated exposure of populations and assets to SLR in many low-lying coastal zones that shelter these communities. SLR and coastal erosion have been reaching significant levels in some coastal sectors of countries, putting infrastructure and fishing villages at risk (e.g. IPCC, 2007). SLR is also expected to threaten the mangrove areas that provide the primary means of subsistence for a large number of collectors of oysters and other invertebrate species, who are mainly women (Cormier-Salem, 2017). The major actors in the artisanal sector post harvesting activities in the sub-Saharan region are also women traditional processors. This activity makes them play a pivotal role in the rural economy in several countries, but makes them also one of the most vulnerable social categories to detrimental climate change-driven impacts through many pathways (increase of losses, irregular fish supplies, coastal erosion, and inundation that threatens assets).

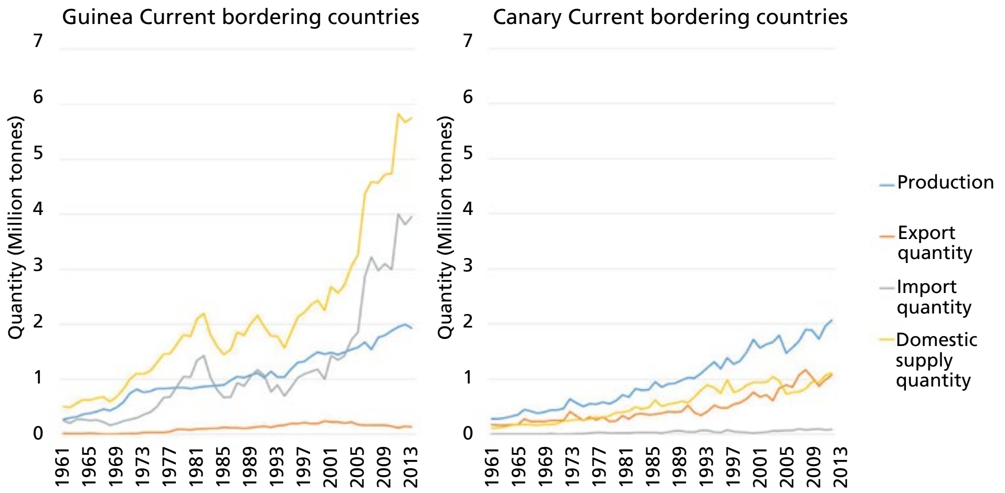
Additionally, the opportunities for fishing communities in almost all countries are quite often limited by a lack of alternative occupations, low education levels, weak social safety nets, and limited access to infrastructure, equipment, and services (see e.g. UEMOA frame survey report; UEMOA, 2014). Artisanal fishing community occupations also often compete with other uses for access to the sea front and coastal waters, which limits their socio-economic space. Therefore, climate change impacts could jeopardise their livelihoods and likely further shrink their survival perimeter in several countries, with the risk of extending poverty traps and fostering "forced" migrations (Alex and Gemenne, 2016).

8.4.3 Implications for larger societies and economies

Many of the interacting economic and social causes of migration and conflicts in West Africa are sensitive to climate change impacts (Niang *et al.*, 2014), with the poor being particularly dependent on natural resources and hence more vulnerable. A large proportion of the population is involved in fishing in many coastal regions and in some small island developing states (SIDS) of the area, where fisheries are a major source of work and income. Fisheries consequently make a multifaceted contribution to their national economies. Countries from Senegal to Nigeria are among the most economically and/or nutritionally fisheries-dependent nations (Barange *et al.*, 2014), with almost all of them being currently low-income food-deficit countries (LIFDCs) and/or least developed countries (LDCs). The proportion of dietary protein that comes from fish is very high in many of these countries (more than 60 percent in Sierra Leone and Ghana, 47 percent in Senegal), even if average per capita fish consumption is, overall, among the lowest in the world (OECD, 2016). The region's overall food supply is already disturbed by climate impacts on its agricultural food production system and now depends largely on imports. Almost all sub-Saharan countries are currently net importers of staple foods. Climate change is expected to increase pressure on already pressured fishery resources and increasingly disrupt crop and livestock production in almost all the region, which could put a further threat on food security in the region (Niang *et al.*, 2014; Lem, Bjorndal and Lappo, 2014; Rhodes, Jalloh and Diouf, 2014). The increasing quantities of fish products imported by many Guinea Current bordering countries (Figure 8.5), is worsening the deficit in value of the food trade balance of almost all West African LIFDCs, the majority of which are also impacted by a decrease of sardinella stock productivity in the main productive area of the Gulf of Guinea. The imports of these countries are mainly composed of SPF (FAO Fishstat, 2017). Major importing countries like Nigeria, Ghana and Côte d'Ivoire are now looking for alternatives to sardinella, by importing herring from Europe with consequences for fish prices (Caillart and Beyens, 2015). The imports value is generating currently an overall annual shortfall of more than 2 billion USD for trade balances of LIFDCs in the area (Figure 8.6). At the same time, sardine and other SPF exports by Morocco (as the main producer and net exporting country of SPF in the region) continue to be mainly oriented towards developing countries' markets (DEPF, 2015). The processing of SPF for fishmeal, boosted by global market demand, is on the other hand showing a marked tendency to increase in the CCS region. Morocco, Mauritania and Senegal are ranked among the top ten fishmeal-producing countries in Africa (FAO Fishstat, 2017). In Morocco, fishmeal production is based on by-products and surplus landings that cannot be absorbed by the canned and frozen product industries. The amount of fishmeal produced is expected to decrease by 50 percent by 2020 and the volume of valued transformed products increased by the same proportion by 2030 according to Morocco's sustainable development goals (SECDD, 2017). The situation seems to be different in Mauritania, where the development of an export-oriented fishmeal industry, transforming sardinellas, would, according to Caillart and Beyens (2015), entail risks for Senegal to maintain its fish food self-sufficiency since sardinellas stocks are shared. However, over the past two decades, a number of fishmeal factories were also implemented in Senegal. The fishmeal production in that country may likely have socio-economic impacts as the fishmeal industry might divert fishery products (SPF) that, previously, were transformed by artisanal women processors. For Senegal, negative consequences of the development of the fishmeal industry is therefore not only for employment, but also for the food security of the rural populations of the whole hinterland of Senegal and also some inland countries, such as Burkina Faso. The population and total food fish consumption demand are expected to rise substantially in the region by 2050, while the anticipated overall fishery production increase will likely be marginal (Grainger and Garcia, 1996) or may decrease according to many estimations (e.g. Chapter 4 of this report). The potential response of international seafood trade to climate change, changes in seafood demand and supply or in local population dietary patterns are uncertain, but some estimates indicate that fish imports in sub-Saharan countries are likely to be 11 times higher by 2030 than the level in 2000 (World Bank, 2013).

FIGURE 8.5

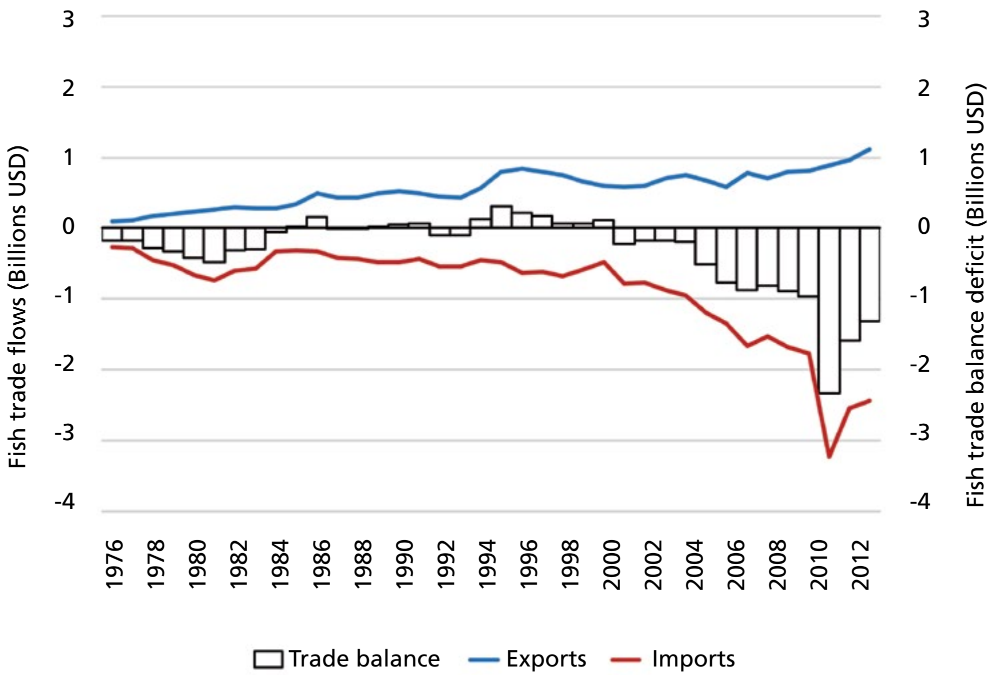
Fish trade flows and fish supply quantity in Guinea Current bordering countries (on the left) versus Canary Current bordering countries (on the right). The bulk of fish-food supplies is made of imports in the Guinea Current region, while most of the production made in the Canary Current region, is exported



Source: FAOSTAT (2017).

FIGURE 8.6

Trends in fish-trade flows and fish trade balance of low-income food-deficit countries bordering the FAO major fishing area 34 from 1976 to 2013. Overall annual shortfall in fish trade balance of LIFDCs resulting from the increasing trend of fish-food imports by these countries, has reached more than 1 billion USD since 2010



Source: FAO Fishstat (2017).

8.4.4 Consequences for fisheries management

The recent trend in abundance and distribution of the main stocks and the uncertainties related to climate change have increased awareness of policymakers of the urgency to take action and improve the management strategies for coastal marine resources. Even if efforts are still needed, many advances have been made in several countries in developing fishery management plans (e.g. in Guinea, Senegal, Mauritania, Morocco), upgrading fishing effort control (through licensing, establishment of a coastal zonation for different types of harvesting), implementing a rights-based approach to coastal fisheries and co-management (Virdin, 2017). An adaptive fisheries management approach was applied for several fisheries in Morocco and Mauritania including individual transferable quota (ITQ) systems. A number of localized territorial use rights fisheries (TURFs) have been established in Cabo Verde, Senegal and Sierra Leone (Virdin, 2017). Mechanisms for supra-national coordination of several marine protected areas (MPAs) in Senegal, Cabo Verde and the Gambia have also been initiated in order to promote a protected marine eco-region (WWF, 2017).

Combining different management or regulatory systems may produce significant socio-ecological climate resilience synergies. The benefits of some spatial tools of fishing regulations and conservation could, however, likely be compromised by climate change impacts. Because of their spatial nature, implementation of tools such as TURFs and MPAs should take into account the likelihood of possible shifts in species distribution patterns and also a possible alteration of currents that could modify the larval connectivity (Andrello *et al.*, 2017). Monitoring of fisheries systems, for example, is not often coupled with MPA research, while pooling of efforts could benefit both management systems (Garcia *et al.*, 2013). Research capacities in the region also remain weak with regard to the scientific advice needed for the sustainable management of fishery resources and marine ecosystems (see e.g. Masumbuko *et al.*, 2011). CECAF and the International Commission for the Conservation of Atlantic Tunas (ICCAT) provide advice for coastal fishery resources and Atlantic tunas and tuna-like fish stocks on a regular/semi-regular basis, but national data collection systems and scientific monitoring capacities have to be improved in many countries of the area (CECAF, 2016; Chavance *et al.*, 2007). Where adaptive fishery management has been implemented (e.g. Morocco), the robustness of the decision-making process varies among fisheries, depending on how much data and scientific analysis are available. This is particularly problematic for the transboundary stocks.

The Regional Fishery Bodies (RFBs) call repeatedly for collaborative management of regional shared stocks, but little progress has been made until now (CECAF, 2016). A strategic action plan for the integrated management of the transboundary Canary Current Large Marine Ecosystem (CCLME) towards 2030 was adopted by the states of the FAO/Global Environment Facility (GEF) CCLME project (CCLME, 2016b), but cooperative governance arrangements between the bordering countries still need to be effectively established. A community-based management approach such as local TURFs could likely be an advantage for diversifying local livelihoods and enhancing social resilience, but presents little flexibility regarding species migration and migrant fisheries (which are some of the most important features of the region), or regarding possible climate-driven change in the species distribution and migration patterns. Connected TURF networks (at national and supra-national level) could be a solution to cope with both. Whilst complex, a management system, tailored at a national and/or regional scale, combining rights-based fisheries regimes (e.g. connected TURF networks and/or multi-species quota/ITQ systems that take into account the multi-species context and the impact of the tenure length and rules regarding transferability, which may affect resilience) could present many potential socio-ecological resilience benefits. Such a system could, as stated by Ojea *et al.* (2017), give rights owners more incentive to implement climate change mitigation and adaptation strategies to maintain their investment and incomes rather than simply exploiting the remaining population to maximize short-term gain. On the other hand, the importance being given to mangrove ecosystems and mangrove social communities in West Africa to generate and sell mangrove carbon credits to multinational companies within the framework of reducing emissions from deforestation and forest degradation (REDD+) and blue carbon projects, raises some issues, according to Cormier-Salem (2017). These are the issues of administration of land rights and community-based decision-making that are of importance to avoid land grabbing, which can impair the socio-ecological equilibrium required to achieve resilience. Local communities are often unaware of the REDD+ mechanism and the negotiation approach is not always participatory, so that the charter signed with some multinational companies leads in some case to traditional harvesters (e.g. oyster harvesters) losing the right to exploit the reforested areas for several decades (Cormier-Salem, 2017). This underlines the importance of the development of knowledge management skills at different levels of decision-making regarding the issue of climate change socio-ecological resilience.

8.5 SYNTHESIS OF VULNERABILITY AND OPPORTUNITIES OF THE MAIN FISHERIES AND DEPENDENT COMMUNITIES AND ECONOMIES

The future climate conditions will likely pose significant uncertainties for countries with a high contribution of fisheries to income, economies, and food security, but tropical LIFDCs and LDCs will likely be socio-economically most vulnerable to climate change. This is not only because the impacts of climate change on infrastructure and the main fish stocks (such as sardinella, tuna and tuna-like fish) will further jeopardize state revenues from fishing, their food security, assets and source of income for many fishing communities, among other consequences, but also because of the weak capacity of these countries to absorb the cost of adapting to climate change (AfDB, 2011; Allison *et al.*, 2009; Rhodes, Jalloh and Diouf, 2014). Considering the position of the labour-intensive artisanal fisheries sector in West Africa, already threatened by many factors as well as increased climate change driven risks, the communities involved are clearly among the most vulnerable. Literature on poverty traps suggests that the poor are unable to mobilize the necessary resources to overcome either shocks or chronic low-income situations. Many were attracted to fishing by the opportunities provided in the fishing sector, but a significant majority were driven into fishing by external circumstances (Binet, Failler and Aggosah, 2015) and now many lack alternatives and are entrenched in a poverty trap. Poverty indices measured for small-scale fisheries in Ghana, for instance, by Asiedu *et al.* (2013) revealed high poverty with up to 80 percent falling below the international poverty line benchmark, with accompanying high vulnerability and marginalization indices. Increasing resilience of these communities will require that artisanal workers who are already entrenched in the poverty trap and those near that threshold must be targeted for assistance such as poverty reduction and alternative livelihood opportunities. For example, some micro-credit mechanisms have been established for local fishing communities in four MPAs in Senegal to support alternative income creation (WWF, 2017).

Some countries of subtropical and mid-latitude regions could benefit from geographical redistribution of stocks, which could create a supplementary opportunity for some net export countries (e.g. Mauritania and Morocco) to further foster their industrial capacities and exports. Tuna and tuna-like species are currently also of economic importance for some tropical countries and SIDS of the area. A climate-driven range shift in the distribution and abundance of these species will likely also create "winners" and "losers" among fishing nations of the region. A climate-driven shift in distribution of SPF stocks will require a management framework for these resources shared within the CECAF regions and a strengthening of the RFBs' mandates (e.g. CECAF). Furthermore, tuna and tuna-like fishes' distribution shifts could also require adaptive adjustments of ICCAT quotas among member states.

It is, however, important to highlight that at this state of knowledge, many uncertainties remain, which require an urgent development of the regional scientific capacities and a regional strategy for knowledge management. These major uncertainties currently prevent decision-makers from considering the climate change factor. Nevertheless, these uncertainties could be an opportunity to boost value additions in fisheries to enhance the contribution and socio-economic impact of marine ecosystem services. It is estimated that the services impact of the two large marine ecosystems of the area (Guinea Current Large Marine Ecosystem [GCLME] and CCLME) is currently 5 percent of the GCLME countries' summed gross domestic products (GDPs) and 11 percent of the CCLME countries' summed GDPs. The greatest share of this impact appears to be from the fisheries sector in the GCLME and "opportunities for tourism and recreation" in the CCLME (UNEP, 2016). Short-term priority to increase socio-ecological resilience should be to ensure that fisheries and ecosystem governance improve in such a way as to mitigate and prevent further degradation of the quality of local and large marine ecosystems of the region and the services they provide.

8.6 RESPONSES (ADAPTATION)

The National Adaptation Plans (NAPs) process is an opportunity for West Africa to promote a mainstreaming of resilience and efficiency in the development policy. The cost of anticipatory adaptation could likely be important for LDC economies (AfDB, 2011) but would actually result in lower long-term costs than reactive adaptation. Without adaptation, GDP in West Africa is projected to decline by two to four percent by 2100 (Rhodes, Jalloh and Diouf, 2014). Key recommendations for proactive adaptation proposed, on the basis of orientations such as those of the African Union 2063 Vision (AU, 2015), the African Union Strategy on Climate Change (AU, 2014), the United Nations Economic Commission for Africa African Blue Economy Policy Handbook (UNECA, 2016) and the Strategic Action Programme for protecting the CCLME (CCLME, 2016b), could be as follows in Table 8.1.

TABLE 8.1
Key recommendations for proactive adaptation

Recommendation	Level of action
Institutional and management	
• The coastal states should 1) promote and support mainstreaming climate resilience, disaster risk management and risk reduction strategies in the social, economic and environmental sectors related to marine and coastal resource exploitation and uses; and 2) ensure that actions taken consider sustainability of ecosystem goods and service provisioning as well as rights of local fishing communities, traditional users and their tenure.	National and regional
• Build or further develop institutional research capacities (competence and research infrastructure) in marine and fisheries sciences and other scientific branches that produce relevant and impactful knowledge, services and tools responding to societal needs.	National
• Develop a framework of multi-disciplinary observations and scientific research: data collection, monitoring, capacity in regional climate modelling, ecosystems, change scenarios, process, prediction, climate change detection, attribution and assessment of all risk factors, early warning, including technology and other tools required.	National and regional
• Support cooperation and synergies to 1) foster collaboration between research institutions and academies; 2) create knowledge networks among researchers and links to professional associations, industry bodies and government ministries; 3) increase regional scientific networking and visibility; 4) foster regional collaboration in fisheries management; and 5) harmonize standards, data collection, management measures, etc.	National and regional
• Improve skills to enable flexible governance and adaptive management to allow for continuing adjustments and improvements, with a focus on strengthening adaptive capacity of fishing sector stakeholders and communities.	National and regional
• Implement adaptive fisheries management plans for priority resources (e.g. shared pelagic and demersal stocks) based on an ecosystem approach to fisheries, including harmonization of management measures (e.g. technical measures, quota systems, MPAs, TURF networks, etc.) and taking into account the climate change added risks.	National and regional
• Take mitigation measures to reduce the negative impacts of human activities on coastal processes, sediment dynamics and essential habitat to enhance marine fisheries resources and ecosystem resilience.	National and regional
Livelihoods and resilience	
• Build preparatory resilience plans to secure livelihoods, income, infrastructure essential for the fishing sector, and take concrete on-the-ground actions such as hazard mapping, strengthened natural barriers (e.g. mangrove protection, sea walls, flood protection), safety at sea, measures to make assets more resistant to damage such as safer fisher folks' village landing sites and location of processing facilities, etc.	National and sub-national
• Design and adopt strategy exit plans and/or other options to create alternative socio-ecologically resilient employment opportunities directed at workers involved in overexploited fisheries, climate vulnerable fisheries and vulnerable fishing communities.	National and sub-national
• Take concrete measures to improve value chains' efficiency and enhance locally the fish-products' added-value: 1) scale up cold chains and sanitary practices; 2) reduce fish product losses and waste; 3) promote climate-smart fishing and processing technologies, involving complementary adaptation and mitigation techniques and practices; and 4) facilitate access to insurances, micro-credits and business skills training to small-scale stakeholders (including artisanal fishing communities).	National and sub-national

8.7 CONCLUSIONS

Overfishing, as well as other anthropogenic impacts on coastal and marine ecosystems, threatens the marine resources of FAO major fishing area 34. The capacity of many of the bordering states to manage their fishing sectors sustainably is limited and more than one third of the monitored fish stocks are currently exploited at biologically unsustainable levels. Climate change may add further pressure, and is potentially an additional threat to the sustainability of the fishing sector, and therefore also to its contribution to economies of these countries and to the alleviation of poverty and food insecurity. The capacity of fisheries-dependent populations to adapt to climate change is very likely to be limited by weak governance, weak development of knowledge including in relation to likely impacts of climate change, and persistent poverty in many of the countries, which collectively may increase their vulnerability. Anticipatory adaptation is recommended as an important means to increase socio-ecological resilience. Though its cost is likely to be an important factor for many countries in the area, such an approach would be likely to result in lower long-term costs than one of reactive adaptation to the projected climate change impacts.

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