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Overview of West African fisheries under climate change: Impacts, vulnerabilities and adaptive responses of the artisanal and industrial sectors

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ABSTRACT

Climate change affects ocean conditions, fish stocks and hence fisheries. In West Africa, climate change impacts on fisheries were projected to be mainly negative through multi-facet ways. However, analysis of adaptation responses of fishers to climate change impacts is scarce. This paper reviews the impacts on climate change on fisheries in West Africa and discusses the potential adaptation strategies adopted by both the artisanal and industrial fishing sectors. Overall, climate change and over-exploitation have altered species composition of fisheries catches in West Africa. The effect of ocean warming on fisheries is indicated by the increase in dominance of warmer water species in the landings, shown from an increase in Mean Temperature of Catch, in the region. Climate change 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 expansion of fishing ground that increases operation costs. Our results highlight that historical changes in target species are more common in industrial than artisanal fisheries. This result challenges the prevailing assumption that artisanal fisheries, given their limited movement capacity, would adapt to climate change by shifting target species and/or gear type.

1. Introduction

West African fisheries resources are relatively abundant, partly resulting from the higher primary production from the major eastern boundary upwelling systems in the Canary Current Large Marine Ecosystem (CCLME) and the Guinea Current Large Marine Ecosystem (GCLME) [41]. The fisheries sector in West Africa supports the livelihood of numerous fishing communities and is important to national economies [24]. The increasing pressure on fisheries resources caused by foreign fishing fleets [23] and an expanding small-scale artisanal sector contributed to the current overexploited status of fish stocks [1,4].

In addition to overfishing, climate change is expected to cause further changes to fisheries in West Africa [51]. Generally, climate change affects the physical and biogeochemical properties of the ocean, including ocean temperature, pH (acidity), oxygen content, regional wind patterns and thus circulation and upwelling intensity [43]. In West Africa, sea surface temperature increased by 0.52, 0.46 and 0.24 °C, respectively, from 1982 to 2006 [25]. These changes affect ocean primary productivity and the eco-physiology and ecology of marine organisms, leading to shifts in species distribution, phenology, species assemblages, ecosystem functions and trophic interactions [26,73]. Shift in distribution of exploited fishes and invertebrates [36] and changes in ocean net primary production are projected to lead to large scale redistribution of global catch potential, with higher latitudes benefiting from an increase while tropical regions suffering from a decrease in catch potential [33]. In West Africa, catch potential is projected to change and projections vary depending on the modelling approach used [32]; however, all approaches suggest that West African fisheries are highly sensitive to climate change, although the direction of changes diverges between modelling approaches. Lam et al. [51] projected a decline in fish landings by 2050 in the Gulf of Guinea along the Guinea Current Large Marine Ecosystem and a slight increase for the African countries along the Canary Current Large Marine Ecosystem, while Barange et al. [7] (Not included herein) predicted that the Gulf of Guinea is expected to have one of the largest increases in fish catch potential with 23.9% and a decline of 14.6% in the Canary Current Large Marine

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Ecosystem under climate change scenarios. The discrepancy in the projections between these two studies may be related to the types of oceanography model used that may have different level of representation of upwelling systems. Specifically, Lam et al. [51] used outputs from coarse resolution global climate model while Barange et al. [7] used high-resolution shelf seas model. Notwithstanding the differences in projected climate change effects on the fisheries, the ultimate impacts on local communities will depend strongly on adaptive capacity of the fishing communities [7].

Species composition of catch also changed according to water temperature, with increase dominance of warmer water species as temperature increases [37]. Warming and changes in oxygen content will potentially lead to an average decrease in maximum body size of exploited fish stocks by 14–24% by 2050 relative to 2000 [35]. These changes will challenge the sustainability of fisheries and their management particularly for countries with fewer alternative resources and lower adaptive capacity [26], such as those in West Africa [51].

Impacts of climate change on the fisheries sectors are still not well-studied [26] and existing knowledge is limited to those regions of the world that are data rich [75], e.g., the North Atlantic [27,34,62]. A few studies analyze the impacts of climate change beyond the ecological and biological scope [51,67,73]. However, there are significantly fewer studies for developing countries, particularly West Africa.

Fishers in West Africa may have already been affected by the impacts of climate change and they have been adopting certain strategies to adapt to these changes. In this region, fishing communities are suggested to be highly vulnerable to climate change, partly because of their high dependence on fish for their livelihoods and food security, and the limited societal capacity for their national economies to deal with climate change impacts [3,51]. Patterns of adaptation to declining fish stocks at a very local level have been described [17,60], notably dealing with change in target species based on species availability [68]. For example, Senegalese fishers have changed target species from bluefish (*Pomatomus saltatrix*), after it collapsed, to small pelagic sardinella (*Sardinella* spp.) [17]. However, the flexibility of small-scale fishers to redirect fishing effort, even in the context of severely depleted fisheries is limited [38] posing constraint to a wider range of adaptation strategies. On the other hand, movement of industrial (notably distant water) fleets throughout West African waters is typically flexible [1], which means they have higher capacity to adapt to the impacts of climate change.

Previous studies suggest climate change will impact artisanal fisheries but their results remain speculative and such analyses do not include the complex interactions of the natural and human systems (e.g., [67]). Studies on the responses of different fishing sectors to climate change focus mainly on understanding adaptive capacity of the countries and/or fishing communities to climate change impacts on food security and fisheries economics, and in relation to the effects of over-exploitation [3,39,51,71]. However, very few analyses have targeted adaptation strategies by fishing fleets and their responses to the symptoms or impacts of climate change on fisheries. These studies describe potential adaptation routes, if only by speculating on different strategies based on the perception that artisanal fisheries are more constrained in time and space than industrial fisheries. However, these studies do not include the cultural and historical frameworks within which these fisheries evolve, the heavy dependence of small-scale communities on fish (and particularly certain species) for their livelihood and diet preferences.

The objective of this paper is to review the impacts of climate change on West African fisheries and their scope for adaptation. Firstly, it provides an overview and evaluate available evidence that link changes in ocean temperature in the Exclusive Economic Zones (EEZ) of West African countries with changes in the fisheries in these countries. Then, it analyzes and discuss potential adaptive directions of both artisanal and industrial sectors to observed and expected future changes in the fisheries under climate change. Finally, it highlights research gaps and priorities.

2. Methods

A literature review was performed to collect quantitative and qualitative data on different indicators that assess a) the status of fisheries in terms of catch, effort and catch per unit of effort resulting from catch reconstructions [10,12–16,18–22,24,8] compiled in the Sea Around Us database (www.seaaroundus.org), b) climate change effects on these fisheries related to the change in species distribution, exploited species composition and the subsequent impacts on socio-economic sector, and c) the changes in behavior of fishers as qualitative and quantitative data reported by the literature. Data on the effects of climate change on fisheries are represented by several indicators which are related to the impacts of climate change on fish biomass, composition, distribution, and potential catch change. These indicators were then used to estimate potential impacts on jobs and economic benefits (Table 1). A literature review of the attributes related to changes in behavior, as a response to symptoms that are similar to the effects of climate change (e.g., declining fish catches due to local extinctions, or change in target species due to local invasion), constitute the second part of the study. This paper then concludes with the potential adaptation pathways of artisanal and industrial fisheries in the West African region.

2.1. Study area

West Africa (Fig. 1) refers to the area between the Strait of Gibraltar (36° 8′ N and 5° 21′ W) and the extreme south of the People's Republic of Congo (05°47S, 12°13′ E). This area, encompassed within FAO statistical areas 34 (Eastern Central Atlantic) includes the following countries: Morocco, Western Sahara, Mauritania, Senegal, The Gambia for the Canary Current Large Marine Ecosystem (CCLME), and Guinea Bissau, Guinea, Liberia, Sierra Leone, Ghana, Benin, Togo, Nigeria, Congo, Sao Tome and Principe and Equatorial Guinea for the Guinea Current Large Marine Ecosystem (GCLME) (Fig. 1).

2.2. Attributes to assess climate change effects on fisheries

A literature review was performed to assess the effects of climate change on fisheries of West Africa, through a range of attributes or indicators. Indicators were collated from the literature to assess the observed and projected impacts of climate change on fisheries in the EEZs of the West African countries within the CCLME and the GCLME. These indicators are related to fisheries catches and fishing dynamics (catch potential, target species and status of fishery). While both categories are inter-linked, assessing impacts of climate change on these indicators separately help capture the drivers and responses of climate change impacts in each country. For indicators that are based on catches, the catch data supplied to the FAO is sufficient for West African countries as catches are largely under-reported particularly for earlier time periods. FAO data omit a large fraction of artisanal catches, all subsistence catches, and industrial foreign catches [9,23,61]. These data also are not sufficiently disaggregated into species and fisheries sector [9]. Thus, reconstructed catch data [9] were used, and species that represented over 9% of the total catch per sector were extracted, as the species that are mainly targeted and/or caught.