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Public Summary

Coastal West African nations, such as Senegal and Cabo Verde, heavily depend on their marine resources. Within these regions, artisanal fishers utilizing line and hook methods face escalating challenges stemming from environmental and societal changes. This study focuses on specific fishing communities in Senegal and Cabo Verde, aiming to characterize artisanal fishers employing line and hook techniques and assess their perspectives on environmental and societal transformations. A comprehensive semi-structured survey was undertaken, engaging with artisanal fishers actively involved in line and hook fishing. The findings gleaned from these interviews illuminate the susceptibility of these fishers to the repercussions of climate change and other societal disruptions. A nuanced understanding of the fishing practices and insights of these communities is imperative for crafting adaptive strategies and implementing effective management policies. This, in turn, is essential for alleviating the impacts of global environmental and societal changes on the artisanal fishers of coastal regions of Senegal and Cabo Verde.

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1. Introduction

Fisheries, the human activity of catching and harvesting fish and other aquatic resources, have for centuries played a pivotal role in the sustenance, economy, and culture of societies around the world (Bennet et al., 2018). Within the diverse realm of fisheries, small-scale/artisanal operations stand out as particularly vital contributors to the global food system, supporting the livelihoods of millions of people, and having causative effects on the overall health of marine ecosystems. The sector represents half the world's fishing effort (Rousseau et al., 2019), over one-quarter of the catch in volume (Watson and Tidd, 2018), and 90% of employment in capture fisheries (FAO, 2015).

The definition of artisanal/small-scale fisheries is complex and challenging, both in scientific literature and elsewhere. In that sense, the FAO glossary provides a broad definition of artisanal fisheries (http://www.fao.org/fi/glossary/):

"Traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption. In practice, definition varies between countries, e.g. from gleaning or a one-man canoe in poor developing countries, to more than 20-m. trawlers, seiners, or long-liners in developed ones. Artisanal fisheries can be subsistence or commercial fisheries, providing for local consumption or export. They are sometimes referred to as small-scale fisheries."

Unlike industrial-scale fishing operations, which have frequently lead to overfishing and ecosystem degradation (Jackson et al., 2001; Merten et al., 2016), artisanal fishing operations often use more sustainable and selective fishing methods (FAO, 2015). Their practices tend to have a lower environmental impact, reducing bycatch and habitat destruction. Importantly, these fisheries often support traditional and indigenous ways of life, preserving cultural heritage and community identity. However, despite their undeniable significance, artisanal fisheries face numerous challenges, such as limited access to resources, inadequate infrastructure, vulnerability to climate change impacts, economic instability, competition with industrial fishing operations, and environmental degradation of fishing habitats (Batista et al., 2014). Economically, artisanal fisheries operate in complex, often informal market environments, with fluctuating conditions and resources. Recognizing and addressing

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these challenges is essential for ensuring the continued vitality of artisanal fisheries and the well-being of the communities they support. In this context, sustainable management and responsible governance are critical to securing the future of these fisheries and the many benefits they bring to society and the environment.

Nevertheless, despite their importance, the artisanal fisheries sector remains largely under-assessed and overlooked by governments and researchers (FAO, 2015; Purcell and Pomeroy, 2015; Salas et al., 2007), highlighting a gap in the current approach to fisheries management. Their management in tropical developing countries is generally constrained by insufficient government funding, lack of political will, open access regimes, multiple and scattered landing sites, and low participation of resource users in decision making (Andrew et al., 2007; Salas et al., 2007). The United Nations Agenda for Sustainable Development, under its Sustainable Development Goal 14, emphasizes the conservation and sustainable use of oceans, seas, and marine resources. This goal particularly focuses on ensuring that artisanal fishers have access to these marine resources, highlighting the importance of their role and inclusion in sustainable development. As such they provide an important lever for achieving the UN Sustainable Development Goals, particularly in rural areas. Bridging this gap, therefore, becomes a critical step towards fulfilling the broader sustainability objectives set forth by the international community.

Understanding the perspectives of artisanal fishers is critical for blending the social and ecological facets of environmental change (Adger et al., 2009). Data derived from community perceptions offer a distinct viewpoint for examining the ecological and economic aspects of services derived from the fisheries sector as well as the community's reactions to these alterations (Quintas-Soriano et al., 2018; Rassweiler et al., 2020). Their observations and traditional ecological knowledge can offer invaluable insights into subtle environmental changes, resource availability, and societal issues that might not be detected by conventional scientific monitoring. This approach helps to decode the intricate connections between the services that the artisanal fisheries sector provides and the well-being of the communities that depend on them.

This work is exploring the perceived ecological and socio-economic impacts of climate change on selected artisanal fishing communities within the West African nations of Senegal and Cabo Verde. These communities are often highlighted as particularly vulnerable to the ramifications of climate change, primarily due to their pronounced sensitivity and their limited capacity to adapt (Allison et al., 2009). Risks and impacts are further compounded by the significant reliance of these nations on

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fisheries for employment. Notably, Senegal and Cabo Verde are ranked 29th and 8th, respectively, in an FAO report evaluating the dependency of countries on fisheries within the economically active population (EAP), placing them in the highest quartile among 143 countries assessed for disaster vulnerability in fisheries (Badjeck et al., 2013). A critical aspect of the risks and impacts in these regions is the degree of specialization by some artisanal fishers, in particular species, fishing grounds, and equipment (Belhabib et al., 2015). Consequently, this research concentrates on hook and line fishers in selected artisanal fishing communities of Cabo Verde and Senegal. These groups, known for their high level of specialization, represent some of the least studied yet vitally important sectors within the artisanal fishing sector. The focus on such specialized groups is essential for a nuanced understanding of climate change impacts on artisanal fisheries and the development of targeted adaptation strategies.

Left: fishers and pirogues used by Senegalese. Right: fishers and pirogues used by Cabo Verdeans. Photos taken by Hans Sloterdijk

2. Materials and methods

Study areas

The data for this study was gathered from specifically selected artisanal fishing communities located in the West African countries of Senegal and Cabo Verde.

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São Vicente Island, Cabo Verde

The Cabo Verde archipelago, situated approximately 500 km west of Senegal in the central eastern Atlantic Ocean (**Figure 1**), consists of ten small, semi-arid islands and several islets, spanning a total land area of 4,033 km² and an expansive exclusive economic zone of 790,000 km². Fishing activity is a primary sector of great socioeconomic importance for the archipelago of Cabo Verde (eastern-central Atlantic), and has played a relevant role in strengthening food security, reducing poverty, job creation, balance of payments equilibrium and Gross domestic product (González et al., 2020). The island of São Vincente was chosen as a case study due to the great importance of small-scale fisheries for local livelihoods. This study covers three of the fishing communities of the island of São Vicente, i.e., São Pedro, Salamansa, and Calhau (**Figure 1**).

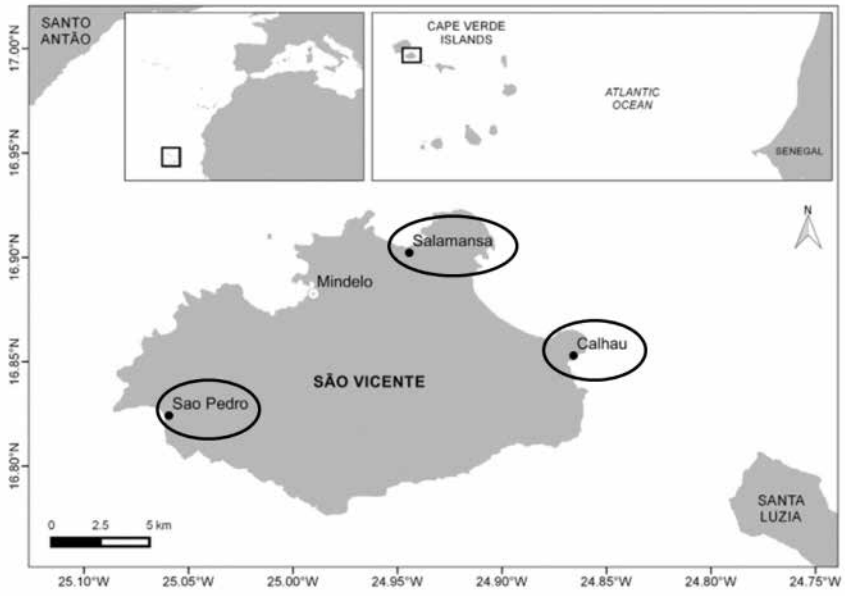

Figure 1. *Map of the island of São Vicente, Cape Verde, where are located the fishing communities of São Pedro, Salamansa, Calhau.*

Senegal

Senegal stands as a prominent fishing nation, with its economy significantly anchored in the maritime industry. The country's coastal waters teem with diverse marine life, making it one of West Africa's richest fishing grounds. Fishing constitutes a vital sector that not only contributes substantially to national food security but also serves as a critical source of employment and income for a large portion of the Senegalese population. Data were collected in Senegal in Kayar, Yoff, and Ouakam (**Figure 2**), three artisanal fishing landing sites fish landing sites near Dakar. The fishing villages were chosen for their strong and long history of fishing and their access close to Dakar.

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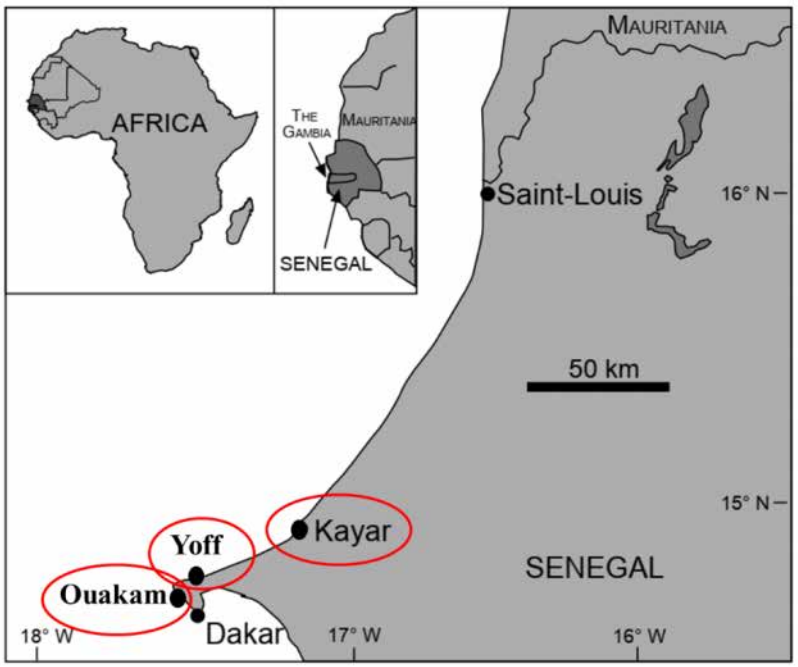

Figure 2. *Map of Senegal, where are located the fishing communities of Kayar, Yoff, and Ouakam.*

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Data collection

This research adopted a mixed-methods approach to investigate the practices and perceptions of artisanal fishers using hook and line techniques in Cabo Verde (São Pedro, Salamansa, Calhau) and Senegal (Kayar, Yoff, Ouakam). The methodology included three primary components: (1) structured interviews with fishers to gather detailed information on their fishing practices, (2) consultative discussions with key informants, such as village leaders and local scholars, to capture community-level insights, and (3) direct field observations at the landing sites. The interviews conducted in Senegal and Cabo Verde, in the local languages of Wolof and Cape Verdean Creole respectively, were facilitated by qualified interpreters. A semi-structured interview format allowed for both standardized and open-ended responses, enabling cross-comparison and rich qualitative data collection. Approximately one and a half hours were spent with the each interviewed fisher to administer the questionnaire, detailed in **ANNEX 1**, which was specifically crafted to explore diverse facets of fishing activities. The questionnaire covered demographic information and extended to encompass perceptions of environmental change. To address the challenge of sampling in the absence of comprehensive demographic data, non-proportional quota sampling was employed (Senegal n = 33; Cabo Verde n = 53), with the research team conducting a series of in-depth interviews (Martínez-Mesa et al., 2016). This method is justified by literature indicating that the quality of data from in-depth interviews remains robust even beyond 20-30 interactions, suggesting that a modest number of interviews can still produce substantial and meaningful insights into the complex experiences of fishers.



Left: structured interviews with fishers. Center: consultative discussions with key informants. Right: direct field observations at select landing sites. Photos taken by Timothée Brochier.

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3. Cabo Verde Results

3.1 Characteristics of Artisanal Fishers

Age Distribution

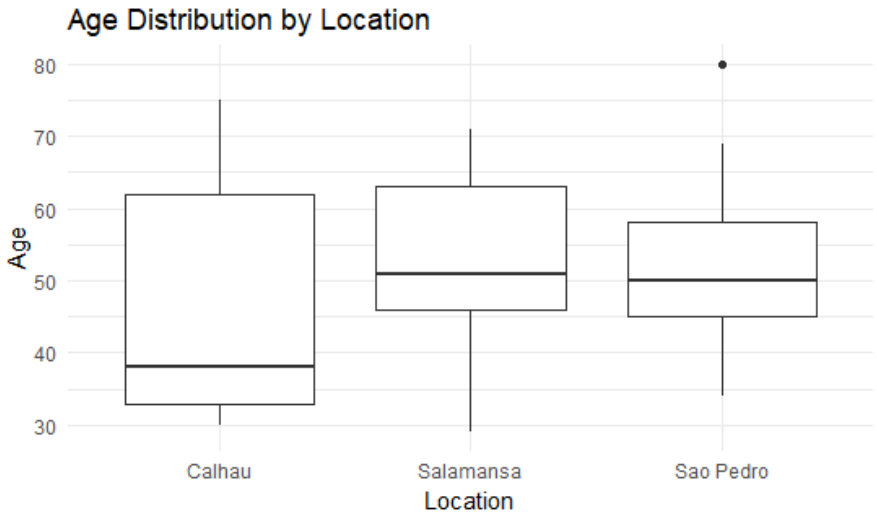

***Figure 3**. Box plot presenting an overview of the age distribution among artisanal fishers in Calhau, Salamansa, and Sao Pedro, Cabo Verde.*

In Calhau, the average age is approximately 45.64 years. The youngest individual is 30 years old. The age data reveals that a quarter of the respondents are 33 years or younger. The median age, which falls in the middle of the dataset, is 38 years, indicating that half of the fishers are younger than this. Moving towards the higher end, 75% of individuals are 59.5 years or younger. The oldest person in Calhau is 75 years old. This age distribution indicates a fishing group compared to Salamansa and São Pedro, with a broader spread of ages. In Salamansa, the mean age of the respondents is approximately 50.9 years. The youngest person is 29 years old, and the ages quartile distribution shows that 25% of the population is 44.5 years or younger, while the median age is slightly above the mean at 50.5 years. The third quartile age is 63 years, suggesting that 75% of the fishers are than this. The eldest fisher in Salamansa is 71 years old. For São Pedro, the population has a mean age of roughly 51.67. The minimum age is 34 years, with a first quartile at 45 years, indicating that a quarter of the fishers are younger. The median age is right at 50 years, and 75% of them are 58 years or younger. The maximum age in São Pedro is notably higher than in Salamansa, at 80 years.

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Fishing Experience

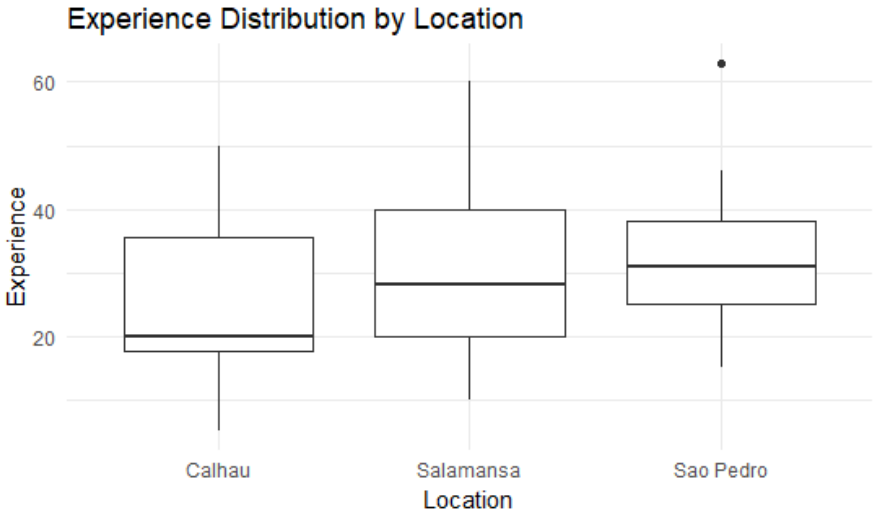

Figure 4. *Box plot presenting an overview of the fishing experience distribution among artisanal fishers in Calhau, Salamansa, and Sao Pedro, Cabo Verde.*

Artisanal fishers in Calhau have a diverse range of experience, with an average of approximately 24.45 years. The experience spans from as little as 5 years to as much as 50 years. Half of the fishers in Calhau have 20 years of experience or less, and the majority have up to 27.5 years, indicating a younger workforce in terms of experience. In Salamansa, the fishers' experience averages at 31.5 years, with the least experienced having 10 years under their belt and the most seasoned having 60 years. The median experience is 29 years, meaning that half of the fishers have more and half have less than this amount of experience. Sao Pedro's fishers show the highest average experience of approximately 32.76 years, with individual experience ranging from 15 to 63 years. The data also indicates that the median experience is 31 years, and most fishers in Sao Pedro have accumulated up to 38 years of experience.

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Fishing Occupation

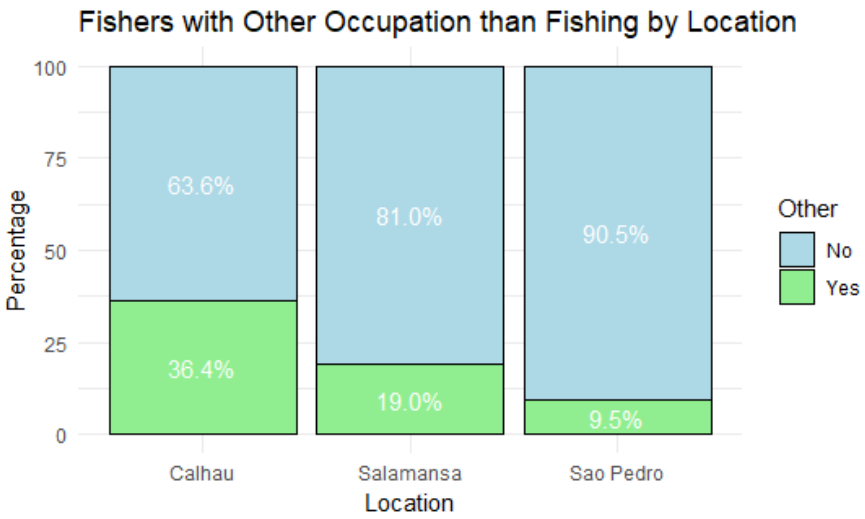

Figure 5. *Bar chart with percentage depicting the proportion of artisanal fishers engage in other occupation than fishing (Cabo Verde).*

In Calhau, a substantial proportion of fishers, 36.4%, reported engaging in occupations other than fishing. This figure contrasts sharply with Salamansa, where only 19.0% of fishers reported secondary occupations, suggesting a stronger reliance on fishing as a primary source of livelihood. Sao Pedro exhibited the lowest incidence of secondary occupations, with a mere 9.5% of fishers indicating engagement in alternative work. This stark increase in the reliance on fishing from Calhau (63.6%) to Salamansa (81.0%), and then to Sao Pedro (90.5%) as the sole occupation denotes significant differences in economic diversification and potential vulnerability to fluctuations in the fishing industry among these communities.

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Education Level

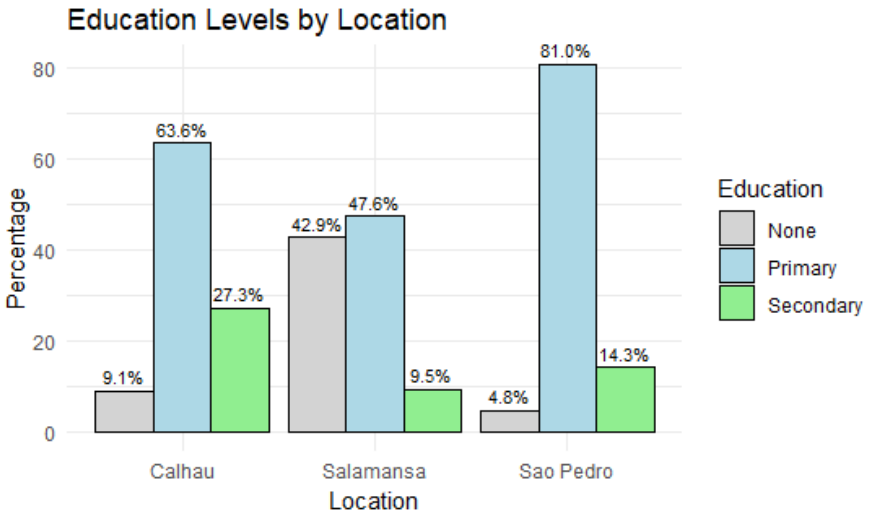

Figure 6. *Bar chart with percentage depicting the level of education of artisanal fishers in Calhau, Salamansa, and Sao Pedro (Cabo Verde).*

In Calhau, a notably higher proportion of fishers have completed secondary education (27.3%), in addition to 63.6% with primary education, and a minority (9.1%) having no formal education. Salamansa shows a different pattern, with the majority (47.6%) having primary education, a lower percentage (9.5%) with secondary education. Contrastingly, Sao Pedro has the largest percentage of fishers without primary education (81.0%), coupled with a relatively small proportion having completed secondary education (14.3%).

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3.2 Perception Change in Fishing Effort

Change in the Number of Fishing Trips per Month

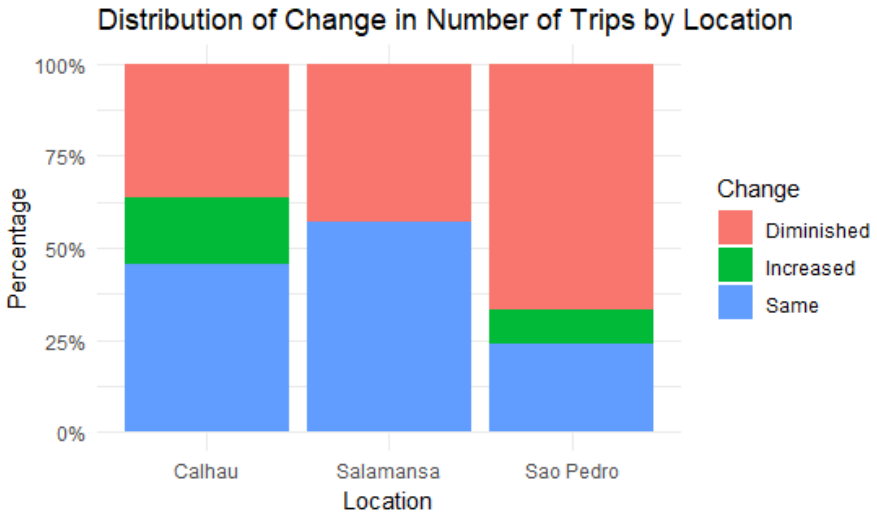

Figure 7. *Fishers perception of change in the number of fishing trips per month (Cabo Verde).*

The collected data on the perceptions of artisanal fishers regarding the change in the number of fishing trips per month over the last decade indicates distinct trends across the three locations of Calhau, Salamansa, and Sao Pedro. In Calhau and Salamansa, the majority of fishers perceive that the number of trips has remained the same, with a smaller yet significant portion reporting a decrease. In Sao Pedro, the sentiment is quite the opposite, with the prevalent view being that the number of trips has diminished.

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Change in the Travelling Distance per Fishing Trip

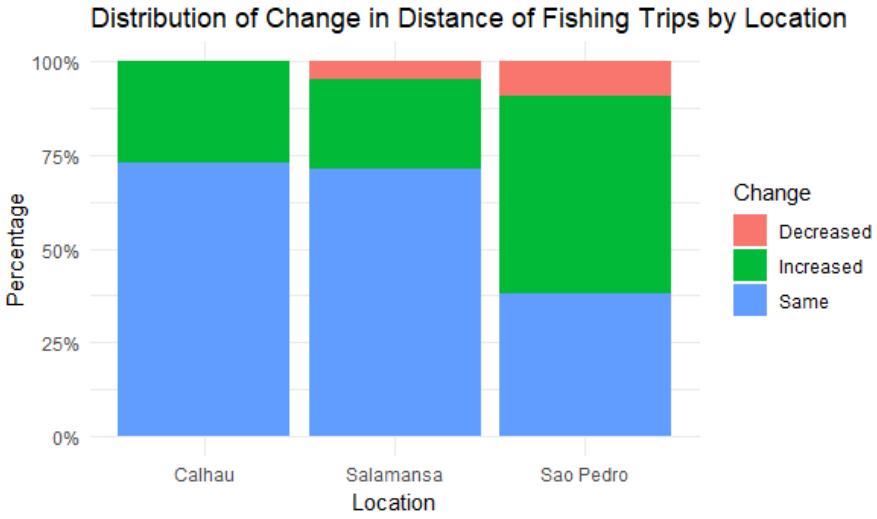

Figure 8. *Fishers perception of change in the distance of fishing trips (Cabo Verde).*

In Calhau, a majority of the fishing trips have seen no change in distance, as indicated by the blue section occupying approximately 50% of the bar. The increase in distances is represented by smaller percentage, about 25%. In Salamansa, the distribution here is similar to Calhau, with the "Same" category occupying the largest portion of the bar. The "Increased" category (green) occupies a larger proportion compared to Calhau, suggesting that more fishing trips have seen an increase in distance. The "Decreased" category (red) is the smallest portion, indicating that fewer trips have seen a decrease in distance compared to the other categories. For Sao Pedro, the profile of change at Sao Pedro is noticeably different. The "Same" category (blue) is again the largest, but it is closer to 75% of the bar. This indicates that a much larger majority of fishing trips have not changed in distance. The "Increased" (green) and "Decreased" (red) categories are much smaller in comparison to the other locations, each constituting roughly 12.5% of the bar, suggesting that changes in trip distances are less common in Sao Pedro. Overall, the chart suggests that for all locations, the majority of fishing trips have not changed in distance.

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Change in Active Fishing Hours per Trip

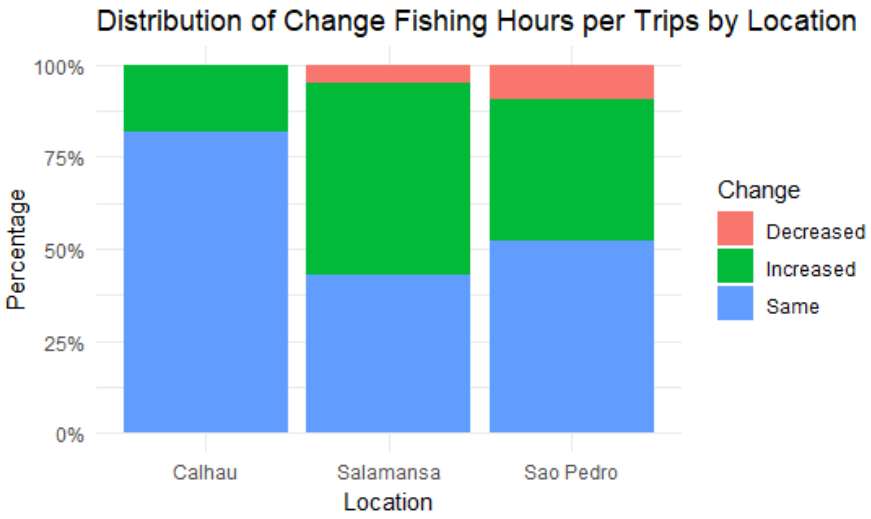

Figure 9. *Fishers perception of change in active fishing hours per trip (Cabo Verde).*

It is evident that there is a variation in the change in fishing hours across three different locations: Calhau, Salamansa, and Sao Pedro. In Calhau, the fishing hours have predominantly remained the same. Salamansa shows a higher increase in fishing hours compared to the other two locations, with a significant proportion of trips experiencing no change and a smaller portion showing decreased hours. Sao Pedro presents a balanced distribution between increased and unchanged fishing hours, with a slight decrease. Overall, the data indicates that, while the tendency to increase fishing hours is more pronounced in Salamansa.

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3.3 Local Climate Change Perception

Water Temperature

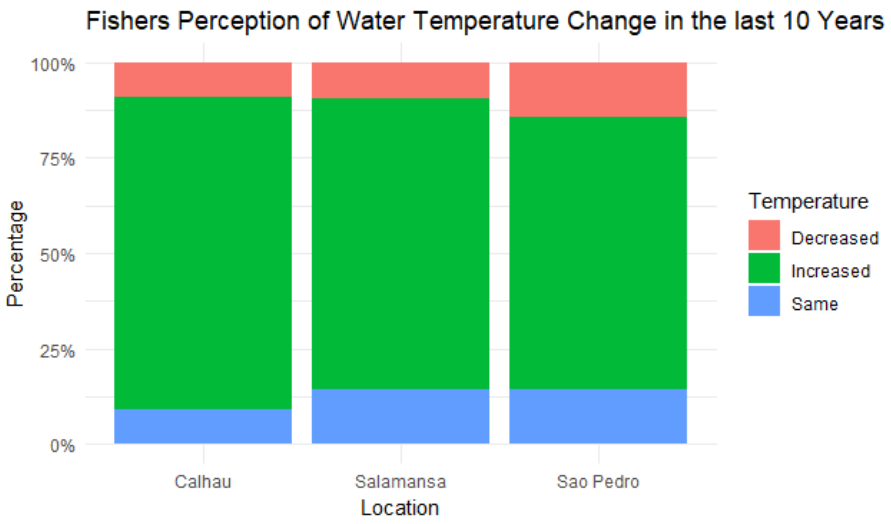

Figure 10. *Fishers perception of water temperature change in the last 10 years (Cabo Verde).*

The graph illustrates the perceptions of fishers regarding changes in water temperature over the past decade across three locations: Calhau, Salamansa, and Sao Pedro. The majority of fishers at all three sites perceive an increase in water temperature, with Calhau showing the highest consensus on this change. A significant proportion of respondents in Salamansa and Calhau also report an increase, while the perception of unchanged temperature is low across all locations. Notably, a minimal percentage of fishers report a decrease in water temperature. These observations suggest a general trend of rising water temperatures as perceived by fishers in the all three locations.

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Precipitation

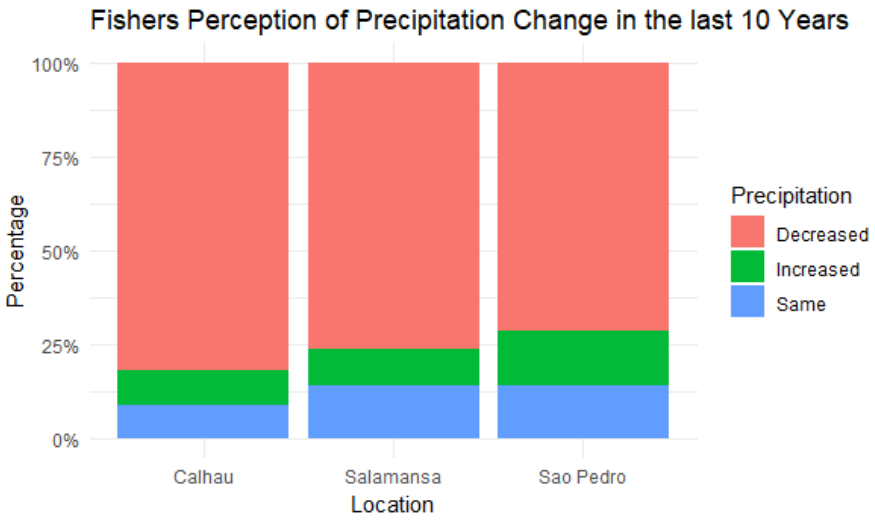

Figure 11. *Fishers perception of precipitation change in the last 10 years (Cabo Verde).*

The provided graph depicts fishers' perceptions of changes in precipitation over the last 10 years. A considerable majority of fishers across all locations have perceived a decrease in precipitation. In all locations, this sentiment is overwhelmingly predominant, with more than three-quarters of respondents indicating a decrease. Salamansa exhibits a slightly lower proportion of fishers noting a reduction in rainfall, yet it remains the majority perception. Notably, the perception of increased precipitation is minimal across all sites, and a modest fraction of fishers report no change in precipitation levels. These findings highlight a notable trend towards drier conditions as experienced by the fishing communities.

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Wind

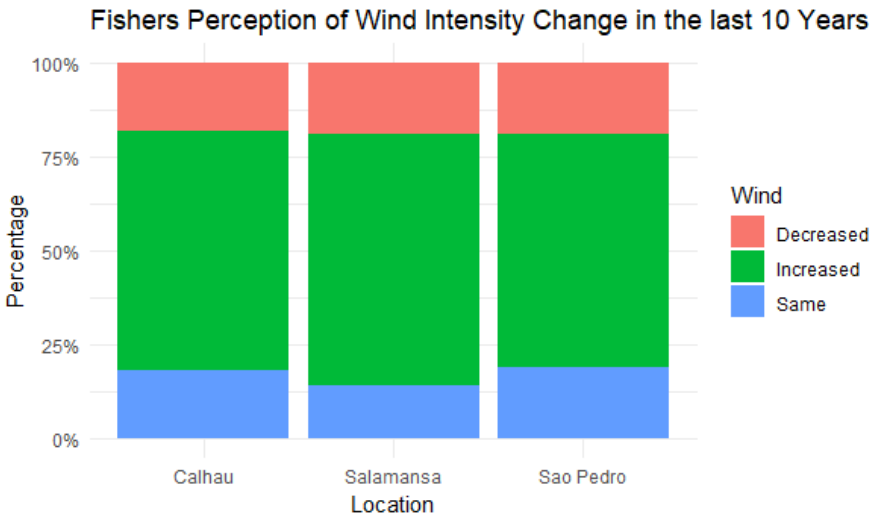

Figure 12. *Fishers perception of wind intensity change in the last 10 years (Cabo Verde).*

The graph illustrates fishers' perceptions of wind intensity changes over the last 10 years. It indicates that a significant majority of fishers at each location have perceived an increase in wind intensity. In all locations, this perception is shared by more than half of the respondents. A smaller portion of fishers in each location perceive no change in wind intensity.

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3.4 Effect on the Resources

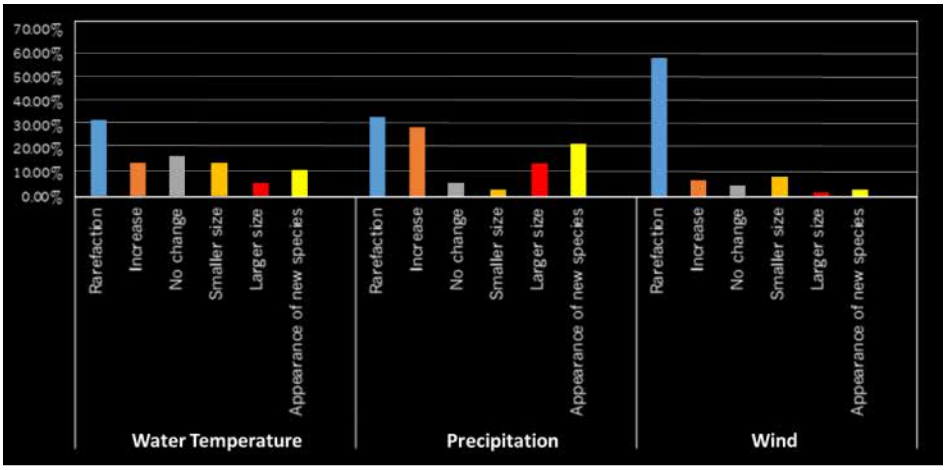

Figure 13. *Fishers perception of impact of water temperature, precipitation, and wind on the fisheries resource (demersal) in Cabo Verde.*

This graph is representing artisanal fishers' perceptions of the impact of climate change on the resources they harvest (demersal fish), broken down by three factors: water temperature, precipitation, and wind. For water temperature, precipitation, and wind, the most commonly perceived impact is a reduction in fish stocks, suggesting fishers have noticed a decrease in the abundance of fish as temperatures have risen, precipitations decreased, and wind intensified. Overall, the graph indicates that artisanal fishers are observing changes in the marine ecosystem that they attribute to climate change, with varying impacts on fish stocks, sizes, and species distribution. These perceptions are critical for understanding local ecological changes and for informing sustainable fishing practices and climate adaptation strategies.

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3.5 Risk Identification

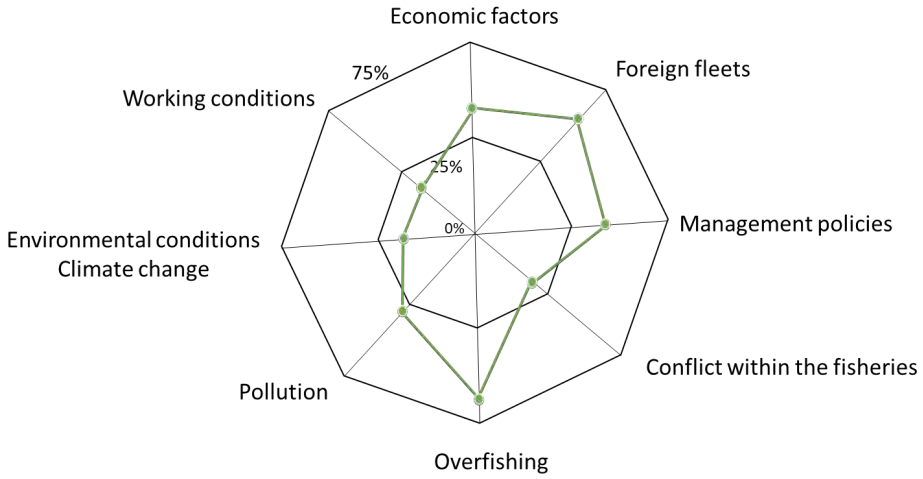

Figure 14. *Radar chart depicting the proportion of total prioritized risks cited by artisanal fishers in Cabo Verde (% of total).*

The radar chart presented here outlines the impact levels of eight distinct perceived prioritized risk factors and how frequent they were mentioned, each plotted on axes with a scale ranging from 0% to 75%. The factors include Working Conditions, Environmental Conditions/Climate Change, Pollution, Overfishing, Conflict within the Fisheries, Management Policies, Foreign Fleets, and Economic Factors. The data, represented by a green line, indicates that overfishing and foreign fleets are at the forefront of concerns, followed closely management policies and economic factors. In contrast, working conditions and pollution are deemed to have a lesser impact at and climate change shows the least impact, positioned near the chart's centre.

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3.6 Standard of living

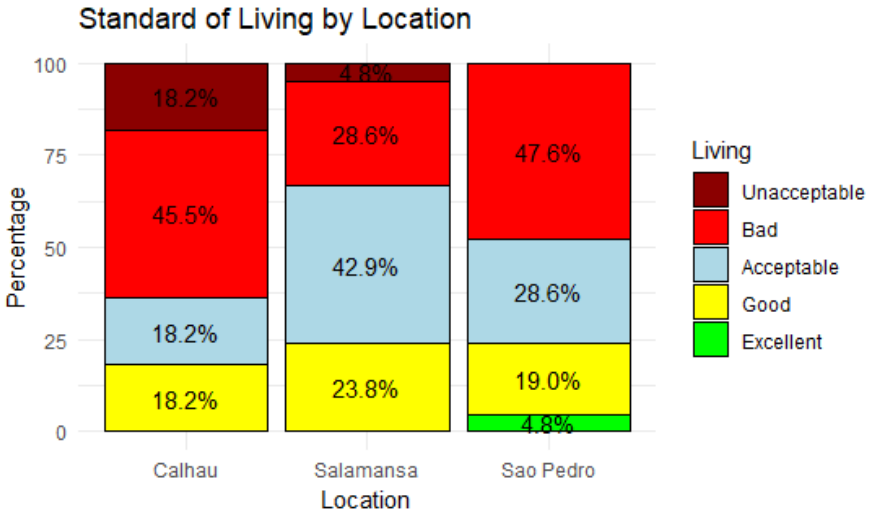

Figure 15. *Artisanal fisher's assessment of their standard of living (Cabo Verde).*

The stacked bar chart offers a view of how the fishers are viewing their standard of living, revealing patterns in the quality of life experienced by residents in each community. In Sao Pedro, the prevailing standard is categorized as "Bad," representing the majority at 47.6%. A significant proportion falls into the "Acceptable" category at 28.6%, while a smaller yet notable segment experiences a "Good" standard, comprising 19%. The "Excellent" standard is observed in a minor proportion, constituting 4.8%. In Salamansa, residents primarily experience an "Acceptable" standard, making up 42.9%. The "Bad" standard follows at 28.6%, with a portion enjoying a "Good" standard, representing 23.8%. In Calhau, a predominant portion of residents faces a "Bad" standard of living, constituting 45.5%. The "Acceptable", "Good", "Unacceptable" standard follow with 18.2% each.

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4. Senegal Results

4.1 Characteristics of Artisanal Fishers

Age Distribution

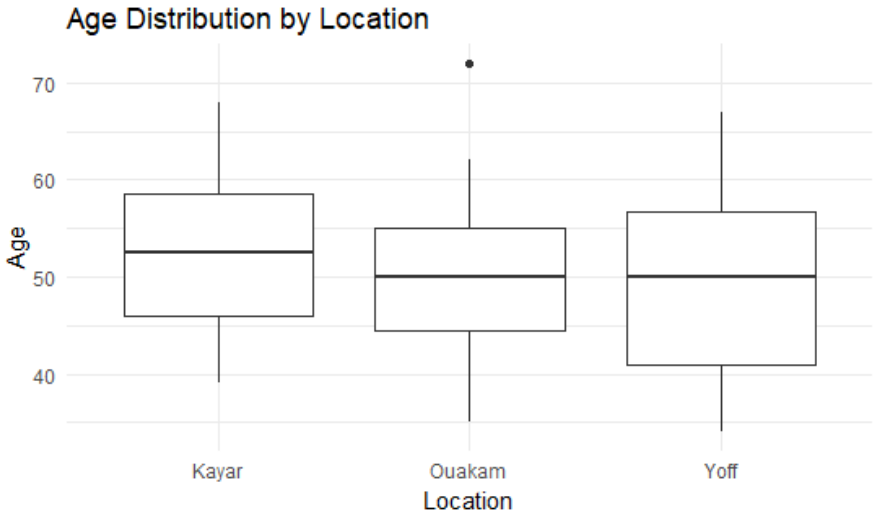

Figure 16. *Box plot presenting an overview of the age distribution among artisanal fishers in Kayar, Ouakam, and Yoff, Senegal.*

Analysis of artisanal fishers' age data from Kayar, Ouakam, and Yoff has illuminated similar age distributions within these communities. Kayar's fishers exhibit a wide age range with recorded ages from 39 to 68 years, indicating a diverse age composition. The median age in this location is approximately 52 years, reflecting a relatively old workforce. Ouakam's fishers have a slightly higher age range, stretching from 35 to 72 years, and a median age closer to 50 years, suggesting a similar workforce maturity. Yoff presents a more slightly more youthful profile, with ages ranging from 34 to 67 years and a median age around 49 years. Notably, the box plot analysis identifies outliers in Kayar and Ouakam, pointing to the existence of exceptionally aged individuals that were interviewed.

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Fishing Experience

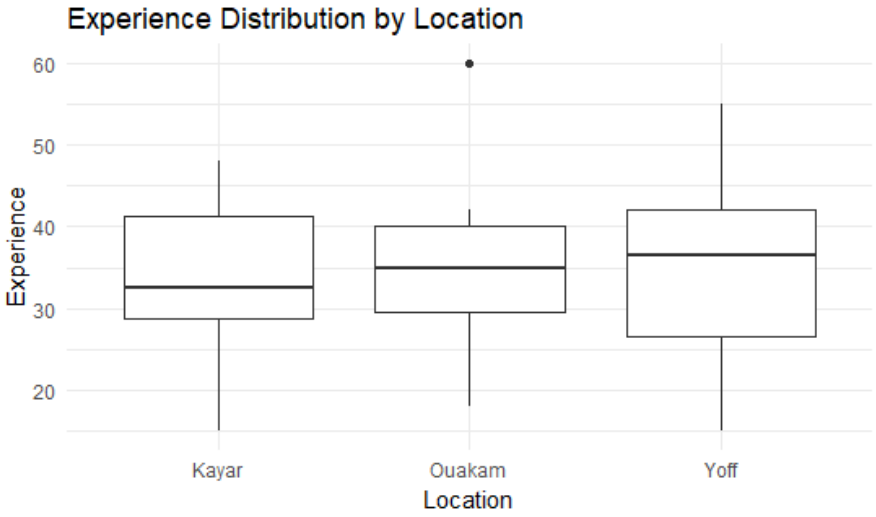

Figure 17. *Box plot presenting an overview of the fishing experience distribution among artisanal fishers in Kayar, Ouakam, and Yoff, Senegal.*

Kayar fishers display a broad spectrum of experience ranging from 15 to 48 years, with a median of 31.5 years. Ouakam's fishers report a higher span of experience, from 18 to 60 years, suggesting a deep reservoir of traditional knowledge, with a median experience of 35 years. Yoff's range of experience, from 15 to 55 years with a median of 36 years, indicating a blend of youth and experience. Notably, the box plot for Ouakam depicts an outlier at 60 years, signifying an individual with exceptional longevity in the profession

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Fishing Occupation

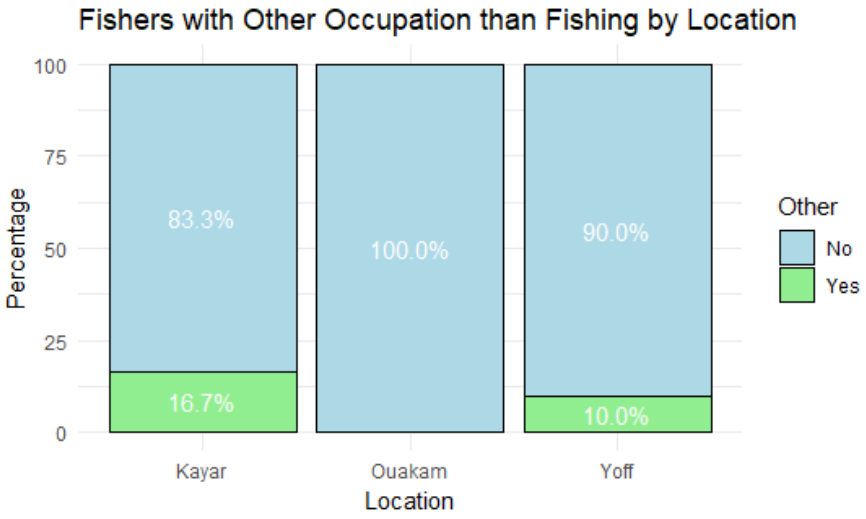

Figure 18. *Bar chart with percentage depicting the proportion of artisanal fishers engage in other occupation than fishing (Senegal).*

The assessment of secondary occupational engagement among artisanal fishers in Kayar, Ouakam, and Yoff has brought to light distinct economic diversifications. In Kayar, a minority of 16.7% of fishers maintain an occupation aside from fishing, suggesting a strong reliance on fishing as the primary economic activity. Ouakam stands out with 100% of fishers dedicated solely to fishing, indicating either a lack of alternative employment opportunities or a strong fishing-based economic structure. Yoff, similar to Kayar, shows a small percentage (10%) of fishers with secondary occupations. This pattern indicates that the vast majority of fishers are primarily dependent on fishing for their livelihood, which may have implications for community resilience to changes in the fishing industry.

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Education Level

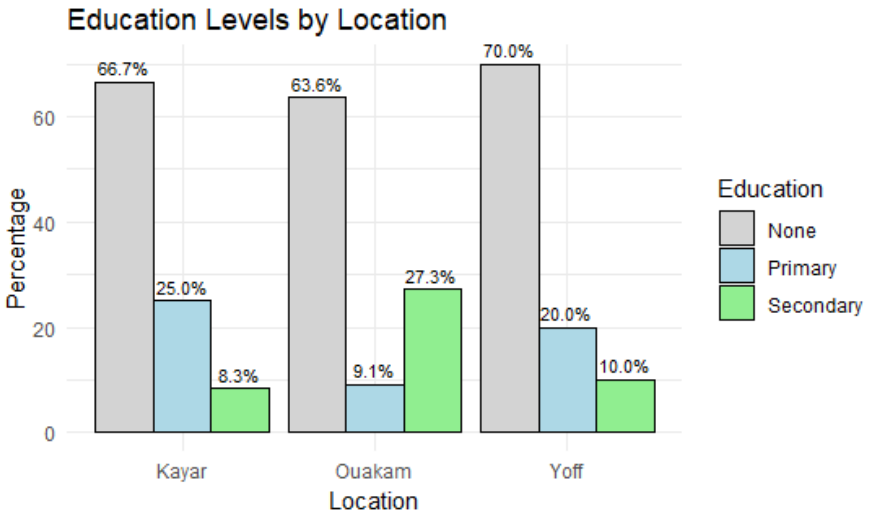

Figure 19. *Bar chart with percentage depicting the level of education of artisanal fishers in Kayar, Ouakam, and Yoff (Senegal).*

The distribution of education levels among artisanal fishers in Kayar, Ouakam, and Yoff offers a portrait of the educational background within these communities. In Kayar, the majority of fishers (66.7%) have not attained formal education, with only 25.0% and a notable minority of 8.3% completing primary and secondary education, respectively. Ouakam presents a higher educational attainment, with 27.3% of fishers having completed secondary education and a proportion of 63.6% with no formal education. Yoff demonstrates the highest level of secondary education completion at 10.0%, albeit still with a substantial 70.0% without formal education. These figures indicate that a significant portion of fishers in these areas may lack formal education, which could have implications for their capacity for other economic activities and their ability to adapt to regulatory or environmental changes within the fishing sector.

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4.2 Perception Change in Fishing Effort

Change in the Number of Fishing Trips per Month

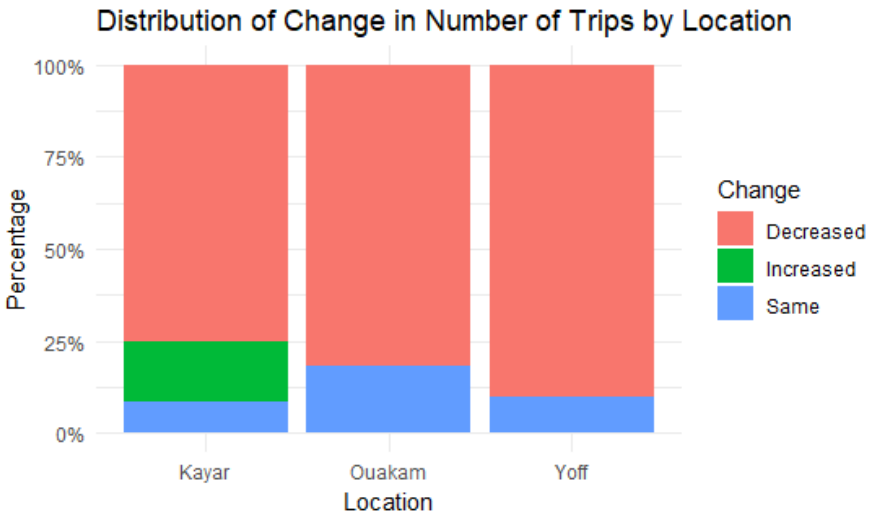

Figure 20. *Fishers perception of change in the number of fishing trips per month (Senegal).*

The bar chart presents a comparative analysis of the variation in trip frequency across Kayar, Ouakam, and Yoff. It is evident that the majority of changes in all three locations indicate a decrease in the number of trips, occupying a substantial portion of the chart. Interestingly, Kayar shows a unique trend with a noticeable green segment, representing a reporting increase in trip frequency for about 20% of the respondents, which is absent in the other two locations. Ouakam and Yoff exhibit a slight presence of no change in trip numbers.

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Change in the Travelling Distance per Fishing Trip

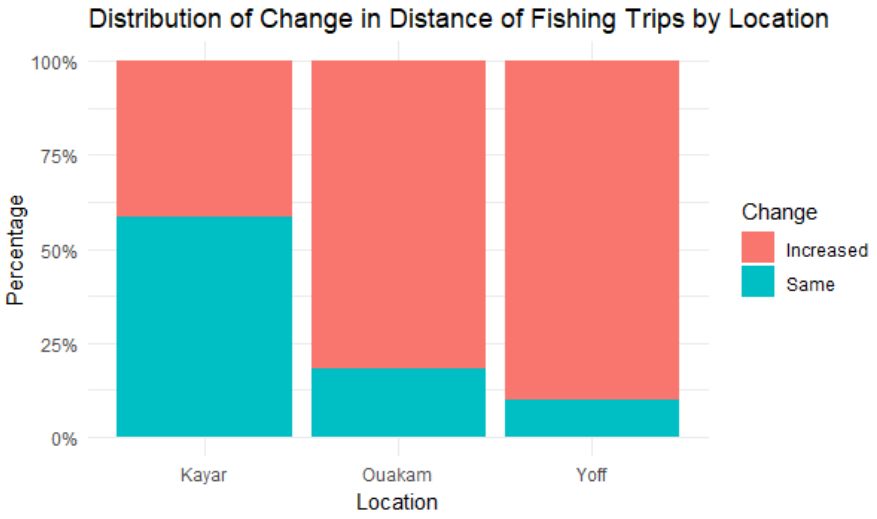

Figure 21. *Fishers perception of change in the distance of fishing trips (Senegal).*

The bar chart delineates the trends in the distances of fishing trips across Kayar, Ouakam, and Yoff. The data reveals a dominant increase in the distance of fishing trips, as indicated by the which represent a significant majority in Ouakam and Yoff. Notably, Kayar exhibits a considerable proportion of respondents reporting that fishing trips have remained at the same distance. Conversely, Ouakam and Yoff show a relatively smaller proportion of the same distance, suggesting that changes in trip distances are more common in these areas. This distribution implies that fishers have to go fishing further as the water closer to the shore are depleted of fish.

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Change in Active Fishing Hours per Fishing Trip

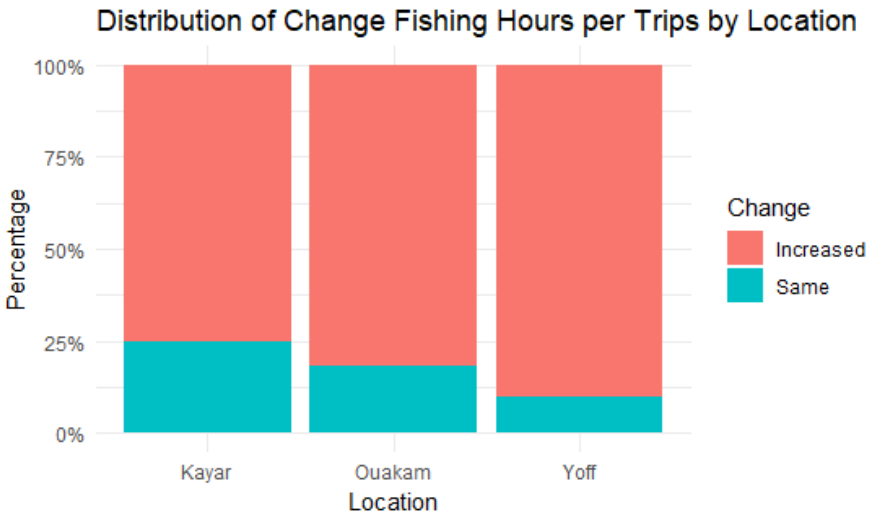

Figure 22. *Fishers perception of change in active fishing hours per trip (Senegal).*

The bar chart illustrates the shifts in the duration in hours of active fishing during a trip across Kayar, Ouakam, and Yoff. In all three regions, there is a prominent increase in fishing hours, indicating that fishers are spending more time at sea to catch fish. The relative uniformity of this pattern across the locations suggests a clear general trend towards longer fishing trips.

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4.3 Local Climate Change Perception

Water Temperature

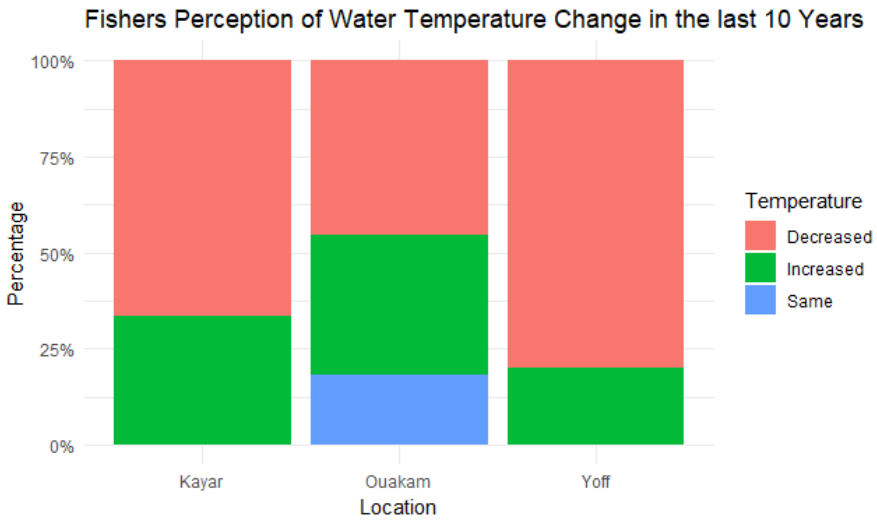

Figure 23. *Fishers perception of water temperature change in the last 10 years (Senegal).*

Kayar's bar reveals that the largest segment of fishers perceives a decrease in water temperature. There's a smaller, yet notable, group who report an increase. In Ouakam, the majority of fishers also perceive a decrease in water temperature, but the percentages of those who feel the temperature has increased or remained the same are closer to each other compared to Kayar. The perceptions in Yoff are similar to Kayar, with the vast majority of respondents perceiving a decrease and a smaller percentage perceiving and increase.

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Precipitation

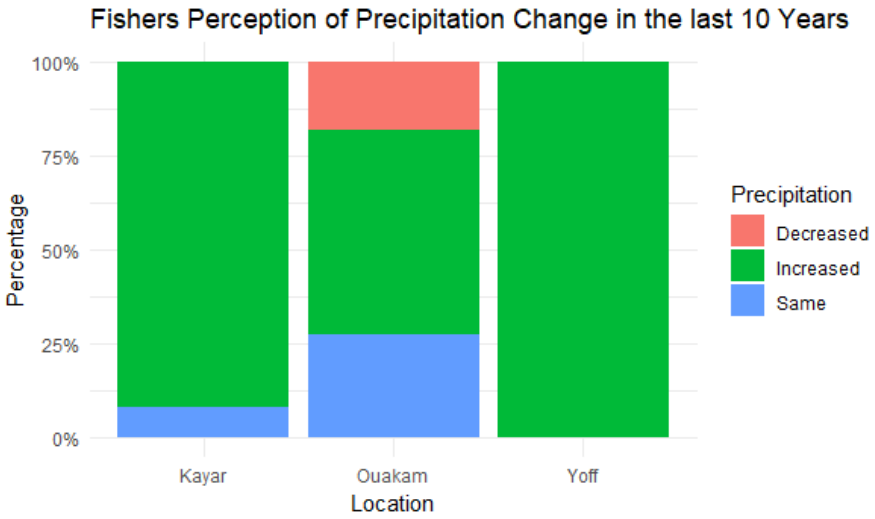

Figure 24. *Fishers perception of precipitation change in the last 10 years (Senegal).*

In Kayar, a majority of fishers perceive an increase in precipitation. A smaller portion perceives no change, and an even smaller percentage believes it has decreased. In Ouakam, the distribution of perceptions is similar to Kayar, with most fishers noticing an increase in precipitation, but different in the sense that there's a substantial number who perceive no change, and a smaller segment feels that precipitation has decreased. Yoff shows a pattern where the all respondents perceive increased precipitation.

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Wind

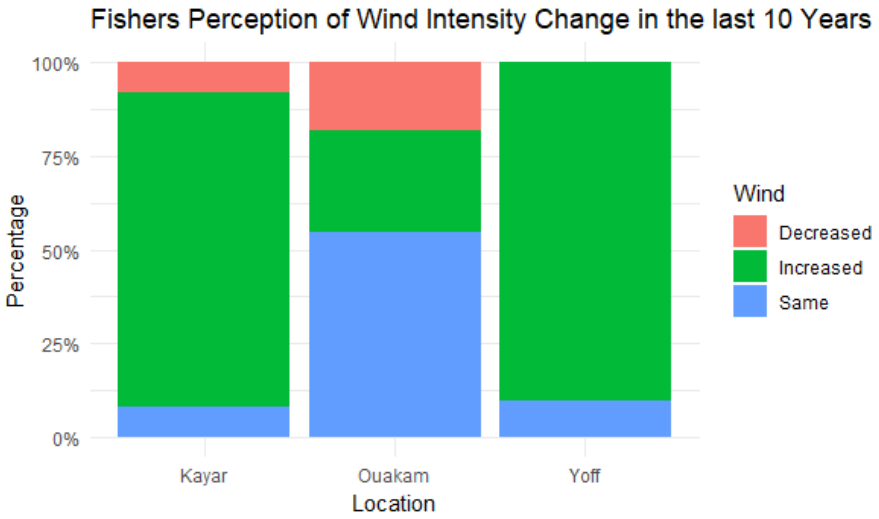

Figure 25. *Fishers perception of wind intensity change in the last 10 years (Senegal).*

In Kayar, a clear majority of fishers have noticed an increase in wind intensity, while a smaller group believes it has remained consistent, and only a few feel that it has decreased. Ouakam presents a more balanced view, with many still sensing stronger winds but a significant number report no change, and a minority perceive a decrease. Yoff's results echo those of Kayar, where most fishers report increased wind intensity, a sizeable number notice no change, but none and think the wind intensities have weakened.

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4.4 Effect on the Resources

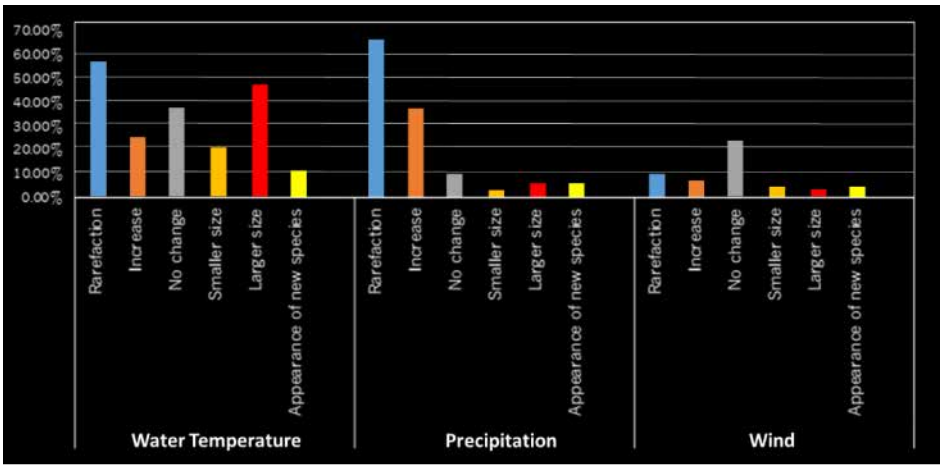

Figure 26. *Fishers perception of impact of water temperature, precipitation, and wind on the fisheries resource (demersal) in Senegal.*

This graph is representing artisanal fishers' perceptions of the impact of climate change on the resources they harvest (demersal fish), broken down by three factors: water temperature, precipitation, and wind. For water temperature and precipitation, the most commonly perceived impact is a reduction in fish stocks, suggesting fishers have noticed a decrease in the abundance of fish as temperatures have risen and precipitations decreased. As for wind intensities, no change was the most commonly cited. Overall, the graph indicates that artisanal fishers are observing some changes in the marine ecosystem that they attribute to climate change, with varying impacts on fish stocks, sizes (e.g. rarefaction but larger size for water temperature), and species distribution. Also for the three factors, a small percentage have reported new species in their catches.

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4.5 Risk Identification

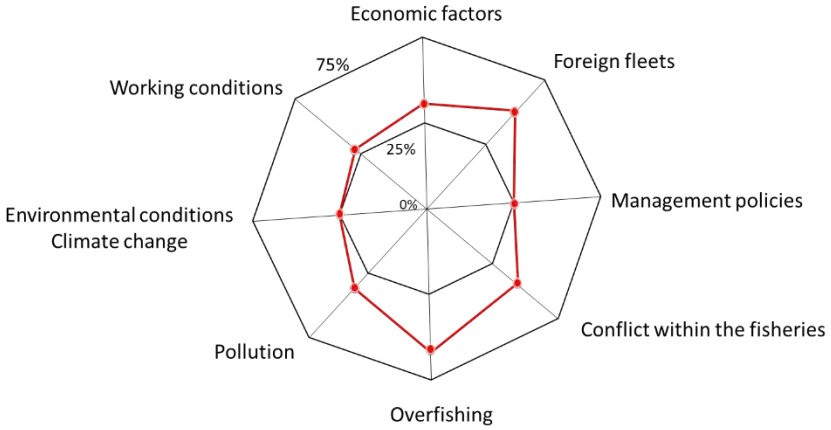

Figure 27. *Radar chart depicting the proportion of total prioritized risks cited by artisanal fishers in Senegal (% of total).*

The radar chart presented here outlines the impact levels of eight distinct prioritized perceived risk factors and how frequent they were mentioned, each plotted on axes with a scale ranging from 0% to 75%. The factors include Working Conditions, Environmental Conditions/Climate Change, Pollution, Overfishing, Conflict within the Fisheries, Management Policies, Foreign Fleets, and Economic Factors. The data, represented by a red line, indicates that overfishing and foreign fleets are at the forefront of concerns, followed closely by conflicts within fisheries and pollution. In contrast, working conditions and management policies are deemed to have a lesser impact at and climate change shows the least impact.

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4.6 Standard of living

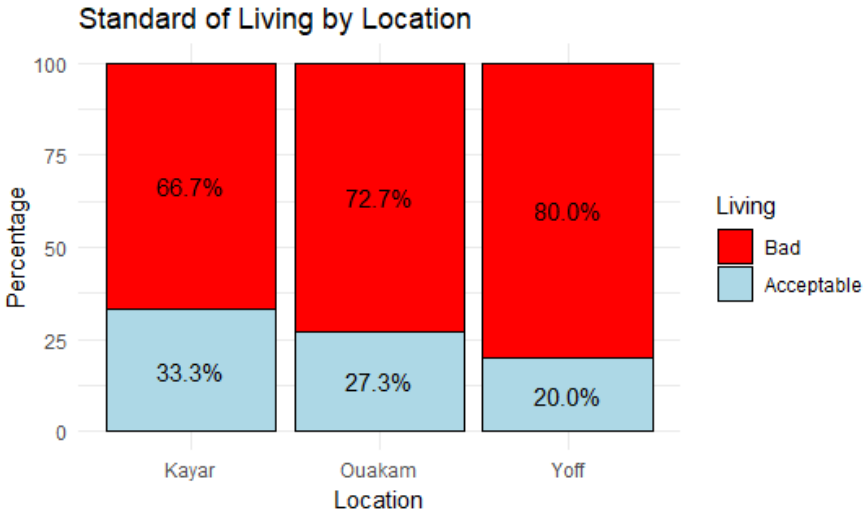

Figure 28. *Artisanal fisher's assessment of their standard of living (Senegal).*

In Kayar, about one-third (33.3%) of the artisanal fishers consider their standard of living acceptable, while the majority (66.7%) rate it as bad. Moving to Ouakam, the situation appears slightly worse, with only 27.3% of fishers reporting an acceptable standard of living and a larger portion, 72.7%, categorizing it as bad. Yoff shows the most concerning results, where only one in five fishers (20.0%) reports an acceptable standard of living, with a significant majority of 80.0% finding their conditions to be bad. It is noteworthy that none of the respondents have chosen "Good" or "Excellent" as descriptors for their standard of living.

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Table 1. *Target species as reported by hook and Line Artisanal fishers in Cabo Verde, with corresponding scientific names, family, and local Creole nomenclature.*

Scientific name	Family	Local name (Creole)
Cephalopholis taeniops	Serranidea	GAROUPA
Thunnus albacares	Scombridae	ALBACORA; ATUM
Seriola rivoliana	Carangidae	ESMOREGAL
Moreia spp.	Muraenidae	MOREIA
Lethrinus atlanticus	Lethrinidae	BICA
Sargo spp.	Sparidae	SARGO
Acanthocybium solandri	Scombridae	SERRA; DJEU
Spicara melanurus	Centracanthidae	DOBRADA
Sparisoma cretense	Scaridae	BIDION
Pseudupeneus prayensis	Mullidae	SALMONETE

Table 2. *Target species as reported by hook and Line Artisanal fishers in Senegal, with corresponding scientific names, family, and local Wolof nomenclature.*

Scientific name	Family	Local name (Wolof)
Epinephelus aeneus	Epinephelidae	THIOF
Pagellus bellottii	Sparidae	YOUFOUF
Trichiurus lepturus	Trichiuridae	TALLAR
Brotula barbata	Ophidiidae	LEER
Argyrosomus regius	Sciaenidae	BEUR
Mycteroperca rubra	Epinephelidae	YATANTE
Octopus vulgaris	Octopodidae	YARANKA
Plectorhinchus mediterraneus	Haemulidae	BANDA

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5. Discussion

In the global context, climate-induced changes are already affecting the livelihoods of individuals, particularly those in developing nations heavily reliant on marine-related activities (Gattuso et al., 2015). Communities relying on artisanal fishing activities are inherently exposed to climate variability and uncertainty (Ellis and Allison, 2001). This study aimed to generate knowledge on the extent to which fishers perceived changes in local climate and the resulting impacts on their resources and livelihoods, recognizing the critical importance of understanding the relationships between climate change and the livelihoods of fishers. Such comprehension is complementary information for resolving fishing conflicts arising from climate-related issues and ensuring the long-term sustainability of these communities (Hobday et al., 2015). Local perspectives on climate change, along with associated socio-economic changes affecting the community, are essential for crafting comprehensive and inclusive mitigation and adaptation plans at both local and national levels (Aswani et al., 2015).

The results of this study revealed that fishers were aware of changes in local climate, manifesting through alterations in water temperature, precipitation patterns, and wind intensities. The discernible effects of climate change on fisheries resources were mostly observed in Senegal's changing rainfall patterns and Cabo Verde's wind variations, both influencing artisanal fishing productivity and sustainability. In both locations, these impacts were predominantly perceived as negative and detrimental to the fishers' livelihoods.

Senegal's artisanal fishing community, while expressing dissatisfaction with their standard of living, benefits from a relatively stable base of infrastructural services. They are part of extensive household systems, suggesting a strong social support network that could be leveraged for community-based adaptation strategies. However, the discontent with living standards is indicating underlying economic vulnerabilities that might be exacerbated by the impacts of climate change. Cabo Verde presents a contrasting scenario where fishers are more content with their living standards, often operating without the support of robust infrastructure. Then being less discontent could be indicative of more resilient livelihood strategies or a cultural adaptation to existing conditions, serving as a buffer against the vagaries of changing environmental conditions.

Despite experiencing changes aligning with anticipated climate impacts, such as shifts in fish migration patterns, breeding seasons, and increased extreme weather events, from the perspective of the fishers, more immediate threats like overfishing, foreign fleets, and pollution took precedence. These

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were emphasized as more immediate and critical day-to-day challenges. This prioritization suggests a nuanced interplay between recognizing the long-term threat of climate change and addressing more pressing livelihood challenges.

Thus, this study underscores the need for future investigations that delve into these perceptions, comparing them with physical and environmental observations. While the survey data serves as a foundational element for deeper analysis, it does not allow for a complete assessment of the participants' exposure to climate change, pointing to significant areas for future modeling and understanding. This involves conducting thorough vulnerability assessments and income analyses to pinpoint areas requiring urgent intervention. Furthermore, integrating the data with projects assessing risk and investment behaviour, credit market access, and nutritional trends holds the potential to provide a comprehensive understanding of the diverse indirect impacts of climate change and socio-economic stressors on these crucial sectors. Nevertheless, the findings suggest that fishers' perspectives are invaluable and complementary sources of information for shaping local and regional adaptation strategies. They offer a distinct and relevant viewpoint from marine-dependent communities to decision-makers. Consequently, the fishers' perceptions presented in this study have the potential to enhance the understanding and interpretation of changes witnessed in recent decades, the associated impacts on livelihoods and coastal ecosystems, and contribute to the development of effective local adaptive strategies to climate change and food security.

One of the most significant hurdles faced in researching artisanal fisheries in tropical regions is the substantial lack of data. This deficiency spans from fundamental details regarding fishing pressure and the demographics of artisanal fishers (Béné, 2006), to the intricate socio-demographic and cultural investigations (Mcconney et al., 2008). Such comprehensive research is essential for effectively planning sustainable co-management initiatives, considering factors such as risks associated with the activity. Concerning artisanal fishing communities in Senegal and Cabo Verde, there still exists a notable gap in the research on artisanal fishers as a social group. In the realm of management, they are frequently perceived as relatively static components within the system. However, in this study, we have seen that artisanal fishers in these regions are diverse, featuring a range of social, economic and environmental perceptions. This diversity contributes to intricate behavioural dynamics in their interaction with fisheries resources.

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6. Conclusion

In conclusion, this study highlights the potential vulnerability of artisanal fishing communities in Senegal and Cabo Verde to climate change. It emphasizes the importance of understanding the complex relationship between climate change and fishers' livelihoods. The differing experiences in these two regions underscore the diverse exposure and associated perceptions by fishers, with implications for community resilience and sustainability. Balancing immediate threats with long-term climate challenges is a delicate task for these communities. Moving forward, it is crucial to conduct further research by comparing fishers' perceptions with environmental data and conducting vulnerability assessments. Combining survey data with risk assessments, investment behaviour analysis, and socio-economic stressor studies is key to comprehending the full impact of climate change on these sectors. Fishers' perspectives are valuable and can shape effective adaptation strategies. However, a significant challenge remains in the lack of comprehensive data on artisanal fisheries in tropical regions. Bridging this data gap is essential for sustainable co-management initiatives. Policymakers and decision-makers should use these insights to develop inclusive and comprehensive mitigation and adaptation plans at local and national levels. Understanding the behavioural dynamics and priorities of artisanal fishing communities can help tailor interventions to address immediate challenges and foster long-term resilience. This approach ensures that climate change adaptation strategies gain crucial community support, ultimately contributing to the resilience of artisanal fisheries in a changing environment.

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Annexe

Example of questionnaire used in semi-structure interviews

ENQUÊTE :

Impacts écologiques et socio-économiques perçus du changement climatique sur la pêche sénégalaise.

Toutes les informations fournies seront utilisées à des fins statistiques uniquement et seront traitées en toute confidentialité. Aucun questionnaire individuel ne sera jamais identifié dans les documents publiés à la suite de cette enquête et aucune des données obtenues ne sera transmise à une autre partie. Nous apprécierions vraiment votre coopération.

NUMERO DU QUESTIONNAIRE : _____

DATE : _____

LIEU DE L'ENQUÊTE : _____

ZONE DE PÊCHE: ☐Yoff
☐Kayar
☒Ouakam

Questions sur le pêcheur :

Q.1) Quel est votre nom ? _____

Q.2) Quel âge avez-vous ? _____ ans

Q.3) Depuis combien de temps êtes-vous pêcheur ? _____ années

Q.4) Avez-vous un autre travail ? Oui☐ Non ☐

→ Si oui, veuillez préciser _____

→ et indiquez si la pêche est votre principale source de revenus : Oui☐ Non ☐

→ quel pourcentage de votre revenu provient des activités de pêche _____%

Q.5) Pourriez-vous, s'il vous plaît, donner quelques détails sur le bateau de pêche que vous utilisez ?

Longueur ? _____ mètres Puissance ? _____ kW / HP (ou voiles)

Q.6) Êtes-vous le propriétaire de ce bateau de pêche ? Oui☐ Non ☐

→ Si non, quel est votre rôle sur le bateau de pêche ? Partenaire ☐ Skipper☐ Pêcheur☐

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Q.7) Quel type d'engin de pêche utilisez-vous le plus souvent au cours d'une année ?

☐ Filet maillant calé de fond Longueur _____ Taille de maille _____
☐ Filet maillant calé de surface Longueur _____ Taille de maille _____
☐ Filet maillant encerclant Longueur _____ Taille de maille _____
☐ Filet maillant dérivant Longueur _____ Taille de maille _____
☐ Ligne Taille de l'hameçon____ Nombre d'hameçons _____
☐ Palangre Taille de l'hameçon____ Nombre d'hameçons _____
☐ Senne tournante Longueur _____ Taille de maille _____
☐ Senne de plage Longueur _____ Taille de maille _____
☐Autres : _____

Q.8) Quel type de poisson pêchez-vous ? (Veuillez noter la proportion dans la prise)

Ordre	Type de poisson	% de prises	Quand (période de l'année – noter les unités)
1st			
2nd			
3rd			
4th			
5th			

Questions d'effort :

Q.9) En moyenne, combien de sorties de pêche faites-vous par mois ? _____

Q.10) Au cours des 5 dernières années, diriez-vous que le nombre de sorties de pêche que vous faites en un mois a……

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

→ **Si augmentation ou diminution, quelle en est la raison ?**

_____

_____

Q.11) À quelle distance de la côte pêchez-vous habituellement ? _____
Miles/Kilomètres

Q.12) Au cours des 5 dernières années, diriez-vous que la distance que vous devez parcourir pour la plupart des sorties de pêche a…

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

→ **Si augmentation ou diminution, quelle en est la raison ?**

_____

_____

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Q.13) Quelle est la durée moyenne d'une sortie de pêche ?_____ Heures/jours

Q.14) Au cours des 5 dernières années, diriez-vous que la durée moyenne d'un voyage de pêche a…

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

→ **Si augmentation ou diminution, quelle en est la raison ?**

_____

_____

Q.15) Lors d'une sortie de pêche, quel est le temps moyen passé à déployer/remorquer pour les activités de pêche ? _____ (Heures)

Q.16) Au cours des 5 dernières années, diriez-vous que le temps moyen passé à déployer/remorquer pendant la pêche a…

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

→ **Si augmentation ou diminution, quelle en est la raison ?**

_____

_____

Question sur l'emploi :

Q.17) Sur votre bateau de pêche, avec combien de personnes sortez-vous pêcher ? _____

Q.18) Au total, combien de personnes différentes (toutes les personnes engagées) travaillent sur le bateau de pêche (y compris le propriétaire) ? _____

Q.19) Au cours des 5 dernières années, diriez-vous que le nombre total de personnes employées travaillant sur le bateau de pêche a…

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

→ **Si augmentation ou diminution, quelle en est la raison ?**

_____

_____

Q.20) Comment êtes-vous rémunéré ?

Montant fixé ☐ % du chiffre d'affaires☐ ☐Autre_____

Q.21) En un mois, combien gagnez-vous en pêchant ?

Moyenne_____ (FCFA) Maximum_____(FCFA) Minimum_____(FCFA)

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Q.22) Au cours des 5 dernières années, diriez-vous que vos revenus mensuels de pêche ont…

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

→ **Si augmentation ou diminution, quelle en est la raison ?**

_____

_____

Commercial question:

Q.23) Quelle est la destination de la première vente ?

	Maintenenant	Il y a 5 ans
Mareyeur	%	%
Vente directe au consommateur final	%	%
Vente directe au restaurant	%	%
Exportateur	%	%
Consommation personnelle	%	%
Autres	%	%
	%	%
	%	%
	100%	100%

Cost questions:

Q.24) Quel type de carburant utilisez-vous ? Diesel☐ Essence☐ Pas de carburant ☐

Q.25) **Combien dépensez-vous en carburant lors d'un voyage de pêche typique ?** _____ (FCFA)

Q.26) **Combien de litres de carburant utilisez-vous lors d'une sortie de pêche type ?**_____(litres)

Q.27) **Combien dépensez-vous en lubrifiant lors d'une sortie de pêche typique ?**_____(FCFA)

Q.28) **Combien de litres de lubrifiant utilisez-vous lors d'une sortie de pêche type ?**_____(litres)

Q.29) **Combien dépensez-vous en appâts lors d'un voyage de pêche typique ?** _____ (FCFA)

Q.30) **Combien dépensez-vous pour la glace lors d'un voyage de pêche typique ?** _____(FCFA)

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Q.31) **Combien dépensez-vous en nourriture lors d'un voyage de pêche typique ?** _____(FCFA)

Q.32) Devez-vous payer la sécurité sociale, les charges sociales et la cotisation de retraite?

Oui☐ Non ☐ → Si oui, veuillez préciser à quoi et combien _____(FCFA)

Perception questions:

Q.33) Au cours des 5 dernières années, diriez-vous que la température de l'eau a…

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Q.34) → Si l'augmentation ou la diminution de la température de l'eau a été sélectionnée, avez-vous remarqué un impact sur la ressource ? (Répondez jusqu'à 5 espèces)

(1) Abondance de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Taille de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

(2) Abondance de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Taille de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

(3) Abondance de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Taille de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

(4) Abondance de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

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Taille de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

(5) Abondance de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Taille de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Q.35) Au cours des 5 dernières années, diriez-vous que les précipitations ont…

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Q.36) → Si l'augmentation ou la diminution des précipitations a été sélectionnée, avez-vous remarqué un impact sur la ressource ? (Répondez jusqu'à 5 espèces)

(1) Abondance de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Taille de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

(2) Abondance de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Taille de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

(3) Abondance de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Taille de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

(4) Abondance de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

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Taille de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

(5) Abondance de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Taille de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Q.37) Au cours des 5 dernières années, diriez-vous que l'intensité du vent a…

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Q.38) → Si l'augmentation ou la diminution de l'intensité du vent a été sélectionnée, avez-vous remarqué un impact sur la ressource ? (Répondez jusqu'à 5 espèces)

(1) Abondance de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Taille de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

(2) Abondance de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Taille de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

(3) Abondance de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Taille de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

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(4) Abondance de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Taille de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

(5) Abondance de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Taille de l'espèce _____

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

Q.39) Au cours des 5 dernières années, avez-vous remarqué la présence de nouvelles espèces dans vos prises ? Oui☐ Non ☐

→ Si oui, veuillez préciser quelle espèce_____

→ Est-ce que la valeur de vente de ces nouvelles espèces….

Plus valable☐ or moins valable ☐

Q.40) Pensez-vous que l'abondance des démersaux dans votre localité a changé au cours des 5 dernières années ?

Augmenté ☐ Diminué ☐ Pas de différence☐ Ne sais pas☐

→ En cas d'augmentation ou de diminution, quelle est la raison principale de ce changement ?_____
_____

Q.41) Pensez-vous que l'abondance des pélagiques dans votre région a changé au cours des 5 dernières années ?

→ En cas d'augmentation ou de diminution, quelle est la raison principale de ce changement ?

_____
_____

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Well-being questions:

Q.42) Comment évalueriez-vous votre niveau de vie ?

Inacceptable ☐ Pas bon ☐ Acceptable ☐ Bon ☐ Très bon☐

Q.43) Quels sont vos principaux soucis dans la vie ? Veuillez nommer 3 !

1) _____

2) _____

3) _____

Q.44) Vous aimeriez que vos enfants soient pêcheurs ? Oui☐ Non ☐

Demographic questions:

Q.45) Quelle est votre nationalité ? _____

Q.46) Avez-vous des convictions religieuses ? Oui☐ Non ☐

→ Si oui, veuillez préciser _____

Q.47) Pouvez-vous écrire et lire ? Oui☐ Non ☐

Q.48) Avez-vous été à l'école ? Oui☐ Non ☐

→ Si oui, veuillez préciser

Enseignement primaire ☐
Éducation secondaire ☐
L'enseignement supérieur ☐

Q.49) Combien de personnes vivent dans votre ménage ?

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Q.50) Combien de membres du ménage sont engagés dans la pêche ?

Q.51) Quelle est la proportion du revenu total du ménage qui provient des activités de pêche ?

→ Si la pêche n'est pas à 100 %, indiquez les autres activités et leur proportion.

Ordre	Autres activités que la pêche	% proportion du revenu du ménage
1st		
2nd		
3rd		
4th		
5th		

Q.52) Vous faites partie d'un collectif ou d'un groupe ? Oui☐ Non ☐

→ Si oui, veuillez préciser _____

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