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Climate Change and Fishing Communities in Pemba Island, Tanzania: Perceptions of Extreme Events and Habitat Degradation

Climate Change and Fishing Communities in Pemba Island, Tanzania: Perceptions of Extreme Events and Habitat Degradation

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Abstract
Coastal communities across sub-Saharan Africa are increasingly vulnerable to climate change, particularly small-scale fishing populations dependent on marine ecosystems for livelihoods and food security. This study explores perceptions of climate-related risks among fishing communities in Pemba Island, Zanzibar, focusing on extreme weather events, sea level rise, and habitat degradation. Using mixed-methods and quantitative data from 361 households across three districts (Micheweni, Chake Chake, and Wete), the research identifies key environmental concerns, economic correlations, and community responses. Results show high awareness of climate impacts, with declining fish stocks (82%) and extreme weather events (68%) being the most commonly reported issues. Statistical analysis reveals significant negative correlations between climate stressors and fishing income, with sea level rise concern ($r = -0.41$, $p = 0.003$), habitat degradation ($r = -0.38$, $p = 0.006$), and extreme weather frequency ($r = -0.32$, $p = 0.011$) all associated with income decline. Regression results indicate these variables significantly predict income loss, with sea level rise concern ($\beta = -0.31$, $p = 0.022$) and extreme weather frequency ($\beta = -0.28$, $p = 0.012$) as the strongest predictors. Chi-square tests highlight district-level differences in adaptation strategies: gear modifications dominated in Micheweni (42%), seasonal migration in Wete (50%), while aquaculture adoption remained low (5–12%, $p = 0.485$). These findings underscore the urgent need for integrated policy interventions that prioritise community-led adaptation, ecosystem conservation, and climate-resilient fisheries management. The study contributes to understanding how local perceptions align with environmental realities and provides a framework for resilience planning in island ecosystems.

Introduction

Climate change poses one of the most pressing and complex challenges of the 21st century, affecting ecosystems, economies, and societies at multiple scales. Nowhere is this more apparent than in coastal zones, where rising sea levels, ocean acidification, warming waters, and more frequent extreme weather events are fundamentally reshaping marine environments and the livelihoods that depend on them (IPCC, 2023). Globally, millions of small-scale fishing communities are experiencing the

combined pressures of ecological degradation and economic precarity, making them among the most vulnerable groups to climate-induced disruptions (McClanahan, 2024; Brodie et al., 2024).

In the African context, coastal and island populations are disproportionately affected due to limited infrastructure, heavy dependence on natural resources, and constrained adaptive capacity. Countries along the continent's eastern seaboard are already witnessing changes in fish distribution, increasing sea surface temperatures, and shifts in seasonal rainfall patterns, factors that directly impact artisanal fisheries, which form the economic backbone of many rural households (Makame & Shackleton, 2020; Mucova et al., 2021). According to UNEP, over 12 million people in Africa rely on small-scale fisheries for their livelihoods, yet they remain largely excluded from formal adaptation planning.

Zooming in on East Africa, the Western Indian Ocean has been identified as both ecologically sensitive and socially vulnerable. Coastal communities in Kenya, Mozambique, and Tanzania are experiencing more frequent cyclones, saline intrusion into freshwater systems, and coral reef bleaching, all of which compromise marine productivity and threaten food security (Muhala et al., 2021; Hussein et al., 2019). While climate models predict a continued rise in sea levels and temperature variability, the immediate concern for local fishers is the observable deterioration of marine habitats and the dwindling of fish stocks.

In Tanzania, the fisheries sector plays a critical role in both national food systems and rural employment. Yet, the country's 2022 climate risk profile identifies coastal fishing zones as hotspots for both biophysical and socio-economic vulnerability. Despite growing evidence of environmental stress, local-level adaptation remains fragmented and under-resourced, with many fishing households relying on traditional knowledge systems and informal coping strategies to respond to increasingly unpredictable conditions (Makame & Salum, 2021; Makame & Mwevura, 2019).

Within Tanzania, Zanzibar stands out due to its insular geography, unique marine ecosystems, and heavy reliance on artisanal fishing. Pemba Island, in particular, is characterised by a network of small-scale fishing communities whose livelihoods are intricately tied to coral reefs, mangroves, and shallow coastal fisheries. Over the past decade, fishers in Pemba have reported declining catches, shifting seasons, and increased damage to critical habitats, all of which mirror broader regional climate trends but are felt more acutely in this isolated context (Makame et al., 2023; Salim & Rubanza, 2015).

Yet, while national climate discourse increasingly acknowledges these challenges, a significant gap remains in empirical data capturing how climate change is perceived at the community-level, and more importantly, how these perceptions influence local adaptation strategies. Understanding local perspectives is vital, not only for designing context-specific interventions but also for ensuring that resilience-building efforts are grounded in the lived realities of those most affected.

This study aims to explore the perceptions of climate change among fishing communities in Pemba Island, Zanzibar, with a particular focus on extreme weather events and habitat degradation. By examining how fishers interpret, respond to, and are impacted by environmental changes, the research contributes to ongoing debates around climate justice, local adaptation, and marine resource governance in small island developing contexts.

Literature Review

Small-scale fisheries have long served as both an economic safety net and a cultural cornerstone for coastal communities around the world. Yet, these systems are increasingly under threat from a changing climate. Globally, fishers are reporting reductions in catch volumes, shifts in fish migration patterns, and more frequent storm events, all of which pose serious risks to the sustainability of

artisanal fisheries (IPCC, 2023; McClanahan, 2024). Climate change is not only altering the physical characteristics of marine ecosystems but also disrupting the socio-economic frameworks that sustain coastal livelihoods.

In sub-Saharan Africa, small-scale fisheries provide critical sources of protein and income to millions. However, the sector is highly vulnerable due to its exposure to climate variability, limited technological capacity, and weak institutional support (Brodie et al., 2024; Musinguzi et al., 2016). Studies from Lake Victoria, Lake Wamala, and coastal zones in Mozambique have illustrated how fishers perceive changes such as rising temperatures, prolonged dry seasons, and habitat degradation as immediate threats to their way of life (Hussein et al., 2019; Mucova et al., 2021). These studies also underline the importance of local knowledge and community perceptions in shaping adaptive responses.

In East Africa and the Western Indian Ocean region, coral bleaching, mangrove loss, and salinity intrusion are intensifying. These impacts are particularly acute in insular territories like Zanzibar, where geographic isolation amplifies ecological and socio-economic vulnerability. Makame and Shackleton (2020) found that fishers in Zanzibar increasingly rely on their observations of the environment, such as erratic rainfall, sea temperature changes, and tide patterns, to interpret and respond to climate risks. Their findings echo broader calls for integrating local perceptions with scientific climate models to co-produce more effective adaptation strategies.

Research on Pemba Island, though more limited, confirms similar patterns. Makame et al. (2023) and Salim and Rubanza (2015) reported widespread community concern over declining fish stocks, coastal erosion, and habitat degradation. Despite these growing anxieties, formal adaptation remains limited, often constrained by a lack of financial capital, technical knowledge, and policy alignment. Moreover, while empirical studies have captured environmental changes through satellite imagery or biophysical assessments, few have systematically examined how these changes are perceived by the communities most directly affected, and even fewer have linked these perceptions to quantifiable livelihood outcomes such as income loss or adaptation behaviour.

This study seeks to fill that gap by merging quantitative community perception-data with climate records, specifically rainfall and temperature trends, and linking both to observed impacts on fishing income and adaptation strategies in Pemba Island. In doing so, it builds on the existing literature while offering new insights into how localised understanding of climate change influences resilience in a small island context.

Methodology

Study Design

This research adopted a convergent parallel mixed-methods design, allowing for the simultaneous collection and analysis of both quantitative and qualitative data streams. This approach was particularly well-suited to the study's aims: to assess not only the perceptions of climate change impacts but also their tangible outcomes on livelihoods and adaptation behaviour. The design enabled integration of climate data, rainfall, and temperature records from the past decade with community-level perception surveys, creating a multi-layered analysis that aligns statistical evidence with local lived experience.

Study Area

The research was conducted on Pemba Island, located in the Zanzibar Archipelago off the coast of mainland Tanzania. The island is well known for its ecological richness and deep reliance on marine

resources, especially among communities engaged in small-scale fishing. These characteristics made it a particularly fitting setting for examining how climate change is perceived and experienced at the local-level.

The study focused on three coastal districts, namely, Micheweni, Chake Chake, and Wete. Each is selected for its unique mix of environmental conditions and socio-economic features. Micheweni, for example, is situated in the northern part of the island and often bears the brunt of strong ocean currents and frequent extreme weather events. Chake Chake, by contrast, lies further south and features a more sheltered coastline, while Wete occupies a central position and offers a blend of both exposure and resilience.

The geographical layout of these districts is depicted in Figure 1: Location of the Study Areas, which provides a visual reference to their spatial distribution across Pemba Island. Their proximity to the coastline—often within just a few kilometres—made them ideal for assessing how climate-related risks such as sea level rise, coral bleaching, and shoreline erosion are perceived by fishing communities.

Beyond environmental considerations, these districts also differ in access to infrastructure, government support, and local adaptation initiatives, allowing for a nuanced comparison of how communities respond to climate stressors. Their inclusion ensures that the study captures a wide spectrum of vulnerability and adaptive behaviour, reflecting the complex realities faced by small-scale fishers in Pemba today.

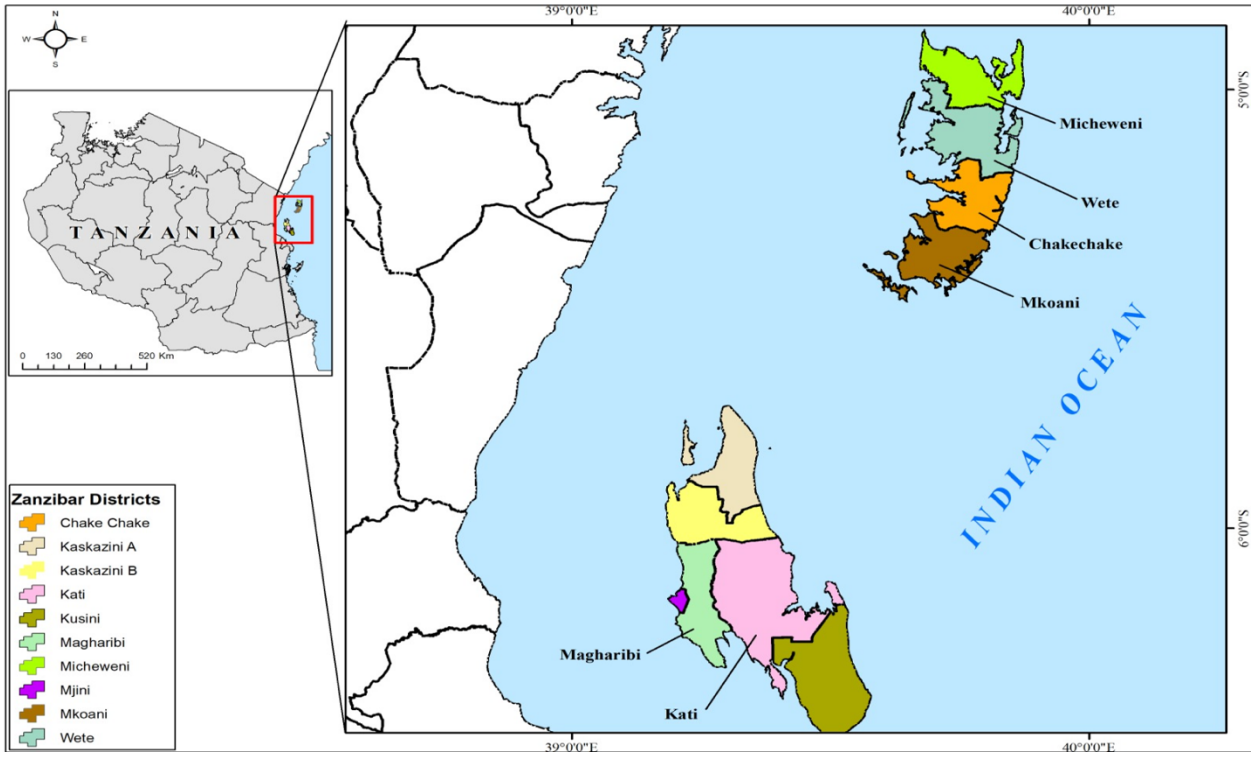

Figure 1: Location of the Study Areas

Source: UDSM, Department of Geography (2025)

Study Population, Sample Size and Sampling

The study focused on fishing households in coastal communities across Pemba Island, with the household serving as the primary unit of analysis. Given the study's aim to capture local perceptions of climate change impacts, the target population included households actively engaged in small-scale fishing within five kilometres of the shoreline, a zone most exposed to coastal climate risks.

To determine the appropriate sample size, the study used Yamane's (1967) formula, which is commonly applied in social science research for calculating sample sizes when the overall population is known or assumed to be large:

$$n = \frac{N}{1 + N(e)^2}$$

Where:

n = sample size

N = estimated population size

e = desired level of precision (commonly 0.05 for a 95% confidence level)

Based on available demographic data and local administrative records, the estimated number of fishing households across the three districts (Micheweni, Chake Chake, and Wete) was approximately **6,000**. Using a 5% margin of error:

$$n = \frac{6000}{1 + 6000(0.05)^2} = \frac{6000}{1 + 6000(0.0025)} = \frac{6000}{1 + 15} = \frac{6000}{16} = 375$$

Although the formula suggested a sample of approximately 375 households, the study achieved 361 completed surveys, representing a 96.3% response rate, which is still well within an acceptable confidence range for statistical inference.

A purposive sampling technique was applied to ensure the inclusion of households with direct exposure to climate-sensitive environments. Specifically, the selection targeted households known to rely on artisanal fishing as a primary livelihood source. This approach allowed the research to focus on those most likely to observe and be affected by environmental change, thereby improving the validity of perception-data related to extreme weather events, sea level rise, and habitat degradation.

Data Collection

Quantitative data were collected using structured questionnaires focusing on community perceptions of extreme weather events, habitat degradation, sea level rise, and declining fish stocks. Respondents were also asked about income levels, observed environmental changes, and adaptation strategies. Secondary data, including monthly rainfall and temperature records from 2010 to 2023, were obtained from local meteorological stations and used to triangulate reported perceptions with actual climatic trends.

Qualitative insights were gathered through informal discussions and field notes, providing contextual nuance to the statistical findings. These narratives were instrumental in understanding district-level differences in adaptation behaviour.

Data Analysis

Quantitative data were analysed using SPSS Version 25. Descriptive statistics were used to summarise household characteristics and perceptions. Pearson's correlation was applied to assess relationships between climate variables and fishing income. ANOVA tests examined district-level variations in perceived impacts, while chi-square analysis was used to explore differences in adaptation strategies. A multiple linear regression model was constructed to evaluate the predictive power of perceived climate stressors on income levels.

Rainfall and temperature trends were analysed using time-series graphs and descriptive statistics to assess consistency with community-reported changes. This comparison was crucial in validating the reliability of local perceptions and identifying possible perception-data mismatches.

Ethical Considerations

Ethical approval and research permits were obtained through the Second Vice President's Office (Research Permit Section) in Zanzibar, permitting data collection in both North and South Pemba Regions. District Commissioners in Micheweni, Wete, and Chake Chake received official instructions to support the research process and assist with fieldwork logistics. Before taking part, all participants were fully informed about the study's goals and their rights. They gave their consent voluntarily, knowing they could opt out at any time without any consequences. The research team also made sure participants' identities were protected, and no names or personal details were recorded. All responses were kept anonymous and handled securely. Moreover, to uphold ethical standards, field staff received training on how to engage respectfully with local communities. The team followed culturally sensitive practices to minimise any potential risks and ensure participants felt safe, heard, and respected throughout the process.

Results

Community Perceptions of Climate Change

Table 1: Perceptions of Climate Change Impacts

Climate Impact	% Reporting Impact (n=361)	Top Districts Affected (by %)
Extreme Weather Events	68%	Micheweni (75%), Chake Chake (62%)
Rising Sea Levels	54%	Wete (70%), Micheweni (58%)
Coral Reef/Mangrove Damage	47%	Chake Chake (53%), Micheweni (45%)
Declining Fish Stocks	82%	All districts (>75%)

Findings from Table 1 show that, out of the 361 households surveyed, an overwhelming 82% reported experiencing a decline in fish stocks, making it the most frequently cited impact. Other common perceptions included extreme weather events (68%), rising sea levels (54%), and coral reef and mangrove degradation (47%). These findings suggest a high level of awareness of environmental change among Pemba's fishing communities.

District-level analysis revealed that Micheweni consistently reported the highest levels of perceived impact. Specifically, 75% of respondents from Micheweni cited extreme weather events, compared to 62% in Chake Chake and less in Wete. Similarly, concerns over sea level rise were most pronounced in Wete (70%) and Micheweni (58%). Reports of habitat degradation were most common in Chake Chake (53%) and Micheweni (45%).

Trends in Rainfall and Temperature

Climate records for Pemba Island were analysed to assess whether observed weather trends align with local perceptions. As shown in Figure 2, there has been a gradual increase in both maximum and minimum temperatures over the past three decades. This warming trend is consistent with fisher-reported increases in heat stress, unpredictable wind patterns, and altered fishing seasons.

Rainfall patterns, in contrast, show no consistent trend but display high inter-annual variability. Years such as 2004 recorded intense rainfall (over 2300 mm), while 2022 and 2018 experienced dramatic drops, with rains falling below 1300 mm. These erratic shifts correspond closely with fishers' narratives about increasing difficulty in predicting weather patterns and adjusting fishing routines accordingly.

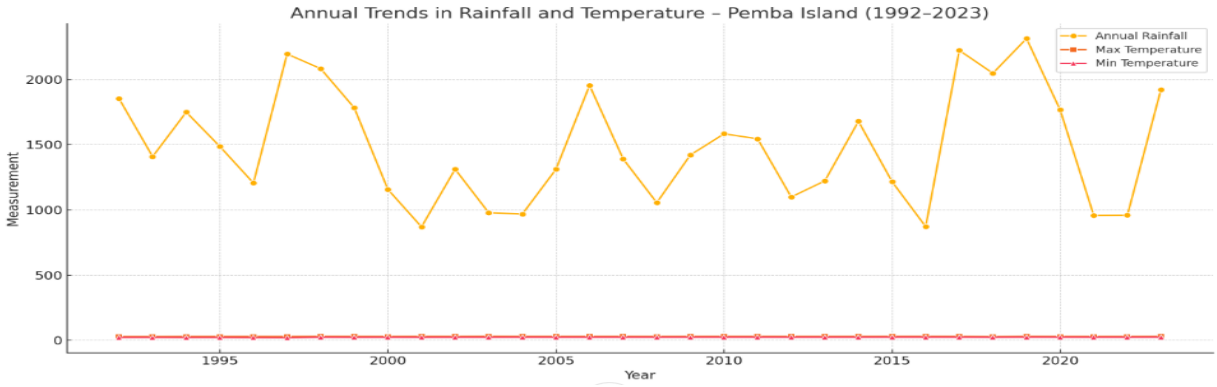

Figure 2: Annual Trends in Rainfall and Temperature in Pemba Island (1992–2023)

Table 2: Summary of Annual Climate Trends in Pemba (1992–2023)

Statistic	Max Temperature (°C)	Min Temperature (°C)	Annual Rainfall (mm)
Mean	29.25	22.04	1740.8
Minimum Recorded	27.83 (1997)	20.76 (1997)	1208.0 (2022)
Maximum Recorded	30.71 (2021)	23.55 (2021)	2322.6 (2004)
Trend (1992–2023)	↑ Gradual increase	↑ Gradual increase	↕ Fluctuating pattern

Figure 2 and Table 2 illustrate the annual patterns of rainfall and temperature on Pemba Island from 1992 to 2023. Over this period, maximum temperatures have steadily risen, indicating a gradual warming trend that aligns with the observations shared by local communities. Similarly, minimum temperatures have shown a slight increase, further suggesting a warming climate. Rainfall, however, remains quite unpredictable, with some years, particularly 2014 and 2022, experiencing notable declines. These trends confirm the climate instability described by local communities and reinforce the validity of their perceptions.

Climate Stressors and Economic Impacts

Correlational analysis revealed a negative relationship between perceived climate impacts and fishing income. As shown in Table 3:

Table 3: Perceived Climate Impacts and Fishing Income

Variable	Mean (SD)	Correlation with Income	*p*-value
Extreme Weather Frequency	2.8 events/year (1.2)	-0.32*	0.011
Sea Level Rise Concern (1-5 scale)	3.9 (0.9)	-0.41**	0.003
Habitat Degradation (1-5 scale)	4.1 (0.8)	-0.38**	0.006
Fishing Income (TZS/month)	28,500 (21,300)	1.00	-

Quantitative analysis demonstrated statistically significant negative correlations between perceived climate stressors and household income from fishing. Specifically, the frequency of extreme weather events showed a correlation coefficient of r = -0.32 (p = 0.011), indicating that higher perceptions of such events are associated with lower income levels. Concerns about sea level rise were linked with a stronger negative correlation of r = -0.41 (p = 0.003), while perceptions of habitat degradation correlated at r = -0.38 (p = 0.006). These findings suggest that as fishers' perceptions of increasing environmental threats grow, their household incomes tend to decrease accordingly.

Regression Analysis: Predicting Income Decline

A multiple linear regression model demonstrated that these perceived climate impacts significantly predicted variations in household fishing income as indicated in Table 4 and 5.

Table 4: Regression Model

Model	R^2	Adjusted R^2	F-statistic	p-value
0.49	0.24	0.20	6.12	<0.001

Table 5: Coefficients

Predictor	Unstd. B (TZS)	Std. Error	Std. Beta (β)	*t*	*p*-value
(Intercept)	45,200	5,800	-	7.79	<0.001
Extreme Weather Frequency	-3,100	1,200	-0.28	-2.58	0.012
Habitat Degradation Score	-2,800	1,500	-0.22	-1.87	0.065
Sea Level Rise Concern	-4,200	1,800	-0.31	-2.33	0.022

A multiple regression analysis revealed that perceived impacts of climate change significantly predicted household income levels, with an adjusted R-squared of 0.24 and an F-statistic of 6.12 (p < 0.001). Among the various predictors, concern about sea level rise exerted the strongest negative influence, with a beta coefficient of -0.31 (p = 0.022). Perceptions of extreme weather events also contributed notably, with a beta of -0.28 (p = 0.012). Habitat degradation, while showing a weaker association, remained relevant, indicated by a beta of -0.22 (p = 0.065).

District-Level Differences in Perceived Degradation

ANOVA results in Table 6 indicated statistically significant differences in perceptions of habitat degradation by district (F = 4.87, p = 0.009). Micheweni recorded the highest mean score (4.3), followed by Wete (4.0) and Chake Chake (3.9). These results may reflect differences in ecological exposure, awareness levels, or recent environmental shocks experienced by specific communities.

Table 6: ANOVA: Perceptions of Habitat Degradation by District

District	Mean Score (1-5)	Std. Deviation	F-statistic	p-value
Micheweni	4.3	0.7	4.87	0.009
Chake Chake	3.9	0.9		
Wete	4.0	0.8		

Adaptation Strategies Across Districts

Adaptation strategies among fishers showed uneven distribution across districts as indicated in Table 7.

Table 7: Adaptation Strategies by District

Adaptation Strategy	Micheweni (%)	Chake Chake (%)	Wete (%)	χ^2	p-value
Fishing Gear Changes	42	28	15	8.76	0.013
Seasonal Migration	18	35	50	10.32	0.006
Aquaculture Adoption	12	8	5	1.45	0.485

Gear modifications were most frequently reported in Micheweni, accounting for 42% of respondents, while seasonal migration was predominantly practised in Wete, with 50% adoption. In contrast, aquaculture adoption remained low across all districts and did not show a statistically significant difference ($p = 0.485$). These patterns suggest that fishers primarily rely on reactive coping mechanisms, such as gear adjustments and seasonal migration, rather than implementing more systematic or proactive adaptation strategies.

Qualitative Analysis Results

This section dives into the insights gathered from focus group discussions and in-depth interviews with 32 participants, 24 small-scale fishers and eight fisheries officers from three districts across Pemba Island. Their firsthand stories add critical context to the quantitative findings by shedding light on how climate change and declining fish stocks are playing out in everyday life.

i. Ecological Drivers behind Falling Fish Catches

When asked about changes in their environment, nearly all participants pointed fingers at climate change. A 58-year-old, long-time fisher from Micheweni, put it bluntly:

"The coral reefs that used to teem with fish when I was young are now white and dead. We call them fish graves because nothing lives there anymore."

Younger fishers echoed the concern but noticed different changes. A 29-year-old fisher, from Wete, observed:

"The fish have become shy; they don't stay in one place like before. We have to chase them farther and farther out to sea."

These lived experiences help explain why 82% of survey respondents reported declining catches (Table 1). Descriptions of bleached coral reefs and fish migration match up with scientific data on marine degradation. The generational contrast also highlights how rapidly ecosystems are changing older fishers speak of a lost abundance, while younger ones are already adjusting to a new, more uncertain normal.

ii. Gender and the Uneven Burden of Adaptation

The way climate change is felt and responded to varies by gender. A 42-year-old lady, a fish processor in Chake Chake, shared:

"When the men can't catch fish, some go to Dar es Salaam for construction work. We women must stay, so we have started small businesses like seaweed farming or selling snacks."

A 36-year-old man, a fisher from Micheweni, confirmed the pattern:

"It's easier for us to migrate seasonally than to change our whole way of life."

These stories help unpack the low aquaculture adoption rates reported in Table 7 (just 5-12%). Women, who often stay behind, have fewer adaptation options due to limited mobility and less access to capital. Men may be more mobile, but migration does not solve the structural barriers women face. So even when solutions like aquaculture are promoted, they often miss the mark unless more profound gender inequalities are addressed.

iii. How Climate Change Feels Depends on Where You Are

Not all communities experience climate impacts in the same way. In Micheweni, the erosion is personal. A 53-year-old man, pointed to what has already been lost:

"Each rainy season eats more of our shoreline. My grandfather's fishing hut is now underwater."

In contrast, a 43-year-old fisher from Wete offered a slightly different take:

"Our mangroves still protect us here, but the big storms come more often now."

These district-level differences align with ANOVA results from Table 6, where Micheweni residents reported the highest levels of habitat degradation (Mean = 4.3). The erosion in Micheweni is hard to ignore because it is visible, immediate, and painful. Meanwhile, areas like Wete still benefit from natural protections like mangroves, which may soften perceptions even as climate risks increase.

iv. Place-Based Vulnerability Perceptions

A common theme across interviews was a deep sense of frustration. Many participants felt caught in a cycle they could not avoid. A 24-year-old man, from Wete, put it this way:

"They tell us to 'adapt', but how? Better boats cost millions, and the bank won't lend to someone like me."

Even fisheries officers recognised the gap between policy and reality. One officer admitted:

"We promote aquaculture, but without start-up grants or training, it's just words."

These comments shed light on the so-called "adaptation trap" where struggling fishers lack the resources to make changes, and that very struggle keeps them stuck. It also supports the strong negative correlation between climate concerns and income seen in Table 3. The fact that concern over sea level rise was the strongest predictor of income decline (β = –0.31) underscores how economic vulnerability and environmental risk feed into each other.

Discussion

The findings of this study contribute to a growing body of evidence that emphasises the disproportionate vulnerability of small-scale fishing communities to the multifaceted impacts of climate change. In line with previous research conducted in similar coastal and island contexts, the perceptions reported by fishers in Pemba Island closely reflect tangible climatic shifts, particularly in

temperature rise, erratic rainfall, sea level increase, and marine habitat degradation (Makame & Shackleton, 2020; Musinguzi et al., 2016).

One of the most striking outcomes of this study is the high proportion of fishers (82%) reporting declining fish stocks. This perception mirrors findings from coastal Mozambique, where Hussein et al. (2019) reported similar concerns among artisanal fishers who linked reduced catch volumes to coral bleaching and changing tidal flows. Likewise, research by Muhala et al. (2021) in the aftermath of Cyclones Idai and Kenneth revealed that small-scale fishers across the Western Indian Ocean attributed stock declines to increasingly unstable weather systems and rising ocean temperatures.

The statistically significant correlation between perceived climate stressors, such as sea level rise and extreme weather and household income further supports the conclusion drawn by Brodie et al. (2024), who argued that economic resilience in small-scale fisheries is directly compromised by climate-induced environmental variability. The study's regression analysis confirms this pattern in Pemba, where concern over rising sea levels had the most substantial negative impact on fishing income. This aligns with findings from Makame and Mwevura (2019), who observed that coastal flooding and salinity intrusion disrupt fishing operations and damage landing infrastructure.

Notably, the rainfall and temperature data in the current study validate fishers' narratives, adding empirical strength to otherwise qualitative claims. This complements the work of Makame and Shackleton (2020), who advocated for the integration of local ecological knowledge with scientific data to improve climate resilience planning. The study's time-series analysis of Pemba's climate over 30 years not only supports the perception of warming and rainfall unpredictability but also reveals years of climatic extremes that likely correspond to lived experience, such as the drought of 2022 and heat extremes in 2021.

The variation in adaptation strategies across districts, such as gear modifications in Micheweni and seasonal migration in Wete, demonstrates the influence of context-specific factors like NGO presence, topography, and resource availability. This echoes the findings of Makame et al. (2023), who documented uneven resilience capacities among coastal communities in Zanzibar. However, the persistently low uptake of aquaculture, despite its promotion in national policy, diverges from some regional studies that have noted growing interest in this sector (Shalli et al., 2024). This inconsistency may reflect local constraints in Pemba, such as limited extension services, capital access, or scepticism rooted in cultural norms, issues that remain underexplored in the literature.

Interestingly, while the perceptions gathered in this study are broadly consistent with existing research, they offer a clearer understanding of district-level dynamics within a small island context. For example, the significantly higher concern reported in Micheweni over extreme weather and habitat degradation may be due to its exposure to ocean currents, erosion-prone coastlines, or the frequency of recent storm events. These locally specific insights build upon generalised findings from studies like Mwalim (2020), who examined community-based adaptation in Pemba but did not disaggregate perceptions spatially.

Furthermore, the correlation between perceived habitat degradation and declining income, although slightly weaker, reflects the argument made by Makame et al. (2018), who suggested that the erosion of ecological assets like coral reefs and mangroves, directly diminishes household adaptive capacity. The study emphasises this by showing that even perceptions of degradation, regardless of biophysical validation, influence livelihood choices and adaptation behaviours.

Generally, this study both supports and extends the current literature by empirically linking community perceptions with actual climate data and measurable livelihood impacts. It confirms the broader understanding that fishers in the Western Indian Ocean are experiencing and responding to real environmental shifts. However, it also raises critical questions about the adequacy and accessibility of adaptation strategies, particularly in geographically and institutionally marginalised settings like Pemba Island.

Conclusion

This study shows a clear picture of how climate change is hitting Pemba's fisheries. A complete 82% of fishers reported declining catches, a trend that strongly correlates with habitat degradation (r = –0.38). Even more telling, sea level rise emerged as the most potent predictor of income loss (β = –0.31), signalling just how deeply environmental shifts are cutting into livelihoods.

Drawing from both the numbers and real-life accounts from fishers and stakeholders, three high-impact recommendations stand out, each targeting a specific challenge revealed in the data:

i. To reverse the damage tied to falling incomes, especially in Micheweni, a focused habitat restoration programme is needed. This should include rebuilding coral reefs with climate-resilient species and protecting coastlines with community-managed mangrove zones. By involving local fishers in monthly monitoring tied to their traditional fishing cycles, the programme ensures both ecological impact and cultural fit.

ii. Women face steeper barriers in adapting to climate change, and their participation in aquaculture remains under 12%. A gender-focused climate fund should offer matched grants to women's fishing groups, support seaweed-aquaculture systems with guaranteed female ownership, and bring mobile training straight to coastal communities.

iii. Fishers are increasingly vulnerable to extreme weather, yet most lack tools to adapt. A climate information service should provide mobile fishing advisories, install weather stations at landing sites, and train local "climate champions" in each district.

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