

Investigating the Adaptive Capacity of Anchovy Fisheries to Changing Conditions and Its Implications for Livelihoods in Tanga and Zanzibar, Tanzania

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Research Article

Keywords: Adaptive capacity, anchovy fisheries, livelihoods, changing conditions, Tanga and Zanzibar

Posted Date: October 13th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10961795/v1>

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Additional Declarations: No competing interests reported.

Abstract

Anchovy fisheries in Tanzania face growing challenges from environmental change, declining fish availability, market pressures, and institutional constraints, raising concerns about the adaptive capacity of fishing-dependent livelihoods. This study examines how access to livelihood resources and value-chain opportunities shapes differentiated adaptive capacity among anchovy-dependent communities in Tanga and Zanzibar. Using a mixed-methods design, the study collected data from 665 respondents across five districts and supplemented it with key informant interviews and qualitative evidence from anchovy value-chain actors. Guided by the social-ecological systems and sustainable livelihoods perspectives, the study examines how financial, physical, social, and institutional resources influence responses to fisheries-related change. Results show that adaptive capacity is unevenly distributed across locations and social groups. Access to credit and livelihood diversification vary significantly among respondents, while constraints in technology, infrastructure, markets, and financial services limit fishing households' and value-chain actors' ability to respond to declining fisheries productivity. These constraints are particularly consequential for women, whose concentration in processing and marketing is not matched by equivalent access to productive assets, finance, technology, markets, and decision-making. The findings demonstrate that adaptive capacity is shaped not only by exposure to environmental change but also by unequal access to resources and opportunities within the fisheries value chain. Strengthening resilience, therefore, requires policies that combine sustainable fisheries management with gender-responsive finance, technology, market access, and livelihood diversification, supported by participatory and locally responsive governance.

1. Introduction

The adaptive capacity of fisheries is crucial to how communities dependent on marine resources for their well-being cope with environmental change. As climate variability, overfishing, and other anthropogenic pressures intensify, small-scale fisheries' adaptive capacity is increasingly tested. Anchovy fisheries, particularly in coastal areas, play a significant role in supporting livelihoods, providing food security, and contributing to local economies. They provide protein, livelihoods, and income for many people engaged in fishing activities (Arthur et al., 2022; Etongo & Arrisol, 2021). According to FAO statistics, 120 million people depend on fisheries for their livelihoods, almost 97 percent of whom are in developing countries, and more than 90 percent participate in small-scale fisheries (Arthur et al., 2022; FAO, 2020). Small-scale fisheries produce more than half of the world's fish catch, and 90–95 percent of the small-scale catch is consumed locally (FAO, 2020). In Africa, fish provide between 32 and 70 percent of animal protein consumed. Small-scale fisheries contribute significantly to total fish production and the well-being of tens of millions of people. The contribution of anchovy fisheries to nutrition and income is particularly immense for low-income households in urban and rural areas.

The anchovy value chain provides a main livelihood for many people who are engaged in the production, cleaning, sorting, salt curing, sun drying, grading, and marketing (Pradhan & Nayak, 2023). The structure of this chain has been studied (Arthur et al., 2022; Yang et al., 2022; Bladon et al., 2022). These studies

generally portray the anchovy value chain in terms of livelihood options created, incomes generated, and the interactions among the actors in the nodes thereof (Ahmed et al., 2021; Patro & Jayaraman, 2022; Pradhan & Nayak, 2023). Gender relations and processes of change in the AVC can affect the livelihood outcomes of the socioecological system-oriented anchovy value chain (SESVC), which receives less attention from the research community.

However, anchovies are highly sensitive to changing environmental conditions, which can disrupt fish populations and affect the socio-economic stability of fishing communities (Robertson et al., 2018). Climate change, in particular, threatens anchovies through rising temperatures and ocean acidification. Fishing intensity can also increase pressure on fishery resources and impair fisheries productivity across scales and levels. In addition to fishing intensity, sea surface temperatures, ocean acidification, and storm surges can affect anchovies and other fish, with detrimental effects pronounced in developing countries. Coral bleaching, for instance, caused by ocean acidification, can destroy the nursery beds and breeding sites of fish and other marine organisms, thereby impairing fish productivity. These effects can be catastrophic to the livelihood activities deriving from these resources (Yanda et al., 2019; Ankrah & Monteiro, 2024).

Tanzania's fishing sector, including anchovy fisheries, is facing challenges from fishing intensity and climate change, which can affect the livelihoods of people who depend on it. An increase in ocean temperatures has been reported to push fish into deeper waters, reducing catches for inshore fisherfolk who often use crude fishing vessels (Yanda et al., 2019; Yanda et al., 2023). An increase in ocean temperatures is often linked to seasonal fish migrations between deep and surface waters, driven by warm-cold current exchanges (Yanda et al., 2019; Yanda et al., 2023). Additionally, the number of fisherfolk and fishing vessels has increased drastically in recent decades (Islam, 2013; Ainsworth et al., 2023). Adaptive capacity in the AVC can vary across social groups attached to the chain, including gender, age, and educational level (Niemann et al., 2024). Therefore, understanding the adaptive capacity of anchovy fisheries to such changes is vital for ensuring sustainable resource management and mitigating negative impacts on dependent populations (Chen et al., 2020; Malakar et al., 2018).

Coastal communities in Tanga and Zanzibar depend heavily on small-scale fisheries, particularly anchovies, a key source of food, income, and employment. However, these fisheries face growing challenges from environmental changes, including climate variability, ocean warming, habitat degradation, and overexploitation of marine resources. These pressures threaten the sustainability of fish stocks and the socio-economic stability of communities that rely on them. Despite the critical role of anchovy fisheries, understanding of their adaptive capacity to shifting environmental conditions remains limited.

Without adequate strategies to enhance adaptive capacity, fishers and their communities are vulnerable to declining catches, reduced income, and increased poverty. The lack of research on how these fisheries adapt to changing conditions and how these changes affect livelihood outcomes represents a significant gap in efforts to promote sustainable fisheries management and improve the well-being of

coastal populations. This research addresses this gap by investigating the adaptive capacity of anchovy fisheries in Tanga and Zanzibar and exploring the implications of these changes for fishing communities' livelihoods. The study seeks to;

1. Assess the key environmental changes affecting anchovy fisheries in Tanga and Zanzibar, including climate variability and fishing intensity.
2. Analyse the socio-economic impacts of changes in anchovy fisheries on the livelihoods of coastal communities in terms of income, food security, and employment.
3. Evaluate the adaptive strategies anchovy fishers use and their effectiveness in maintaining fishery sustainability under changing environmental conditions.

The findings provide policymakers and stakeholders with insights to develop adaptive strategies that ensure fishery sustainability and communities' adaptive capacity.

2. Theoretical Framework

This study employs the socioecological System (SES) model to explore the social dimension of the AVC. The Socioecological System (SES) adaptive capacity theory is a framework for understanding how human and ecological systems interact, adapt, and transform in response to various stresses and disturbances. It emphasises the interconnectedness of social (human) and ecological (environmental) systems, recognising that these systems do not function independently but are highly interdependent (Refugio-Coronado et al., 2021; Carter et al., 2021; Brown et al., 2021; Jamshidi et al., 2019; Cheung et al., 2021). Adaptive capacity in this context refers to a system's ability to absorb shocks, reorganise, and continue functioning in the face of disturbances without undergoing a fundamental shift or collapse. Hence, the socioeconomic theory is the model's strength: its malleability and multipurpose nature, bringing a welcome pluralism of methods, data, and associated concepts (Partelow, 2018).

The theory draws on Elinor Ostrom's research on common-pool resources, institutions, and collective action. Widely used in fisheries and environmental governance, SES theory emphasises dynamic interactions between ecological and human components. The socioeconomic theory is rooted in the three elements that form its foundations: a) the common-pool resource, b) institutions, and c) collective action (Plessis, 2008; Partelow, 2018). The elements are the building blocks to the dimensions that form a basis for explaining the socioecological systems-oriented anchovy value chain based on the three premises: 1) resource use indicators representing pressures on the environment, 2) resource efficiency indicators, and relating resource use indicators to the socio-economic side, and 3) environmental impact indicators linking resource use impacts on the state of the natural system (Eisenmenger et al., 2016). Sustainability is the central concept in the theory seeking to understand the dynamic interactions between nature and society. It is further based on the premise that, to address the complexity of human-nature interactions, a fundamental change is needed in how science is undertaken (Plessis, 2008).

This study's conceptual model is grounded in and informed by well-established frameworks in fisheries research and the climate change adaptation literature. It draws from the following conceptual foundations: i) Social-Ecological Systems (SES) Frameworks, widely used in fisheries and environmental governance, SES frameworks (e.g., Ostrom, 2009), that emphasize the dynamic interactions between ecological and human components; ii) vulnerability and adaptation frameworks that draw on IPCC vulnerability frameworks (IPCC, 2024), particularly those involving exposure to environmental change (e.g., climate variability, fishing intensity), sensitivity of livelihoods (income, food security, employment), and adaptive capacity (strategies fishers use to respond). These ideas are commonly found in studies on the impacts of climate change on small-scale fisheries (Allison & Ellis, 2001). These insights also align with the Sustainable Livelihoods Framework (Scoones, 1998), which links natural resource dependence to economic and social well-being and treats adaptation strategies as key to adaptive capacity. The model (Figure 1) illustrates the interconnected dynamics of anchovy fisheries and aligns with this study's objectives. It maps the causal relationships and feedback loops between environmental, socio-economic, and adaptive dimensions, ultimately focusing on fishery sustainability.

This model integrates the Sustainable Livelihoods Approach (SLA) to analyse how environmental stressors affect key livelihood assets: the natural, human, social, physical, and financial capitals of coastal communities. Adaptive strategies are framed as responses that maintain or rebuild these assets, influencing the adaptive capacity and sustainability of livelihoods and fisheries under changing climatic and ecological conditions. The adaptive capacity of the AVC is critical to its adaptive capacity. Fishers and processors may adopt strategies such as changing fishing techniques, shifting to alternative livelihoods during low-fishing seasons, or improving processing and storage methods to cope with fluctuations in fish supply.

Additionally, the adaptive capacity can be enhanced through community-based management, access to financial resources, and policies that support sustainable fishing practices. Socioecological system adaptive capacity theory provides a comprehensive understanding of how environmental changes affect the anchovy value chain and associated communities. Focusing on the ecological and social dimensions of adaptive capacity, this framework highlights the importance of integrated management strategies that sustain fish stocks and the well-being of communities that depend on them.

3. Methodology

3.1. Study Areas

The study was conducted in the Zanzibar Isles and the Tanga region; Tanga is in the extreme northeast of Tanzania, between 4° and 6° south of the Equator and 37° and 39° East of the Greenwich Meridian. The region covers 27,348 sq. km (Tanga, 2018). About 45 major fishing villages are along the Coast. Most people in those villages work in fisheries and agriculture, but only on a small scale. Fishing occurs along the coastal belt over about 210 kilometres (Tanga, 2018). Zanzibar lies off the eastern coast at its narrowest point, 40 km east of the Tanzania Mainland.

The northern tip of Unguja Island is at 5.720° south, 39.300° east, and the southernmost point is at 6.48° south, 39.51° east. The northern tip of Pemba Island is located at 4.87° south, 39.68° east, and the southernmost point is located at 5.47° east. To the east, both islands are in the deep Indian Ocean. The Zanzibar islands cover a total area of around 2,654 sq. kms. The study areas were chosen because they are coastal areas that practice small-scale pelagic fisheries, among other anchovy species harvested (RGZ, 2020)

3.2. Selection of the study areas

Anchovies are a vital resource for local economies. Understanding fisheries dynamics can inform better management strategies that support livelihoods and food security. Several reasons prompted the selection of Tanga and Zanzibar as the focal points in this study. Zanzibar and Tanga are biodiversity hotspots, rich in marine biodiversity, that provide a unique opportunity to study ecological interactions affecting anchovy populations (United Republic of Tanzania (URT), 1997; Zanzibar Planning Commission, 2020). However, these coastal ecosystems in Tanga and Zanzibar are sensitive to environmental changes, making them critical areas for assessing the impacts of climate change and other environmental factors on fisheries. Communities in these areas have traditional fishing practices and local knowledge that can complement scientific research and offer insights into fisheries management. The areas were therefore selected to represent areas with anchovy fisheries, fisherfolk, and the dynamic environmental conditions that affect them.

3.1.3. General Climatic Conditions

The Tanga Region has a warm, wet climate along the coast and inland. Temperatures remain relatively stable along the coast due to the influence of the Indian Ocean. During the hot months (December to March), the average daytime temperature in Tanga ranges from about 30°C to 32°C, and the average nighttime temperature ranges from 26°C to 29 °C. In the cool months (May to October), temperatures range from approximately 23°C to 28°C during the day and 20°C to 24°C at night. The region also experiences high atmospheric humidity, ranging from 65% to 70% at the minimum and 100% at the maximum. The average annual rainfall along the coast is about 1,100-1,400 mm.

3.1.4. Socioeconomic Activities

In the Tanga region, the predominant livelihood activities are subsistence agriculture, livestock keeping, and fishing. Smallholders largely undertake food production, while both smallholders and large-scale farmers (public and private institutions) produce cash crops. Livestock reared are cattle, goats, and sheep. Modern dairy farming and poultry keeping are uncommon in rural areas, though a few people practice them.

3.2. Study Design

The study was exploratory and cross-sectional, using a mixed qualitative and quantitative approach to collect data on both measurable and unmeasurable parameters, such as people's behaviour and perceptions.

3.3. Data collection

The data were collected from primary and secondary sources. The study collected primary data through key informant interviews (KIIs), particularly with informants well-versed in the study area and the dynamics of the AVC. The study collected primary data using a combination of qualitative and quantitative methods to complement each other (Table 1).

We collected quantitative data using household questionnaires. The quantitative data collection process began with subject sampling, using simple random sampling to select 665 respondents who engage in the AVC. The study sought to obtain a sample frame for each AVC node. The study identified AVC nodes, and participants provided approximate counts of people at these nodes. This approximate number (a sample frame) served as the basis for the sample size, aiming to obtain at least 5% for each category in the AVC chain. The rate (5%) is recommended by studies as it can be derived from the representative sample. Hence, the sample frame comprised 12,879 people, of whom 665 were selected, yielding a response rate of 5.16% using simple random sampling (Table 2). Before the main survey, the questionnaire was tested with 10 households to assess its effectiveness in collecting relevant information. The pilot results were used to improve the questionnaire's clarity and remove irrelevant items, ensuring only relevant information was collected.

The main survey was then conducted at the household level, with the household head as the principal target. The questionnaire contained items that probed household demographic characteristics (age, street/village, sex, education, household size, occupation, migration history, among others) and community-level data (roles, norms, and relations in the anchovy fisheries value chain, markets for captured fish, gender-specific norms for men's and women's participation in the anchovy value chain, shocks and their impacts and the dynamics in the anchovy value chain, sources of these shocks and gendered capacity to overcome these shocks). The questionnaire was designed to capture data on the specific roles played in each node and how these roles influence other nodes in the AVC. The questionnaires were administered face-to-face to allow for clarification during the interrogation process. Focus group discussions were conducted to gather data from AVC actors on their capacity to respond to dynamics affecting their livelihoods. Lastly, field observations complemented the other data collected by visually observing the status of anchovy fisheries. Secondary data were obtained by reviewing available and accessible archives, including government publications, websites, seminar write-ups, and articles by various authors. The field-collected data were revised to assess their sustainability and accuracy.

3.4. Data Analysis

We analysed qualitative data based on the content and themes of the recorded audio, which we transcribed and then translated. The process involved several key stages: all interview notes and

recorded responses were transcribed into text format. We then read the transcriptions multiple times to familiarise ourselves with the content, context, and nuances of the responses. The identified themes revealed patterns of similarity and difference that elucidated a narrative of AVC's adaptive capacity in the face of changing phenomena. Following familiarisation, the data were grouped thematically according to the study's core focus areas. The quantitative data were analysed by cleaning the questionnaires, coding the variables, and entering the data into the spreadsheet. Descriptive statistics summarised the data, with frequencies and percentages computed in the Statistical Package for the Social Sciences (SPSS), and the results presented in tables, graphs, and charts.

4. Results

4.1. Demographic information

In this study, 665 respondents were contacted: 29.9% (n=199) were females and 70.1% (n=466) were males. The average age of respondents was 35.86 years. This result suggests the studied population is relatively young and can creatively pursue livelihood options and explore new frontiers of knowledge to improve livelihoods. Education was categorised as non-formal (18.0%, n=120), primary (55.6%, n=370), secondary (25.1%, n=127), tertiary non-university (0.6, n=4), tertiary university (0.3%, n=2), and vocational training (0.3%, n=2). This result implies that small-scale fisheries are mainly carried out by low-skilled personnel with limited education. The majority were married (54.4%, n=367), followed by singles (22.0%, n=146), married polygamous (6.6%, n=57), divorced (7.8%, n=52), separated (4.5%, n=30), and widows (2.7%, n=18). Marital status can influence household adaptive capacity to household shocks in the study areas.

4.2. Value Chain and Gender

The value chain is dominated by two roles: Post-production (processing/marketing) and Production (fishers/catch). Post-production: 337 respondents (50.7% of the sample), production: 243 respondents (36.5% of the sample). Smaller shares are in pre-production, auxiliary activities, or mixed roles. Women are concentrated in post-production. Females totalled 183 in post-production ($\approx 27.5\%$ of the whole sample; $\approx 92\%$ of all female respondents' main placement). Men dominate production. The total number of males was 241 ($\approx 36.2\%$ of the whole sample; the vast majority of production roles). Few women report production roles (only 2 in the "Production" column), and far fewer men are in pure post-production than women.

All streets show the same overall gender split, though magnitudes differ: Kipumbwi, Fungurefu, Mangapwani, Kasera, Kigobe — in each site, women predominate in post-production while men predominate in production. Some streets (e.g., Kipumbwi, Fungurefu) have especially high female post-production counts; others (e.g., Kasera, Mangapwani) show very high male production counts. Gendered division of labour is entrenched: women carry out processing/marketing, men do the harvesting. This segregation likely affects income distribution, access to assets/credit, decision-making power, and vulnerability to shocks. For example, male dominance in production concentrates physical risk and

influence over resource management on men. Additionally, women's concentration in post-production may limit their direct access to upstream activities, bargaining power, and technology that could boost earnings. These results point to the need to strengthen women's access to finance, training in value addition and market linkages, and inclusion in co-management and decision-making forums; and to support men in adopting sustainable fishing practices and diversification to reduce pressure on stocks.

We used χ^2 tests to examine whether gender is associated with value-chain position within each landing site (street) and in the full sample ($n=665$). All tests are statistically significant (two-sided $p < .05$): Kasera: $\chi^2 (4) = 35.48$, $p < .001$, Kipumbwi: $\chi^2 (7) = 69.64$, $p < .001$, Kigobe: $\chi^2 (4) = 40.35$, $p < .001$, Fungurefu: $\chi^2 (4) = 69.81$, $p < .001$, Mangapwani: $\chi^2 (6) = 16.42$, $p = .012$ and Total sample: $\chi^2 (9) = 216.83$, $p < .001$). Gender and value-chain position are significantly associated at each site and overall: men and women are not uniformly distributed across value-chain roles (production, post-production, auxiliary, etc.). This supports the clear gendered patterns: women concentrated in post-production and men in production. Chi-square tests indicate a significant association between gender and anchovy value-chain position (overall $\chi^2 (9) = 216.83$, $p < .001$), confirming a strongly gendered division of labour.

4.3. Changing Conditions Affecting Anchovy Fisheries

When asked whether they experienced shocks in fisheries, 89.8% of respondents ($n=597$) said yes, while 10.1% ($n=68$) said no. They linked the shocks to environmental change (climate change and fishing intensity). Climate change was widely reported as increasing (24.3% among females, 58.3% among males), less often as decreasing (0.3% among males), and as normal (1.8% among females, 4.8% among males). Here, the proportion of males is much higher, probably due to direct involvement in fish catch. There was also mixed perception of fish abundance: decreasing (8.7% females, 20.5% males), increasing (6.0% females, 15.9% males), and no change (4.8% females, 6.9% males) (Table 3). Apparently, this study widely reported climate change and declining stocks as the causative reasons. Men and women reported these as major setbacks affecting anchovy fisheries, though the magnitude differed slightly in relative terms.

4.3.1. Trends in anchovy availability

From the outset, this study captured respondents' perceptions of anchovy availability. The overwhelming majority ($n=546$, 82.1%) answered "Don't know" when asked whether anchovy availability in the past 1–5 years has increased, decreased, or stayed the same. Only a small share reported a clear trend: decreased (24 respondents (3.6%)), increased (15 respondents (2.3%)), and Same (35 respondents (5.3%)). Fungurefu and Kipumbwi contributed the largest absolute numbers of "Don't know" responses (172 and 153, respectively), consistent with their larger sample sizes. Kasera, Kipumbwi, and Fungurefu show the largest absolute counts of people reporting "decreased" or "same", but these counts remain very small relative to the total per street. Very few respondents across all streets reported "increased" anchovy availability (only 15 people total). The dominant response is "Don't know" (82%). That suggests respondents either lack reliable short-term observations, trends are unclear/variable, or the question timeframe (1–5 years) is difficult to recall. Because counts for "increased" and "decreased" are very

small, there is no clear, widely agreed direction of change in anchovy availability across the sampled streets.

The Chi-Square test assessed whether street and perceived trends in anchovy availability (1–5 years) were statistically associated. Pearson Chi-Square = 31.074, df = 16, p = .013. Since $p < 0.05$, the result is statistically significant. This indicates evidence of a relationship between *street* and people's perceptions of anchovy availability trends. In other words, perceptions of trends are not randomly distributed across streets. Likelihood Ratio = 34.079, df = 16, p = .005. This confirms the same conclusion—the association is statistically significant. Chi-Square ($\chi^2 = 31.07$, df = 16, p = .013) indicates a significant but statistically fragile association between street and perceived anchovy trends.

4.3.2. Circumstantial factors affecting anchovy availability

Most respondents report that shocks produce a neutral effect on their livelihoods/income (no major negative or positive change). The dominant response was “neutral” across the sample 77.6% and every street had a large majority of respondents (range: 66.0% in Fungurefu, 92.3% in Kigobe). Negative responses were relatively uncommon overall (3.2%) but concentrated in Fungurefu. Fungurefu reports a negative rate of 9.1%, substantially higher than on other streets (where the negative rate is essentially 0–1.8%). This suggests Fungurefu households are more likely than others to experience negative livelihood impacts from shocks. Positive responses are modest (11.3% overall) and vary by street. Kasera (14.7%) and Fungurefu (15.3%) show the highest share of positive responses; Kigobe (3.1%) and Mangapwani (2.7%) have much lower. Some localities report gains (or perceived positive impacts) for a minority; these may reflect localised opportunities or seasonally advantageous conditions. Overall, 8% was non-negligible and varied by street, with the largest in Mangapwani (15.2%) and Kasera (10.5%). Whilst dominated by “other / don’t know / mixed responses”, it indicated a substantial group whose experiences don’t fit simple negative/neutral/positive labels and therefore deserve targeted qualitative follow-up.

The overwhelming majority view is neutral, but important heterogeneity exists: Fungurefu shows more negative impacts; Kasera and Fungurefu show larger positive shares; Mangapwani has many respondents in the “other”. Policy can target support to Fungurefu (higher negative impacts) and investigate why Kasera/Fungurefu report more positives — learnable practices could be scaled elsewhere. The Chi-Square test assessed whether street of residence is statistically associated with perceived shocks to income (*negative, neutral, positive, other*). Pearson Chi-Square value was 76.571 (df = 12, $p < .001$). Since $p < 0.05$, the result is statistically significant. This means the distribution of responses differs across streets. Where someone lives influences whether they see shocks as negative, neutral, or positive. Likelihood Ratio = 87.185, df = 12, $p < .001$ confirms the same result — strong evidence of an association.

Other challenges related to capital, fishing infrastructure, and overall management of fishery resources, among other factors, influenced anchovy fishery productivity (Table 4). These reasons were both direct and indirect causes. To examine the association between geographical location and the causes of

phenomenological changes in the area, we conducted a chi-square test. All P-values were < 0.05 (95% CI), indicating that people's perceptions centre on the belief that these drivers cause environmental change.

Based on qualitative findings, we highlighted that instability in anchovy prices, declining fish stocks, high operational costs, food and income insecurity, high government tariff rates, the absence of fisheries cooperative unions, a high cost of living, and inadequate social services, among others, constrain anchovy fisheries. These and other causes operate diffusely, influencing fishing intensity. Additionally, cooperative unions could help ensure reliable anchovy markets. Fishing intensity stems from pressures such as a lack of capital, low incomes, unemployment in the formal sector, and high interest rates in financial institutions, among others. Household income shortfalls drive increased fishing effort to optimise production and meet household needs. Respondents acknowledge that the number of fisherfolk and vessels has been increasing. Anchovy fisheries were described as a way to cushion escalating unemployment because they do not require specialised skills.

Fisheries regulations can motivate or demotivate fishing intensity in several ways. When regulations are stringent, they tend to reduce fishing intensity, thereby relieving pressure on the fishery resource. The same applies to other drivers, including inadequate infrastructure, women's involvement in decision-making, efforts to enhance adaptive capacity, access to credit, and health conditions. Inadequate infrastructure, in particular, influences increases or decreases in fishing effort in two ways: first, postharvest management infrastructure failures to store fishery products for an adequate period, such as cold chain systems, can lead to rapid spoilage. The second relates to transport infrastructure, which can delay the delivery of anchovy fishery products to their intended destinations. These drivers operate through changes in anchovy fishing intensity. For instance, household-level income shortfalls from a lack of diversified income sources necessitate increased fishing effort. Climate change was strongly expressed by 82.7% of our respondents as one of the main drivers of phenological changes.

4.3.3. Perspectives on key environmental changes according to sex

Figure 2 illustrates the proportion of respondents who express their views on the trends of climate change effects. An equal number of men and women believe that the effects of climate change are increasing (81.3% of females, 83% of males). There is no statistically significant difference between men and women ($P=0.615 > 0.05$, 95% CI). Perspectives do not differ by sex, suggesting that climate change effects are felt equitably between men and women, despite men's slightly higher levels. Similar results were obtained concerning the increase in fishing pressure reported by respondents as decreasing (11.6% women, 12.2% men), increasing (47.2% women, 47.4% men), and remaining the same (28.6% women, 29.4% men), suggesting the possibility of a decline in fish availability; if at all, the number of fisherfolk is increasing. Again, there is no statistically significant difference in the proportions of women and men acknowledging increased fishing pressure, suggesting that the proportions of men and women reporting high-intensity fishing are nearly equal. According to interview results, the increasing unemployment crisis is pushing many people, particularly school leavers and tertiary education graduates.

4.3.4. Perspectives on environmental changes according to age

Figure 3 shows respondents' perceptions of key environmental changes (climate change and increasing fishing intensity) in the anchovy fisheries by age. Almost equal proportions of respondents acknowledge the environmental changes happening regardless of age. Age does not significantly affect the number of respondents with different perspectives on the effects of climate change on anchovy fisheries ($P=0.416 > 0.05$, 95% CI). This result implies that the impacts of climate change are felt almost equally across age groups. The histogram shows slight variations in peaks. Similar perspectives are deduced about the fishing intensity, whereby respondents observed it as decreasing (12.0%), increasing (47.4%) from ages 18-25 years (43.7%), 26-35 years (45.8%), 36-45 years (53.7%), 46-55 years (44.3%), and ≥56 years (47.4%), whereas those who reported absence of change were 29.5%. There was also no statistically significant difference in the proportions of respondents reporting this ($P > 0.05$), suggesting that the current environmental change affects all age and gender groups.

4.3. Socio-economic impacts of changes in anchovy fisheries on the livelihoods

Most respondents report that shocks produce a neutral effect on their livelihoods/income (no major negative or positive change). The dominant response across the sample is "neutral" (77.6%). Every street had a large majority of respondents (ranging from 66.0% in Fungurefu to 92.3% in Kigobe). Negative responses are relatively uncommon overall (3.2%), but are concentrated in Fungurefu, where 9.1% are negative, substantially higher than in other streets (where negative responses are essentially 0–1.8%). This suggests Fungurefu households are more likely than others to experience negative livelihood impacts from shocks. Positive responses are modest (11.3% overall) and vary by street. Kasera (14.7%) and Fungurefu (15.3%) show the highest share of positive responses; Kigobe (3.1%) and Mangapwani (2.7%) have much lower. Some localities report gains for a minority; these may reflect localised opportunities or seasonally advantageous conditions.

A proportion (8.0% overall) is non-negligible and varies by street, with the largest in Mangapwani (15.2%) and Kasera (10.5%). It represents do-not-know/mixed responses, indicating a substantial group whose experiences do not fit simple negative/neutral/positive labels and therefore deserve targeted qualitative follow-up. The overwhelming majority view is neutral, but important heterogeneity exists: Fungurefu shows more negative impacts; Kasera and Fungurefu show larger positive shares; Mangapwani has many respondents in the "other". Policy can target support for Fungurefu (higher negative impacts) and investigate why Kasera/Fungurefu report more positives—learnable practices could be scaled elsewhere.

This Chi-Square test checks whether there is a statistically significant association between street of residence and the *perceived effects of shocks on livelihoods/income (negative, neutral, positive, other)*. Pearson Chi-Square = 76.571, df = 12, $p < .001$. Since $p < 0.05$, the result is statistically significant. This means the distribution of responses differs across streets. Where someone sees shocks as negative, neutral, or positive. The Likelihood Ratio = 87.185, df = 12, $p < .001$ confirms the same result — strong evidence of an association. The Chi-Square test shows a significant relationship between *street* and *perceived livelihood impacts*. Different streets do not experience shocks in the same way. For example:

Fungurefu: more likely to report *negative impacts*. Kasera and Fungurefu: higher shares of *positive impacts*, and Kigobe: overwhelmingly *neutral*. This result supports the idea that livelihood shocks are spatially differentiated, and local context strongly shapes perceptions and impacts. More or less, adaptation strategies must be localised, since communities experience and interpret shocks differently.

In this study, we anticipated that the socioeconomic impacts of changes in anchovy fisheries and in communities' livelihoods would be reflected in employment, incomes, and food security. To assess the distribution of job actors, descriptive statistics were used to examine the sample distribution along the AVC (Table 5). Results indicate that all respondents engaged in this study are involved in the different stages of the fishery value chain, notably production, pre-production, and post-production. Pre-production alone accounted for 6.3% of our survey respondents, and the production stage accounted for 37.8%. Moreover, the post-production stage was employed by the largest share of our respondents (56.2%). This result indicates that AVC has the potential to generate jobs, even for non-skilled labour. Nonetheless, all our respondents in the AVC consume fish, suggesting that household nutritional demands are met.

The pre-production stage included boat builders and repairers (6.0%, n=40), whereas the production stage included fish catchers (37.4%, n=249). Post-production included auxiliary actors such as middlemen/agents (0.6%, n=9) and processors (18.9%, n=126). Some actors performed the role of processor, agents, and traders (0.2%, n=1), processor, trader, wholesaler, and retailer (11.6%, n=77), trader, wholesaler, and retailer, and processor (5.4%, n=36), and porters and processors (1.2%, n=8). Others included porters (123%, n=62). These stages are autonomous but interdependent. This interdependence supports each node's performance in the AVC by creating a 'buffer' between them, thereby enabling diversification of activities within the AVC.

4.3.1. Impacts on employment

The study assumed that changes in the AVC affect employment based on the number of men and women employed in the sector. Table 6 shows mixed perceptions among people engaged in fisheries. Most respondents (66.9%) believed the number of fisherfolk is increasing, while 49.5% reported no change in women's participation in AVC.

4.3.2. Impacts on income and food security

There were also mixed perceptions on the incomes generated from AVC. Those reporting a decreasing trend constitute the largest proportion, but males outnumber females (10.5% of females, 24.2% of males) (Figure 4). The decrease in incomes is associated with lower anchovy catches and, therefore, lower sales, even though scarcity elevates prices.

4.4. Adaptive strategies by anchovy fishers and their effectiveness in maintaining fishery sustainability

The cross-tab shows how people perceived their approaches to addressing livelihood impacts. In Kasera Street, the main strategies are savings, income diversification, credit/loans, casual labour, and alternative

sources (such as farming and asking friends for help). Households here depend heavily on small savings, borrowing, and side hustles to cope with shocks. They rely less on formal interventions. In Kipumbwi Street, residents strongly emphasised diversifying income sources, including casual jobs, farming, savings, migration, credit, and help from others. This street was the most responsive in pursuing multiple adaptation pathways, showing greater livelihood flexibility than Kasera. In Kigobe Street (246, 37.0%), respondents reported a mix of savings, loans, migration, asking friends for help, farming, and diversification. Migration features more in Kasera. Kigobe had a balanced mix of coping strategies, including both traditional (savings, farming) and adaptive (migration, diversification, credit).

Across all streets, the most common livelihood strategies are: savings (individually or from high seasons), diversification of income (side hustles, farming, petty business), credit/loans (from friends, bosses, processors, shops), migration (seeking opportunities elsewhere), and asking for help from friends/family. Kasera relied more on savings and small loans; Kipumbwi had the highest livelihood flexibility and diversification; and Kigobe depended more on migration and borrowing. The results show that while all streets rely heavily on savings and income diversification to cope with livelihood impacts, Kipumbwi demonstrates greater adaptive flexibility, Kasera depends more on basic savings and borrowing, and Kigobe shows a mix of traditional and adaptive responses, including migration (Figure 5).

4.4.1. Adaptive capacity

Descriptive statistics on livelihood diversification indicated that, although diversification was implemented, it remained within the anchovy AVC. Even trading activities remain within the fisheries sector. Hence, fisheries are the primary source of livelihood, cushioning the lack of formal employment in the formal sector. Accordingly, these activities are grouped at various stages: pre-production, production, and post-production (Table 8). Various reasons were associated with engagement in AVC: local employment (57.3%, n=380), and the only available job (42.9%, n=285). Fisheries are therefore used to cushion the lack of employment (Table 7).

Nonetheless, through AVC node activities, all respondents generate nutrition and income. The autonomous and interdependent nature of these activities along the AVC provides another form of adaptive capacity that transcends all AVC nodes. Fluctuations in anchovy harvesting determine income levels. AVC income has fluctuated with anchovy availability, which is primarily influenced by fishing intensity and oceanographic conditions. Survey results show that the number of fisherfolk and vessels has been increasing. Such an increase can put pressure on anchovies and other fishery resources. This increase can affect fish harvests across space and over time. The clear demarcation of roles and responsibilities among chain actors defines the specific needs of each chain node.

4.4.2. Adaptive strategies by anchovy fisherfolk

In exploring the intensity of adaptive strategies used by anchovy fishers, the results indicate that community-based management, integrated coastal management, closures, and eco-management were supported to varying degrees (Table 8). The proportions of respondents supporting these vary

significantly ($P=0.00\text{--}0.05$, 95% CI). These interventions were designed to ensure that coastal and marine resources are well protected and managed to meet the needs of current and future generations. Respondents view the success of interventions differently: most see no change (25.6%, 31.8%, and 20.6% for community-based management, integrated coastal management, and closures, respectively), whereas most see eco-empowerment as increasing (20.8%).

When a gender lens is applied to rate these interventions, results show no statistically significant differences between men and women ($P > 0.05$; 95% CI for all interventions). This result implies that gendered perceptions of interventions for sustainable adaptive strategies are the same (Table 9). The same perceptions also hold across age groups. Therefore, community ratings of interventions for adaptive strategies in anchovy fisheries are nearly equal across social groups.

The hardships that changing environmental conditions impose on the anchovy fishing community include failed attempts at livelihood optimisation, seemingly imposed by phenomenological changes. Indeed, anchovy fisheries carry community expectations for increased incomes and improved standards of living. With gendered perspectives on adaptive responses to changing conditions, anchovy fisheries are situated on the premise that women bear the brunt of these changes, regardless of age and social status.

4.4.2. Perceptions on effects of contemporary fisheries on sustainability

To describe trends in the anchovy fisheries, respondents noted that the effects resulted from efforts to increase anchovy catches. Respondents reported that anchovy adaptive capacity is decreasing (29.0%, $n=194$), increasing (27.3%, $n=194$), or unchanged (23.2%, $n=194$; Table 10). These changes influence perceptions across various aspects of fisheries. About 87.5% ($n=585$) acknowledged an increase in the number of actors in the AVC, which is associated with an increase in the number of markets (82.5%, $n=553$). Respondents also reported increased participation (76.0%, $n=503$), suggesting a possible rise in women's participation in fishery livelihoods and, therefore, perceptions of an increase in the number of actors in the AVC. Respondents' perceptions of the trend in anchovy fisheries differ significantly ($P=0.001 < 0.05$, 95% CI). The decline in anchovy fisheries can reduce catches, which in turn affects incomes.

Infrastructure for AVC was reported as unchanged (55.3%, $n=570$). In contrast, income was reported to decrease (34.5%), suggesting shifts in fish catches and markets. In comparison, 25.5% reported an increase, suggesting that increased fishing effort tends to increase catches and offset the risk of income decline. The average decrease in fisheries income can result from market unreliability, mediated by several factors, including infrastructural inadequacies. These varied views on infrastructure and its impact on AVC can be attributed to inadequate transport and the cold chain. Survey results suggest that inadequate infrastructure contributes to low anchovy prices. This is attributed to unpredictable rainfall, which can compromise the drying process, since anchovies are sun-dried. Moreover, most respondents still see access to credit as unchanged (41.1%, $n=274$), compared with 25.2% ($n=136$) who reported an

increase and 13.5% who reported a decrease (Figure 6). The chi-square test yielded P-values > 0.05 (95% CI).

Additionally, adaptive responses to changing anchovy phenomena in the area are not adequate to sustain inshore anchovy fisheries. Actors along the AVC acknowledge the fluctuating catch, amid intensity and climate dynamics. Those commenting on the decrease were 78.3% (n=521), while those commenting on the increase were 8.9% (n=59). Figure 4 shows that respondents hold different views on the available fish stock. Opinions vary across study sites in Tanga and Zanzibar, suggesting that spatial factors influence anchovy availability and may also reflect social and economic factors.

The chi-square test assessed differences in respondents' perceptions of fish stock availability by location, yielding a value of 57.93. The p-value was 0.00 (< 0.05; 95% CI). Therefore, respondents' perceptions of the fish stock are associated with specific geographical locations. Therefore, area-specific factors are likely to influence anchovy stocks. Area-specific reasons influence variations in fishing intensity, mediated by increases in the number of fisherfolk and fishing vessels. According to the discussion results, different areas experience varying pressures from variable fishing populations, placing different strains on fishery resources. Differences in livelihoods can explain these results across areas.

4.4.3. Adaptive capacity enhancement strategies

To examine perceptions of how strategies enhance the AVC's adaptive capacity (Table 11), respondents agree that livelihood diversification and flexibility are necessary to enhance the adaptive capacity of coastal livelihoods (97% and 87.3%, respectively). This includes sustainable fishing practices and climate-resilient technologies (79.1%, n=529). Other aspects respondents identified as necessary to enhance livelihood adaptive capacity include access to assets and knowledge, equal gender relations, capacity building and training, gender-inclusive policies, access to markets, value addition, and network involvement and collaboration. Additional strategies largely agreed upon included research, government engagement, and stakeholder engagement. However, most respondents (45.1%, n=322) were neutral on legal rights and security of tenure as factors that can enhance adaptive capacity.

5. Discussion

In this section, we discuss the effects of phenomenological changes on anchovy fisheries resources and their socioeconomic impacts, culminating in the AVC. We then assess the strategies local communities use to adapt to these changes and their influence on coastal livelihood outcomes. Drawing on SES theory, we discuss how changes in anchovy fisheries affect coastal community livelihoods, including income, food security, and job creation. Consistent with the SES framework, the discussion aligns with perspectives on ecological, social, institutional, and economic adaptive capacity (value chain structure), as well as AVC.

5.1. Adaptive capacity and SES framework

Adaptive capacity refers to the ability of a system (in this case, the fishery and the communities that depend on it) to respond to environmental changes and stressors (Allison & Ellis, 2001). Diversification was reported as a potential livelihood adaptive response (Huynh & Stringer, 2018). The results indicate that in both Tanga and Zanzibar, many fishers rely solely on marine resources for their livelihoods, making them highly sensitive to changes in fish populations. This study further suggests that communities with diversified livelihoods—such as tourism, aquaculture, or agriculture—might exhibit greater adaptive capacity. This result is consistent with other studies conducted elsewhere (Adger et al., 2005; McDonald et al., 2019; Hahn, 2017; Buurman & Babovic, 2017). Governments and NGOs in Tanzania could invest in climate adaptation strategies specifically tailored to coastal communities. This may include improving fishing infrastructure (e.g., better vessels and cold storage facilities), expanding access to alternative livelihoods, and supporting sustainable aquaculture practices.

Fish value chains offer opportunities for trade and livelihood enhancement (Pradhan & Nayak, 2023) thereby strengthening adaptive capacity to climate shocks. Likewise, this study has found that livelihood strategies are mainly shaped by anchovies, whose relative abundance is mediated by fishing intensity, which in turn is influenced by ecological dynamics. Diversification was pursued within the AVC, so changes in its conditions can disrupt diversification potential and therefore impair adaptive capacity. This result is supported by other studies. According to Njock *et al.* (2009), a combination of climate-related stressors and overexploitation reduces the scope of adaptation and increases the risk of stock collapse.

A study by Torre-Castro *et al.* (2022) indicated that factors underlying adaptive capacity are complex and interact, with positive, negative, and unclear effects. The results suggest that complexity is partly mediated by the autonomous and interdependent nature of actors in the fishing nodes, particularly in the AVC. Moreover, consistent with other studies, access to scientific knowledge, fishing technologies, and market information can enhance fishers' ability to adapt to changing environmental conditions. For example, early warning systems about climate change or training in sustainable fishing practices can improve adaptive capacity. This means that local institutions and cooperative organisations can play a key role in building adaptive capacity. In Zanzibar, for example, cooperatives and collaborative management strategies may offer fishers greater support than in regions with weaker governance structures.

Community-based resource management can enhance the adaptive capacity of small-scale fishers. In both Tanga and Zanzibar, successful adaptive strategies often involve a participatory approach in which local fishers have a voice in decisions about marine resource use. Policies that balance conservation needs with fishing communities' livelihoods are crucial. Well-managed MPAs can lead to healthier fish stocks over time, but restrictive policies that exclude local fishers without offering viable alternatives could exacerbate poverty and food insecurity.

Examining the adaptive capacity of anchovy fisheries in Tanga (mainland Tanzania) and Zanzibar (Tanzanian islands) through the lens of Social-Ecological Systems (SES) theory provides a

comprehensive framework for exploring the interconnectedness among ecological changes, fisheries, and human livelihoods. SES theory emphasises the dynamic interactions between human and natural systems. It examines how these systems co-evolve and adapt to environmental, social, and economic changes. Within the context of fisheries, SES provides a useful perspective for understanding how the livelihoods of fishing communities are influenced by both the marine ecosystems they rely on and broader external forces, such as market demands, governance, and climate change (Plessis, 2008; Partelow, 2018). In this study, adaptive capacity in an SES is mediated by the interplay among livelihood strategies, anchovy abundance, community-based management, integrated coastal management, closures, and eco-management.

5.2. Changing Environmental Conditions and Ecological Adaptive Capacity

The aspects of changing conditions and their influence on ecological adaptive capacity are discussed (Wynberg & Hauck, 2014; Grêt-Regamey et al., 2019; Ainsworth et al., 2023). Climate change and changes in oceanographic conditions have been reported to be widespread in recent decades, causing shifts in fish movements at sea (Allison et al., 2009; Badjeck et al., 2009). People's perceptions of these changes provide additional evidence that the coastal waters of Tanga and Zanzibar are also shifting due to warming sea temperatures, altered currents, and unpredictable weather patterns, which can affect anchovy populations.

Additionally, anchovies, like other fish, are highly sensitive to changes in water temperature and nutrient availability (Allison et al., 2009). The declining anchovy catches observed in this study can be linked to these environmental dynamics. Intensive fishing practices and environmental degradation can reduce anchovy populations, further stressing the ecosystem's adaptive capacity. This result is consistent with results from other studies, which reported that intensive fishing was associated with declines in fish catch (Brugère, 2015; Onyango & Yahya, 2022; Pradhan & Nayak, 2023; Malakar et al., 2018). This result calls for effective governance structures and marine protected areas (MPAs) to improve ecosystem adaptive capacity. Success depends on enforcement, community participation, and balancing conservation with livelihoods.

5.3. Impacts on Livelihoods

The livelihood activities entail the extraction of coastal resources; thus, any change in these resources can affect livelihoods that depend on them (Robertson et al., 2018; Shalli, 2017; Silas et al., 2020). This study shows that anchovy fisheries are often small-scale and characterised by seasonal income. As anchovy availability fluctuates with environmental changes, fishing communities' economic security is directly affected. Reduced catches can lead to lower income, food insecurity, and increased risk of poverty. Moreover, Social factors such as education, gender roles, and access to alternative employment opportunities influence how different members of fishing communities experience and cope with environmental changes. In Zanzibar, where fisheries provide a significant source of employment, the adaptive capacity of both men and women fishers varies, with women being more vulnerable to economic disruptions. In areas where fishing becomes unsustainable, migration to urban centres or

alternative coastal regions might increase (Awinia, 2020; Bushesha, 2020; McCabe, 2022; Griffith et al., 2023). This can strain urban infrastructure and result in overcrowded, underdeveloped rural areas.

Conclusion

Through an SES framework, the intricate balance between ecological, social, and institutional factors shapes the adaptive capacity of anchovy fisheries in Tanga and Zanzibar. While the autonomous and interdependent nature of the nodes in the AVC plays a crucial role in enhancing adaptive capacity, it lacks a specific policy option to provide adequate support. Enhancing adaptive capacity requires a multi-faceted approach that integrates sustainable resource management, livelihood diversification, and local governance. Strengthening these areas could improve fishing communities' adaptive capacity to the dual threats of environmental change and socio-economic challenges, ensuring more sustainable livelihoods in the future.

Declarations

i. Ethical approval & accordance

Ethical approval & accordance: The Commission for Science and Technology (COSTECH), the Directorate of Research, and the University of Dar es Salaam Ethical Review Board approved all research activities. The study protocol was conducted in accordance with the Declaration of Helsinki guidelines.

ii. Consent to participate

We obtained informed consent from all study participants.

iii. Consent to publish

Not applicable

b) Acknowledgments

This paper is an output of the Samaki, Fisheries, Nutrition, Livelihoods, Gender, and Rights in Tanzania project. Funded by the Norwegian Agency for Development Cooperation (Norad) via the NORHED program, the project investigates coastal ecosystem health, food security, and sustainable community Livelihoods through better fisheries governance. It assesses nutrient content in small fish species to address micronutrient deficiencies and improve public health policies; examines the roles and economic disparities faced by women in small-scale fisheries and post-harvest activities; and seeks to protect local fisherfolk's access to coastal spaces from restrictive conservation rules or commercial evictions. The authors appreciate the valuable assistance and information provided by Tanga Regional and Zanzibar Municipalities, District Officers, Institutions and organisations, and the community in the four study wards/shehias.

c) Author contribution statement

Victoria H. Moshy: Writing – Review & editing, Writing – original draft, Visualisation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualisation.

Anselm R. Mwajombe: Writing – Review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualisation.

d) Funding: This study was funded by Norad via the NORHED program through the Samaki, Fisheries, Nutrition, Livelihoods, Gender, and Rights in Tanzania Project Number 70322.

e) Competing interests: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article

f) Clinical Trial Number: Not applicable

g) Data Availability Statement: Data will be available upon request

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Tables

Table 1: Data Collection and Sources

Objective	Method	Data sources
1. To assess the key environmental changes affecting anchovy fisheries in Tanga and Zanzibar, including climate variability and overfishing	- Household questionnaires to capture household adaptive responses to changes in the AVC - Informal interviews to obtain an in-depth understanding of the changes and the occurrence of such changes	- The 665 respondents were obtained by the randomised process to obtain unbiased data. - The targeted 10 key informants who have a broad understanding of the issues surrounding their local environment
2. To evaluate the adaptive strategies used by anchovy fishers and their effectiveness in maintaining fishery sustainability under changing environmental conditions	- Household questionnaire to obtain the gender aggregated data on household adaptive capacities - The interviews to find the detailed information on household adaptive responses to changes	- The randomly obtained 665 households - The 10 targeted key informants with knowledge and understanding of their surroundings
3. To analyse the socio-economic impacts of changes in anchovy fisheries on the livelihoods of coastal communities, particularly in terms of income, food security, and employment.	- Informal discussions with locals on socioeconomic and cultural factors shaping the adaptive capacity. - Household questionnaire survey to obtain the gender aggregated data on household social and demographic characteristics shaping such adaptive capacities	- Targeted discussants to narrate social and cultural factors and how they influence adaptive capacity - The randomly selected 665 households

Table 2: Sampling strategy for exploration of the AVC

Region	Village	Anchovy value chain node		Population	Sample size
Tanga	Kasera		Watenga	62	6
		Harvest	Fishermen	1000	51
		Post-harvest	Traders	200	15
			Porters	350	18
			processors	50	20
	Kipumbwi		Watenga	860	43
		Harvest	Fishermen	4660	233
		Post-harvest	Traders	280	14
			Porters	1080	54
			processors	270	13
	Kigombe		Watenga	70	4
		Harvest	Fishermen	657	33
		Post-harvest	Traders	75	4
			Porters	231	12
			processors	70	4
Zanzibar	Fungurefu	Harvest	Watenga	132	7
		Post-harvest			
			Fishermen	1867	94
			Agents	11	2
			Porters	1172	59
			processors	561	28
	Mangapwani		Watenga	360	18
		Harvest	Fishermen	3240	162
		Post-harvest	Agents	16	2
			Porters	360	18
			processors	427	21

Source: Field Data (2024)

Table 3: Perceptions on environmental change effects on anchovy fisheries

Environmental change	Sex	Don't know	Decreased	Increased	No change	Total
Climate change	Female	3.6% (24)		24.3% (163)	1.8% (12)	29.9% (199)
	Male	6.6% (68)	0.3% (2)	58.3% (388)	4.8% (32)	70.1% (466)
Resilience	Female	3.6% (24)	8.7% (58)	6.0% (40)	6.9% (46)	29.9% (199)
	Male	6.8% (69)	20.5% (136)	15.9% (106)	16.4% (109)	70.1% (466)

Source: Field Data, 2024

Table 4: Respondent perceptions on non-climatic factors affecting anchovy fisheries

	Decrease	Increase	No change	N/A	Total
Technology*	9.8% (65)	45.0% (97)	34.7% (230)	10.4% (69)	100% (665)
Markets access*	33.2% (220)	21.4% (139)	34.9% (230)	10.5% (70)	100% (665)
Infrastructure*	33.2% (219)	21.4% (142)	34.3% (231)	10.5% (70)	100% (665)
Resource depletion*	12.2% (78)	47.4% (313)	29.5% (198)	11.1% (74)	100% (665)
Fisheries regulations*	4.7% (29)	35.3% (233)	49.9% (332)	10.1% (67)	100% (665)
Access to credits*	13.5% (90)	58.5% (385)	17.7% (119)	10.2% (68)	100% (665)
Decision-making involvement*	10.5% (68)	3.8% (25)	46.3% (320)	37.4% (249)	100% (665)

Source: Field Data, 2024

Table 5: Respondent engagement in the various stages of the AVC

AVC stage	Street					Total
	Fungurefu	Kasera	Kigombe	Kipumbwi	Mangapwani	
Post-production	18.1% (120)	7.1% (47)	1.0% (30)	16.0% (106)	10.6% (57)	56.2% (393)
Pre-production	1.1% (7)	0.6% (4)	0.3% (2)	3.0% (20)	1.4% (9)	6.3% (42)
Production	12.6% (84)	6.5% (43)	5.1% (34)	8.8% (58)	4.8% (31)	37.8% (250)
Total	31.7% (211)	14.1% (94)	9.9% (56)	27.7% (194)	16.5% (110)	100% (665)

Source: Field Data (2024)

Table 6: perceptions on employment trends

	Decrease	Increase	No change	Do not know	Total
Number of fisherfolk*	2.0% (13)	66.9% (443)	20.5% (135)	10.7% (77)	100% (665)
Women's participation*	11.1% (74)	10.1% (67)	49.5% (327)	29.3% (193)	100% (665)

Source: Field Data (2024)

Table 7: proportion of respondents justifying engaging in the AVC

Engagement reason	Street					Total
	Fungurefu	Kasera	Kigomba	Kizumbwi	Mangapwani	
Local employment	18.5% (123)	8.9% (59)	4.4% (29)	16.1% (114)	8.5% (56)	57.3% (380)
Only available job	13.4% (88)	5.3% (35)	5.7% (37)	10.6% (34)	8.3% (54)	42.9% (285)
Total	31.7% (211)	14.1% (94)	9.9% (65)	27.7% (184)	16.5% (110)	100% (665)

Source: Field Data (2024)

Table 8: proportion of respondents rating interventions for adaptive strategies in anchovy fisheries

Adaptive strategy	Decrease	General	Increase	No change	N/A
Community-based management*	6.2% (41)	13.8% (92)	15.2% (101)	25.6% (177)	38.2% (291)
Integrated coastal management*	3.5% (23)	11.1% (71)	15.0% (98)	31.8% (201)	38.9% (259)
Closures*	9.0% (60)	9.0% (60)	22.6% (150)	20.6% (136)	38.9% (259)
Eco empowerment*	20.6% (137)	11.7% (78)	21.1% (140)	8.1% (54)	37.9% (252)

Source: Field Data (2024)

Table 9: rating of intervention to enhance adaptive strategies to anchovy fisheries according to gender

Adaptive strategy*	Decrease %		General %		Increase %		No change %		N/A %	
Sex	F	M	F	M	F	M	F	M	F	M
Community-based fish management	0.9	5.3	3.5	10.4	4.2	10.5	8.4	15.0	12.5	26.8
Integrated coastal management	0.8	2.7	2.9	8.3	3.6	10.8	9.3	17.4	12.3	26.6
Closures	3.3	5.7	2.6	6.5	6.0	15.8	4.4	3.5	3.3	5.7
Eco empowerment	6.2	14.4	3.6	8.1	6.5	14.4	1.1	4.1	11.3	26.6

Source: Field Data (2024)

Table 10: perceptions on changes in anchovy fisheries aspects in the AVC

Anchovy fisheries attributes	N/A	Decrease	Increase	No change	Total
Number of actors in the anchovy value chain	10.1% (71)	0.6% (4)	87.4% (585)	1.3% (9)	100% (669)
Markets	10.2% (68)	1.8% (12)	82.4% (553)	5.5% (37)	100% (669)
Women participation	10.2% (69)	0.4% (3)	76.0% (508)	13.3% (89)	100% (669)
Decision-making involvement	10.6% (71)	7.9% (53)	26.4% (177)	55.0% (368)	100% (669)
Infrastructure	10.3% (69)	5.4% (36)	29.0% (194)	55.3% (570)	100% (669)
Resilience	10.5% (70)	29.0% (194)	27.3% (250)	23.2% (155)	100% (665)
Income	10.2% (68)	34.5% (231)	25.5% (238)	19.7% (132)	100% (669)
Access to credit	10.3% (69)	13.5% (90)	25.2% (136)	41.0% (274)	100% (665)

Source: Field Data (2024)

Table 11: Resilience enhancement strategies

Resilience enhancement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Livelihood diversification	7.9% (53)	89.1% (596)	2.7% (18)	0.3% (2)	-
Livelihood flexibility	5.5% (37)	81.8% (614)	2.4% (16)	0.3% (2)	-
Sustainable fishing practice	5.1% (34)	70.7% (473)	21.4% (143)	2.1% (14)	0.3% (2)
Climate resilient technology	3.9% (26)	75.2% (503)	20.0% (134)	0.9% (6)	-
Financial access, credit and insurance	4.2% (28)	82.5% (555)	10.2% (68)	1.5% (10)	0.7% (5)
Access to material assets	3.7% (25)	73.4% (491)	19.7% (132)	1.6% (11)	0.6% (4)
Ability to access knowledge	4.2% (29)	78.2% (523)	15.0% (107)	1.2% (8)	0.1% (1)
Equal gender relations	3.1% (21)	49.9% (334)	41.1% (275)	4.6% (31)	1.0% (7)
Capacity building and training	3.7% (25)	73.4% (481)	21.1% (141)	1.5% (10)	0.1% (1)
Gender inclusive policies	12.3% (62)	44.5% (298)	36.6% (258)	3.4% (23)	1.0% (7)
Access to markets	10.0% (57)	76.8% (514)	12.6% (84)	0.4% (3)	0.1% (1)
Value addition for price regulation	0.5% (4)	62.3% (417)	25.9% (173)	0.4% (3)	11.1% (74)
Network collaboration	11.1% (74)	64.3% (430)	22.9% (123)		1.0% (7)
Legal rights to security of tenure	8.8% (59)	37.5% (251)	45.1% (322)	4.8% (31)	0.7% (5)
Research and monitoring	11.4% (76)	47.3% (317)	34.2% (229)	6.0% (40)	1.0% (7)
Government and stakeholder engagement	6.8% (59)	78.0% (522)	11.4% (76)	1.2% (8)	0.5% (4)
Agency	6.6% (44)	39.6% (265)	49.3% (330)	3.0% (20)	1.4% (10)

Source: Field Data (2024)

Figures

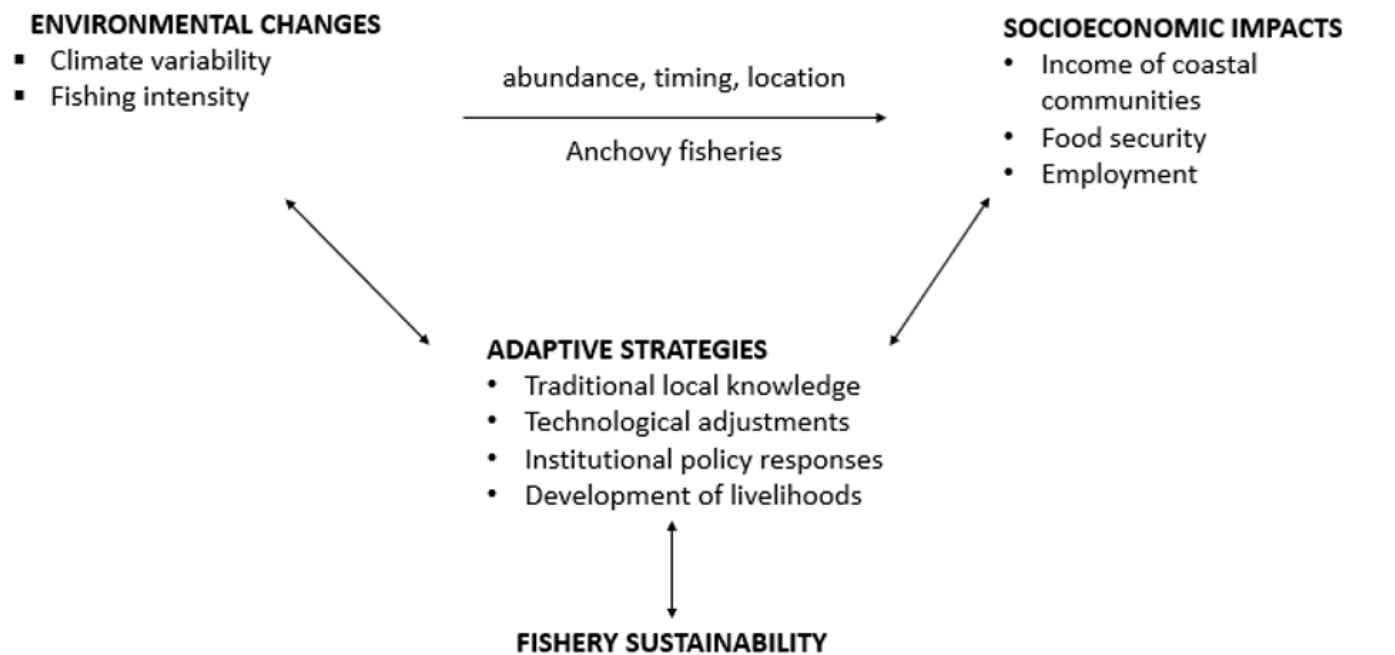


Figure 1

Integrated Socio-Ecological Resilience Model for Anchovy Fisheries: Insights from IPCC (2014), Scoones (1998), and Allison & Ellis. (2001)

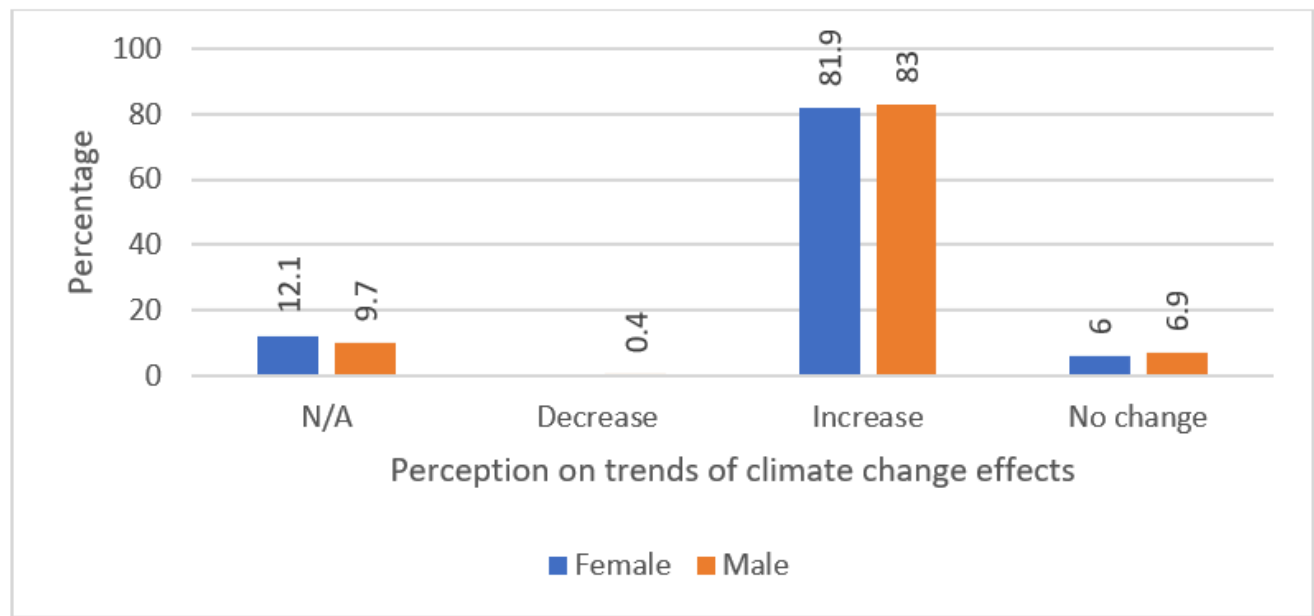


Figure 2

Gendered proportion of respondents expressing trends of climate change effects in the anchovy fisheries. Source: Field Data (2014)

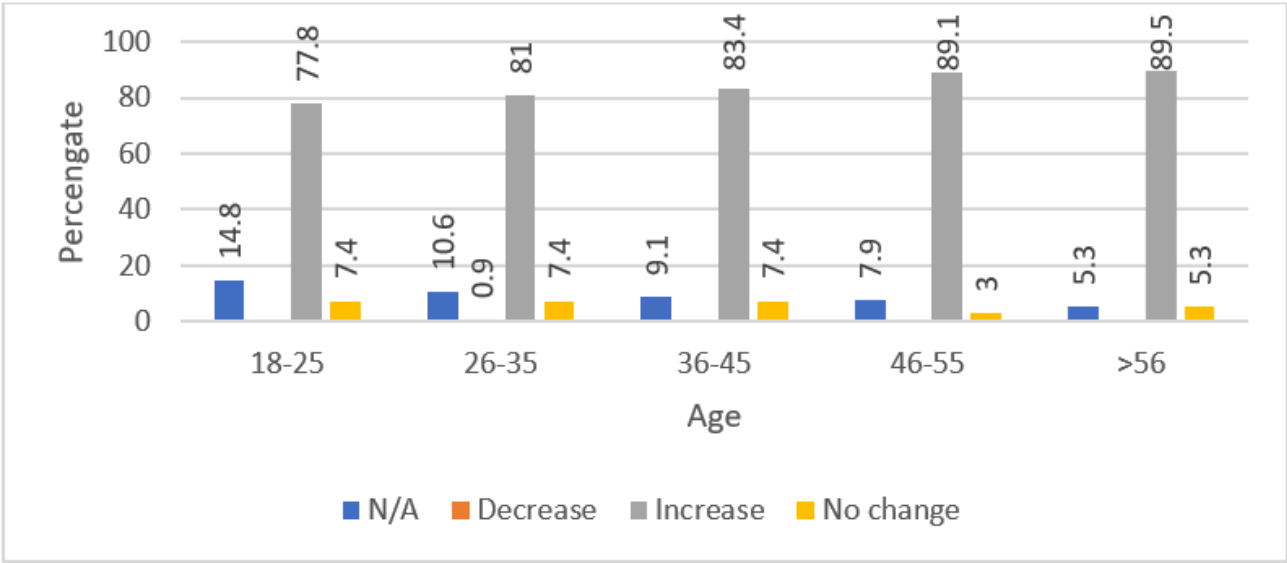


Figure 3

Perspectives on key environmental changes according to age. Source: Field Data (2024)

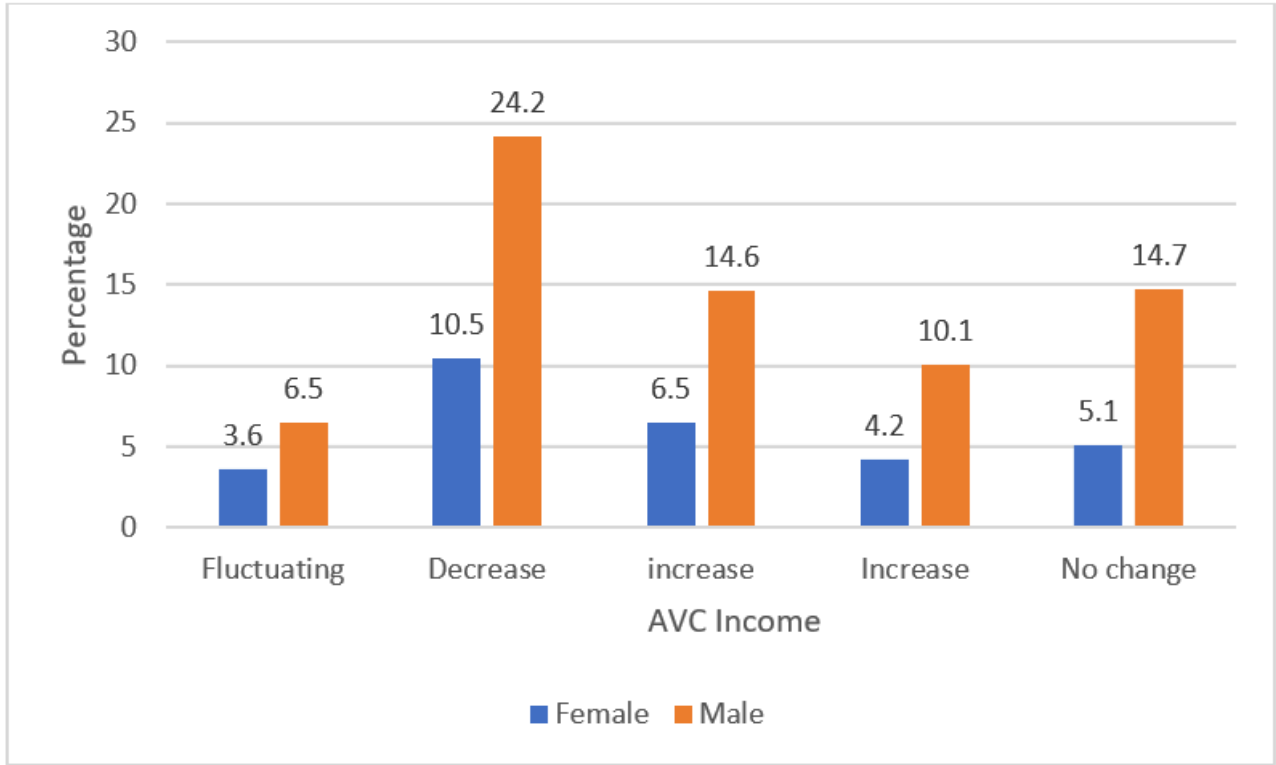


Figure 4

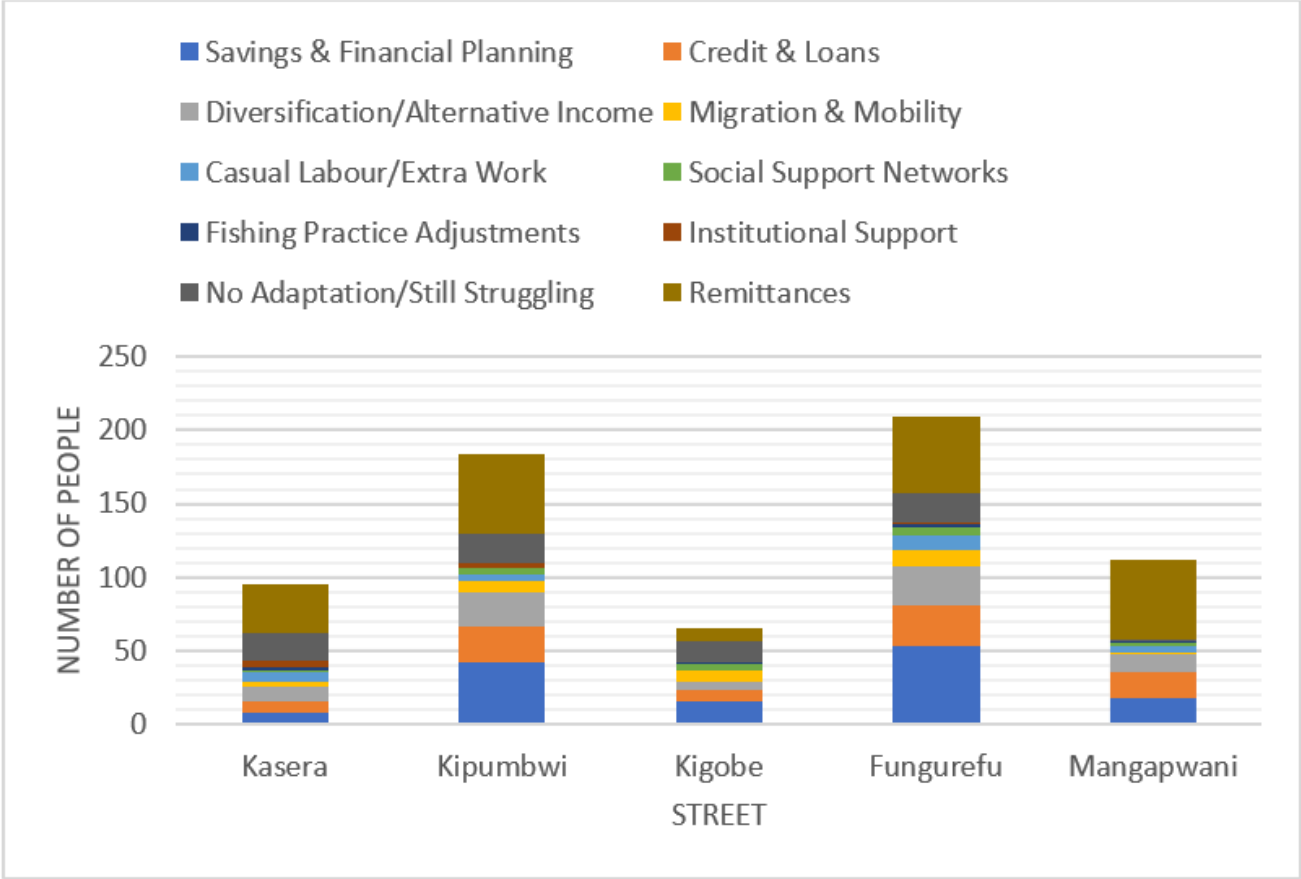


Figure 5

Distribution of adaptation strategies. Source: Field Data (2024)

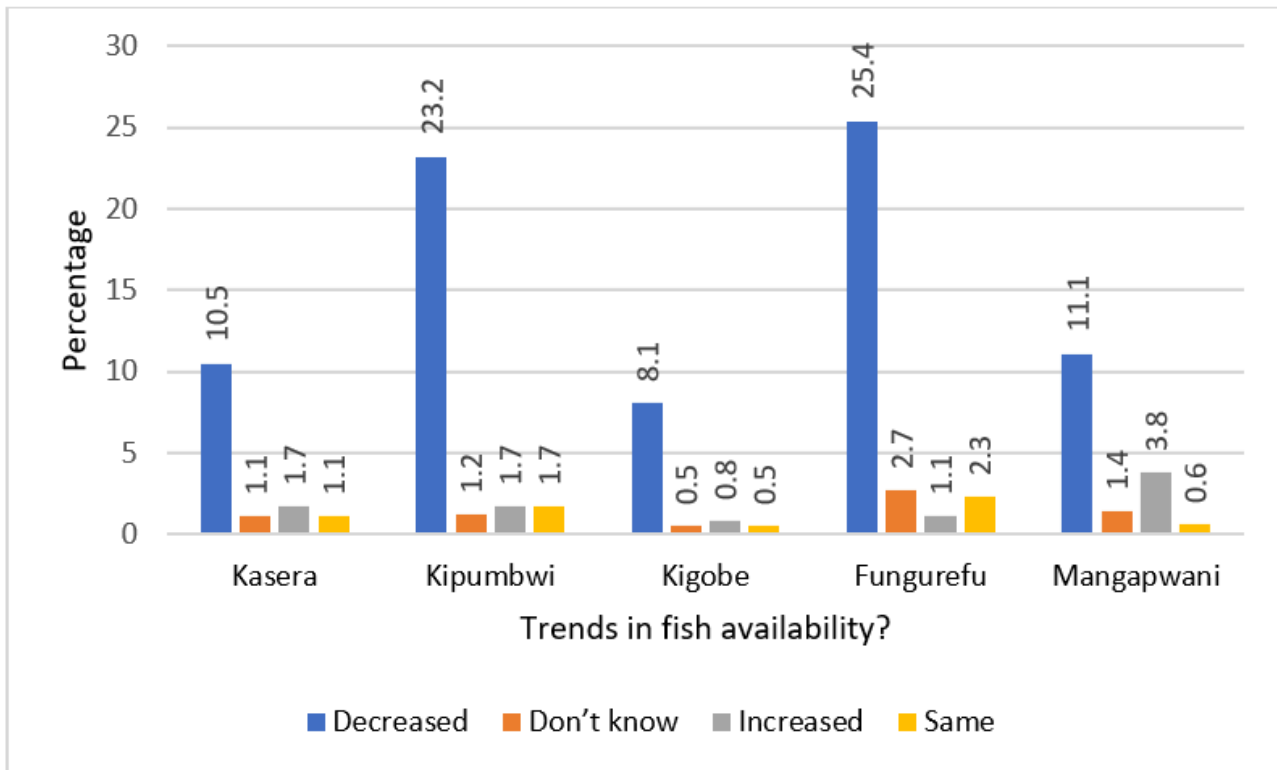


Figure 6

respondent perceptions on fish availability. Source: Field Data (2024)