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Fishers' Perception of Climate Change from 1986 to 2023 in the Dar es Salaam Coast of Tanzania

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Abstract
Most coastal communities depend on marine resources for their sustenance. However, the impacts of climate change have seriously affected fishing activities in the area. The present study explored the fishers' perception of climate change in the coastal areas of Kinondoni District in Tanzania. Fishers' perceptions on climate change were evaluated through semi-structured questionnaires and in-depth interviews. The data were analysed through discourse and theme content analysis, relative importance index, and Statistical Package of Social Sciences version 22. The results show that, during the span of three decades (1980s to 2020s), there has been a notable change in climate change, weather patterns and their associated effects on fishing activities. Furthermore, most fishers believe that fish migration patterns and the variations in annual temperature are important indicators of climate change. It was also pointed out that climate change affects the precision of forecasting the wind patterns, and storm occurrences, and thus affects the fishing activities. This uncertainty in weather forecasting brings difficulties in fishing operations. Specifically, climate change has led to fish population declines, shifts in fish distribution, and interruptions to fishing operations.

Introduction
Climate change poses significant impacts to communities that depend on coastal resources for their livelihoods, and this situation has been more pronounced in the 21st century. It is estimated that approximately two-thirds of major cities worldwide, which accommodate approximately 40% of the world's population, are situated within 60 miles of a coastline. This implies that climate change has posed a direct threat to many coastal populations, as it affects coastal ecosystems and the resources they support. The persistence of extreme weather events and ocean climatic conditions, coupled with coastal disasters, has resulted in severe losses and damage to the coastline worldwide (Urwin & Jordan, 2008).

In the Philippines, for instance, climate change impacts accelerated sea-level rise, affecting coastal areas and causing physical effects, including. The physical effects include inundation (submersion) of low-lying wetland and dryland areas, erosion, saltwater intrusion, increased flooding risk, and the occurrence of destructive storms (Paw, 1991). The persistence of such physical changes influences changes in coastal structures, both natural and man-made, as well as population displacement, which, in the final analysis, impedes people's livelihoods (Paw, 1991).

The persistence of current trends in climate change and variability increases the frequency of prolonged periods of insufficient rainfall, along with unpredictable drought-related shocks and more episodes of heavy rainfall (Bedeke, 2023). It is projected that by 2080, the temperature across the coastal area will increase within the range of 2 -4 degrees, coupled with extreme heavy rain during the short rain period. It is expected that these trends will continue over the next 10-15 years. Based on projections, Tanzania,

as one of the East African countries, is at high risk of climate change, given the scale of existing weather-related impacts (Oswald & Conradie, 2024).

So far, in Tanzania, coastal areas are major sources of people's livelihoods, as they offer ecosystem services and other economic potentials that contribute to economic growth at the individual and national levels (Rubekie et al., 2022). Coastal communities depend heavily on agriculture, which is more vulnerable to a changing climate. Despite their potential contribution, coastal areas are more vulnerable to ongoing climate change and variability, exacerbated by rising sea levels (Misana & Timimanywa, 2019). It is under that parameter that this study aimed to investigate coastal communities, specifically fishers' perceptions of climate change and the adaptation strategies they use during the era of climate change.

Torrell et al. (2017) and Mangora et al. (2014) focus on explaining the potential of coastal areas for people's livelihoods and responses and less is known about fishers' perceptions and adaptation to climate change, as they are key stakeholders in coastal resources. Therefore, this paper aims at (i) investigating fishers' perceptions of climate change, and (ii) exploring the adaptation mechanism adopted by the fishers.

Climatic Characteristics of the Study Area

The study area experiences a modified equatorial climate, with hot, humid seasons throughout the year. The district has an annual temperature range of 25 °C to 29 °C, with the hottest and coolest seasons occurring during the same period. It is also characterised by the occurrence of a bimodal rainfall season, which includes short rains which occur from October to December and long rains that occur between March and May. It receives an average annual rainfall of 1300 mm. The area's climatic characteristics are influenced by the Southwest monsoon winds, which occur from April to October, and the Northeast monsoon winds, which occur between November and March. (URT ,2020).

Topology of the Area

Mbweni and Ununuo Wards, in Kinondoni District, are characterised by a diverse terrain of coastal plains, hills, and valleys. The wards are located in the coastal zone, with an altitude of 100 meters above sea level (Geological Survey of Tanzania, 2019). The western parts of both wards are characterised by coastal plains that stretch inland from the shore. Most of these plains are composed of alluvial deposits formed over time by streams and rivers (TCMP, 2001). In addition, the wards under study are characterised by hills and small valleys and depressions that lie in the central and eastern parts. These valleys play a significant role in supporting local communities' agriculture because they are endowed with rich soils that support the cultivation of crops such as maize, cassava, and vegetables (District Council, URT, 2020).

Furthermore, the wards are characterised by water bodies, including seasonal streams and wetlands, which affect the area's topography. Such water features support ecosystems and provide water for household and agricultural needs. The presence of water bodies, such as seasonal streams and wetlands, shapes the area's topography. These water features are essential for maintaining nearby ecosystems and supplying water for household and agricultural needs.

Major Livelihoods in the Study Area

The people of Kinondoni engaged in various activities that formed the basis of their livelihoods. Fishing is an important livelihood activity for the people, as the wards are adjacent to the coast. Artisanal fishing is practised by local fishers, who catch a range of fish species for both commercial and subsistence uses (Mwakalobo et al., 2018). In addition to creating jobs, the fishing sector is an essential source of nourishment for the local population (Mwakalobo et al., 2018).

Similarly, tourism is another important livelihood activity conducted in the area. The presence of immaculate beaches and cultural heritage monuments influences tourism in the area. Thus, the local communities benefited from such activities in tourism-related activities, which are not limited to tour guiding, souvenir sales, and jobs in hospitality (Mwakalobo et al., 2018)

Sampling Techniques and Sample Size

This study employed purposive sampling to select the Kunduchi and Mbweni wards as specific locations. The two wards represent 10% of the total area of Kinondoni District. These wards were purposively selected for their proximity to the coastline and potential for fishing activities, and they serve as centres for the fish business in the district. In this study, the sampling unit was fishers. In the next step, simple random sampling was employed to select the fishers, whereas 10% (35) of the 350 fishers in Mbweni were selected. On the other hand, another 10 % (74) of the 740 fishers in Ununio were selected.

Data Collection

A questionnaire with demographic information, fishing experience, and income was administered to respondents. In addition, an in-depth interview was conducted to explore information on fishers 'perceptions of climate change impact and adaptation. A questionnaire with demographic information, fishing experience, and income was administered to respondents. In addition, an in-depth interview was conducted to explore information on fishers' perceptions of climate change impacts and adaptation. The collected data were carefully checked, cleaned, and coded before being entered into the statistical software for analysis. Qualitative responses from interviews were transcribed, organised into thematic categories, and analysed to complement the quantitative findings.

Data analysis

The data were mainly analysed using the Relative Importance Index (RII) and the Statistical Package for the Social Sciences (SPSS) version 22. A relatively important index analysis was selected in this study to rank respondents' perceptions and adaptation to climate change using the following formulae. The RII is calculated as the weighted mean of respondents' ratings for each item, considering the Likert scale weights (1 to 5). The following formula was used

$$\text{Relative Importance Index} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{A*N}$$

Whereas, A*N
N5 = Number of respondents for Strongly Agree
N4 = Number of respondents for Agree
N3 = Number of respondents for Neutral
N2 = Number of respondents for disagree
N1 = Number of respondents for strongly disagree
A = Highest weight (5)
N = Total number of respondents

Based on the ranking (R) of relative indices (RI), the weighted average for the perception and adaptation to climate change was determined. Thus, five important levels were transformed from RI value as suggested by Tonidandel et al. (2011), high (H) ($0.8 \leq RI \leq 1$), high medium (H–M) ($0.6 \leq RI \leq 0.8$), medium (M) ($0.4 \leq RI \leq 0.6$), medium-low (M-L) ($0.2 \leq RI \leq 0.4$) and low (L) ($0 \leq RI \leq 0.2$).

For the qualitative data theme, content analysis was employed, following six thematic steps: familiarisation with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. Data from the in-depth interviews and focus

group discussions are presented straightforwardly, with rich descriptions supported by representative verbatim quotations.

Ethical considerations

The study adhered to ethical standards, including voluntary participation by respondents, confidentiality, and anonymity throughout the research process.

Validity and reliability of the Data

The questionnaire was developed based on the research objectives and the literature, and its items were reviewed by experts, yielding a CVI score of 0.80, confirming relevance and clarity. A pilot study involving twenty-seven participants from Mbweni Ward was conducted to assess the instrument's reliability and clarity. Cronbach's Alpha yielded a value of 0.79, indicating good reliability for the research instruments.

Limitations of the Study

No specific limitations were encountered in this study, as the information was collected as required.

Results and Discussion

Demographic Characteristics of the Respondents

Understanding the demographic characteristics of the respondents is very important because it informs the basic variables that define individual identity. Some key demographic parameters investigated include age, sex, marital status, education level, experience, and the respondent's main economic status.

In the study, the respondents were in different age groups, ranging from 20 to 60+. Still, most were between 20 and 49, as they are physically strong enough to handle unpredictable risks in the coastal environment. The findings of this study are consistent with those of Mulyasari et al. (2018) in Bengkulu Province, which reported that most participants were between 15 and 64 years of age, as this age group represents the productive age range capable of performing tasks at maximum capacity.

Table 1: Demographic Characteristics of respondents

Age	Frequencies	Percentages
20-29	22	20.2
30-39	34	31.2
40-49	33	30.3
50-59	18	16.5
60+	2	1.8
Total	109	100
Sex		
Female	1	0.9
Male	108	99.1
Total	109	100
Marital status		
Married	77	70.6
Separated	6	5.5
Single	21	19.3
Widowed	5	4.6
Divorced	0	0
Total	**109**	**100**

Source: Field Survey 2023

Based on sex, the findings revealed that all respondents were male, totaling 108. There was only one female respondent These findings concurred with the studies conducted by Bennet (2005), Torell et al.,

(2021) and Oloko et al., (2024) as they found out that at the global scale there is dominance of men in fishing activities which is influenced by gender division of labour where women in large extent are occupied with pre and post-harvesting activities.

The dominance of male respondents over female respondents was attributed to men's dominance in fishing activities in society, particularly during pre-harvesting activities conducted at night on the shoreline. On the other hand, females are commonly engaged in post-harvest activities, such as fishing, processing, and trade, conducted outside the shoreline. In supporting this, one respondent from Ununio asserted that:

In our community, more men are involved in fishing activities due to the nature and risks of the activity, which is done even at night, something women cannot easily do. Based on our African traditions, women are restricted by their daily household and reproductive responsibilities, which restrict them from actively engaging in activities outside their homes.

Fishers' Perception of Climate Change

To understand the fishers' perceptions of climate change, the study investigated their experiences in fishing. This parameter was important because climate change is generally defined as a long-term change in the main weather patterns observed over 30 years. When the fishers' experience was explored, the outcomes showed that about 40% had experiences in fishing activities of 1-10 years, followed by 33% with an experience of 11–20 years, while only the smallest proportion, 1.8% had an experience of between 31 years and above.

Although Ruosteenoja et al. (2021) argued that climate change can be depicted over 30 years in an area, this study revealed that respondents' experiences depicted climate change through the effects on their daily livelihood activities. Given that most respondents (59.6%) had more than 10 years of experience, it is clear they understood the changes in the major weather elements in the coastal area, as they had adequate knowledge of the geological conditions along the coast, enabling them to manage their businesses well.

Table 2: Fishers' experience in fishing

Experience	Percentage	Total
1-10	44	40.4
11-20	36	33
21-30	17	15.6
31-40	10	9.2
41+	2	1.8
Total	109	100

Source: Field Survey 2023

Respondents' Perceptions of Climate Change from 1993–2023

The study examined the perceived climate change in the study area from 1986 to 2023. The findings revealed a noticeable shift in the main weather elements associated with changes in annual temperature, rainfall intensity, frequency of rain days, sea-level rise, direction of wind speed, direction of ocean currents, and migration of fish into a more distant area (Table 3).

Table 3: Relative Importance Index on the perception of climate change

Perceived Climate Indicator	RII	MEAN	SD	Rank
Migration of fish into distant areas	0.888	4.44	0.914	1
Change in the annual temperature	0.806	4.13	1.031	2
Sea-level rise	0.768	3.84	1.07	3
Intensity of rainfall	0.68	3.4	1.456	4
Frequency of rainy days	0.626	3.13	1.368	5
Direction and strength of the ocean currents	0.622	3.14	0.969	6
Direction and wind speed	0.582	2.91	0.996	8
Average	*0.710*	*3.57*	*0.541*	

Source: Field Survey 2023

The relative importance index was used to establish insights into the perceived importance of various climate parameters among fishers. The higher the RII value, the more crucial it is that the fishers consider that specific parameter in their perception of climate change as important. Thus, the findings clearly showed that migration of fish into distant areas is perceived as an extremely important indicator of climate change among fishers (88.8%). These findings concurred with those of Amoutchi et al. (2021), who found that a fisher usually relies on shifts in fish distribution as key indicators of climate change in marine ecosystems. This parameter likely stands out as a critical factor in their perception of climate-related changes, potentially significantly influencing their livelihoods by enabling them to catch more fish, which could serve as a source of income.

This was supported by a respondent in Ununio who had this to say:

"I am diving and reaching from 5 to 30 metres. The water is hot, and the ocean current is very warm and not as strong as the cold ocean current. However, I have found that from 50 to 60 metres, the water is very cold, and the ocean current is strong and extremely high. If the temperature is extremely high, it causes fish to shift to the deeper, colder ocean current; that is why other fish are not available."

Another indicator perceived as significant was the change in annual temperature, which increased by 80.6%. The overall change in temperature affects fish species distributions, interrupts fish activity levels, and influences fishermen's decisions about where to fish, whether in shallow or deep water. Moreover, it determines the timing of fishing and influences fish behaviour. Although the change in the annual temperature influences fishing activities, one respondent did not concur with the fact obtained from the questionnaire, as he reported, "*The temperature change was there since long time ago that change did not affect the fishing activity, the fishing activities has been affected with the increase of fishermen who uses poor tools in fishing and thus causes fishes to be obtained in a distant area*."

Based on the information obtained, temperature changes are not the sole factor affecting fishing activity in the study area. This deviation was based on the respondent's inadequate knowledge of how temperature changes could affect fishing activities. These findings, in one way, converge with the study by Prakash (2021), which demonstrated that temperature change is one of the key parameters that shape marine ecosystems and fisheries, thereby shaping their understanding of climate change, which in turn enables them to develop adaptive capacities.

Similarly, changes in wind direction and speed were perceived as having moderate importance for detecting climate change in the study area, as they contributed 58% to the overall perception. This findings concurred with Doe et al. (2019) as he revealed that the fishers in coastal communities often lacked awareness regarding the significance of monitoring wind direction and speed as indicators of climate change This variable had a moderate score since most fishers revealed that in most cases they experience variability in wind patterns, which change unpredictably and are influenced by factors such as the existence of heavy fog and rain light as well as the existence of many buildings excavated by

urbanisation. Moreover, in most cases, they used their indigenous knowledge and skills, such as observing birds' behaviour, the movement of clouds, and the rustling of leaves.

Effects of climate change on fishing activities

Climate change has several impacts on fishers, affecting their daily activities in one way or another. The study findings revealed that most fishers acknowledged the decrease in fish species catch as one of the effects of climate change, as reflected by 87.4% The decline in fish catch in the study area was caused primarily by a combination of factors that were not limited to human activities, such as poor fishing methods and environmental change, which manifested itself through changes in oceanic temperature and ocean currents. This is supported by Barage & Cochrane. (2018), Doe (2019), Worm and Lotze (2021) as they found out that warming waters have an impact on the distribution and abundance of marine species, which is one reason which causes a decline in fish species as well as causing fish to become in accessible to fishers.

Another prominent effect in the study area was the recurrence of fish migration and change in fish distribution, as reflected by 0.870. The respondents acknowledge the fact that climate change has caused temperature change, which affects the water temperature, which, in the final analysis, influenced the fish to migrate into a more suitable, conducive area and thus caused some fish to disappear.

Among the notable species which disappeared are the *red snapper, kingfish, kolekole, sehewa, vibua, ngogo* (the trunk fish), *mwatiko* (burning fish), and small fishes (dagaa). This finding, in one sense, aligned with Doe et al. (2019) and Whitfield et al. (2023), who observed that variation in water temperature and precipitation patterns has impacted fish migration and distribution, thereby affecting ecosystem structure, species, and fisheries management. The reason for the current study findings was that the observed climate change in the study area caused a shift in the strength, direction, and pattern of the ocean currents, as well as affecting the composition of the marine ecosystem and the distribution of plankton, which are the primary sources of marine organisms' food. Currently, the fish migrate and are widely distributed from their common origin zones to other zones due to the interaction of river runoff flowing towards the oceans. Such pollution has caused fish such as red snapper, kingfish, and lobsters to migrate into large volumes of saltwater.

Moreover, a decrease in fish population was another effect of the climate in the study area, as reported by 88.4% of the respondents**.** The decline in fish populations was attributed to changes in temperature, ocean acidification, and precipitation patterns, which, in most cases, are associated with long-term shifts in major weather elements. This causes some fish species to struggle to adapt to the changed weather pattern, which in the final analysis causes a decline in population size as studies support it coincided with studies conducted in Africa by Muringai et al. (2022) who supports the fact that rising of sea temperature, changing in precipitation pattern coupled has posed a significant decline in fish population since the change of those parameters has caused changes of water quality, habitant availability as well as food supplies availability (Table 4).

Table 4: Relative Importance Index on the impacts of climate on fishing

Effects	RII	MEAN	SD	Rank
Decreasing fish population	0.884	4.42	0.768	1
Decreasing fish species catch	0.874	4.37	0.747	2
Changes in fish distribution and migration	0.870	4.35	0.999	3
Changes in the reproduction pattern of the caught fish	0.862	4.31	0.8	4
Decreasing fish production	0.854	4.27	0.886	5
Potential catch reduction	0.848	4.24	0.866	6
Changes in the East and West Monsoons	0.810	3.82	1.077	7
Coral bleaching	0.744	3.72	0.996	8
Difficult to predict the fishing time	0.710	3.55	1.373	9
Difficult to predict the coming of a storm	0.654	3.27	1.37	10
Difficult to determine wind direction	0.506	2.73	1.49	11
Average	0.706	3.551	1.089	

Source: Field Survey 2023

Conversely, difficulty in determining wind direction has the smallest RI representation, with values of 50.6% and 65.4%, respectively. The finding is similar to those of Baffour (2024) and Johnson (2019), who found that fishers in Ghana had a limited understanding of wind patterns due to limited education, limited access to information, and reliance on traditional knowledge. Usually, the current study noted that most fishers tried to determine wind direction when it was blowing by using their sensory and observational expertise, such as the movement of clouds, the behaviour of birds, and the appearance of the water.

Hence, they identified four wind directions: Kus (south winds), Kas (north winds), Matrai (east winds), and Mwanashanga (west winds). They further revealed that strong winds (South Westerlies) usually blow from May to October, while kaska (North Easterlies) are prominent from November to February and from the end of May to June. On the other hand, the respondents also identified the slow winds as Matrai (easterlies) and Mwanashanga (westerlies), which occurred at unpredictable times or in March due to climate change.

Adaptation Strategies

Fishers are more vulnerable to the impacts of climate change on marine ecosystems, weather patterns, and fish behaviour because these changes affect their livelihoods. To cope with these challenges, they normally use various adaptation strategies. The findings from the study area revealed that changes in the fishing ground are highly used adaptation strategies among fishers, as supported by 80.4%

Fishers usually changed their fishing grounds to obtain suitable catches. Insisting on the importance of changing the fishing ground, one respondent reported:

> *"I have three months in this place from Unguja for finding fish to increase my income; also, other friends have gone to Lindi-Kilwa for fishing because in our place fish are not found due to the climatic change and unacceptable fishing by using bombs, and the government is supposed to follow up on this because we are getting difficult to travel by using tanga mashua to find in another area' 'this signifies that the fisherman usually move to nearby and far regions to obtain fish."*

The findings **of this study** echo those of Mulyasari et al. (2018) in Indonesia, who found that changes in fishing grounds and fishing times were among the strategies used by fishermen to cope with climate change. The change in fishing grounds in the current study was influenced by the fact that a fisher could obtain various fish species that were not available at their current destination.

Looking for information about weather and climate change was another significant adaptive mechanism used by the fisher, as it was acknowledged by 76.4% of the respondents. However, Mede et

al (2025) contend that the abundance of weather and climate information available through various sources could overwhelm individuals, thereby affecting their ability to make decisions and, in turn, leading to ineffective adaptation strategies. The current study contradicts these results, as it revealed that fishermen could obtain relevant information on climate change through mass media, such as television and the telephone, by listening to different radio programmes. The mass media usually disseminates information about climate change accurately and promptly, which, in the final analysis, enables the fisherman to make a clear decision regarding their activities and thus enhance their adaptive capacities.

A change in fishing time was also considered an important adjustment mechanism used by fishermen in the studied area, as acknowledged by 75.8% of the respondents. This finding obtained in the current study is more or less similar to the study conducted by Cheung et al. (2013), as they found that changing fishing time is one of the potential adaptation strategies to cope with climate change, since it enables the fishermen to align their activities with the availability as well as behaviour of target species. By adjusting to the fishing time, the fishermen were able to align their activities by projecting when the targeted fish species are more likely to be present in the fishing grounds, ensuring safe fishing for both the crew and the fishing gear (Table 5).

Table 5: Relative Importance Index on the adaptation measure

Adaptation measures	RII	MEAN	Ranks
Changes in the fishing ground	0.804	4.02	1
Looking for information about weather and climate change	0.764	3.82	2
Time fishing adjustment	0.758	3.79	3
Diversification of fishing gear	0.708	3.54	4
Adjust or replace the fishing gear used	0.632	3.16	5
Use of social networks	0.632	3.16	5
Plant mangroves or other coastal vegetation in coastal areas	0.57	2.85	7
Diversification of economic activities	0.544	3.12	8
Mobilisation of family members to work	0.534	2.67	9
Develop boats that are resistant to weather changes and big waves	0.52	2.6	10
Use of geo-information and communication technology systems such as GPS and Fishfinger	0.488	2.44	11
Increase knowledge and information about climate change through climate field schools early warning systems, and climate information network systems	0.484	2.72	12
Strengthening fishers' institutions for resilience to climate change	0.468	2.34	13
Build fishing settlements designed to anticipate sea-level rise	0.44	2.2	13
Build fishing settlements designed to anticipate sea-level rise	0.436	2.18	15
Targeting new fish species	0.37	1.85	16
Average	*0.572*	*2.9*	

Source: Field Survey 2023

Conversely, targeting new fish was perceived as the least important adaptation measure among the fishers, with only 37% acknowledging it. Area, as was suggested by Cheung et al. (2016). Thus, enabled fishers to maintain their livelihoods, exploit emerging opportunities, and increase their resilience to environmental changes in marine ecosystems.

Conclusions

This study reveals that coastal communities, particularly fishers, have noticed the changes and impacts of climate. It has also been confirmed that fishers have adopted several adaptation measures to kerb the situation. However, it is an undeniable fact that climate change will continue to affect the fishing industry, thus there is a need to formulate a vigorous policy which includes climate change adaptation training, flexible fisheries management, promotion of alternative livelihood supporting activities to

coastal people, as well as development of insurance and risk management programmes to enable the fishers to cope with climate change. Moreover, it should include recognition of climate change impacts as a transboundary issue that requires joint, coordinated efforts at the local, regional, or international level. Finally, there is a need to expand the number of climate change adaptation experts and practitioners to provide the necessary skills to save fishing communities.

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