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Assessing Small - Scale Fisher's Use of Traditional Knowledge for Climate Adaptation in Southern Coastal

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ABSTRACT

The study aimed to assess small-scale fishers' use of traditional knowledge for climate adaptation in Lindi and Mtwara regions located in the Southern Coastal areas of Tanzania. The study used a qualitative research approach wherein in-depth interviews, focus group discussions and observation were used to collect data. Climate change affects fishing activities since rainfall is suitable for fish fertility, whereas extreme temperatures make fish run to the deep sea after birth. Further analysis shows that the climate changes affect the seasonal cycle of fishing activities as they take place from time to time. The study findings also revealed changes in the availability of fishing species and fishing prices. Further analysis showed that coastal communities engage in different income-generating activities such as farming, small business, and livestock keeping. Also, other fishermen migrate from one area to another for fishing activities to find suitable places to fish. The responses from the Mnazi village revealed that the shortage of fish harvest affects the purchasing power of fishers, even to accommodate food purchases; hence, they opt for a reduction in the number of meals per day. The study recommends integration with formal systems of education. Policymakers also need to be sensitive to local contexts, which are important mechanisms for the continuity of knowledge systems; and for designing policies to protect TEK. Therefore, participatory methods, such as inclusive community-level media or outreach programs, should be designed and integrated into extension work for easier acceptability.

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CHAPTER ONE
INTRODUCTION

1.0 Chapter Overview

This chapter presents the general overview of the study. It begins with the background of the study, statement of the research problem, and then presents the research objectives both main and specific objectives. It also explains the research questions and the rationale of the study. The aim is to scrutinize the traditional ecological knowledge (TEK) as the small-scale fishers' adaptive practices in climate change context.

1.1 Background of the Study

Oceans have been a food source throughout history providing humans with multiple nutritional benefits (Willett et al. 2019). Many of the world's poorest families, communities, and countries rely heavily on seafood harvesting and other ocean resources for their income (Golden et al., 2016). However, the growing diversity of pressures on the marine environment, including climate change, jeopardize the security of these sea food production systems. Climate change threatens the ability of coastal resource-dependent communities to maintain sustainable livelihoods and achieve development goals. The least developed countries and small island developing states that are most dependent on fisheries to deliver most of their animal protein are among the most vulnerable (Barange et al., 2014). Due to climate change and variability, such coastal resources are increasingly facing degradation and management threats. The coastal zones of Tanzania, with a large and growing population and a low adaptive capacity due to low national wealth, are reported to be highly vulnerable to climate change and sea-level rise (Kebede et al. 2010). Changing weather patterns affect the distribution and range of species and these disrupt the natural balance of many ecosystems with implications for availability of fish and other coastal resources, including mangrove forests (Yanda *et al.,* 2019).

There are records of numerous initiatives in the literature about the use of Traditional Ecological Knowledge over the years. Such efforts have helped develop perspectives on the nature, form and content of TEK in various contexts and settings (Kaijage, 2021). Sustaining TEK systems have been a crucial element in terms of people's ability to cope with the changing environment (Workineh, 2007). However, like what is happening in many places globally, effectiveness of traditional knowledge is questioned because of the shifting nature of current ecological processes (Kirsty, 2009). In addition, the associated social and economic impacts of such knowledge cannot be easily discerned (Hart & Vorster, 2006); whose implication is that a broad understanding, and hence a concerted approach, is demanded in addressing them (Nyong *et. al.,* 2007). More importantly, there are issues concerning the content and nature of traditional ecological knowledge being handed down from one generation to another by mechanisms that are themselves evolving continuously with societal dynamics (Cole & Durnham, 2007; Nyong *et. al.* 2006).

Adaptation strategies differ in terms of effectiveness depending on the adaptive capacity of the community, organisms and social economic factors (VPO, 2013). At the same time, traditional ecological knowledge is captured when the knowledge holder joins a network or a community of practices (Goffin *et. al.* 2011). That is seen in traditional fishing systems where construction and use of traditional fishing techniques have for generations comprised perception of identity and continuity of people in some communities (Berkes *et. al*. 2000), whose ideas are passed on from one generation to another generation over time. There is evidence that, in some communities, local people have developed a wide array of coping strategies whereby their traditional ecological knowledge, including practices, provide an important basis for adapting to or mitigating potential impacts of climate change (Galloway, 2009).

The coastal zone, an area vulnerable to multiple stressors, is of societal and environmental significance and needs to be studied. Meanwhile, the linkage between climatic factors and household welfare in coastal and mainland fisheries can be understood by noting that such fluctuations ultimately translate into some form of income shock and consumption fluctuations. As a result, it is necessary to assess how local communities' traditional ecological knowledge has been used to adapt to the impact of climate change in supporting current and future generations' small-scale fisher livelihoods in Tanzania's southern coast. Therefore, it is important to establish whether the use of traditional ecological knowledge would enable people to adapt to climate change-related problems.

1.2 Problem Statement

Presently, about 40% of the world's population lives within 100 km of a coastline. Although climate change and variability are a global phenomenon, their impacts are mainly locally specific (Yanda et al., 2019). In the context of increasing uncertainties with respect to climate change impacts on natural and social systems (Hubert, 2019), adaptation will be essential at all levels to help affected or threatened communities or groups protect themselves and sustain their livelihoods (Beamount, *et. al* 2007; Martinez et al., 2011). Human beings gather knowledge basically for two purposes: survival and development. Understanding how people and societies acquire and use knowledge is essential for improving people's lives, especially the lives of the poorest (World Bank, 1998). Adaptation measures found worldwide are diverse and different from context to context and from country to country (Mulyasari et al., 2018). Barange *et al*. (2018) stress that adaptation responses in developing countries like traditional weather predictions, understanding of seasonal calendar, and traditional fishing methods, such as those in Mtwara and Lindi communities in Tanzania, often target small-scale and coastal fisheries and fishing communities. However, adaptation in developed countries is often focused on industrial and large-scale fishing and aquaculture operations.

Nevertheless, existing knowledge on current uses of TEK is also limited. Many studies have focused on content of traditional knowledge systems, but the social and economic context whereby such knowledge is produced seems to be of less interest (Semali &

Stembach, 1997). There is also inadequate qualitative data that has been systematically collected in Tanzania about the impact of evolving social and ecological processes on traditional knowledge practices. Therefore, in developing countries, understanding how communities or groups are adapting to the impacts of climate change at the local level is necessary to guide future adaptation strategies to best support threatened communities and groups (Parry et.al. 2007). As a result, the study aimed at *assessing small scale fishers' use of traditional knowledge for climate adaptation in Southern Coastal areas* to various communities to understand, experience, and conceptualize it in various ways for future planning and strategies.

1.3 Research Objectives

1.3.1 Main objective

The general objective of this study was to assess the traditional ecological knowledge in small-scale fishers' adaptive practices in a climate change context in southern coastal areas.

1.3.2 Specific Objectives

(a). To examine the influence of climate change in the seasonal cycles of primary fishing activities.

(b). To determine the way changes in the coupled ocean ecosystem, affect coastal households.

(c). To determine the uses of TEK in response to multiple stressors of climate change.

(d). To identify the possible enhancement of natural climate change mitigation mechanisms in the ocean.

1.4 Research Questions

(a). How did climate change influence the seasonal cycles of primary fishing activities?

(b). How do changes in the coupled ocean ecosystem affect coastal households?

(c). How did coastal communities use traditional ecological knowledge to respond to the multiple stressors of climate change?

(d). How best can we enhance natural climate change mitigation mechanisms in the ocean?

1.5 Rationale for the research project

Worldwide, the oceans provide a unique set of goods and services to society, including moderation of the climate, processing of waste and toxicants, provision of vital food and

medicine, and employment for a significant number of people. The coasts provide space to live and directly and indirectly create wealth, including millions of jobs in industries such as fishing, aquaculture, and tourism (Beaumont and Tinch, 2003). However, anthropogenic modifications of the biosphere have led to drastic global changes in the structure and functioning of marine food webs and, ultimately, in the productivity, stability, and resilience of marine ecosystems. Hence, the need for this study. The study aligns with Sustainable Development Goals (SDGs) 1, 13, and 14, which pledge to end poverty, take immediate action to reduce emissions, and conserve and sustainably use the ocean, in that order. Specifically, this study is relevant to the Tanzania Five-Year Development Plan (2021/22–2025/26) aimed at building a competitive and industrial economy for human development and strengthening the national capacity for addressing climate change adaptation and mitigation measures (URT, 2021). The study was intended to shed light on how climate change has impacted fishermen and how they have adapted to those changes. Hence, the study is designed to facilitate the incorporation of mitigation measures into strategies that can be enhanced and integrated into policies and development programs. In this way, this study contributes to the reduction of hunger and food shortages as the number of people suffering from hunger increases, for which the World Food Program (WFP) (2020) estimated in May 2020 that 270 million people were facing food insecurity and would need food assistance in Tanzania.

Secondly, this study provides an opportunity to understand and document traditional ecological knowledge as well as coastal households in the context of climate change. Hence, it contributes to the growing body of literature concerning climate change and the living conditions of the fisherman's household in general. Specifically, the findings from the study will be published in the relevant scholarly journal, such as Frontiers in Marine Science or Nature, hence becoming a source of reference for further studies on the subject.

CHAPTER TWO
LITERATURE REVIEW

2.0 Chapter Overview

Chapter two presents a review of different literature related to this study. The review is composed of the following sections: the significance, the nature and the relevance of traditional ecological knowledge in climate change. The reviews include various theories relevant to the study of TEK on adapting to climate change. Attention is also given to theoretical propositions and perspectives propounded by social constructivists and how they could be used to understand the subject matter of TEK in adapting to climate change. The chapter concludes with an account of recognised research gaps and a synthesis of the reviewed literature.

2.1 Significance of TEK in Climate change

Climate change (CC) is still a contested issue in the scientific, political, economic and social arena (Carvalho, 2003). It is a long-lasting change in the weather arrays across tropics. It is a global threat that has put stress on various sectors (Abasi *et al.,*2022). CC is an inter-governmental complex challenge globally with its influence over various components of the ecological, environmental, socio-political, and socio-economic disciplines (Leal Filho et al. 2021; Feliciano et al. 2022). It involves heightened temperatures across numerous worlds (Schuurmans 2021). Climatic conditions affect almost all aspects of human society and well-being, including where people make their homes or the way they make a living, mobility patterns and what people do for recreation.

Climate change has caused substantial damage, and increasingly irreversible losses, in terrestrial, freshwater, cryosphere, and coastal and open ocean ecosystems (high confidence). Hundreds of local losses of species have been driven by increases in the magnitude of heat extremes (high confidence) with mass mortality events recorded on land and in the ocean (very high confidence) (IPCC, 2023). Being heavily dependent on natural resources for its peoples' livelihoods, and with fewer capacities for mitigation as well as adaptation, Africa has become the most vulnerable of all regions to climate change and it has frequently experienced natural disasters such as drought and floods that heavily impact on agricultural systems dependent on rainfall. Regions and people with considerable development constraints have high vulnerability to climatic hazards. Increasing weather and climate extreme events have exposed millions of people to acute food insecurity and reduced water security, with the largest adverse impacts observed in many locations and/or communities in Africa, Asia, Central and South America, Small Islands and the Arctic, and globally for Indigenous Peoples, small-scale food producers and low-income households (IPCC, 2023).

This situation necessitates the continent to consider taking various measures in its strategy for adaptation, including assessing current uses of TEK. This is because traditional knowledge are foundational systems within which most indigenous populations operate (Bwambale, 2020). It evolves from generations of experience - a base that is incomparable in terms of the depth, breadth, and holistic perspectives that it provides for a given ecosystem. Through the depth, breadth, and length of documented TEK, there is a wealth of information that provides models that Western science cannot reach through Western science approaches alone *(*Bwambale,2020*).* The local interaction is based on experiences and observation of the environment and has

already been used for several generations. Hence, knowledge transfer practices continue to be an important resource, especially for local-level decision-making in all aspects of life, including agriculture, health care, food security, education, natural resource management and a host of other community activities (Çakmakçı, et al., 2023). Traditional knowledge and practices developed over time have been used to provide practical solutions in dealing with the impacts of climate change (Chikonzo, 2006). In this regard, this study has used TEK of climate change to develop an understanding on how communities rely directly on environmental resources in their areas to deal with impacts of climate change, which has had negative effects on their livelihoods.

Studies on TEK have illustrated the way it has been a valuable component in the continuity of community value systems, but it is also dynamic. For example, some of the studies have established that TEK is not static because it changes and improves over time, whereby people incorporate new tools, skills and knowledge (Jain, 2005; Mazzochi, 2006). Thus, it is experienced in terms of either the decline of certain practices or the incorporation of different methods into the knowledge system, depending on demand. This dynamism can be witnessed in several aspects of life in communities, such as their relationship with biodiversity, faith, dwellings, marine, agricultural or other day-to-day practices (Jain, 2005). In asserting control and direction over their lives to safeguard social structures, communities applying what is termed 'informal science' have been known to utilise knowledge, practices, skills and tools that have been developed over the course of centuries (Rugumamu, 2003). Local communities do not remain silent while they are hit by climate change impacts. They develop ways to cope with the situation, and the new knowledge they develop, which is of value and relevant to other members from the community, is taken up and integrated into local practices that may become traditions (Hart and Vorster, 2006).

An example can be seen in fishing communities, whereby the skills for constructing a traditional fishing tool such as the fish trap (*dema*), is one such traditional practice whose maintenance in the contemporary world has been through apprenticeship of younger fishers to older experienced fishers. It is through such cases that Berkes *et. al.* (2000) noted that the sustainability of "traditional knowledge" depends mostly on its generational transfer, which means that without intergenerational knowledge transfer, no "traditional" ecological knowledge will persist.

2.2 Relevance of TEK in Climate Change

The relevance of traditional knowledge in addressing environmental and livelihood problems confronting coastal communities has also been widely studied in relation to challenges brought about by climate change. This is because one cannot adequately assess TEK without reviewing its existence. This section scrutinises TEK practices that deal with weather forecast, rainfall shortage, floods and other disasters caused by climate change to elaborate on the understanding of adaptation strategies of coastal communities towards climate change vagaries.

Currently, climate change is one of humanity's most pressing challenges in the 21st century (Mertz *et. al.* 2008; Odada *et. al.,* 2008; Liwenga *et. al.,* 2007), and its impact is mostly felt in developing countries. In Africa, and Tanzania in particular, it has affected not only local communities but also key sectors of economic development such as agriculture, water resources, health, forestry, livestock, wildlife and biodiversity (Mertz, *et. al.* 2008; URT, 2007). As many local people in developing countries depend on

fishing, hunting and agriculture for their survival, climate change considerably affects almost every economic activity they engaged in. Likewise, as foods, medicines, fuels and habitats are disappearing, small communities suffer hardships while at the same time local cultures, traditions, and languages are facing major challenges to their development (Kirsty, 2009). Other literature on TEK and climate change shows that climate change/variability leads to increased frequency of floods, droughts, storm surges, a rise in sea levels and other severe weather-related phenomena (Yanda *et. al.,* 2019). The impacts of climate change affect more seriously the poor and marginalized communities compared to other segments of the population.

Further analysis discloses that climate change is also difficult to manage given the fact that environmental issues often result in difficult trade-offs and political conflicts. This is because resolving them requires limiting some economically productive activities or technologies causing unintended environmental harm (Dessler & Parson, 2010). Yet, its unavoidable aspect has caused narratives of climate change to be a central component of development discourses and negotiating global challenges. Recall, this is because climate change is one of humanity's most pressing challenges in the 21st century (Mertz, *et. al.* 2008; Odada *et. al.* 2008; Liwenga *et. al.* 2006). Its adverse impacts are now evident in many parts around the world, with the least developed countries being the most vulnerable.

Based on foregoing, impacts of climate change affect the poor and marginalized communities more seriously compared to other segments of the population. Scholars have argued that climate change cannot be divorced from sustainable development, because this may be the most effective way of framing the mitigation question and a crucial dimension of climate-change adaptation and impacts (Swart *et. al.,* 2005). For example, climate change is impacting fish migration patterns thereby affecting fish recruitment and stocks in traditional fishing sites, especially for artisanal fisher folks. Sedimentation in freshwaters is negatively affecting fisheries in freshwater bodies, for example, by destroying breeding and feeding sites. This problem is aggravated by drought and frequent floods resulting from climate change (URT, 2012).

Incorporating traditional knowledge in climate-change policies could lead to development of productive mitigation and adaptation strategies that are cost effective, participatory as well as sustainable (Robinson & Herbert, 2001). In the Sixth Assessment Report of the IPCC (IPCC, 2023), it was reported that deep, rapid, and sustained mitigation and accelerated implementation of adaptation actions in this decade would reduce projected losses and damages for humans and ecosystems and deliver many co-benefits, especially for air quality and health. Delayed mitigation and adaptation action would lock-in high-emissions infrastructure, raise risks of stranded assets and cost-escalation, reduce feasibility, and increase losses and damages. Feasible, effective, and low-cost options for mitigation and adaptation are already available, with differences across systems and regions. There is now increasing appreciation by policy makers on the need for understandings on the local perceptions of climate change, its problems and solutions (Feign et al., 2023). The rich and detailed TEK reflects and embodies a cultural as well as spiritual relationship to land, ocean and wildlife. However, it also reflects knowledge used by many local communities whereby most of them depend on it to cope with the changing environment.

In explaining the linkage between TEK and climate change, Adugna (1996) pointed out that traditional knowledge adds value to climate change studies in different ways. First,

traditional knowledge identifies a person in a cultural context and therefore, provides for the decision-making process or rule of thumb to be followed, based on observed indicators or relationships between events (*ibid.*). People's behaviour has been impinged on by the context in which they live. Second, traditional knowledge is increasingly exhibiting resemblance to scientific methods because many ideas in traditional knowledge that were once regarded primitive and misguided are now seen appropriate as well as sophisticated. Third, traditional knowledge systems provide a mechanism for participatory approaches.

Lastly, traditional knowledge systems can facilitate understanding and effective communication between people and increase the rate of dissemination including utilization of climate change mitigation and adaptation options (Adugna, 1996). It means that local communities from all regions around the world have an identity and culture that depend on the natural environment (Galloway, 2009). In a situation where farming systems have become increasingly vulnerable to climate change effects, Philippart *et. al.* (2011) argue that traditional ecological knowledge has the potential to enhance small-scale farmers' capacity to mitigate or reduce impacts of climate change such that its value needs to be promoted, especially among the younger generation.

Correspondingly, many proponents contend that TEK is used to solve various problems associated with the environment. A good example is what is observed by Kihupi*et. al.* (2002) that the use of traditional knowledge for forecasting an extreme weather event is well-known and is used by most farmers in Africa. Such forecasting system has been largely helpful to farmers in managing their vulnerability (Mwaura, 2008; Kihupi*et. al.* 2002), and they can access information before the next season. A study by Orlove, *et. al.* (2009), in southern Uganda, observed that local indicators such as increased night temperatures, a shift in direction of prevailing winds, flowering of trees, especially coffee trees, and arrival of migratory birds are signs that most people use to predict the starting of rainfall. It was also observed by Mhita (2006), in Morogoro region of Tanzania, where sprouting of '*KiaziKikuu*', a *Diascorea yam*, 'Myombomkuu' an *old brachystegia* tree found in Gongo village, as well as flowering of *wege*, a bulbous underground stem in November, signal the start of rainy season.

Moreover, a study by Liwenga (2003) in central Tanzania revealed that local people in Mvumi village in Dodoma region use indicators such as fog, fruit trees and wind to forecast rainfall. Appearance of fog, known locally as *hungulyosi*, on the mountains surrounding the village in August/ September is an indicator of good rains. Meanwhile, if baobab and mango trees produce many flowers and fruits, it is regarded as an indicator of insufficient rain. Frequent winds during daytime resulting in whirlwinds and dusty conditions known locally as *chifulafumbi*, in August/September is associated with good rains, and starting of rains in November is regarded as a sign that there will be adequate rainfall. If the first rains only fall during daytime, then speculation is that the rainfall period is likely to be short (*ibid.*).

However, climate change is critically changing the relevance of these indicators since natural signals that were used to trigger activities during the past are now less reliable, and the indicators used are important tools in illumination of transfer of TEK now

provide the alarm on its fading. This is due to the fact there is direct correlation between natural indicators and traditional ecological knowledge transfer.

A study conducted in Tanzania, Kenya, Swaziland and South Africa recognizes the value of TEK for national development and claims that much of it has not been documented in written form such that it is in danger of being lost (UNEP, 2008). In due regard, understanding how intergenerational transfer of TEK happens is vital because in the light of social, economic and cultural changes that are happening in society, threats to sustainability of such knowledge is increasing, especially so because of its undocumented nature. How such information will be useful for dealing with climate change effects is the main subject of this study.

2.3 Theoretical Framework

Several perspectives have been utilised to help explain and understand the issue of traditional knowledge in the climate change context. The most common versions used in this study are the social constructivist perspectives.

2.3.1 Social Constructivism Theory

Social Constructivism theory claims that all human knowledge is developed, transmitted and maintained in social situations (Berger and Luckmann, 1991). It means that knowledge arises from people's social, cultural and historical experiences (Thomas, *et. al.* 2014). There is no neutral, objective and absolute or value-free knowledge. Knowledge must be embedded in people's cultural, social and political lives and usually flows from ideological assumptions shaped by factors such as gender, class, ethnicity, language and religion (Dei, 1996). Knowledge puts skills learnt into practice and experience is brought to bear on a specific matter on a specific occasion (Hobart, 1993).

Social constructivists emphasize on the importance of culture and context in understanding what occurs in society and constructs knowledge based on this understanding (McMahon, 1997). There are observable differences between societies in terms of what is taken for granted as knowledge to them (Berger and Luckmann, 1991). TEK, as a knowledge system, also develops within its own cultural contexts, having meaning for the people who construct it. Local people have their knowledge on how to adapt in different situations that arise in their communities. Knowledge on weather predictions, soil conservation, storage facilities and drought-resistant crops are some of examples, whose practice is informed by traditional knowledge.

According to Social constructivists, reality cannot be discovered, and it is constructed through human activities ((Berger and Luckmann, 1991; Dei, 1996). Therefore, knowledge is a human product and is socially as well as culturally constructed. Individuals create meaning through their interactions with each other and with the environment they live in (*ibid*.). In this sense, knowledge acquisition is a social process. It neither takes place only within an individual nor is it a passive development of behaviours that are shaped by external forces (McMahon, 1997). Meaningful learning occurs when individuals are engaged in social activities and/or practices (Hobart, 1993). For example, the youth learn about fishing techniques as they engage in farming and as they continue practicing it in their daily activities, to internalize it in their minds and live

by it. The same is applied to weather prediction where a person needs to know situations where there is shortage or sufficient rainfall to carry out proper timing for farming seasons and this becomes part of the daily life.

Certainly, the theory has its strength in relation to this study. First, its contention that traditional practice does not exist within a vacuum but in social, historical and cultural contexts, implies that certain understanding stances are possibly shared and applied in particular social contexts including, certain age groups because of socio-cultural constructions of reality by the concerned people. As observed in the study, TEK is reflected by specific surroundings and social circumstances of the area. Throughout experience, people construct knowledge to fit with their environment. They construct knowledge as they interpret their socio-economic and environmental situations. Hence, the TEK experiences among small scale fishers are embedded in the socio-cultural and environmental problems.

At the same time the constructivist perspective gives an indication that people's constructions of their reality may change because of dynamics of social contexts. People create meaning in response to the particular social context existing in the specific time. This implies that knowledge systems or meanings are constructed according to or by generations in changing time frames, and hence, social contexts. If the context changes, the meaning also changes, in response. These ideas were reflected by Boellstorff*et. al.* (2012), who contended that to understand any people's action, one must recreate the entire picture of its life's ways, habits, needs and peculiarities of land and the sky above it, which informs what one does. The same applies to understanding of different generations such that one must be familiar with circumstances, which make people act in a certain way. It is in such circumstances that different ideas about the environment arise.

Hence, the likelihood that certain generations may have contrasting views about certain ideas on society becomes an outcome of changes in social contexts. This is usually a result of different experiences or encounters with nature or having different sources of information about the environment. The changing conditions of nature overtime also allow people at different times to give diverse accounts about nature. The same understanding was advocated by Weber (1976), who explained that human existence is interpretive of life around him /her because it flows by in time. That means people need to observe and see the features/transpires in their specific circumstances of time and place. Weber's (1976) conceptualization of the ideal type gives an example of how people construct certain mental images about their society or certain social phenomena and how such ideal types could be seen as systems, which unify certain historical relations and events in a non-contradictory cosmos of thought interconnections. The ideal type is constructed by historical circumstances and reflects the way communities apply their experienced facts based on values and norms of the society.

Another important contention from this theory is its argument about the nature of knowledge production, which develops when community members interact with more knowledgeable members of society. Traditional knowledge is distributed variedly in communities based on factors such as gender, age, class, position, residence location,

political affiliation, ethnicity and religion (Sillitoe, 1998). It implies that in every society, there are certain people who are more knowledgeable than others by virtue of their positions as repositories on certain knowledge about society and life. In many cases, traditional medicine practitioners, for example, would be highly informed on certain natural sources to treat common ailments, but also how such sources are changing in their availability. Without social interaction with such knowledgeable persons, it is impossible to acquire experience because people seem to greatly work through a certain body of practices that enables them to know how to do things and even react to changes when they occur.

From this perspective, it can also be seen how the same knowledge aspects can be understood and perceived differently among community members. Such patterns may be a result of poor levels of interaction between elders and the youth, which creates a gap in the knowledge transfer system. Another reason may be miscommunication between different groups of the youth, a situation which develops when part of the youth remains active in cultural practices or engaged with the youth but fails to transmit information adequately to other groups of the youth in the same community. As a result, knowledge systems remain patchy and may not be readily usable for addressing societal needs.

The social constructivist perspective can also be applied to understand how the existence of fresh contact creates a gap in understanding about the environment between the youth and elders. Such gap results in changes in knowledge, skills, behaviour and attitude as youth start afresh to reflect on the needs of their generation. Individuals use new information and knowledge to make sense of existing practices and how the meaning of new knowledge may change because of changes in individuals existing knowledge base, and how one strives to gain relevance of the new knowledge to existing practices (Thomas *et. al.* 2014). The scenario can lead to complexity of having two or more bodies of knowledge application in the same communities on knowledge contents, but also loosening another important content that can be useful for future. Such situation is not explained adequately enough in the perspective, and it is, hence, treated as a shortcoming of the perspective.

Finally, it can be argued that knowledge constructed in society depends on social distances that determine interactions among community members, their perceptions on knowledge being constructed, and strengths of culture of a particular community. That means, if there is frequent contact between community members, and in the case of TEK among youth and elders, it reflects on the knowledge construction taking place among all fishing communities of both ages as they are involved in different social interactions. On the other hand, a gap in communication interaction especially from elder to youth, reflects on the existence of a knowledge gap, and it becomes difficult for knowledge transfer to take place.

2.4 Other Relevant Studies on TEK

A study by Mwiturubani (2019) on the Impact of Climate Variability and Change on Communities' Access to and Utilization of Coastal Resources in Pangani District, Tanzania focused on understanding the impacts of climate variability and change on

coastal resource governance, communities' vulnerability and livelihoods security in the district. Specifically, the study aimed to assess the effects of rainfall and temperature variability and change on coastal resource. The study does not focus on small scale fisher's adaptation strategies by using TEK. Also, Makame and Mwevura (2019) conducted a study in Zanzibar about Vulnerability and Adaptation Strategies of Coastal Communities to the Associated Impacts of Sea Level Rise and Coastal Flooding. Findings show that rice farmers in Pemba were highly exposed to sea level rise and coastal floods. They mainly based on farmers adaptive strategies and not small-scale fishers' as intended by this study.

Further study about Poverty Levels and Vulnerability to Climate Change of Inshore Fisher Mangrove-Dependent Communities of the Rufiji Delta, Tanzania by Mung'ong'o and Moshy, 2019) revealed that, despite differences in wealth status, community members of the study villages generally shared similar socio-economic characteristics and were thus anticipated to be impacted in similar magnitudes. The study does not emphasize on TEK adaptation mechanisms which is the endeavor of this study. Misana and Tilumanywa (2019) assessed the Vulnerability and Response of Coastal Communities to Climate Change Impact in Lindi Region, Southern Tanzania the main objective of this research was to provide an understanding of how the coastal communities are changing in their vulnerability to climate change and how the livelihood systems are adapting to the change and the implications on coastal resource use, governance and management. The study also, does not concentrate on TEK adaptation strategy. Lastly, Liwenga et al., (2019) study on the Coastal Communities' Perceptions on Climate Change Impacts and Implications for Adaptation Strategies in Mtwara, Southern Tanzania. This study aimed at identifying pathways to reduce vulnerability and enhance resilience of livelihoods of the concerned coastal communities. Common impacts included destruction of coral reefs, coastal erosion, destruction of coastal infrastructures and human settlements. However, the study was not concentrated on TEK adaptive mechanisms to the climate change impacts.

2.5 Knowledge Gap from Existing Studies

The need for traditional ecological knowledge and its adaptation to climate change context has been addressed in various studies as documented above. Chikonzo (2006) explains that cultural continuity lies in the preservation of traditional ecological knowledge and its transfer to future generations. Researchers are, however, increasingly seeing that the situation is changing as decision makers in developing countries are seeing more and more examples of how traditional ecological knowledge can be put into good use (Nawe & Hambati, 2014). They are beginning to realize that traditional ecological knowledge is the largest and single most powerful asset that many developing countries possess but have not yet mobilized it for sustainable development (Hambati & Rugumamu, 2005). For example, traditional tools used by certain communities for clearing bushes and for farming, such as the hand hoe, are still in use where the terrain does not permit modern technologies such as tractors to be used, and the traditional soil erosion control technique of constructing ridges is still applied as demanded in certain areas (Nawe & Hambati, 2014). These studies indicate that even

in a context where technological development helps people to control nature, traditional knowledge should not simply be seen as redundant.

The current study aimed to contribute to the global debate on the ongoing efforts by many scholars towards integrating TEK into the formal knowledge system and its complementary value in mitigating the changing environment and fishers' communities. Current communities are facing many environmental challenges, of which effective adaptation options are of urgent attention. Equally important, this study contributes to the knowledge towards addressing drought and household food security. This is because local knowledge is being excluded in environmental management frameworks of which it has a key role, and the users are also key stakeholders. This study assessed the adaptation strategy to climate change impacts among small scale fishers in southern coastal regions of Tanzania.

2.6 Chapter Summary

The chapter has provided a detailed and critical account of major issues embodied in relevant variables, theories and frameworks required for a better understanding of the dynamics surrounding the TEK. Specifically, the chapter has discussed relevant literature on TEK and adaptation to the effects of climate change. In the chapter, different TEK practices used to address climate change related problems in African societies and Tanzania have been discussed. The details in the discussion are based on examples from different parts of Tanzania and Africa in general, and they include a review of perspectives from various sources about traditional knowledge system.

Furthermore, the chapter has attempted to provide a critical appraisal of the climate change situation drawing examples from parts of Africa, the World in general, and its effects on the wellbeing of people at households, and national levels. In developing the framework for a critical analysis and broader understanding, the study discusses the perspective of social constructivism in relation to traditional ecological knowledge, and in adapting to climate change challenges that guide the main theme for this study. Finally, from reviewed literature, the chapter also underscores the research gap in related studies, and on which explanations offered with the support from different literature have helped facilitate this study to fill in some of the gaps.

CHAPTER THREE
RESEARCH METHODOLOGY

3.0 Introduction

Chapter three describes how the research inquiry and analysis of the collected data were carried in the reported study. It highlights the methodology employed, its rationale, data analysis methods and ethical considerations. The chapter therefore focuses on nature of data collected, how the data was collected and the justifications for the choice and use of the methods. The chapter also provides the rationale for choosing both the study area as well as the communities and shows its relevance to the objective of the study in understanding the TEK in small-scale fishers' adaptive practices in a climate change context with southern coastal areas as a case study. Finally, issues about trustworthiness of the process as well as ethical considerations are presented.

3.1 Research Approach

The qualitative approach has been useful for this study because it enabled community observations accompanied by in-depth questioning about settings and activities of participants to the study regarding how TEK in small-scale fishers has been used as adaptive practices in a climate change context. Furthermore, the approach provided opportunities for recognizing trends and themes as well as collecting supportive empirical materials including reports of personal experiences, and from interviews related to TEK in adapting to climate change and overcoming CC related challenges. Thus, the approach enabled both the elderly and youth to highlight their views on TEK practices.

This study adopted the qualitative research approach to give emphasis to local meanings attached to TEK. The view that social reality is constructed by individuals who interact and make meaning of their world in an active way was applied as a key aspect in data collection and analysis. A qualitative study was chosen because it offers that extra mileage for providing a deeper understanding of complex issues underlying the contexts within which the system of TEK and practices is pursued. The study took the position that, by virtue of being part of the natural and social setting of the research, it will be easy to understand perceptions on the setting and activities of participants under review, hence provide the research with an opportunity to gain sensitive insights into multiple realities, experiences as well as interactions of individuals and groups, by allowing participants to be heard (Krzyzanowski, 2008).

3.2 Research Design

A research design in general, sets the foundation and selection of strategy, methods and techniques to be employed in determining data collection methods, sampling procedures and organisation of the presentation. The research strategy is determined by methods and nature of data to be collected (Henning *et. al.* 2004). This study employed a case study research design. Yin (2003) and Patton (2002), recommend use of qualitative case study in studies that seek to understand complex issues, investigate

a contemporary phenomenon in its natural settings and in programme evaluation, where the objective is to answer the questions; what, why, where, and who, for critical examination of an event or theory.

The case study research design further allowed the researcher to employ multiple data collection methods to gather information from various sources in the research area. Also, it included focusing on the "how" and "why" questions/issues to understand the nature and complexity of processes taking place (Cepede & Martin, 2005); such as how TEK in small-scale fishers have been used as adaptive practices in a climate change context within southern coastal areas.

In compliance with the above approach, the study in the form of an evaluation, first geared towards examination of how TEK in small-scale fishers have been used as adaptive practices in a climate change context. This included investigation of how did climate change influence the seasonal cycles of primary fishing activities; how do changes in the coupled ocean ecosystem affect coastal households? how did coastal communities use traditional ecological knowledge to respond to the multiple stressors of climate change; and how can we best enhance natural climate change mitigation mechanisms in the ocean? Secondly, the study also carried out critical analysis of the views received from different groups (youth and elders) about the TEK transfer, and which for purposes of reliability had to be considered with an understanding of their contexts.

3.2.1 Philosophical orientation of the qualitative case study

The qualitative paradigm is guided by the subjective and interpretative stance to confirm the argument that reality is both relative and socially constructed (Bryman, 2008; Robins, 2004). Guba and Lincoln (1989) outline five assumptions, which underpin the constructivism approach: First, truth is a matter of consensus among informed instructors. Second, there is no objective assessment of a social phenomenon. Third, a phenomenon can only be understood in a given context. Fourth, any social construction represents the perspective and interest within a given context and finally, any social construction represents the perspective and interest of its creators (*ibid.*). This study employed relativist (ontology), subjectivist (epistemology), and hermeneutic stances to examine the underlying factors for applying TEK in climate change context by analysing views of the elders and youths.

3.3 Study Area

This study was conducted in Mtwara and Kilwa districts in Mtwara and Lindi regions respectively. Specifically, the study was conducted in 2 villages, i.e., Mnazi village in Mtwara rural and Kilwa Kivinje in Kilwa district. Kilwa District is one of the six administrative districts of Lindi Region in Tanzania. The district covers an area of 15,000 km^2 (5,800 sq mi) (Kilwa District Profile, 2022). The district is comparable in size to the land area of the nation state of East Timor. Kilwa district is bordered to the north by Rufiji District in Pwani Region, to the east by the Indian Ocean, to the south by the Lindi District, Nachingwea District together with Ruangwa District, and to the west

by the Liwale District. The district borders every other district in Lindi Region except Lindi Municipal District. The district seat (capital) is the town of Kilwa Masoko. The district is named after the medieval Swahili city state of Kilwa Kisiwani. According to the 2012 census, the district has a total population of 190,744.

Mtwara District is one of the five districts of the Mtwara Region of Tanzania. It is bordered to the south by Mozambique, to the west by the Tandahimba District, to the north by the Lindi Region and to the east by Mtwara-Mikindani District and the Indian Ocean. In 2016, the Tanzania National Bureau of Statistics report that there were 132,329 people in the ward, from 228,003 in 2012 before split of Nanyamba Town Council is 2014.

Selection of Kilwa District as part of the study area was influenced by the following strategic factors: To begin with Kilwa, fishing plays a big role in the economic activities of Kilwa district. 4.5 million tons of fish are harvested annually with over 1700 registered fishermen using 600 vessels in the district. Mtwara district is home to the Mnazi Bay-Ruvuma Estuary Marine Park that is one of the largest marine parks in the country.

Figure 1: A map of Mtwara district showing the study area.

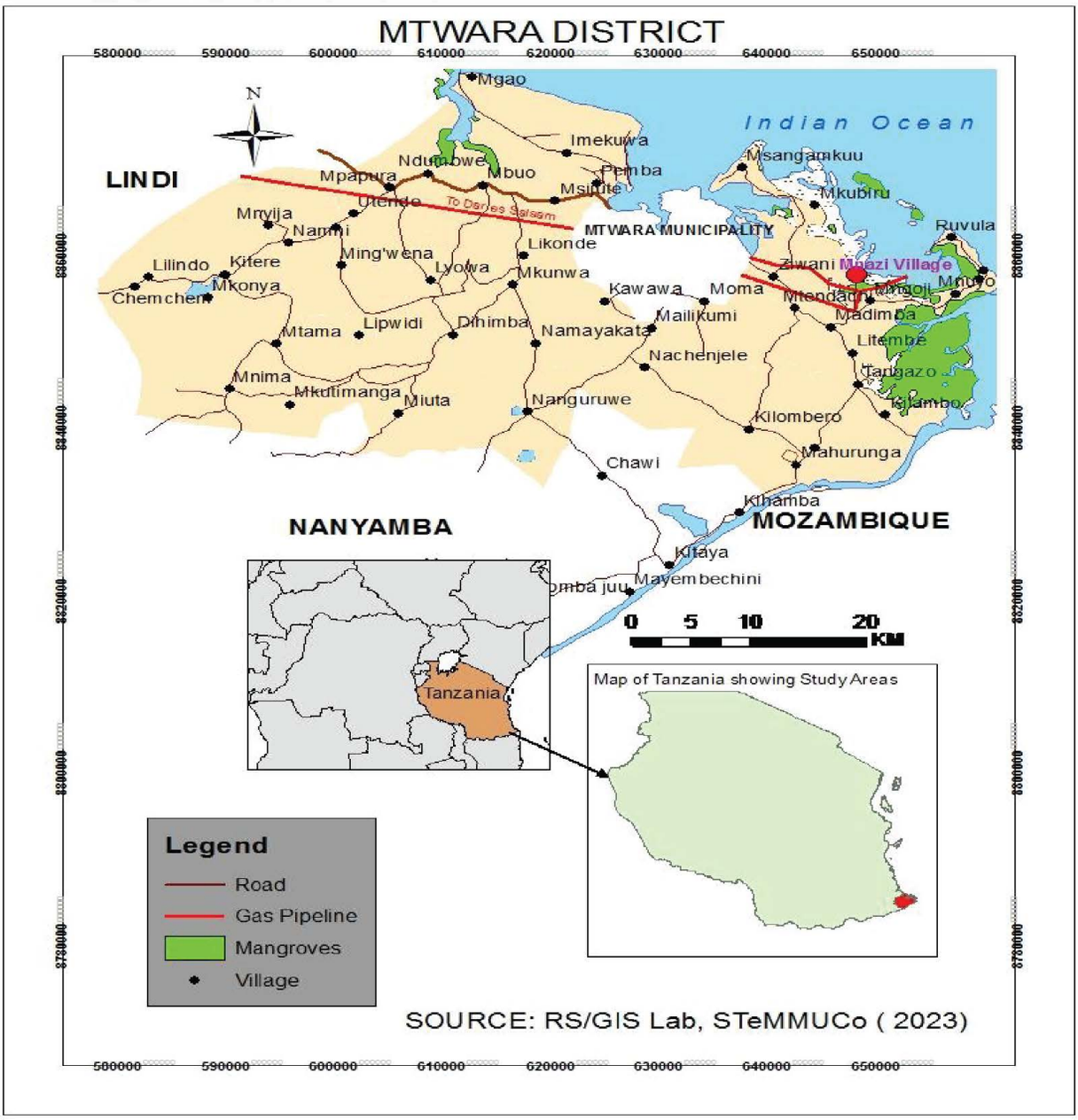
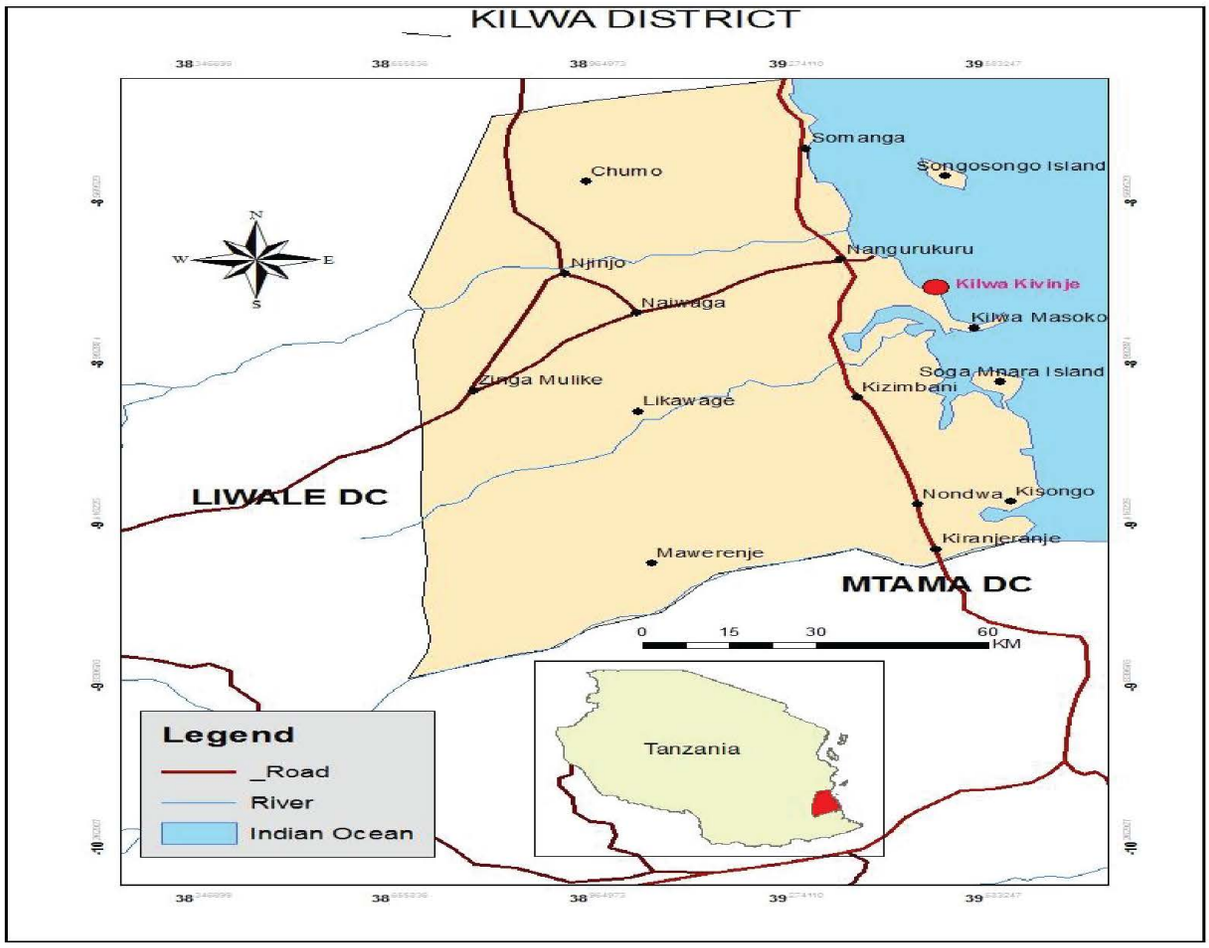


Figure 2: A map of Kilwa district showing the study area



3.4 Sampling Procedures

Sampling procedures applied included both the purposive and snowball sampling to select the various participants to the study basing on characteristics matching the criteria for selection. From records available in the village administrative offices, purposive sampling was used to identify participants for Focus Group Discussions (FGDs), and key informants for the key informant's interviews. The village leaders - particularly the village chairpersons, Fisheries officers and Village Executive Officers (VEO) assisted the research in selecting respondents who would provide detailed and reliable information on the topic under study.

The FGD participants were selected and grouped according to gender and age with the intention of minimizing any cultural constraints, which may have influenced people's ability to communicate freely in the discussions. In each village, three FGD sessions were conducted involving five people with common characteristics of either age or sex and residence/origin.

Table 1 Distribution of FGD participants in study villages

Village	The Distribution of Participants in FGDs in their Respective Age Group			
	Youth	Middle age	Elders	Total
Mnazi	10	10	10	30
Kilwa Kivinje	10	10	10	30
Total	20	20	20	60

Source: Field Data, (2023)

Thirty participants to Key Informants' Interviews (KII) were selected in each village by using the snowball sampling procedure, which targeted people who could provide detailed information about the subject. Selection of local individuals for key informants' interviews (KII) considered characteristics in social differences particularly age, gender and origin. The participants included ten elders (64 years old and above), ten middle-aged people (30-50 years) and ten youth (below 30 years). The interviews were carried out in each village.

Table 2 Distribution of key informants for key informants' interviews from selected villages

Village	Youth	Middle Age	Elders	Total
Mnazi	10	10	10	30
Kilwa Kivinje	10	10	10	30
Other Officials				5
Total	20	20	20	65

Field Data (2015)

3.5 Data Collection Methods

For reliable information to support the research, and in line with the assertions by Kombo & Tromp (2006), that construction of a research instrument or tool for collecting data is the most important aspect of a research project, and that research instruments can reflect validity and precision of data (*ibid.*) the objectives in the applied data collection methods were focused on (1) examining the influence of climate change in the seasonal cycle of primary fishing activities, (2) determining the way changes in the coupled ocean ecosystem affect coastal households, (3) determining the uses of TEK in responses to multiple stressors of climate change, (4) identifying the possible enhancement of natural climate change mitigation mechanism in the ocean. To achieve these objectives, data collection was from both primary and secondary sources, which are: in-depth interviews, documentary reviews, and Focus Group Discussions.

3.5.1 Documentary review

Through documentary sources both published and unpublished, secondary information was collected to enrich data required for this study. Among the main sources of secondary data were historical texts on people and communities of Mtwara and Kilwa districts, literature on environmental changes in Tanzania and reports of the Tanzania Meteorological Agency (TMA) from which rainfall and temperature patterns were drawn. Such type of information is very useful for comparative analysis of both temporal and

spatial variability of the reported findings to validate results. Also, data related to traditional knowledge, weather patterns, traditional leadership and the socio-economic as well as cultural profile of the area were obtained from Kilwa districts, and the Jordan University College Library. The secondary data sources were used to supplement data obtained from the local communities about TEK. This includes background information and empirical evidence on what is already known concerning the research topic.

3.5.2 Interviews

3.5.2.1 Key informant's interviews

Key informants' interviews (KII) in this study were aimed at getting beneath the surface of superficial responses to obtain the meaning that individuals assign to events and to understand complexity of their attitudes, behaviour and experiences (Bowlings, 2002). Interviews were conducted with the aid of an interview schedule that guided the researcher in gathering information from selected well-informed key informants.

The key interview questions directed at selected respondents focused on the following:

a. How did climate change influence the seasonal cycles of primary fishing activities?
b. How do changes in the coupled ocean ecosystem affect coastal households?
c. How did coastal communities use TEK to respond to the multiple stressors of climate change?
d. How can we best enhance natural climate change mitigation mechanisms in the ocean?

The key informants selected for interviews were those aged 18 years and above with good knowledge of the environment of their community (and have been residents of the area for at least 15 years). Criteria for selection of informants in Key Informant Interviews:

(a) *Men and women aged over 60*: resident in respective area all his/her life. First-hand experience directly from people who have witnessed dynamism of climate change, have knowledge in traditional practices. Information sourced from the group included type of knowledge relating to environment and utilisation of traditional knowledge in coping with climate change related problems.

(b) *Middle-aged Group (35 to 59 years of age* – Male and Female). Selected according to their familiarity with the villages. These were selected on the basis of their familiarity with the villages, since they have lived there throughout their lifetime. From the group it was intended to draw the following: establish whether and how information exchange, knowledge acquisition and transfer from elderly to middle aged was conducted, whether they have traditional knowledge and its source, and their perspectives on value of traditional knowledge.

(c) *The youth (Male and female 18 to 34 years):* This group consists of the young and able bodied involved most in various productive activities. Their inclusion was aimed at: obtaining perspectives on values of traditional knowledge in the context

of the future, and to gauge the levels of understanding on traditional knowledge in adapting to related problems associated with climate change.

In conducting key informant interviews, informants were briefed on the objectives and main theme of the research. Confidentiality of the information was ensured, and prior to the interviews' respondents were requested to give consent to participation in verbal exchanges and tape recordings – to which all informants agreed. Recordings of each interview were reviewed for accuracy and relevance in issues covered, and follow-up interviews were conducted where necessary including further clarifications from village leaders, youth and elders.

3.5.2.2 Focus group discussions

Focus Group Discussions (FGDs) were done to collect information about the study. FGD is a dialogue of individuals that results in an exchange of views/ideas among people in the group. FGDs derive their root from a combination of two standard social research methods. First, as a focused interview in which an interviewer elicits information on the topic without use of a fixed guide and second, as a group discussion in which a possibly homogeneous but carefully selected group of people involved whereby a series of a particular questions are raised by a skilled moderator (See Kasemir*et. al.* 2003). In this study, all two combinations were used.

The FGDs were central in capturing trends and perceptions of the current intergenerational transfer of traditional knowledge. Key research issues pursued in the FGDs included sharing information on how traditional practices dealing with environmental issues have changed over time; where and how the practices were learned, what mechanisms are in place to ensure continuity of the practices, the use of TEK in responses to multiple stressors of climate change, opportunities available and challenges encountered in sustaining such knowledge. Focus group discussions involved various groups of youth and the elderly, defined by gender and age. Focus group discussions were conducted with various groups of youths and elderly people. Each Focus Group Discussion session comprised 5 participants. Sessions were organized in each village (Mnazi and Kilwa Kivinje villages), one comprising male young people, followed by female young people, male middle-aged people, female middle aged-people, female elderly people and male elderly people. Therefore, each group was made up of participants defined by gender and age as stated with the intention that a homogenous group would allow free discussion. Female FGD sessions were administered with the help of Female assistant researcher to increase confidence among participants to share experiences without fear. For the most part, the topics covered were slightly different with those covered under key informant's interviews, intended to explore and compare the general views held by young people and elders separately in the communities. In all groups, it was ensured that members had some degree of familiarity and had the same level of interactions.

3.6 Data Analysis

A content analysis was used to interpret phrases, terms and expressions used by respondents to respond to questions and in discussions conducted in line with the

objectives. The audio- recorded information from key informant's interviews, photo narratives and FGDs was first transcribed and later translated from Swahili to English, carefully done to maintain the original meaning of the information. This process involved fine tuning recorded information, revisiting informants wgo identified gaps, and synthesising information in a complementary fashion between field notes, recordings and discussions.

The Data analysis involved developing codes to identify themes and sub themes, related to the institutions and social construction of TEK in the climate change context. By examining the presence or repetition of certain words and phrases in the texts, inferences were made to ascertain the values and attitudes of the respondents and the information gathered through other methods. Information gathered from secondary sources was synthesized using the same guide with reference to important themes. Conclusions drawn were preceded by a detailed description of the data in connection with the theoretical framework that guided this study. This was important in that it guarantees validity and representation of the data. The data analysis exercise ensured addressing of discrepancies, methodological consistency and validation of information from all activities involved in data collection, compilation, and verification.

3.7 Ethical Considerations

In line with required standards, the study-maintained adherence to research ethics at all stages, specifically, data collection and analysis, treatment of participants and the ethics of responsibility to society (Singleton & Straits, 2005). Attendant care was taken in preparation of FGD guides and interview schedules to eliminate questions that could trigger emotional discrimination of respondents. Moreover, consent by the respondents was sought for the activities involving interviews, photography and publishing pictures of people. Confidentiality with regard to personal records, identities, information about respondents was duly observed including careful use of name and preservation of tape recordings, and so were the necessary procedures for conducting research, i.e., obtaining research clearance/permits from respective authorities, which included Jordan University College, President Office Ministry of Local Government and Regional Administration, Regional Administrative Secretary's (RAS) of Mtwara and Lind regions, Kilwa District Council and Mtwara District Council.

3.8 Validity and Reliability

To ensure consistency and reliability of research tools and instruments, a pilot study was conducted in Mtwara district prior to the main primary data collection process. A local assistant who is a resident from the study villages was engaged to facilitate introduction and familiarization to build trust between the targeted interviewees/respondents/persons contacted and the researcher. The accuracy of data collected was maintained by, first, ensuring questions posed to respondents /interviewees were directly related to the Research Questions, and secondly, participants to focus group discussions were purposefully selected from communities where responses for interview schedules were drawn. Responses obtained from interviews with those from the focus group discussions proved to be effective and

informative although, however, this was done by pairing responses according to covered themes.

Furthermore, the researcher addressed validity at two important level: validity data collection methods and validity of interpretation. In deciding the methods to use, concern was on accuracy of the methods and its relevance to generate intended information. Therefore, multiple methods were used in the study towards examining the same phenomena. Through triangulation, as noted by Mason (2002), the researcher can measure the same phenomenon from different angles but getting the same results. Different research methods were used to approach the research questions from different angles and come out with more than one data set which may inseparably be pointing in different directions but complementing each other in describing the knowledge gap. However, in this study, triangulation did not mean that all the methods aimed at getting the same results. Instead, the methods were complementary.

3.9 Limitations of the Study

The researcher comes from a different socio-cultural background, which sometimes made interpretation of data difficult. Attempts to mitigate this aspect involved giving a proper introduction and clarification of the objectives of the study to the respondents in collaboration with key community leaders. It also involved self-assessment of the researcher and much flexibility (See Mason, 2002).

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.0 Chapter Overview

This chapter explains findings related to the subject matter. It provides answers to the four research questions addressed by this study in relation to the research objectives. These include the influence of climate change on the seasonal cycles of primary fishing activities, the way changes in the coupled ocean ecosystem affect coastal households, the use of traditional ecological knowledge in response to multiple stressors of climate change, and the possible enhancement of natural climate change mitigation mechanisms in the ocean. Also, it provides different literature related to the study findings with the aim of triangulating the study findings.

4.1 The Influence of Climate Change in the Seasonal Cycles of Primary Fishing Activities.

4.1.1 Changes in the seasonal cycles of fishing activities

The study results reveal the variation of climate from time to time, which affects fishing activities. It is revealed that there are changes in temperature and rainfall patterns from time to time compared to the past ten years. In Mnazi village, for example, participant's responses revealed that climate change affects fishing activities since rainfall is good for fish fertility, whereas extreme temperatures make fish migrate to the deep sea after being born. As shown below, the participants showed that the rise in temperature influences fishing activities as fish migrate to faraway areas that fishers cannot reach due to the poor technology they have.

Further analysis shows that the changes in climate affect the seasonal cycle of fishing activities as they take place from time to time. The study observation revealed that the changes in climate led to changes in the fishing seasonal cycle. For example, in past years August, September, October, and November were the fishing boom months, but now even in those months sometimes it is not guaranteed. There are variations from time to time that make the peak unpredictable, though even in those mentioned months there are daily variations. The study revealed that the previous cycle of fishing was disturbed by the changes in climate, where fishermen sometimes failed to predict and make interpretations of the season compared to past years when the season was constant and predictable. This affects the availability of fish compared to past years, when the seasonal cycle was more predictable. As the participants in the in-depth interviews revealed:

Text Box 1: Response from participants

The ocean environment has changed something that affects the harvest, which is not enough even to run our daily lives. Fish availability depends on weather conditions. As the temperature rises, the fish migrate to the deep sea, whereas as the weather becomes cold, the fish become sufficiently available. (Participant, IDI, Mnazi Village, May 23, 2023).

Fishing seasons are changing; for example, right now (May) is the seafood season. In the past, during the mango, we got fish, but now fish are plentiful in four months, that is, in August, September, October, and November. Now we rely on fish nipples, but they are not available in large quantities and will be found in October. This is now uncertain as in the past (Participant, IDI, Mnazi Village, May 22, 2023).

Rainfall causes fish to be born, but shortages of rainfall cause a rise in temperature in the ocean; hence, fish have the tendency to fear temperature, hence they run in the deep ocean. Fish continue to be born, but they run when the temperature rises. Like farmers, lack of rainfall also affects fisheries (Participant, Mnazi Village, May 23, 2023).

The same observation was revealed in *Kilwa Kivinje,* which denotes the changes in the wind patterns that affect the previous system of TEK indicators of fishing cycles. The study findings revealed that there is a slight change in the wind system from their original pattern of months as observed in the past years, though the changes are easily adapted by the community members. Overall, the study observed that fishers are aware of the best times to fish, when the fish are naturally most active. The sun, moon, tides, and weather all influence fish activity. The presence of high temperatures means fish move to faraway areas, whereas low temperatures attract more fish to nearby areas. Similarly, Juana et al. (2013), studying climate perceptions and adaptations elsewhere in Africa, concluded that there was increasing awareness of climate change among local communities in sub-Saharan Africa. The same way observed by Yanda and Mung”ongo (2019) that, these coastal residents have many connections with the sea, both economically and sociocultural. Except for cities and major towns like Tanga, Dar es Salaam, Lindi, and Mtwara which sprawl far inland, most coastal communities are located directly adjacent to the sea and are exposed to climate change through various impacts such as sea level rise, changes in the fishery productivity, and damage to infrastructure.

4.1.2 Changes in the availability of fishing species and fishing prices

The study findings also reveal changes in the availability of fishing species and fishing prices. The evidence of both Mnazi and Kilwa Kivinje, as shown below, reveals the changes in the availability of some fishing species due to environmental changes. The participant interviewed in this study revealed the disappearance of some species that commonly existed in the past few years in specific months. Other species exist in small

amounts compared to past years, making the harvest difficult in the ocean. For example, some species that were common to Mnazi fishing grounds are now scarce compared to the past few years. Species like *Chuchungi* (halfbeak, a fish in the genus *Hemiramphus*) and *Vibua macho* (Indian mackerel) remain common compared to the past years, but species like *Kolekole* (kingfish) and *Pono* (parrot) were common too in the past years but are now very scarce. This shows that the changes in the environment affect the favorable areas for fish to live, hence they move to the areas with attractive environments to settle in the deep sea, which small-scale fishers fail to reach due to poor boats.

Text Box 2: Response from participants

Climate change affects the availability of fish but also reduces the existence of some fishing species. In my opinion, the changes are also associated with increases in the number of fishermen. (Participant, IDI, Kilwa Kivinje, June 15, 2023).

The study findings further reveal the changes in the prices of fish due to its scarcity. The price of fish has increased compared to what it was in the past years due to its scarcity which increases the demands. In the past years, fishes were many something which affects the selling prices but currently the price is higher due to its scarcity. For example, in Kilwa Kivinje, it was observed that in the past ten years a bucket of seafood was sold for about TZS, 4,000/= to 6,000/= but nowadays the prices have gone higher to TZS. 15,000 to 50,000 depending on the season. As participants revealed:

Text Box 3: Response from Participants.

Right now, the income from the fish has become more different from the past because when something is available in large quantities, the price decreases, but if it is not available in large quantities, the price increases. Fish have diminished, so even though income is good, when you get fish, there is a good market for it. (Participant. Mnazi village, May 24, 2023).

Also, the fish income is not uniform; it changes according to the fishing cycle or existence of buyers, and hence, sometimes fisheries can go to the ocean for two to three days with no harvest. However, there are other seasons where the income becomes high, so fishermen tend to buy all the household needs. However, the general analysis of the participant's responses revealed that the income of fishermen has decreased when you compare the past years to the present, though fish prices are high. For example, a fisherman in Kilwa Kivinje revealed that during the good fishing cycle in the past, he could earn up to TZS.50,000/=. per day, but now the income drops to TZS. 25,000/= As other participants revealed:

Text Box 4: Response from participants

Income must be affected because you can go to the sea for two days and up to a week without earning, and if you earn, you have already left debts, so you use money to pay debts. So, we always have alternative jobs like farming, breeding, and the sea; we don't give up the day you get TZS. 100,000; you buy rice and put it inside. (Participant, FGD, Mnazi Village, 25th May 2023).

Therefore, study findings reveal that climate change is real and affects the communities that depend on fishing, and, likewise, agriculture. The changes in the climate affect the fishing cycle and may create a conducive environment for fishing settlement. This in turn affects the availability of some fish varieties that migrate to the deep sea. Changing weather patterns affect the distribution and range of species and disrupts the natural balance of many ecosystems with implications for availability of fish and other coastal resources, including mangrove forests (Liwenga *et al.,* 2019). Climate change and variability in Mtwara region is manifesting itself through an array of changes. The findings from FGDs and household surveys across all study villages indicate that villagers perceived climate change as a change of many things associated with changes in temperature, rainfall as well as wind patterns, coupled with scarcity in the climate sensitive resources such as water and food (ibid, 2019).

4.2 Changes in the coupled ocean ecosystem affect coastal households.

The study was also interested to find out if the changes in the coupled ocean system affect coastal households. The study findings revealed that the environmental changes affect the coastal households, and hence they use different alternative mechanisms to cope with the changing situations. The study analysis revealed that coastal communities engage in different income-generating activities such as farming, small business, and livestock keeping. Also, other fishermen migrate from one area to another for fishing activities to find suitable places to fish. Though the trend of Mnazi village is different from that of Kilwa Kivinje, many of the community members of Mnazi village engage in alternative income-generating activities compared to those of Kilwa Kivinje. Also, in Mnazi, the number of fishermen who migrate for fishing is high compared to that of Kilwa Kivinje. That means, comparing the two, Kilwa Kivinje fishing ground is more accessible to fish than that of Mnazi, such that some fishermen from Mnazi migrate to Kilwa Kivinje for fishing. The findings show that household efforts to mitigate the effects of environmental changes differ, as shown in text box 5.

Text Box 5: Response from Participants

The income nowadays is low, but we can't ask for help from the government because the government is neither cultivating nor fishing. So, we engage in other activities, including agriculture, but agriculture is also challenging. The rise in temperature affects agriculture; hence, we citizens have become lonelier, like a child without a father and mother. When your parents die, you became scattered. Even now, people are moving to other places, such as Mahurunga and Masasi, to cultivate sesame seeds. Fishing becomes challenging. What will we do? (Mr. K.A., IDI, Mnazi Village, May 23, 2023).
Climate change is affecting us because we depend on the sea. Other things don't go well if there are no fish in the sea; even the family is affected. I am also an entrepreneur to deal with climate change; where my wife stays in the shop, I go to the sea to find something to eat and sell in the market (Participant. IDI, 22nd May 2023).

Other responses revealed changes in meal patterns and a reduction in the number of meals per day to cope with the challenges of food shortage. In particular, some households opted to reduce the number of meals per day from three to two or one meal per day to cope with the food shortage. The responses from the Mnazi village revealed that the shortage of fish harvest affects the purchasing power of fishers, even failing to accommodate food purchases; hence, they opt for a reduction in the number of meals per day. The number of meals acts as a coping strategy to cope with the decline of income, which in turn influences the nutrition of fishers and their families, especially children who are still in school. Further analysis shows that the evening meal remains constant, but they forgo lunch and breakfast. The Study findings concur with those of Misana and Tilumanywa (2019), which show that climate change and variability are realities in the two districts (Kilwa and Lindi). These climatic events cumulatively or singly had resulted into reduced crop harvests, increased incidences of food shortages, decline in fish stocks, and loss of income. The data points to increasing temperatures and decreasing rainfall trends. Climate variations that have been taking place have inflicted heavy losses on agriculture, which is the main livelihood source for the majority of the population in the study villages. The high poverty levels in the two districts have worsened the situation, with individual households and communities becoming more vulnerable to climate change impacts. A majority of the poor and intermediate households have been experiencing food shortages for almost half of the year, and sometimes deaths have been reported, as was the case during the severe drought of 1997.

Text Box 6: Response from participants.

In the past, we used to eat two to three meals a day; nowadays, we only eat one meal in the evening, and in the morning, we only drink porridge due to low income. I have engaged in the cultivation of cassava and cashews to deal with the drought (Participant. Mnazi village, May 25, 2023).

Food becomes scarce, which affects nutrition in the household. Even though I am busy with cashews to increase my income, the drought has made the cashews not in a normal condition in terms of yield. Things have been difficult (Participant. IDI, Mnazi village, May 24, 2023).

As revealed text box 6, the food shortage among coastal households affects the nutrition status of household members. The responses from Mnazi village revealed that the nutrition of the household was affected due to food scarcity, as the people now eat two and one meal daily compared to the past years, when they used to consume food three meals daily. Moreover, findings revealed that coastal communities depend on coastal resources to educate their children. The community members rely on the fishing activities to afford education expenses for their children. Hence, if they fail to obtain a good income from fishing, the children will be affected by a lack of proper care and school fees. The participants labelled the ocean as a farm to show the dependence of the coastal household on the ocean. They depend on the ocean to run their lives and meet other livelihood expenses. If fish are not found in the ocean, the money circulation in the communities is affected, resulting in a failure to obtain the basic needs for their survival.

Text Box 7: Response from participants

Climate change has affected the availability of money because the income from the sea has been difficult for a long time because fish are not found. So, I am involved in the cultivation of cashew nuts so that I can deal with climate change. (Participant. IDI, Mnazi Village, May 22, 2023).

In the Mnazi village, our farm is on the ocean, and most of us rely on the ocean to even educate the children. I have no other capital, and at the ocean we get marine park restrictions, which gives us a difficult situation. Livelihood is what God plans—what you get today that you can't find tomorrow. There is no continuation of marine income (Participant. IDI, Kilwa Kivinje, June 13, 2023).

Life is changing; production is reduced; hence the income is low. To get money to eat with the kids, I am involved in other things that make me a living. I go to the beach to carry seafood, and I am paid TZS 1,000 for a bucket full of sea food. When I get some money, I buy wheat in the store, cook the peas, and sell them. I also cultivate nuts and peanuts. (Participant. IDI, Mnazi village, 2023).

Therefore, coastal households have been affected by the changing climate to the extent of struggling to cope with those changes. The changes affect income, nutrition, and affordability for other needs such as education. However, many household communities attempted to cope with climate changes by engaging in other income-generating activities, or they such as farming, small businesses, seaweed harvesting, and other activities, migrate to places where the fishing environment was more conducive, like Songosongo Island in Kilwa. It was also noted that most of them were engaged in multiple activities as a strategy to boost their income and livelihood options The study concurs with Mwiturubani (2019) observation in Pangani district, that at household level, the strategies adopted by community members in the study areas included change of their occupations and engagement into other livelihood activities. Thus, many residents from the study areas whose source of livelihoods had once depended on natural resources such as farming and fishing diversified their means of livelihoods.

4.3 TEK Responses to Multiple Stressors of Climate Change

4.3.1 Knowledge on fishing calendar

The study was also interested in examining the TEK-based practices used to responded to the multiple stressors of climate change in the study area. The study revealed that fishermen are aware of different weather dynamics in their areas, and hence they take different measures to mitigate the impacts of those dynamics, including using TEK. The analysis from interviews and Focus Group Discussions (FGD) revealed dynamism in the fishing cycle. However, there was agreement that the following calendar (Table 3) revealed the general picture of the fishing activities in Mnazi village and Kilwa Kivinje, in spite of the changes in the weather patterns.

The findings analysed during the interviews and FGDs in both Mnazi and Kilwa Kivinje revealed that communities know the fishing cycle calendar, which directs them either to fish frequently or to take a break and engage in other economic activities. The findings revealed that the month of December, January, February, March, and April have few sea crops in Mnazi village fishing grounds compared to the other months. The same observation was revealed in Kilwa Kivinje: these months experience hardship in fishing income compared to other months. During those months, communities find alternative solutions for their livelihoods, such as engaging in farming, small businesses, and seaweed. Furthermore, other fishermen migrate to other areas, such as Songosongo and Nyororo islands in Kilwa, for fishing. Participants also identified the months of May and June as the most famous months for seafood compared to the other months. During the seafood season, women are involved in carrying seafood buckets to the village markets, while men are involved in fishing activities. July is labelled as the most troublesome month compared to others as the wind always causes accidents for fishermen. The researcher witnessed higher harvests of sea foods in both Mnazi and Kilwa Kivinje during the data collection in May and June 2023. The seafood is sold for the price of between TZS. 20,000 and for TZS. 35,000 TZS in Mnazi and for 15,000 to 20,000 TZS in Kilwa Kivinje.

Further analysis revealed that fishing in July requires great attention due to the high speed of the wind on the coast, which sometimes destroys the fishing vessels. The month experiences a lot of accidents that need great care to overcome. During July, people who learn to fish are discouraged due to their nature. Therefore, fishing in July requires taking precautionary measures. Likewise, favourable fishing months, namely. August, September, October, and November are mainly good for fishermen as they have the highest harvest compared to other months (see table 3). The season experiences higher income as the market for fish is reliable, and the season also relates to the cashew nut harvest season.

Table 3. Fishing cycle calendar

SN	MONTH	FISHING ACTIVITIES/DESCRIPTIONS
1	January	There are famous months for Halfbeak. In this period, the sea crop is low (few fishes).
2	February	
3	March	
4	April	
5	May	During the months of May to June the seafood harvest is numerous. Kusi wind (southern wind), seafood often enjoys the gentle wind. Seafood likes to stay in the cold.
6	June	
7	July	In July the wind often causes accidents. It's a tough season for fishing.
8	August	Seasonal fish are found in August, September, October and November. Seasonal fish are more available during these months. There are moons, it is a sign to show the presence of fish, a sign of the wind, the wind coming from the northeast. These months are characterized by seasonal fish that pass by. These months even the income is also increasing.
9	September	
10	October	
11	November	
12	December	It's a famous month for Halfbeak. In period the sea crop is low

Source: Field data (2023)

As stated in Table 3, fishermen are aware of the different mechanisms to adopt with the changing climate throughout generations. With knowledge of the context and changes in seasonality in the ocean, fishermen can plan for their future endeavours. It helps them identify the best months to earn income and the lower income months, identify the alternative mechanisms as per season, and plan to either go to the ocean or not go. The study participants provided a picture of communities understanding of the climate and how they take advantage of their understanding to cope with seasonality.

4.3.2 Knowledge on the ocean indicators and its dynamics

The study findings revealed that community members were knowledgeable about their surroundings and the dynamics that arise therein. Community members know different winds and their meanings. As such then, awareness and interpretation of the things and events that happen in their areas are very important in coping with the ongoing climate changes. It was observed that the northern winds are a very important indicator for fish, as there will be fish in abundance, though they need awareness. The upper northern

wind experienced in September, come with fish in abundance. Muddy northern winds are dominant in March and April, but when it rains, there are good conditions. However, northern Japan does not have fish like ma*tarai*; it is often seafood, but the market is difficult because of the rain and the price is low. Matarai winds (August, September, October, and November) are beneficial because fish are born in abundance, water becomes mixed, and creatures do not see nets early (see Table 4). Kilwa District has a coastal climate, with rainfall being influenced by the monsoon winds (Misana and Tilumanywa, 2019).

Southern sand winds are very dangerous, always tearing the sails, and many people are overturned. They always appear between the months of May, June, and July. The dry land is dangerous, and the ocean becomes difficult. Many accidents occur at the ocean. Therefore, during this time, many fishermen take precautions, including going to fish with their mobile phones in case of anything they can report to fellow fishermen. Further findings revealed that the *matarai* wind, which frequently occurs in the months of August, September, October, and November, is a good indicator of abundant fish because the matarai wind is associated with a cold condition that is favourable for fish to be born. Hence, during this season, fish are growing in abundance. Also, it was observed that during the matarai season, it is also the cashew season; hence, there is a big market for fish as the purchasing power of farmer's increases after selling cashew nuts. Furthermore, the analysis revealed that matarai manifests in different types, such as matarai kusi, matarai upper, and matarai kaskazi. Also, Matarai East, Matarai Kusi, occurs in the southeast, and Matarai Kaskazi is in the northeast.

The study also revealed that TEK is to be used in disaster detection. Sunset and the bow (ingamo) are very helpful when fishermen are faced with disasters in the ocean. For example, if the fisherman gets lost in the ocean, he has to look for the area where the sunset is but also the stars, which provide the direction of where to go specifically on dry land. However, the participants mentioned different indicators of disaster, which include strong wind, clouds moving fast, and a red sun when rising (Jicho la Simba). Thus, the indicator guides fishers to decide whether to go to the ocean to fish or not. Strong wind is very dangerous to fishermen as it can destroy their fish vessels and result in disasters. Hence, upon this indicator, many fishermen opt not to go to the ocean. The study findings revealed that, TEK has been used to determine the seasonal calendar. The participants in both FGD and In-depth interview revealed the existence of the different mechanisms used to determine fishing seasonality based on the moon. For example, Charu starts from 9 to 12 days, days 13 to 16 spring tide, day 17 the water returns. The same observation revealed by Mung'ong'o and Kiza (2019), people could also recognize occurrence of high or low tides using the hijri calendar and the onset of hilari kiza (full moon). Hilari kiza normally occurs from the 25th to 30th day of the Islamic month.

Table 4. Traditional knowledge and its meanings

Northern Wind	Fishing during the upper northern wind- December to January, are not so good meanwhile, muddy northern wind which occurs in March to April when it rains, there are good conditions. However, during northern wind there isn't enough fish like during matarai wind. It is often seafood, but the market is difficult because of the rain, the price is low. However, the northern wind is beneficial, fish are born in abundance, water becomes mixed, and fish do not see nets early.
Southern wind	Southern sand wind *(Kusimchanga) these are dangerous winds for the fishers and are always* tear the sails, many people are overturned and die during this wind season. It always occurs between June and July. The wind comes from the dry land is very dangerous, the sea becomes difficult. Many accidents at ocean occurs.
Matarai wind	Always occurs in August, September, October, and November. During this season, fish are abundant. The good thing is that the months are also cashew nut season, hence there is a big market for fish.
Spring tide (Bamvua)	Charu starts from 9 to 12 days. Days 13 to 16 spring tide. Day 17 the water returns.[1]
Neap tide (MajiMafu)	Days 17, 18, and 22 It's neap season. Water does not move, and fishermen do not go far.
Identification of type of fish in the water	The behaviour of Jack's fish used to show up as not playing much. Hopscotch jumps like a tuna. Indian mackerel are very violent; they play fast in the water like it was raining, like Saladin.
Disaster detection	Sunset and the bow (ingamo) help when you have a disaster in the ocean. If you get lost in the ocean, look for the area where the sunset is, but also the stars, which provide the direction of where to go. However, the indicator of disaster includes strong wind, clouds moving fast, Red sun when rising (Jicho la simba)

Source: Field data (2023)

Furthermore, the study findings revealed that there exists of different coral reefs that are known by fishers in the study areas. The reef has different characteristics and once they plan for fishing, they always know where to fish according to the season and weather of the day. It was observed that the reefs have names that are known to the community members, so upon any disaster in the ocean, one could call for assistance from other fishers. Tables 5 and 6 mention the names of coral reefs in Mnazi and Kilwa Kivinje, respectively. As it was shown in the study areas, the coral reefs have some characteristics. For example, Chumbu Reef in Mnazi village is the big reef that takes the shape of the ocean as it is in the middle of the coast. Non-seasonal fish such as Baracuda (Mzira), Rabbit (Tasi), Mackerel (vibua), and Jack's fish are available. Fishing is always done, especially during the spring tide.

[1]The fishers use Arabic months. Arabic calendar is based on 12 lunar months – a new month begins when a new moon is sighted.

Table 5: Names of coral reefs and their characteristics in Mnazi village

Name of the Reef	Characteristics
Chumbu	Chumbu Reef in Mnazi village is the big reef that takes the shape of the ocean as it is in the middle of the coast. Non-seasonal fish such as Baracuda (Mzira), Rabbit (Tasi), Mackerel (vibua), and Jack's fish are available. Fishing is always done, especially during the spring tide.
ChumbuyaTenga	Connected to Chumbu is a very small stream with a lot of water.
Ruvula	Near the gas well is bordered by Ruvula and Bwanaoga,
Bwanaoga	It is connected to the Chumbu on the north side. It has deep water.
Lizuwiyo	It is famous for mackerel and parrod fish.
Dadi	Catfish, emperor fish, and thumbprint emperors are more dominant. The water is average in depth.
Tumbika	There are low water areas and high-water areas.
Msilo	It is close to Tenga.
Matenga	Located nearby Tumbika
Mcheche	Located nearby Msilo and Mchata
Mchata	Located nearby Msilo and Mcheche
Kiwale	Located nearby Msilo
Hazina	Hazina (Treasure) is characterized by having abundat fish, which is the true meaning of the name itself, although now it is despised.
Chemchem	There is a spring-the water boils.

Table 6: Names of coral reefs and their characteristics in Kilwa Kivinje

Name of the Reefs	Characteristics
Amana	It is the big coral reefs that takes the shape of the ocean in the middle. On this reef, non-seasonal fish such as barracuda, rabbit, mackerel, Jack's fish, and thumbprint emperor are all available. Fishing takes place during the spring tide.
Jewe	Connected to Chumbu, it is a very small stream with a lot of water.
Mkaya	Near the gas well, it is bordered by Bwanaoga
Bwanaoga	It has deep water.
Lizuwiyo	Famous for mackerel.

4.4 Enhancement of Natural Climate Change Mitigation Mechanisms in the Ocean.

4.4.1 Introduction of TEK education forum for youth

The study was also interested in examining the enhancement of natural climate change mitigation in the ocean. The study findings revealed propositions of different mechanisms suggested as enhancements of natural climate change mitigation. Youth

who are the main recipients of TEK suggest being educated on the significance of the TEK in fishing practices rather than relying on observation and experience from the fields. There should be a programme in place to educate youth on various matters concerning the TEK as a strategy to mitigate the impact of climate change. As explained in text box 8, youth learn more through practices, observation, and experiences, and participants thought of the need for a special forum for learning.

Text Box 8: Response from participants

I think youth should be educated on traditional ecological knowledge by experienced elders because some of the youth have their own groups. We don't have to assume their observation is enough; there should be a programme in place in our village to educate people on how to reduce accidents that can be prevented and increase the fishing harvest (Participant. IDI, Mnazi Village, 22nd May 2023).

4.4.2 Establishment of TEK Committee

Further study and observation have shown the need for a TEK committee to safeguard its sustainability. They proposed that a committee be established in each village to regulate and moderate use of TEK in the respective area of jurisdiction. The committee will be responsible for providing instructions about the fishing season and different TEK practices. Also, the committee will provide direction for the TEK transfer from one generation to the next. It will provide a forum for learning about different practises held within the area that can be used effectively in the present and future generations. The participant in Mnazi revealed that:

Text Box 9: Response from participants

There is a need for a committee to safeguard TEK for its sustainability. The committee will provide instructions on how to adapt to climate change depending on the season. This will provide assurance on the transfer of TEK (Participant. IDI, Mnazi village, May 22, 2023).

4.4.3 Integration of TEK in the formal system

TEK cannot be put into practice if it is not acknowledged and supported by the formal system. Hence, the participants noted the importance of incorporating TEK into the different formal programmes and projects to facilitate its use. This is because TEK has been used by small-scale fishers (SSFs) to mitigate the changing environment. Therefore, supporting TEK means empowering SSFs in the changing environment to adapt, as shown below:

Text Box 10: Response from participants

There are efforts made by the government to improve the livelihood of fishermen by providing loans to youth groups. Youth now own boats that use fishing machines. Hence, there is improvement among fishermen as time goes on. However, the government should look at small-scale fishers as there is a significant need to integrate traditional ecological systems into the formal system (Participant. IDI, Mnazi village, May 24, 2023).

Further analysis revealed TEK to be ignored by some of the youth who think traditional issues are outdated; hence, it cannot be used to provide better results. Participants proposed that TEK should be incorporated into the formal education system, which is believed by many youths to be competent and modern.

Text Box 11: Response from participants

During training, the youth reject some of the knowledge. You know, youth nowadays think they are more knowledgeable than elders. They wait until things break down, but this is caused by the government's failure to promote TEK. This should go hand in hand with formal education (Participant. IDI, Mnazi village, May 25, 2023).

Consequently, other participants confirmed that TEK is sustainable as new fishers were always taught different practices and learned through experience about various issues concerning the ocean and fishing. After completing primary school, youth who wish to join fishing are trained by elders on different fishing practices.

Text Box 12: Response from participants

There are no challenges to the sustainability of TEK. Normally, we teach each other; the youth who have completed primary school are given directives from elders. It's hopeful that these practices will continue throughout generations. Youth continue to practice, though nowadays they need to have a fishing license (Participant. IDI, Mnazi village, May 23, 2023).

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

5.1.1 The influence of climate change in the seasonal cycles of primary fishing activities
The study observations revealed that climate change is real and affects the communities that depend on fishing and, likewise, agriculture. The changes in the climate affect the fishing cycle and create a conducive environment for fishing settlement, and the variation of climate from time to time affects fishing activities. It was revealed that there has been changes in temperature and rainfall patterns from time to time compared to what it was in the past ten years. The observations from the participant's responses revealed that climate change affects fishing activities because rainfall is good for fish fertility, whereas extreme temperatures make fish run to the deep sea after being born. The participants showed that the rise in temperature influences fishing activities as fish migrate to faraway areas that fishers cannot reach due to the poor fishing technology they have. Further analysis revealed that the previous cycle of fishing was disturbed by the changes in climate, where fishermen sometimes failed to predict and make interpretations of the season compared to past years when the season was consistent and predictable. Generally, the study observed that fishers are aware of the best times to fish, when the fish are naturally most active. The Sun, Moon, tides, and weather all influence fish activity. The presence of high temperatures means fish migrate to faraway areas, whereas low temperatures attract more fish to nearby areas.

Also, climate change leads to changes in the availability of fishing species and fishing prices. The evidence of both Mnazi and Kilwa Kivinje, as presented in Chapter 4, reveals the changes in the availability of some fishing species due to environmental changes. The participants interviewed in this study revealed the disappearance of some species that commonly existed in the past few years in specific months. Other species exist in small number compared to past years, making the harvest difficult in the ocean. The study findings further revealed the changes in the prices of fish due to its scarcity. The price of fish has increased compared to past years due to its scarcity, which increases with demand. However, the general analysis of the participant's responses revealed the income of fishers has decreased when you compare with what it was in past years to the present, though its price is high.

5.1.2 The way changes in the coupled ocean ecosystem affect coastal households
The study findings revealed that coastal communities engage in alternative income-generating activities such as farming, small business, and livestock keeping. Also, other fishermen migrate from one area to another for fishing activities to find suitable places to fish. Other participants, in their responses, revealed changes in meal patterns and a reduction in the number of meals per day to cope with the food shortage challenges. Some households opted to reduce the number of meals per day from three to two and

one meal per day to cope with the food shortage. Moreover, analysis revealed that coastal communities depend on the coastal resources for their livelihood, including educating their children. The community members rely on the fishing activities to afford education expenses for their children. Hence, if they fail to obtain a good income from fishing, it means they cannot afford other life expenses. For example, it will affect the whole household because of the failure to accommodate children's education, lack of proper family care, and lack of health insurance. Throughout the study, participants labelled the ocean as a farm, to show their dependence on the coastal resources as they depend on the ocean to run their lives and meet other livelihood expenses.

5.1.3. The uses of TEK in response to multiple stressors of climate change

This study has shown that the use of TEK by fishing communities has been a common aspect of their lives. Local people have drawn on nature based on TEK to make predictions about the weather but also to mitigate the negative impacts of bad weather. The findings analysed during the interviews and FGDs in both Mnazi and Kilwa Kivinje revealed that communities know the fishing cycle calendar, which directs them either to fish frequently or to take a break and engage in other economic activities. Generally, with knowledge of the context and changes in seasonality in the ocean, fishermen plan for their future endeavours. For example, it helps them identify the best months to earn income and the lower income months, identify the alternative mechanisms as per season, and plan to either go to the ocean or not to go. The participants' responses provide a picture of the community's understanding of the environment and how they take advantage of their understanding to cope with seasonality.

Furthermore, study findings revealed community members to be knowledgeable about their surroundings and the dynamics that arise therein. For example, the study shows community members know different winds and their meanings, where to fish, and when to fish. Awareness and interpretation of the things and events that happen in their areas are very important in coping with the ongoing climate changes. It was observed that the northern wind is a very important indicator for fish, as there will be fish in abundance, though it takes awareness to catch fish due to the heavy wind. The application of such TEK practices drawn from nature indicates how people themselves not only regard nature as part and parcel of their lives but also how nature unfolds to them what exactly they should do or can do to make their lives productive and better. Knowledge in this sense is acquired through observation and experience.

5.1.4 The possible enhancement of natural CC mitigation mechanisms in the ocean

The findings of this study revealed propositions of different mechanisms suggested as enhancement of natural climate change mitigation. Youth who are the main recipients of TEK prefer being educated on the significance of the TEK in fishing practices rather than relying on the observation and experience from the fields. There should be a program in place to educate youth on various matters concerning the TEK as a strategy to mitigate the impact of climate change. Another recommendation is about having TEK committee towards safeguarding its sustainability. They propose that the committee to be established in each village to regulate and moderate TEK uses in the respective area

of jurisdiction. The committee will be responsible to provide instructions about the fishing seasonality and different TEK practices.

TEK cannot be put into practice successfully if not acknowledged and supported by the formal system. Hence, the participants recommend on the importance of TEK to be incorporated in the different formal programs and projects as to facilitate its uses. Consequently, other participants revealed TEK to be sustainable as new fishers are always taught different practices and learn through experience about various issues concerning the ocean and fishing. After completing primary schools, youth who wish to join fishing should be trained by elders on different fishing practices.

Generally, the study has managed to generate significant findings about TEK adapting to climate change in fishing communities. The study observes that in the current world, the existence of multiple sources of knowledge is an unavoidable fact, but it has not in any way, completely eradicated the value of TEK and hence, the necessity for its continuity. Therefore, it's upon fisheries stakeholders to start integrating TEK in their plans as a mechanism of adapting to climate change. In many ways, also, the localization of adaptation measures to climate change is very important in the sense that TEK could be adjusted to inform the government policies and plans. In relation to this, learners are said to be integrated into the learning community within their environment and acquire what would be appropriate knowledge based on the conditions or realities of their immediate learning environment. Therefore, climate change adaptation strategies need to incorporate TEK for the sustainability of the strategies and plans because TEK are context and time specific.

5.2 Recommendations

Based on the study findings and subsequent analysis and discussions, the following are recommended:

(i) Since the continuity of TEK in sustaining the environment and especially mitigating the effects of climate change is challenged by societal dynamism and changing perceptions, it may be prudent for the development process to seek for innovative ways of supporting its transfer from generation to another. This could be in the form of its integration with formal systems of education, such as the school system, or through more interactive and youth appreciated channels such as social media.

(ii) Policy makers also need to be sensitive to local contexts, particularly systems or institutions of authority, which may serve as important mechanisms for the continuity of knowledge systems, which are important for sustaining the environmental and social lives of the people. This may include designing policies to protect TEK.

(iii) The communities themselves are the vehicles for the continuity of TEK, but as it has been seen, this is so when the value of TEK is appreciated. In this case, it is recommended that participatory methods, such as inclusive community-level media programmes or outreach programmes should be designed and integrated in extension works for easier acceptability.

5.3 Suggestions for Further Studies

Key following areas are suggested for further research based on the findings of this study.

(i) The implications of 'modern' ways of knowing fishers' vulnerability to the implications of climate change.

(ii) Integration of TEK into local content policies for the benefit of community empowerment processes. The incorporation of TEK into local content policies will increase the relevance of different development projects/programmes to the local communities for their sustainability.

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