EVIDENCE AND IMPACTS OF CLIMATE CHANGE ON SMALLHOLDER PADDY FARMERS IN PEMBA ISLAND

Abstract

This study presents evidence of climate change and its impacts on paddy farmers in Pemba Island. The phenomenon of ocean warming and accelerated ice mass loss has led to a significant rise in global sea levels, averaging 4.62 mm per year between 2013 and 2022, reaching an unprecedented peak in 2022. As a result, Pemba Island is experiencing escalating challenges due to rising sea levels, shifting precipitation patterns, and increasing temperatures. The primary objective of this study is to examine the evidence of climate change in the study area and assess the specific ways in which paddy farmers are affected by these changes on Pemba Island. Conducted in the Wete District, this research utilizes a cross-sectional design, involving 71 respondents selected through a combination of multistage cluster, purposive, and random sampling techniques. Data collection was carried out through surveys, focus groups, and interviews, and subsequently analyzed using SPSS and content analysis methodologies. The findings indicate that paddy farmers are grappling with higher temperatures, altered rainfall patterns, prolonged dry spells, intrusion of seawater, and an increase in pest infestations. As a result, their agricultural production is significantly reduced, exacerbating food insecurity and negatively impacting their livelihoods. In light of these findings, it is evident that robust adaptation measures must be implemented to address the challenges faced by paddy farmers. The study recommends the construction of sea walls as a means of mitigating the adverse effects of rising sea levels. Furthermore, developing drought-resistant paddy seeds varieties is proposed as a strategy to improve productivity and enhance resilience in the face of changing climatic conditions.

Key words: evidence; impacts; climate change; paddy farmers; Wete district; Pemba Island

1.0 Introduction

Climate change is an urgent global challenge that has significant implications for human social, economic, and environmental well-being (Amjath-Babu*et al*., 2016). The Earth's average surface temperature has been rising, with an increasing rate of ocean warming over the past two decades. In fact, the ocean heat content in 2022 reached the highest recorded levels (IPCC, 2007a; WMO, 2023). This warming, along with the accelerated loss of ice mass from ice sheets, has contributed to a rise in global mean sea level. Between 2013 and 2022, the global mean sea level increased by 4.62 mm per year, reaching a new record high in 2022 (WMO, 2023). Projections indicate that the rise in global sea level is likely to continue throughout the 21st century, with estimates ranging from 18-59 cm above 1990 levels by the end of the century (Meehl*et al*., 2007).

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The consequences of these changes are already becoming evident as climates and ecosystems undergo significant shifts (IPCC, 2007b). Island communities, such as Zanzibar, are particularly vulnerable to the impacts of climate change. Rising sea levels, changing precipitation patterns, and increasing air and sea surface temperatures are placing additional

stress on already limited island resources. At the same time, climate change policies often constrain local decision-making (Lazrus, 2012).

Zanzibar, due to its geographic position and limited land area as islands, is highly exposed to climate change and its associated impacts. The region is already experiencing sea level changes, extreme events, and saltwater intrusion into underground aquifers, all of which threaten the availability and quality of water resources. Consequently, water stress has increased, and crop productivity has been affected. Furthermore, the projected rise in sea levels will exacerbate the problem by leading to coastal inundation and erosion, further reducing the already scarce land area. The degradation of coastal resources like mangroves and coral reefs, which support important sectors like fisheries and tourism, is also expected (RGoZ, 2010; Mwangora*et al*., 2015).

Zanzibar faces additional challenges in adapting to climate change due to its limited economic capacity to respond effectively. The high cost of implementing adaptation measures further compounds vulnerability. Climate change not only poses a threat to achieving sustainable development and poverty reduction but also has the potential to undermine the progress made towards the Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs) through Zanzibar's Strategy for Growth and Reduction of Poverty (MKUZA) (RGoZ, 2010; Mwangora*et al.*, 2015).Small island developing states (SIDSs), including Pemba Island, are expected to be particularly affected by increasing temperatures, changes in precipitation patterns, and rising sea levels. Their vulnerability stems from their sensitive ecological and economic systems, as well as other interacting stressors (Mangora*et al.*, 2015; Bakari, 2015; Makame, 2013). Changes in the timing and amount of rainfall have an impact on freshwater resources, which are crucial for island living and activities such as agriculture (Lazrus 2012). As a result, this can have potential adverse effects on island economies and food security.

Paddy farming was introduced to Pemba Island from Asia in the second century AD as a response to a wet climate and population growth on the island. This agricultural innovation was adopted from Asia due to monsoon exchanges (Walshaw, 2010). The wet climate, combined with a growing population, necessitated the intensification of paddy production to meet the food demands of the island's inhabitants, ultimately leading to rice (paddy) becoming the staple food on the island (Walshaw, 2005). Despite the increasing challenges posed by climate change and variability, the tradition of paddy farming during wet seasons has persisted to this day.

However, like any other agricultural crops in Pemba and other developing countries, paddy farming is being affected by the impacts of climate change and variability. Crop production in Pemba, including paddy farming, is heavily dependent on weather and climate conditions. The island is also influenced by regional patterns of extreme weather events and rising sea levels, which result in floods, droughts, and storms. Despite the existing research on climate change and adaptation in Pemba Island and Zanzibar as a whole, empirical evidence regarding how paddy farmers in Pemba Island are affected by climate change and variability is relatively limited. Therefore, there is a need to understand how these farmers are impacted in order to develop adaptation strategies for future climate change. This study aims to address this knowledge gap by identifying indicators of climate change and its impacts on paddy farming production in Pemba Island.

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This study is aligned with the Zanzibar Climate Change Strategy (RGoZ, 2014), which emphasizes the need for climate-smart agriculture, improved natural resource management, and the development of climate information, capacity, and disaster risk management. Additionally, this study is in line with Sustainable Development Goal 2, which relates to food security. Therefore, this study contributes to identifying the impacts of climate change on paddy production, ultimately jeopardizing food security in the changing climate of Pemba Island.

2.0 Methodology

The study was conducted in Wete District, North Pemba Region, Pemba Island, Zanzibar, Tanzania. Pemba Island is one of the two main islands that compose the Zanzibar Archipelago. The other main island is Unguja, and together with several small islands, they form Zanzibar. Located in the western parts of the Indian Ocean between latitudes 4 and 6 south of the Equator, and longitudes 39 and 40 east of Greenwich, Pemba Island is situated 40 to 60 kilometers off the coast of East Africa. The main activities in Pemba Island include crop farming, livestock keeping, fishing, and trade, all of which are climate-sensitive. Pemba Island earned the nickname "Green Island" from an Arab writer due to its historical role as a supplier of agricultural produce, including rice, grains, and cereals, to Malindi and Mombasa (Pollard, 2009).

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Figure 1: The main islands of the Zanzibar Archipelago: Unguja (left) and Pemba (right)

Pemba Island has a tropical climate, which is milder than both mainland Tanzania and Unguja Island. The average temperature is 25.5°C (78°F), and the average annual rainfall is 1,364 mm. Monthly average temperatures range between 24 and 27.4°C (75 and 81°F). There are two rainy seasons, with the majority of rainfall occurring between April and May, and a smaller rainy season between November and December. The drier months are January and February, with a longer dry season from June to October.The decision to select Pemba Island for this study is twofold. First, historically, Pemba Island has been a supplier of agricultural produce, including rice, grains, and cereals, to Malindi and Mombasa. However, due to rising sea levels, changes in precipitation patterns, increasing temperatures, and floods, Pemba Island is more vulnerable to the impacts of climate change compared to other areas in Zanzibar. Secondly, like other smallholder farmers in Tanzania, paddy farmers in Pemba Island rely on rainfed agriculture. This practice makes them particularly vulnerable to the impacts of climate change.

A cross-sectional research design was utilized for this study, which allowed for the collection of multiple cases at a single point in time (Babbie, 1990; Bailey, 1998). The selection of districts, wards, shehias, and households was done through a multistage cluster sampling procedure. This approach enabled the use of multiple sampling methods. Wete District was purposively selected based on its geographical location and the prevalence of paddy farming. Wards, shehias, and households were then randomly selected. A total of 71 respondents, determined using Cochran's formula, were randomly drawn to ensure that each household had an equal chance of being selected (Cochran, 1977).

Both quantitative and qualitative data were collected for this study. Quantitative data was obtained through a household questionnaire survey, while qualitative data was gathered through focus group discussions and key informant interviews. The questionnaire was pre-tested and revised before being administered to the heads of household paddy farmers in Wete District, North Pemba Region. The aim was to gather information on the impacts of climate change on paddy farmers. Three focus group discussions were conducted, each involving seven to nine participants. Key informant interviews were also conducted with experienced paddy farmers, taking into account their years of experience working in the field.

Descriptive analysis was performed using the Statistical Package for Social Sciences (SPSS) for the quantitative data, while qualitative data was analyzed using content analysis. This involved coding the qualitative data and drawing conclusions based on the emerging themes of the study.

3.0 Results and Discussion

3.1 Evidence of Climate Change in Pemba Island

3.1.1 Increase in temperature

The findings reveal that respondents are aware of the changing climate. More than 79% of the respondents agreed that the temperature is increasing, while 20% of respondents were neutral and did not know whether the temperature is increasing or not. However, one respondent disagreed that the temperature is increasing. Rising temperatures associated with climate change will likely have a detrimental impact on crop production, livestock, fisheries, and allied sectors (Kumar *et al*., 2017). This finding was complemented by a key informant interview, in which one key informant in Gando Ward, Wete District, stated:

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Comment [D9]: There is no empirical evidences that reveals the rise of sea level in the study area. To say it as a problem, how many cm does it changed?

Comment [D10]: The sample procedure is not clear. Which Cochran's formula do you employed? When the population size is infinite or finite? I don't think the sample respondents to be 71 based on Cochran's formula of sample size determination.

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"There is a noticeable increase in temperature, causing plants to dry up, paddy fields to become yellowish, and the soil to become dry and cracked due to high temperatures."

According to climate science, further warming is inevitable over the next decade and likely beyond (Woetzel*et al.*, 2020). With increasing global average temperatures, climate models indicate a rise in climate hazards worldwide. These models also suggest that further warming will continue to increase the frequency and/or severity of acute climate hazards and intensify chronic hazards (Woetzel*et al.*, 2020).

Table 1:The temperature is increasing

Temperature	Frequency	Percent
Agree	56	79
Neutral	14	20
Disagree	1	1
Total	**71**	**100**

3.1.2 Changes in rainfall pattern

The findings indicate that 49% of respondents agreed that there have been noticeable changes in the rainfall pattern of Pemba Island. Meanwhile, 47% of respondents remained neutral on the matter, and 4% disagreed that any changes had occurred. During focus group discussions, it was revealed that the rainfall on the island is unreliable. It occurs unpredictably, sometimes resulting in insufficient rain for crop production, while at other times, heavy rainfall leads to flooding in farmlands and low-lying areas. Regardless of the amount of rainfall, whether it is minimal or excessive, it has significant impacts on crop production.

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Table 2:Changes in Rainfall Pattern

Rainfall pattern change	Frequency	Percent
Agree	35	49
Neutral	33	47
Disagree	3	4
Total	**71**	**100**

3.1.3 Rise of sea level

The rise of sea levels is one of the evidences revealed on climate change in Wete District, Pemba Island. Approximately 66 percent of respondents agreed that the sea level is rising, while 25 percent remained neutral, and nine percent disagreed with the idea of sea level increase. However, these results were supported by the findings of focus group discussions which also indicated that the sea level was indeed rising. This increase in seawater has led to the intrusion of saltwater into paddy farms, resulting in crop destruction. As stated by Mwangora, *et al* (2015), the intrusion of saltwater into natural wells and agricultural lands has resulted in increased water stress and reduced crop productivity.

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Table 3:Rise of Sea Level

There is rise of sea level	Frequency	Percent
Agree	47	66
Neutral	18	25
Disagree	6	9
Total	**71**	**100**

3.1.4 Increased dry spells

The findings revealed an increase in dry spells during the rainy season. 51 percent of respondents agreed that there were prolonged dry spells during the rainy season, 34 percent of respondents were neutral, and 15 percent of respondents did not agree that there was an increase in dry spells. These findings were complemented by a focus group discussion, which revealed that there was an increase in dry spells during the rainy season to the extent that the soil cracks. Increased dry spells adversely affect crop production by limiting the water supply to the crops, inhibiting plant growth, and reducing overall production (Woetzel, 2020). Consequently, this could have adverse impacts on the livelihoods of farmers.

Table 4:Increase in dry spells

There is Increase in dry spells	Frequency	Percent
Agree	36	51
Neutral	24	34
Disagree	11	15
Total	**71**	**100**

3.2 Impacts of climate change in paddy production

3.2.1 Intrusion of sea waterinto Paddy farms

Climate change has had a significant impact on paddy production in Wete District, North Pemba Region. One of the consequences of climate change is the intrusion of seawater into paddy farms. The research findings indicate that 75 percent of the respondents acknowledged that their paddy production was negatively affected by seawater intrusion. In contrast, 25 percent of the respondents claimed that their paddy farms were unaffected by sea water. The focus group discussions further supported these findings, revealing that when seawater enters the paddy farms, all crops in the affected areas perish. This intrusion of seawater not only jeopardizes food security but also affects the income of paddy farmers who rely on paddy production as their primary source of sustenance. The affected farms remain unproductive until rainfall washes away the salt brought by the sea water. According to the World Meteorological Organization (WMO) (2023), the global mean sea level has risen by 4.62 mm per year from 2013 to 2022, reaching a new record high in 2022. Considering this

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ongoingrise in sea levels, paddy production will continue to be impacted by seawater unless effective measures are taken to prevent its intrusion into paddy farms.

Table 5: Intrusion of Sea Water in Paddy Farms

Sea water enters paddy fields	Frequency	Percent
Yes	53	75
No	18	25
Total	**71**	**100**

3.2.2 Increased pests affecting paddy production

Climate change has also had an impact on paddy production by leading to a rise in pests in paddy farms. Approximately 61 percent of the respondents acknowledged an increase in pests that adversely affect paddy production in Wete. Conversely, 39 percent did not report any noticeable rise in pests affecting paddy production (see Table 6). These findings were further supported by the focus group discussions conducted in the study area. The discussions revealed that the increase in pests was primarily due to higher temperatures. This surge in pests not only affects paddy production but also increases the costs of production due to the need for purchasing pesticides. Consequently, the presence of pests in paddy farms results in reduced paddy production, causing farmers to experience food insecurity and a decline in income.

Table 6:Increase of pests affecting paddy production

Increase of pests	Frequency	Percent
Yes	43	61
No	28	39
Total	**71**	**100**

3.3 Impacts of climate change on food security among paddy farmers in the study area

Climate change has a direct and significant impact on food insecurity. The changing climate affects all four dimensions of food security: availability, accessibility, utilization, and stability of food systems (Rao, *et al.*, 2017; FAO, 2018). Many countries are facing the negative impacts of climate change, particularly in terms of decreased agricultural productivity, which leads to lower levels of national and household food security (Nyang'au, 2021). As global temperatures rise due to climate change, the production of food becomes more difficult and uncertain due to changes in weather patterns, extreme weather events, and other environmental disruptions (Rao*et al.*, 2017; WEF, 2023). In the study area, climate change played a major role in food insecurity among paddy farmers. The findings showed that 94 percent of respondents experienced food insecurity, while six percent did not (Table 7).

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May we generalize the climate change is the only cause to food insecurity?

Table 7:Impacts of climate change on food security

Food insecurity	Frequency	Percent
Yes	67	94
No	4	6
Total	**71**	**100**

Paddy farmers in Wete District, Pemba Island have been experiencing various challenges due to climate change. These include increased temperatures, changes in rainfall patterns, longer dry spells during the rainy season, intrusion of seawater into paddy farms, and increased pest infestations that negatively affect paddy production (refer to table 1, 2, 4, 5, and 6). These changes have had a significant impact on the farmers' ability to produce an adequate amount of paddy crops, thus affecting food security in the study area. The availability, access, and stability of food have all been compromised, as farmers' incomes have also been affected. These findings were further supported by three informant interviews conducted in the study area:

The first informant stated:

"The increasing temperature has a detrimental effect on paddy production. The soil becomes dry and cracks, leading to the death of paddy plants. As the head of the household, this has had a significant impact on my ability to provide for my family. Paddy farming is our primary source of food and income, so the decrease in production has caused great hardship."

The second informant shared:

"We have been harvesting fewer paddy crops due to adverse weather conditions such as higher temperatures, increased pest attacks, and the intrusion of sea water into our farms. As the head of the household, I am highly affected by this situation. I struggle to provide enough food for my children, as well as clothing and healthcare in case of illness. Drought and famine have become significant challenges for us."

The third informant explained:

"As women, we bear the brunt of these challenges. Sometimes, our husbands are forced to seek casual labor elsewhere due to the low paddy harvest. In their absence, we are left to shoulder the entire responsibility of taking care of our families, including providing food, clothing, and healthcare for our children when they fall ill. This situation adds an immense burden to us women."

4.0 Conclusion

The findings indicate that paddy farmers in Wete District, Pemba Island are facing several challenges related to climate change. These include increased temperatures, changes in rainfall patterns, longer dry spells during the rainy season, intrusion of sea water into paddy farms, and increased pest infestations that negatively impact paddy production. These climate-related changes have led to a reduction in paddy production, which in turn has affected food security and the livelihoods of paddy farmers in Wete District, Pemba Island. If no strong adaptation measures are implemented to enhance the resilience of paddy farmers against the impacts of climate change, paddy production will continue to be adversely affected. The study recommends that the Ministry of Agriculture of the Revolutionary Government of Zanzibar and other stakeholders take action to protect paddy farmers from the impacts of climate change. This can be achieved by implementing adaptation strategies that build the resilience of paddy farmers. For example, constructing a concrete wall along the Wete District beach can help reduce or eliminate the intrusion of sea water into paddy farms. Additionally, the development of drought-resistant paddy seed varieties will enable farmers to increase paddy production regardless of the prevailing weather conditions in the study area. By prioritizing the resilience of paddy farmers against the impacts of climate change, there will be improvements in paddy productivity, self-sufficiency in food security, and the overall livelihoods of paddy farmers.

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