Paddy Farmers Perceptions on Climate Change and AdaptationStrategies in Pemba Island

Abstract

Climate change is already exerting its impact on smallholder farmers, necessitating their acknowledgment of these changes and investment in adaptation strategies. The perception of climate change among farmers plays a crucial role in determining their willingness to adapt.This study focuses on the perceptions of paddy farmers regarding climate change and their responses to its impacts. Specifically, the study aims to answer the following questions: How do paddy farmers perceive climate change? To what extent do demographic characteristics influence the adoption of adaptation strategies in response to climate change impacts? How do paddy farmers respond to the impacts of climate change? The study was conducted in Wete District, North Pemba Region on Pemba Island. A cross-sectional research design was used, employing multistage cluster sampling along with purposive and simple random techniques. Both qualitative and quantitative data were collected, with questionnaire surveys used for quantitative data and key informant interviews for qualitative data.Also, the study used climate data from Tanzania Meteorological Authority, temperature and rainfall data over the past 31 years(1992-2023). Quantitative data were analyzed using the statistical package for social sciences software, while qualitative data were analyzed using content analysis. The study findings reveal that paddy farmers in the study area perceive an increase in temperature, changes in rainfall patterns, an increase in dry spells, and a rise in sea level. The study also identifies various strategies used by paddy farmers to cope with the impacts of climate change, including the construction of ridges, the use of pesticides, irrigation, and skipping meals. However, the construction of ridges to prevent seawater intrusion into paddy farms was found to be less effective. Therefore, the study recommends that the Revolutionary Government of Zanzibar should consider building a sea wall to help paddy farmers build resilience against the current and future impacts of climate change. Paddy farmers in Pemba Island are also advised to adopt transformative adaptation strategies that are more sustainable and capable of withstanding the projected harsh climate changes in the future.

Key words: perception; adaptation; climate change; paddy farmers;Wete district; Pemba Island.

1.0 Introduction

Climate change impacts are already being experienced and are expected to have even greater consequences in the future (Legesse*et al*., 2012). The ongoing shifts in global climate patterns are increasing the vulnerability of communities, particularly in developing countries, endangering their livelihoods (Hisali*et al*., 2011). The African continent has been consistently warming, with an average rate of +0.3 °C per decade between 1991 and 2022, compared to +0.2 °C per decade between 1961 and 1990. This recent trend is slightly higher than the global average warming trend of +0.2 °C per decade for the same period (WMO, 2023). Despite agriculture being a vital sector for Africa's economy, supporting 55% to 62% of the workforce in sub-Saharan Africa alone, agricultural productivity growth has declined by 34% since 1961 due to the impact of climate change (WMO, 2023). Agricultural drought predominantly affects individuals employed in the agricultural sector, as insufficient water supply inhibits plant growth and diminishes production (Woetzel*et al*., 2020). Additionally, rising sea levels resulting from oceanic thermal expansion and melting ice pose a threat to

coastal agricultural lands, particularly in regions with limited capacity for implementing or modifying sea defenses (Webster, 2008).

It is essential for smallholder farmers, including paddy farmers in Pemba, to recognize the existing climate changes in their respective areas and make appropriate investments towards adaptation (Komba and Muchapondwa, 2012). The ability of farmers to perceive climate change is a fundamental requirement for them to choose to adapt (Acquah and Onumah, 2011; Mengistu, 2011; Moyo*et al*., 2012; Kitinya*et al*., 2012). The coping and adaptation strategies of smallholder farmers depend largely on their level of knowledge regarding climate change and the sources of information available to them (Bello et al., 2013; Malekela*et al*., 2024). Those who perceive changes hypothetically adopt one or more climate-smart agriculture practices to mitigate the negative impacts associated with climate change (Nyang'au*et al*., 2021; Mafie, 2021).

Implementing strategies for adapting to climate change has the potential to mitigate its adverse effects on agriculture and other sectors (Smit and Pilifosova, 2001; Hussain *et al*., 2022). These adaptation strategies also aid farmers in achieving their objectives of food security, income, and livelihoods under extreme weather conditions, such as droughts and floods (Hassan and Nhemachena, 2008). The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as "adjustments in ecological, social, or economic systems in response to actual or projected climate stimuli and their effects" (Smit and Pilifosova, 2001).Adaptation can be classified as either autonomous or planned. Autonomous adaptation occurs without conscious response to climatic stimuli, but rather in response to ecological changes in natural systems or market and welfare changes in human systems. It is also known as spontaneous adaptation (Smit and Pilifosova, 2001). On the other hand, planned adaptation is the result of deliberate policy decisions made when it is recognized that conditions have changed or are about to change, and action is necessary to achieve, maintain, or restore a desired state. Autonomous adaptations are typically reactive and are often initiated by private actors such as individuals, households, or private companies, as opposed to government-led initiatives. Planned adaptations, on the other hand, are referred to as public adaptations and are initiated and implemented by governments at all levels (Smit and Pilifosova, 2001).

Pemba Island is highly vulnerable to climate change and its impacts due to its geographical positioning as an island with limited land area. Key threats include sea level change, extreme events, and seawater intrusion into underground aquifers. The intrusion of saltwater into natural wells and agricultural lands has resulted in increased water stress and reduced crop productivity on Pemba Island. Like other Small Island Developing States (SIDS) worldwide, Pemba Island is expected to be severely impacted by rising temperatures, changing precipitation patterns, and sea level rise due to its high vulnerability stemming from sensitive ecological and economic systems and other interacting stressors (Mangora*et al*., 2015; Bakari, 2015; Makame, 2013). Shifts in the timing and amount of rainfall have detrimental effects on freshwater resources, which are crucial for island living and activities such as agriculture (Lazrus 2012). This, in turn, has potential adverse impacts on island economies and food security.

Paddy farming, like other agricultural crops in Pemba and developing countries, is being significantly affected by the impacts of climate change and variability. The success of crop production in Pemba, including paddy farming, relies heavily on favourable weather and climate conditions. However, the island is frequently subjected to extreme weather patterns such as floods, droughts, storms, and rising sea levels, which further exacerbate the

challenges faced by farmers. Despite extensive research on climate change and adaptation in the region, there is limited empirical evidence regarding how paddy farmers in Pemba Islands perceive and adapt to these impacts. Therefore, it is crucial to understand the perceptions and adaptation strategies of paddy farmers in Pemba Islands towards climate change and its variability. This study aims to address the perceptions of paddy farmers regarding climate change and explore their adaptation strategies to mitigate its impacts in the study area.

2.0 Methodology

The study was conducted in the Wete District, North Pemba Region, Pemba Island, Zanzibar, Tanzania. Pemba Island is one of the two main islands that form part of the Zanzibar Archipelago. The other main island is Unguja, and together with several small islands, they make up Zanzibar. Wete District is is one of two administrative districts of Pemba North Region in Tanzania. The district covers an area of 295 km^2. The district has a water border to the east and west by the Indian Ocean. The district is latitudes 5° 6′ 57.6″ S and longitudes 39° 45′ 18″ E and isbordered to the north byMicheweni District.The main activities carried out in Weteare crop farming, livestock keeping, fishing, and trade, like the remaining part of Pemba Island, all of which are climate-sensitive. Pemba Island acquired the nickname "Green Island" from an Arab writer due to its history of supplying agricultural produce, including rice, grains, and cereals, to Malindi and Mombasa (Pollard, 2009).

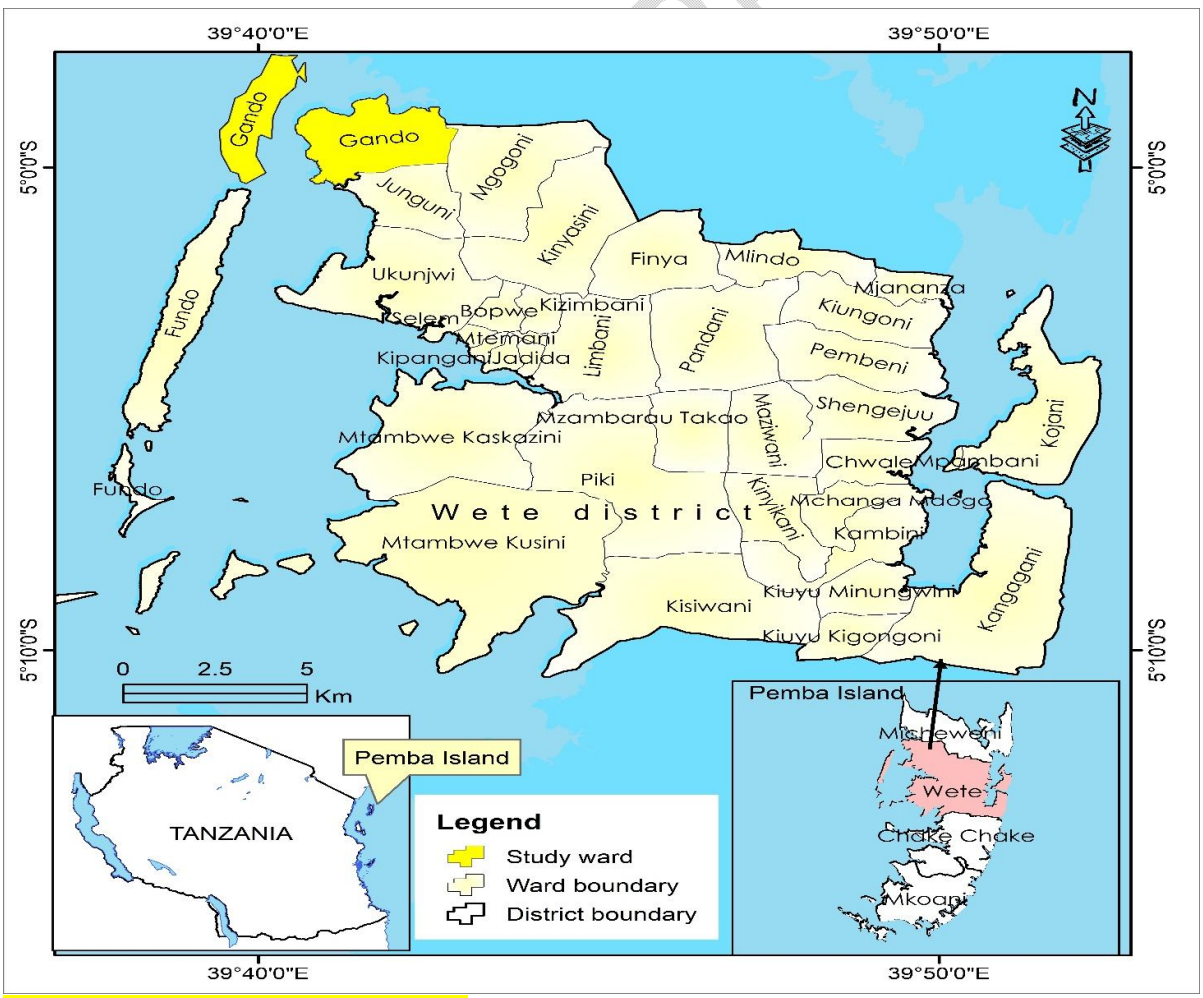

Figure 1:Wete District – Pemba Island

Pemba including Wete has a tropical climate, which is slightly milder than the mainland of Tanzania and milder than Unguja Island. The average temperature is 25.5°C (78°F), and the average annual rainfall is 1,364 mm. The monthly average temperatures usually range between 24 and 27.4°C (75°F 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.

There are two main reasons for choosing Wete District in Pemba Island for this study. Firstly, 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, Wete is more vulnerable to the impacts of climate change compared to other areas in Pemba Island. Secondly, like other smallholder farmers in Tanzania, paddy farmers in Wete District, Pemba Island rely on rainfed agriculture. This practice makes them particularly vulnerable to the impacts of climate change.

A cross-sectional research design was used for this study, as it allowed for the collection of multiple cases at a single point in time (Babbie, 1990; Bailey, 1998). A multistage cluster sampling procedure was employed to select districts, wards, shehias, and households. This procedure allowed for the use of multiple sampling methods. Wete District was purposively selected based on its location and the presence of paddy farmers. Wards, shehias, and households were then selectedrandomly.71 respondents, based on Cochran's formula, were randomly chosen 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 gathered through a household questionnaire survey, with the questionnaire serving as the tool for this method. The questionnaire was pre-tested and revised to produce the final version that was administered to the heads of household paddy farmers in Wete District, North Pemba Region. Qualitative data was obtained through key informant interviews, specifically from fiveexperienced paddy farmers who had several years of experience working on farms. Literatures shows that influence on years of farming possess a greater knowledge of indigenous practices and information about climate changes and agronomic practices that facilitate adaptation(Atube*et al*. 2021;Amare *et al*., 2018).Meteorological data of rainfall and temperature covering a period of 31 years between 1992 and 2023 were collectedfrom Tanzania Meteorological Authority (TMA).A descriptive analysis was conducted using the Statistical Package for Social Sciences (IBM SPSS) version 20 software to analyse the quantitative data.Qualitative data were analyzed basing on their content. Climatic data from Tanzania Meteorological Authority (TMA) were analyzed using Microsoft Office Excel.

3.0 Results and Discussions

3.1 Paddy Farmers' Perception of Climate Change

Farmers have varying perceptions of climate change, and their understanding of climate variables is crucial for rain-fed agriculture. Paddy farmers in the study area perceives climate

change. Their perception based on their involvement in agricultural activities over longer time as well as their indigenous knowledge.

3.1.1Temperature Increase

The study findings indicate that paddy farmers in the study area perceive a significant increase in temperature. According to the data presented in Table 1, approximately 79 percent of respondents reported an increase in temperature, while 20 percent disagreed with this perception. These findings align with a study conducted by Kihupi*et al.* (2015a) in Ismani Division, Iringa District, Tanzania, which also found that smallholder farmers perceived a rise in temperature. Similarly, a study by Nyang'au*et al.* (2021) in Masaba Sub-county, Kisii, Kenya, revealed that farmers in that region also perceived an increase in temperature. These findings were further supported by an informant interview conducted in the study area as illustrated below by one of the Key Informant;

"There has been a significant increase in temperature, resulting in the drying up of plants and yellowing of paddy crops, as well as an excessive dryness of the soil."

Rao *et al.* (2017) and Herath *et al.*, (2020) asserted that the increasing temperatures associated with climate change have a detrimental impact on crop production, as evidenced by the negative effects experienced by paddy farmers in Pemba. Studies carried in China and Nepal revealed that paddy production is negatively affected by increase in temperature (Devkota*et al.*, 2020; Liu *et al.*, 2020; Zella *et al.*, 2024).The meteorological data revealed increase in temperaturewhereby in 1992 the minimum average temperature was 22.2^{0}C this changed to 24.9^{0}C in 2023. On the other side the maximum average temperatures changed from 28.83°C in 1992 to 30.09°C in 2023. The trend lines for both minimum and maximum temperatures indicate a substantial increase in temperature (P= 0.0905, R^2=0.5122; P=0.0112, R^2=0.0379) respectively as shown in Fig. 2. The study conducted by Niranjan and Paija (2020) in Nepal shows that rice yield is negatively affected by increase in temperature. Liu *et al.*, (2020) also shows increase in temperature of 1.5 and 2.0^{0}C global warming has negative impacts across the main rice growing regions of China.

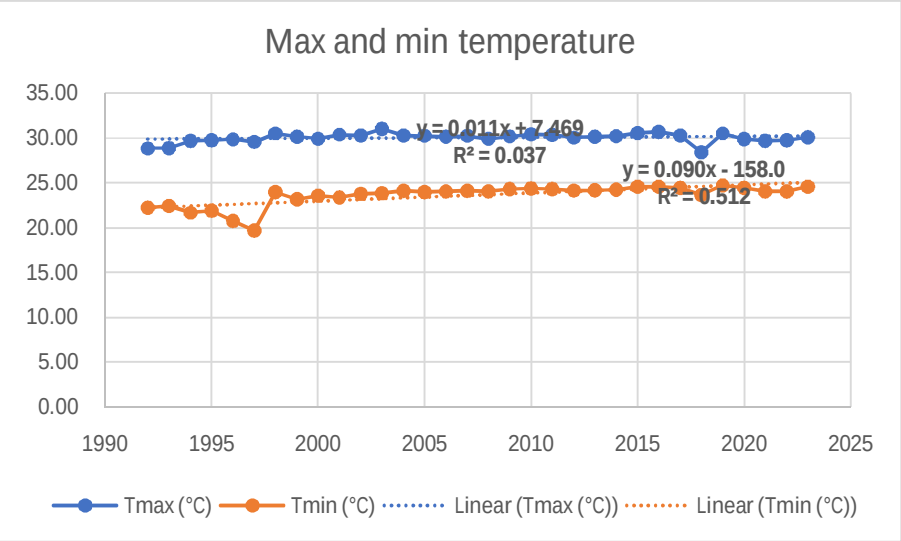

Figure 2: Minimum and maximum temperature of 31 years in the study area from 1992-2022

3.1.2 Changes in rainfall pattern

The findings of the study demonstrate that paddy farmers in Pemba Island have observed changes in the rainfall pattern. Approximately 49 percent of the respondents (as shown in Table 1) agreed that there was a noticeable shift in the rainfall pattern. However, 47 percent of the respondents remained undecided, while 4 percent did not agree with the notion of change. These findings align with the results of a study conducted by Nyang'au*et al.* (2021) in Masaba Sub-county, Kisii, Kenya, as well as with findings from Apac district in Northern Uganda by Atube*et al.* (2022) and study from Sri Lanka by Chandrasiri*et al.*, (2023). In all these studies, farmers reported perceiving a decrease in rainfall. These findings are consistent with a study carried out by Antwi-Agyei and Nyantakyi-Frimpong (2021) in Northern Ghana, which also highlighted farmers' observations of changes in rainfall patterns. Chandrasiri*et al.*, (2020) asserted that rainfall variability as the primary reason for low paddy production in Sri Lanka.The impact of these changes on agricultural crops is significant, particularly for paddy farmers in the study area who face the challenges associated with unpredictable rainfall. The findings were further supported byone of keyinformant interview conducted in the study area, as illustrated belowbyone of the Key informants;

"The rainfall is unreliable and unpredictable. Sometimes it arrives early, sometimes it is delayed. When it does come, it is often heavy, resulting in flooding in low-lying areas."

Table 1: Perception of Climate Change among Paddy Famers in Wete - Pemba Island

Variables	Disagree	Undecided	Agree
The temperature is increasing	20	1	79
There are changes in rainfall pattern	4	47	49
There is rise in sea level	9	25	66
There is increase in pests	38	4	58
There is increase in dry spells	15	34	51

Source: Field Survey

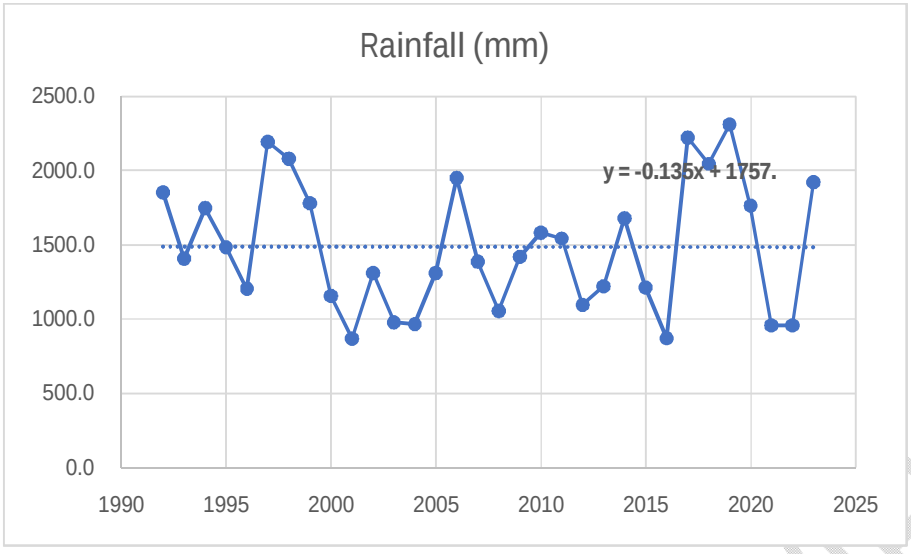

Figure 3: Annual rainfall of 31 years (1992 – 2023) in the study area

The meteorological data revealed much variations in average annual rainfall pattern. For example, in 1992 the annual average rainfall was 1853.5mm, 1997 was 2194.2mm, 2016 was 871.8mm, 2017 was 2222mm, 2018 was 2047.2mm, 2019 was 2312.8mm, 2021 was 957.7mm, 2022 was 958.7mm and 2023 was 1921.9mm. These findings show remarkable variations in annual rainfall in the study area. These variations confirm respondents' perception and has much impacts on rainfed paddy production in the study area. Fig. 3 demonstrates a frequent variation in average annual rainfall over the past 31 years (1992-2023) in the study area.

3.1.3 Increase in dry spells, pests and rise of sea level

The findings indicate that paddy farmers have observed an increase in dry spells. Approximately 51 percent of the respondents (see table 1) reported experiencing an increase in dry spells during the rainy season. These findings align with a study conducted in Ismani Division, Iringa District by Kihupi*et al.* (2015a), which also found that smallholder farmers perceived an increase in dry spells during the rainy season. Meteorological data of rainfallconfirm that there is prolonged dry spell. Normally there is dry spell in February,however,the trend shows that there wereprolonged dry spellsup to March in several years. For example, in 2016 the average rainfall in March was 20.5mm, 2017 was 43.5mm, 2019 was 30.1mm, 2021 was 0.0mm, 2022 was 46.1, and 2023 was 28.0mm. Generally, the rainfall pattern in Wete District have changed more frequently, fluctuating in both amount and distribution Fig. 3, 4 and 5 shows. Paddy production is affected bythis fluctuation since it has an impact on when and how much water is available for paddy growth.Reduced yields, a greater risk of crop failure, and water scarcity are all effects of droughts and periods of low rainfall. In addition, flooding and severe rain can result in water logging losses.

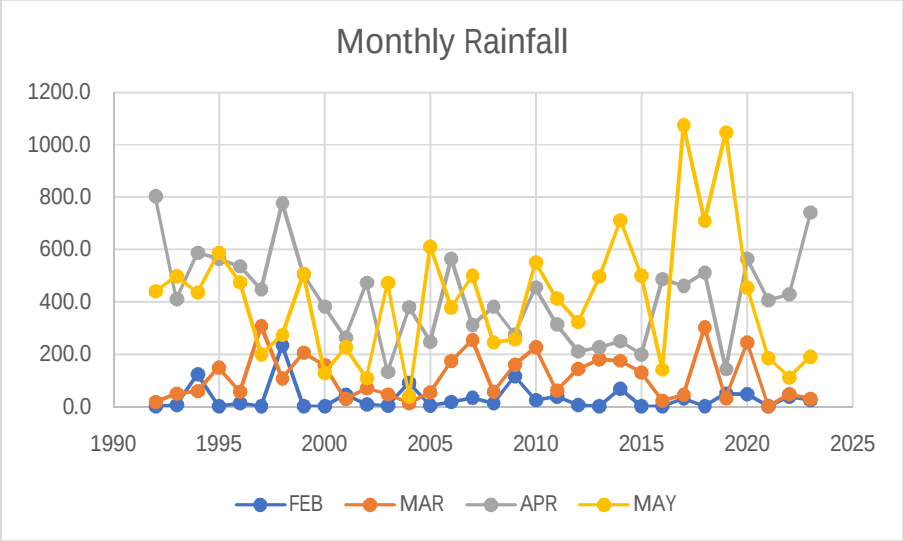

Figure 4: Monthly Rainfall for February, March, April and May in the study area

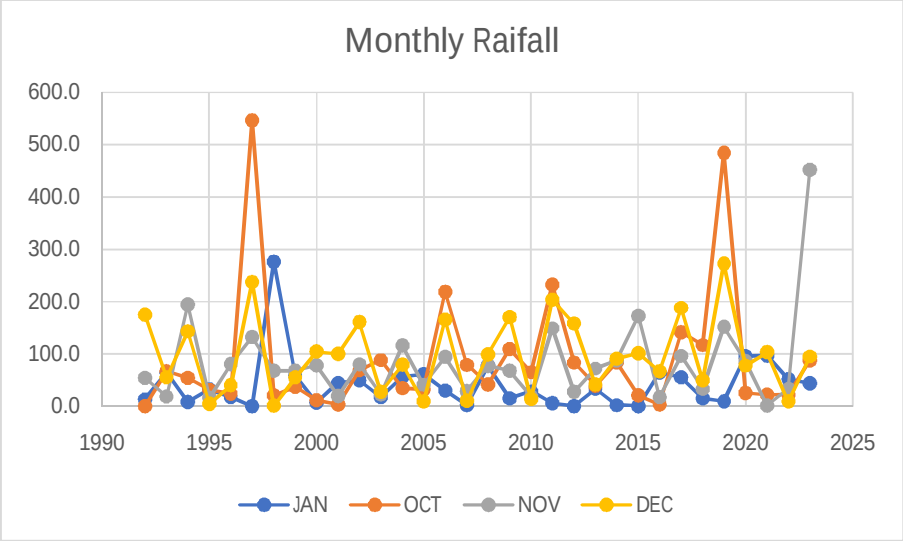

Figure 5: Monthly Rainfall for Octoba, November, December and January

The findings also show that there has been an increase in pests infesting paddy crops due to rising temperatures. This finding is consistent with a study conducted in Northern Uganda (2021) by Atube*et al*., which revealed that smallholder farmers perceived an increase in pests. Furthermore, the study found that 66 percent of the respondents acknowledged a rise in sea levels in the study area. These findings were further supported by informant interview conducted in the study area, as confirmed by one of the informants below.

"The salinity of seawater continues to rise over time, often encroaching upon our rice fields and devastating our crops. Additionally, high temperatures can lead to excessive soil dryness, resulting in the formation of cracks. Furthermore, there has been a noticeable increase in pest infestations that pose a threat to our paddy crops."

3.2Paddy Farmers Adaptation and copping Strategies against Impacts of Climate Change

Paddy farmers in Pemba Island are employing a range of adaptive measures and coping strategies in response to the effects of climate change, as depicted in Table 2.

3.2.1Construction of embankments

Paddy farmers observed the rise in sea levels and its impact on their farms.The research findings indicated that paddy farmers in Pemba Island are taking adaptive measures to mitigate the effects of climate change by constructing ridges along the coastline to prevent the intrusion of seawater into their paddy farms. Over 60 percent of the respondents reported that they have constructed ridges for this purpose. These findings were further supported by one of the informant interviewed in the study area who said:

"I construct substantial embankments, like others do, to provide some degree of control over the influx of seawater into our paddy fields. Nonetheless, paddy crops located in close proximity to the ocean succumb to the deleterious effects of saltwater intrusion, irrespective of the presence of these embankments. Regrettably, there is no viable solution at my disposal to aid those particular paddy crops."

Based on the key informant statement provided, it becomes evident that the construction of ridges as a strategy to prevent the ingress of seawater into paddy farms is not highly effective. As a result, it is imperative to implement more efficient measures to address this issue.

3.2.2 *Application of pesticides*

Paddy farmers in the study area have reported an increase in pests as one of the several impacts of climate change affecting paddy production. More than 51 percent of respondents stated that they use pesticides to combat the pests that affect their paddy crops. These findings are consistent with a study conducted by Kihupi*et al.* (2015b) in Ismani - Iringa District, which revealed that farmers used pesticides to address the issue of increased pests damaging their crops. Furthermore, these findings are supported by a study conducted in Northern Uganda (2021) by Atube*et al.,* which indicated that smallholder farmers adopt intensive insecticide use to control the growing pest infestations in their crops. Key informant interviews conducted in the study area also confirmed these findings, as one of the informants stated:

"When we have sufficient funds, we purchase pesticides and apply them to our paddy farms in order to safeguard the paddy crops from pest infestation."

3.2.3 Irrigating paddy farms during dry spells

Dry spells were identified as one of the major factors affecting paddy production in the study area. A significant proportion of respondents (more than 22 percent) confirmed that they employed irrigation methods to mitigate the stress caused by dry spells on their crops. These findings are consistent with a study conducted in Isimani - Iringa District by Kihupi*et al*., (2015b). The key informant interviews conducted in the study area also supported these findings. One of the informants stated the following:

"We construct water ponds for irrigation purposes during periods of drought in order to reduce heat stress on our crops."

Table 2:Paddy Farmers Adaptation and Copping Strategies in Wete-Pemba Island (n=71)

Adaptation&copping strategies	Frequency	Percent of cases
Irrigating farms during dry spells	15	22.7
Construction of embankments	40	60.6
Involving in casual labour	1	1.5
Ask for financial help from relatives	5	7.6
Less than three meals per day	9	13.6
Migration for men	6	9.1
Use of pesticides	34	51.5
Use of fertilizers	1	1.5
Construction of water reservoir for irrigation	2	3.0
Pray to God so that he can have mercy on us	26	39.4
Plant cassava	9	13.6
Glowing vegetables	6	9.1

Source: Field survey

3.2.4 Other adaptation and coping strategies

Table 2 presents additional adaptation and coping strategies employed by paddy farmers in the study area to mitigate the effects of climate change. These strategies include engaging in casual labour, utilizing social networks, skipping meals, migrating, using fertilizers, cultivating cassava, and growing vegetables. These findings align with a study conducted in Northern Ghana by Antwi-Agyei and Nyantakyi-Frimpong (2021), which also identified skipping meals as a coping strategy for climate change impacts among farmers. Praying to seek divine intervention was another strategy adopted by paddy farmers to address the challenges of climate change, with more than 39 percent of respondents indicating its use. These findings were further supported by informant interviews conducted in the study area, as outlined below:

"We, as human beings, have committed many sins against God, resulting in the current events we are facing. Consequently, there is little we can do to resolve this situation, as God is the ultimate authority and is punishing us for our transgressions. Our only recourse is to pray to God, seeking His forgiveness and mercy, in the hope that He will deliver us from our present circumstances."

By key informant 1

"When faced with limited or no food supply in our household, we practice meal skipping in order to stretch the duration that the available food can sustain us. Occasionally, I provide my children with a single serving of porridge per day, to last them until the next day."

By key informant 2

4.0 Conclusion

The study findings reveal that paddy farmers in the study area perceive increased temperatures, changes in rainfall patterns, more frequent dry spells, and rising sea levels. The meteorological data revealed increase in temperature,variations in rainfall pattern andprolonged dry spells.The study also identifies various strategies used by paddy farmers to mitigate the impacts of climate change, such as constructing ridges, applying pesticides, using irrigation, and skipping meals. However, the construction of ridges to prevent seawater intrusion proved to be ineffective, as saltwater from the ocean still managed to affect some paddy crops. This highlights the need for more effective measures to improve the current situation of paddy farmers and address the projected impacts of climate change in the future. In general, climate change poses significant threats to rainfed agriculture and islander communities, hindering the achievement of Sustainable Development Goals, particularly those related to poverty reduction (Goal 1: End poverty in all its forms everywhere) and food security (Goal 2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture). Therefore, this study recommends that the Revolutionary Government of Zanzibar construct a sea wall to help paddy farmers build resilience against the impacts of current and future climate changes. Additionally, the study suggests that paddy farmers in Pemba Island adopt transformative adaptation strategies that are more sustainable and can withstand the projected harsh climate changes in the future.

Disclaimer (Artificial intelligence)

I author Mary Kihupi hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

8.0 References

Acquah, H. and Onumah, E. E. (2011). Farmers' perception and adaptation to climate change: an estimation of willingness to pay. Agris-on-line papers in *Economics and Informatics* 3(4): 31-39.

Amare, Z. Y., Ayoade, J. O., Adalekan, I. O., and Zeleke, M. T. (2018). Barriers to and determinants of the choice of crop management strategies to combat climate change in Dejen District, Nile basin Ethiopia. Agric Food Secur.7(1):37. https://doi.org/10.1186/s40066-0188-y

Antwi-Agyei, P. and Nyantakyi-Frimpong, H. (2021). Evidence of Climate Change Coping and Aaptation practices by Smallholder Farmers in Northern Ghana. *Sustainability* 13https://doi.org/10.3390/su/1303108

Atube, F., Malinga, G. M, Okello, D. M., Alarakol, S. P. and Okello – Uma, I. (2021). Determinants of smallholder farmers adaptation strategies to the effects of climate change: Evidence from Northern Uganda. *Agriculture and Food security. https://doi.org/10.1186/s40066-020-00279-1*

Babbie, E. (1990) Survey research methods, Second Edition. Wadsworth, Cengage Lerning, Belmont, USA. 395 pp.

Bailey, D. K. (1998), Methods of social science research. The free Press Collier Macmillan Publisher, London.345 pp.

Bakari, S.M. (2015). Climate Change Impacts and Adaptation Strategies of Small-Scale Agriculture in Micheweni District, Pemba, Tanzania. MA thesis, Sokoine University of Agriculture.

Bello, M., Salau, E. S., Galadimal, O. E. and Ali, I. (2013). Knowledge, perception and adaptation strategies to climate change among farmers of Central State Nigeria. *Sustainable Agriculture Research* 2(3): 107-117.

Chandrasiri,C.K., Tsusaka, T.W., Ho, T. D. N., Zulfiqar, F., and Datta, A. (2023). Impacts of climate change on paddy yields in different c zones of Sri Lanka: a panel data approach. Asia-PacJRegSci7455-487. https://doi.org/10.1007/s41685-022-00264-5

Chandrasiri, S., Galagedara, L., and Mowjood, M. (2020). Impacts of rainfall variability on paddy production. A case from Bayawa minor irrigation tank in Sri Lanka. Paddy water Environ. 18 443-454 https://doi.org/10.1007/s10333-020-00793-9

Cochran, W. G., (1977). *Sampling techniques* 3rd (ed). John Willey & Sons, New York. 442pp.

Devkota, N., and Paija, N. (2020). Impacts of climate change on paddy production: Evidence from Nepal. Asian Journal of Agriculture and Development 17(2) 63 - 77

Hassan, R. and Nhemachena, C. (2008). Determinants of African farmers' strategies for adapting to climate change: multinomial choice analysis. *African Journal of Agricultural and Resource Economics* 2(1): 83- 104.

Herath, g., Hasanov, A., and Park, J. (2020). Impacts of climate change on paddy production in Malaysia: empirical analysis at the national and state level experience. In J. Xu, S. E. Ahamed, F. L. Cooke, and G. Duca (Eds), Proceedings of the thirteenth International Conference on Management Science and Engineering Mangement (1st ed., 1 656-664. *Springer*. https://doi.org/10.1007/978-3-030-21248-3_48

Hisali, E., Birungi, P., and Buyinza, F. (2011). Adaptation to climate change in Uganda: evidence from micro level data. *Global Environmental Change* 21: 1245-1261

Hussain, J., Hussain, S., Tahir, N., Rasool, I., Ullah, A., Ahmad, S. (2022). Climate Change and Rice Production: Impacts and Adaptations. In: Sarwar, N., Atique-ur-Rehman, Ahmad, S., Hasanuzzaman, M. (eds) Modern Techniques of Rice Crop Production. Springer, Singapore. https://doi.org/10.1007/978-981-16-4955-4_29

Kihupi, M. L.,Chingonikaya, E. E., and Mahonge, C. (2015a)Smallholder Farmers' Perception of Climate Change Versus Meteorological Data in Semi-arid Areas of Iringa District, Tanzania.*Journal of Environment and Earth Science*.ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online) 5(2).

Kihupi, M. L., Mahonge, C., and Chingonikaya, E. E.(2015b)Smallholder Farmers' Adaptation Strategies to Impact of Climate Change in Semi-arid Areas of Iringa District Tanzania.*Journal of Biology, Agriculture and Healthcare*. ISSN 2224-3208 (Paper) ISSN 2225-093X (Online) 5(2).

Kitinya, K. T., Onwonga, R. N., Onyango, C., Mbuvi, J. P. and Kironchi, G. (2012). Climate change and variability: farmers' perception, experience and adaptation strategies in

Makueni County, Kenya. *Asian Journal of Agriculture and Rural Development* 2(3): 411-421.

Komba, C. and Muchapondwa, E. (2012). Smallholder farmers in Tanzania. ERSA working paper 299. Economic Research South Africa. 33pp. [http://econrsa.org/home/index.phd?option=comdocman&task=docdownload&gid=443&Itemid=67] Site visited on 05/07/2012.

Lazrus, H. (2012). Sea change: Island Communities and Climate Change. Annual Review of Anthropology. DOI: 10.1146/annurev-anthro-092611-145730

Legesse, B., Ayele, Y. and Bewket, W. (2012).Smallholder Farmers, Perceptions and Adaptation to Climate Change Variability and Climate Change in Doba District West Hararghe, Ethiopia. *Asian Journal of Empirical Research* 3(3): 251-265.

Liu, Y., Tang, L., Qiu, X., Liu, B., Chang, X., Liu, L., Zhang, X., Cao, W., and Zhu , Y. (2020). Impacts of 1.5 and 2.0^{0}C global warming on rice production across China.Agricultural and Forest Meteorology. 284 ISSN 0168 – 1923 https://doi.org/10.1016/J.ogrformet.2020.107900

Mafie, G. (2021). The impacts of climate change on agricultural productivity in Tanzania. *International Economic Journal* Doi:10.1080/10168737.2021.20102299

Makame, M. O. (2013). Vulnerability and Adaptation of Zanzibar East Coast Communities to Climate Variability and Change and Other Interacting StressorsDoctor of Philosophy dissertation, Rhodes University.

Malekela, A. A., Sieber, S., Mapunda, J., and Chobo, J. S. (2024). Contemporary Agricultural land management practices under climate change and population increase scenarios: Insights from Tanzania's Southern highlands. Journal of Geography, Environment and Earth Science International. 28(04) 41 -52

Mangora, M., Shalli, M. S., Kaur, N., Jumah S.M., Mwita F. & Bakar S. (2015). Local Adaptation Investment Planning in Zanzibar. A Baseline Review of Policy and Institutional Framework. Retrieved from https://www.researchgate.net/ publication/ 27628835.

Mengistu, D. K. (2011). Farmers' perception and knowledge of climate change and their coping strategies to the related hazards: Case study from Adiha, central Tigray, Ethiopia. *Agricultural Sciences* 2(2): 138-145.

Moyo, M., Mvumi, B. M., Kunzekweguta, M., Mazvimavi, R., Craufurd, P. and Dorward, P. (2012). Farmers' perceptions on climate change and variability in semi-arid Zimbabwe in relation to climatology evidence. *African Crop Science Journal* 20(2):317-335

Nor Diana, M. I., Zulkepli, N. A. Siwar, C. and Zainol, M. R. (2022). Farmers' adaptataion strategies to climate change in South-east Asia: A Systematic Literature Review. *Sustainability* DOI: 10.3390/su14063639

Nyang'au, J. O., Mohamed, J. H., Mango, N., Makate, C., and Wangea, A. N. (2021). Smallholder Farmers' Perception of Climate Change and Adoption of Climate Smart Agriculture Practices in Masaba South Sub-County, Kisii, Kenya. *Heligon* e06789

Pollard, E. (2009). Settlement Adaptation to a Changing Coastline: Archaeological Evidence from Tanzania, During the First and Second Millennia AD. *Journal of Island and Coastal Archaeology*, 4(1): 82–107). Doi: 10.1080/15564890902779677.

Rao, R. K., Sharma, P.K., and Raghuraman, M. (2017). Impact of Climate Change on Food Security. *Indian Journal of Agriculture and Allied Sciences* 3 (2) ISSN 2395-1109

Sand, S., Wang, D., Fahad, S., Alharby, H. F., Bamagoos, A. A., Mjrashi, A., Alabdallah, N. M., ALZahrani, S.S., AbdELgaward, H., Adnan, M., Sayyed, R. Z., Ali., S., and Hassan S. (2022). Comprehensive impacts of climate change on rice production and adaptive strategies in China. *Front microbiol.* Doi:10.3389/fmicb.2022.926059

Smit, B., and Pilifosova, O. (2001). Adaptation to Climate Change in the context of sustainable development and Equity.' In: *Climate Change 2001 Impacts, Adaptation, and Vulnerability.*Contribution of Working Group II to the Third Assessment Report of the IPCC. (Edited by McCarthy J.J., Canziani, O. F., Leary, N. A., Dokken, D. J., White, K. S.) Cambridge University Press, Cambridge.877 – 912.

Webster, P. J. (2008). Myanmar's deadly daffodil. *Nat Geosci*. 1 488-490.

WMO (2023).*State of the Climate in Africa 2022*. World Meteorological Organization. Geneva, Switzerland. 34pp.

Woetzel, J., Pinner, D., Samandari, H., Engel, H., Krishnan, M., McCullough, R., Melzer, T. and Boettiger, S. (2020). Climate Risks and Response Physical Hazards and Socioeconomic Impacts: How Will African Farmers Adjust to Changing Patterns of Precipitation. Case Study. McKinsey Global Instute. 20pp

Zella, A. Y., Kitali, L. J., Lunyelele, S. S., Asenga, S. S., and Ntaturo, E. M. (2024) Effects of climate change among paddy farmers in Kahama District, Tanzania. International Journal of Geography, Geology and Environment 5(2)122-132 Doi: https://doi.org/10.22271/27067483.2023.v5.i2b.180