SSRG International Journal of Agriculture & Environmental Science
ISSN: 2394-2568/ https://doi.org/10.14445/23942568/IJAES-V12I3P102

Volume 12 Issue 3, 9-13, May-Jun 2025

Original Article

Impact of Climate Change and Adaptations in Clove Farming in Pemba Island, Zanzibar, Tanzania

Fatma Masoud Ali[1], Mary Mtumwa Khatib[1], Yussuf Abdul Rahim Yussuf[1*], Abdalla Ibrahim Ali[1]

[1]*School of Natural Sciences, The State University of Zanzibar, Zanzibar, Tanzania.*

[*]*Corresponding Author : mnyasi 15@gmail.com*

Received: 03 April 2025 Revised: 08 May 2025 Accepted: 27 May 2025 Published: 16 June 2025

Abstract - *Clove farming is highly impacted by climate change, specifically changes in rainfall and temperature. The study evaluated how cloves farming is affected by climate change and the adaptation approaches farmers have used to deal with the problems. Climatic data on temperature, rainfall, and clove production from 2015 to 2019 were collected. Furthermore, questionnaires were used to collect information about problems facing clove farming and adaptation measures taken by the farmers. The study demonstrated a strong positive relationship between rainfall and clove production (R=+0.989, p = 0.001). The productivity of cloves was significantly correlated negatively with temperature (R=-0.903*, p=0.036). In addition, the study results revealed that 24.4% of farmers were affected by pest diseases,51.1% dryness of the clove trees, 3.33% frequent flooding and 34.44% seed dormancy. The study also revealed several adaptations measured undertaken by farmers to overcome climate change: 20% of farmers used irrigation, 56% mulching, 8.89% replanting, 11.11% application of fertilizers, 20% changing of planting pattern, 10% weeding, 14.44% increased plant spacing and 50% used intercropping method. Therefore, clove farming was affected by climate change factors, and farmers took several adaptation measures to overcome the challenges.*

Keywords *- Clove farming, Climate variability, Climate change Adaptation.*

1. Introduction

Syzygium aromaticum (clove) is globally recognized as the most valuable spice from Moluccas Island [1]. The trees thrive in coastal regions with temperatures ranging from 15 to 30 degrees, and they are little trees with a height range of 12 to 20 meters [2].

Clove trees have brilliant pink juvenile leaves that turn greenish as they ripen [2]. These trees, ranging in height from 12 to 20 meters, flourish in coastal areas with temperatures between 15 and 30 degrees. Juvenile clove trees feature vivid pink leaves that change to greenish when matured [2]. This spice is commonly found on spice racks worldwide [2]. The United Arab Emirates and India buy cloves from Madagascar and Indonesia, major clove growers [3].

Clove cultivation, which forms the cornerstone of the nation's economy each year, employs most people directly or indirectly in Zanzibar [4]. In Zanzibar Island, Millions of clove trees are grown on Pemba Island [4].

However, based on information from the Ministry of Agriculture in 2010, the number of clove trees appears to have declined over the preceding ten years [4]. Climate change-related variables like high temperatures and insufficient rainfall significantly impact clove production and cultivation, leading to dryness, disease, and ultimately death [5]. Climate change in Zanzibar is harming the island's ability to maintain productive agriculture. Recently, clove farmers have seemingly claimed the growth of the clove trees from the stage of clove seedlings up to the production age. According to farmers, slow growth, dryness and dying are the most prevailing issues [6].

Clove farmers attribute the problems to rising temperatures and inadequate rainfall [6]. Clove producers are especially vulnerable to environmental and climatic threats since they have few options for diversifying their income streams [6]. Knowledge of how climate change affects Zanzibar's clove production is an essential component of enhancing the clove industry. As a result, the study was conducted to determine the consequences of climate variability, particularly temperature and rainfall, and the adaptation techniques farmers employed to eliminate the challenges. By using the study's findings, farmers will be able to understand the effects linked to climatic variability to improve adaption techniques for better clove production. Stakeholders, including policymakers, would probably use the study's results to make policies for improving clove farming.

2. Methodology

2.1. Study Area

The study was conducted in three settlements on Pemba Island: Gando, Junguni, and Ukunjwi—United Republic of Tanzania. The island is located at 4˚45' to 5˚30' south and 39˚35' to 39˚49' east of the equator, and its size is about 988 square kilometers (Sheha, 2018). It is divided into two regions: Northern and Southern Pemba. It comprises four districts: Mkoani districts, Chake Chake districts, Wete districts, and Micheweni districts. (Figure 1).

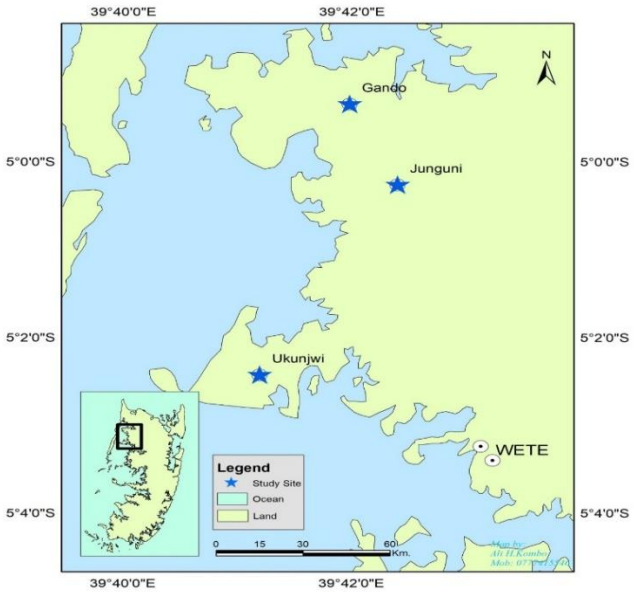

Fig. 1 Pemba island and its respective villages Gando, Junguni and Ukunjwi

2.2. Study Design

Both descriptive and an exploratory research design were utilized.

2.3. Data Collection

Data about climate variabilities was obtained from the Tanzania Meteorological Agency in Zanzibar, and clove production was obtained from the Zanzibar State Trade Corporation (ZSTC).

The study also employed questionnaires to get information from farmers on problems facing clove producers and the adaptation measures adopted to overcome the challenges.

2.4. Sampling Procedures

Using purposive sampling, a total of ninety farmers were chosen for the survey of the three Shehias—Gando, Ukunjwi, and Junguni.

3. Data Analysis

Statistical Programs for Social Sciences (SPSS) version 20 was utilized to analyze the data to obtain the p values and correlation coefficients. Microsoft Word and Excel were also used to draw the bar charts and scatter plots.

4. Results and Discussion

4.1. Impacts of Rainfall Variability on Clove Production

The current study showed that high clove production was obtained in 2017 and 2018. The two years received the highest rainfall (figure 2). The findings indicated that the amount of rainfall and clove production were positively correlated (R=+0.989, p = 0.001). (Figure 3). The years with less rainfall experienced low clove production in 2015, 2016, and 2019; the years that showed high clove production experienced the highest rainfall; therefore, rainfall variation affected clove production. This was also supported by several studies [7,8,9] that the communities in Tanzania have perceived a decrease in rainfall that led to interference with clove production. A study by [10] also depicted that rainfall is necessary for flowering clove plants, enhancing high production. Variation of Rainfall was also insisted by [10] that in Zanzibar, there is a changing pattern in rainfall which may affect agriculture, specifically clove farming.

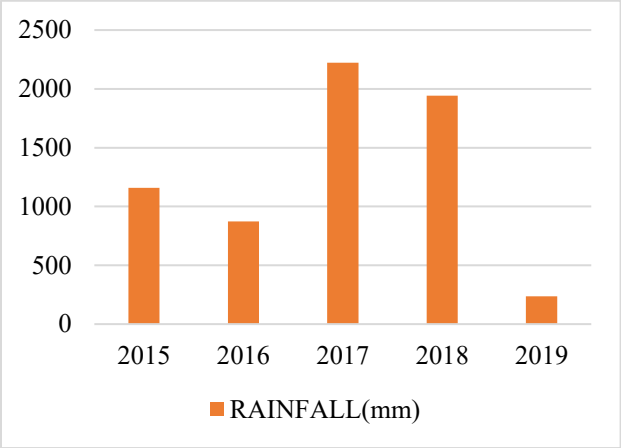

Fig. 2 Variation of rainfall (mm) with clove production in Pemba from 2015 to 2019 (Source Tanzania Meteorological Agency (TMA)

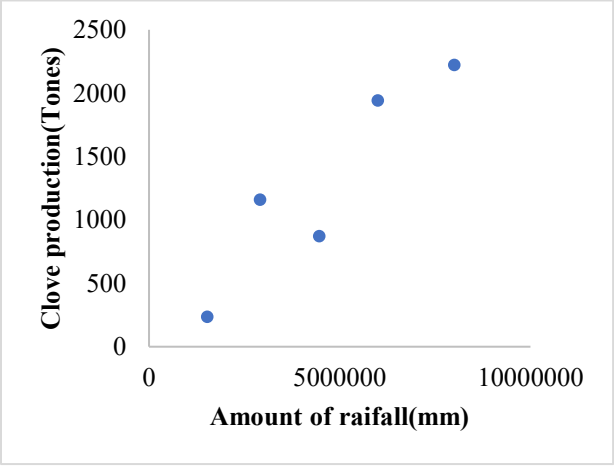

Fig. 3 Correlation between clove production and temperature

4.2. Impact of Temperature Variability on Clove Production

The years 2017 and 2018 experienced low temperatures and, consequently, high clove production. In 2015,2016,2019, the temperature was high, and clove production was low in these years. This is evidence that clove production was influenced by low temperatures and affected by heat and dry conditions (Figure4). This signifies that the temperature was negatively correlated (R= -0.903*, p=0.036) with clove production. (Figure 5) The result of the study also concurred with that of [10] and portrays that the clove tree requires a mild tropical climate with temperatures between 20°C and 30°C. An increase in maximum temperature leads to a decrease in crop yield. The same result was also narrated by [11], which states that climate change contributed significantly to the decrease in the number of clove trees.

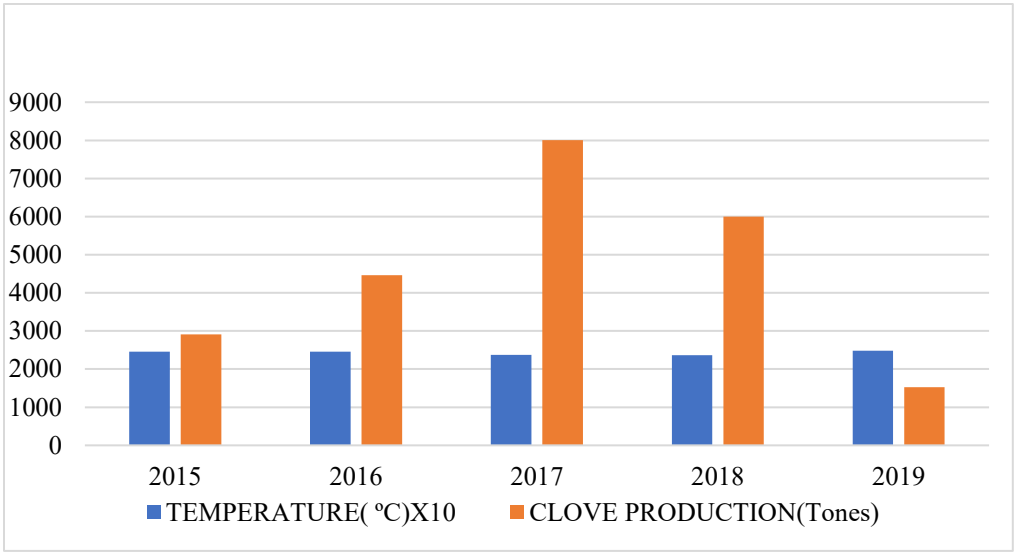

Fig. 4 Variation of temperature from 2015 to 2019((Source Tanzania Meteorological Agency (TMA)

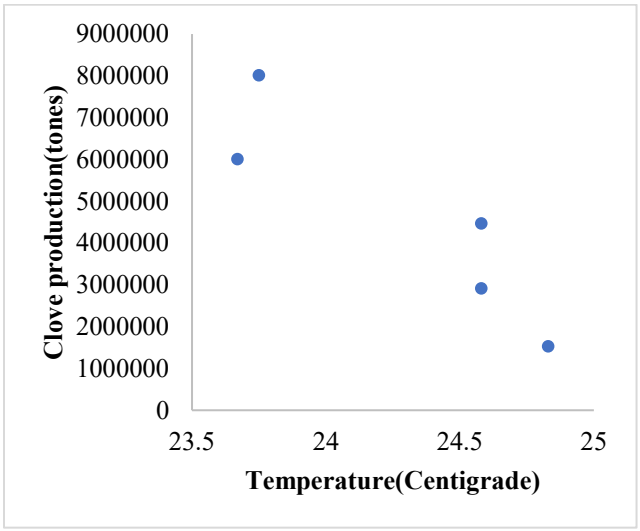

Fig. 5 Correlation between clove production and temperature(˚C)

4.3. Other Factors Affecting Clove Production in Pemba

The result of the current study also showed that the majority (51.1%) were affected by dry weather conditions that led to dryness of the clove trees, 24.4% of clove farmers were affected by Pests and diseases,3.33% frequent floods and 34.44% seed dormancy. The results are supported by [12] and [13] that pests and diseases affecting crops are more common due to climate alteration. A study by [14] found similar results that both temperature and rainfall variations can result in vector-borne diseases in crops. These changes will also affect insect, pest, and other vector populations. [15] supports the findings by stating that farmers believe crop pests have been more common in recent decades.

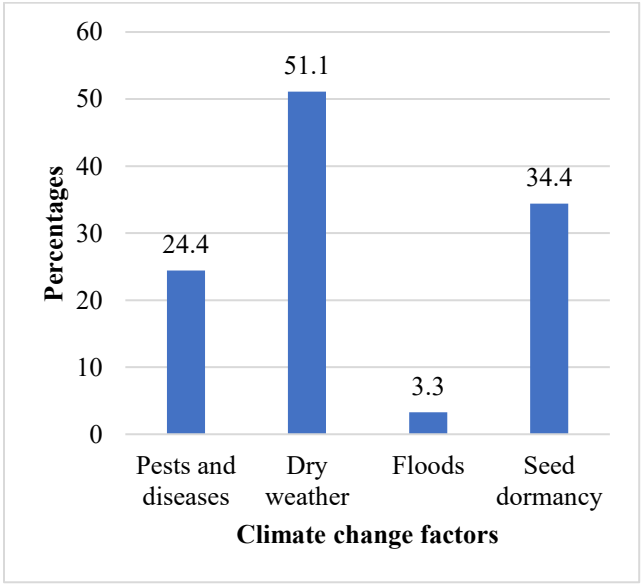

Fig. 6 Climate change factors affecting clove farming

4.4. Adaptation Measures taken by Clove Farmers

Moreover, the current study's findings showed that farmers responded to the effects of climate change on clove plants in a variety of ways; the majority,50%, used the Mulching method 20% of farmers employed irrigation, 56% mulching, 8.89% replanting, 11.11% applied fertilizer on their farms.20% of them changed their planting patterns, 10% weeding, 14.44% increased plant spacing to prevent insect transmission (Figure 7). In contrast, [16] discovered that irrigation was a highly successful way to control climate change, even while adaptive methods were employed to mitigate its consequences. The results are analogous to a study by [17] in Tanzania's Pangani River Basin. These strategies include increasing the application of fertilizers, shifting from arid to wetlands, irrigating the farms, soil management, exchanging planting dates, planting crops that grow more quickly, planting drought-resistant crops, mixed farming, transformation to non-farm activities, planting vegetation to provide shade, and mulching with bark. A study by [18] depicted that clove farmers adapt to climate change by applying manure, making tillage and pest control because they do not know about adaptation.

Furthermore, [19] applying seaweed debris as an organic fertilizer has enhanced clove seedling growth in nurseries. According to a study by [20], clove producers only adjust using manure, tillage, and insect management since they lack adaptation knowledge. Moreover, a study by [21] demonstrated that using seaweed waste as an organic fertilizer for clove seedlings in nurseries might improve their growth**.**

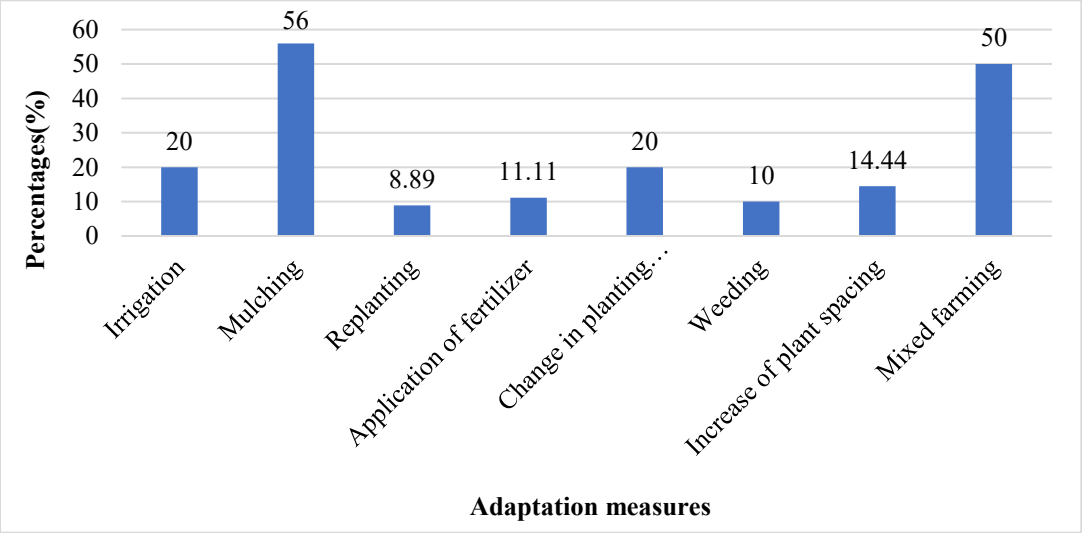

Fig. 7 Adaptation measures applied by farmers to overcome climate change

5. Conclusion

The current study's findings showed that rainfall and temperature affected clove production on Pemba Island in one way or another. Also, clove farming was significantly impacted by pests and diseases, drought, floods, and seed dormancy. Despite the challenges, farmers implemented several adaptation strategies to combat the consequences of climate change.

5.1. Significance of the Study

The results of this study will help farmers better understand how climate variability affects their crops and develop adaptation strategies for increased clove production. Policymakers will likely utilize the study's findings to inform policies to enhance clove farming.

5.2. Recommendations

In order to implement the adopted measures and achieve better farming practices, which are the best ways to save clove farming communities, governments should develop policies on improved farming mechanization and infrastructure, such as water management facilities and conservation actions, to prevent climate change constraints. Increasing the capacity through disseminating knowledge through magazines, flyers, radio and television programming, and mass media could assist farmers in enhancing their agricultural methods for increased output across the nations.

5.3. Limitations

Moreover, the negative and positive correlation between clove production, respective to rainfall and temperature, may affect the clove production, and other factors may have influenced the results.

5.4. Future Research

Future studies on other factors that affect clove farming must be carried out to increase research diversity and better understand the challenges facing clove farming.

References

[1] Isabel Gutierrez, "*Phytochemical Composition and Bioactivity of Clove (Syzygium Aromaticum) Oil and Post-Distillation Biomass Extract*," Electronic Theses and Dissertations for Graduate School, 2021. [Google Scholar] [Publisher Link]

[2] Parle Milind, and Khanna Deepa, "Clove: A Champion Spice," *International Journal of Research in Ayurveda and Pharmacy*, vol. 2, no. 1, pp. 47-54, 2011. [Google Scholar] [Publisher Link]

[3] Natacha Arimalala et al., "Clove Based Cropping Systems on the East Coast of Madagascar: How History Leaves Its Mark on the Landscape," *Agroforestry Systems*, vol. 93, pp. 1577-1592, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[4] Suleiman Ali Bakar, "*Contribution of the Zanzibar State Trading Corporation (ZSTC) to Clove Production in Zanzibar*," Dissertation, Dodoma: The University of Dodoma, 2015. [Google Scholar] [Publisher Link]

[5] Dwi Aulia Puspitaningrum, Eko Amiadji Jutianto, and Herwin Lukito, "Perception and Adaption of Farmers on Climate Change (A Case Study at Clove Farmer in Samigaluh Kulonprogo, Yogyakarta," Urban Development and Lifestyle Nova Science Publissher, 2020. [Google Scholar] [Publisher Link]

[6] Suddhasuchi Das, and Amit Baran Sharangi, "Impact of Climate Change on Spice Crops," *Indian Spices: The Legacy, Production and Processing of India's Treasured Export*, pp. 379-404, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[7] Makame Omar Makame, "*Vulnerability and Adaptation of Zanzibar East Coast Communities to Climate Variability and Change and Other Interacting Stressors*," Dissertation, Grahamstown: Rhodes University, 2013. [Google Scholar] [Publisher Link]

[8] Riziki Silas Shemdoe, "Tracking Effective Indigenous Adaptation Strategies on Impacts of Climate Variability on Food Security and Health of Subsistence Farmers in Tanzania," 2011. [Google Scholar] [Publisher Link]

[9] M.A. Lema, and A.E. Majule, "Impacts of climate change, variability and adaptation strategies on agriculture in semi-arid areas of Tanzania": the case of Manyoni District in Singida Region, Tanzania," African Journal of Environmental Science and Technology, vol. 3, no. 8, pp. 206-218, 2009. [CrossRef] [Google Scholar] [Publisher Link]

[10] Miraji K. Miraji, "*Effect of Weather on Clove Production in Pemba Island, Tanzania*," Dissertation, Nairobi: University of Nairobi, pp. 1-41, 2013. [Google Scholar] [Publisher Link]

[11] S.K. Slim, "Impact of Changes in Agriculture Systems on Environment: The Case of Clove Decline in Wete District-Pemba," Dissertation, University of Dar es Salaam, 2012. [Google Scholar]

[12] Peter J. Martin, "The Zanzibar Clove Industry," *Economic Botany*, vol. 45, no. 4, pp. 450-459, 1991. [Google Scholar] [Publisher Link]

[13] Aklilu Amsalu, and Alebachew Adem, "Assessment of Climate Change-Induced Hazards, Impacts, and Response in the Southern Lowlands of Ethiopia," Addis Ababa, Forum for Social Studies, 2009. [Google Scholar]

[14] Zakaria A. Mani, Amir Khorram-Manesh, and Krzysztof Goniewicz, "Global Health Emergencies of Extreme Drought Events: Historical Impacts and Future Preparedness," *Atmosphere,* vol. 15, no. 9, pp. 1-21, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[15] Mohammad Anwar Hossain et al., "Heat or Cold Priming-Induced Cross-Tolerance to Abiotic Stresses in Plants: Key Regulators and Possible Mechanisms," *Protoplasma*, vol. 255, pp. 399-412, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[16] P. Parvatha Reddy, "Climate Change Adaptation," *Climate Resilient Agriculture for Ensuring Food Security*, pp. 223-272, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[17] G.J. Sanga, A.B. Moshi, and J.P. Hella, "Small Scale Farmers' Adaptation to Climate Change Effects in Pangani River Basin and Pemba: Challenges and Opportunities," *International Journal of Modern Social Sciences*, vol. 2, no. 3, pp. 169-194, 2013. [Google Scholar] [Publisher Link]

[18] R. Lal et al., "Management to Mitigate and Adapt to Climate Change," *Journal of Soil and Water Conservation*, vol. 66, no. 4, pp. 276-285, 2011. [CrossRef] [Google Scholar] [Publisher Link]

[19] D. Rusmin et al., "Improving the Growth of Clove Seedlings by the Application of Seaweed Waste as Organic Fertilizers," *IOP Conference Series: Earth and Environmental Science*, vol. 418, no. 1, pp. 1-9, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[20] Marco Valente et al., "Reducing the Emission of Climate-Altering Substances in Cementitious Materials: A Comparison Between Alkali-Activated Materials and Portland Cement-Based Composites Incorporating Recycled Tire Rubber," *Journal of Cleaner Production*, vol. 333, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[21] Snehasis Dalal, "*Master of Science (Horticulture) in Vegetable Science*," Dissertation, Cooch Behar: Uttar Banga Krishi Viswavidyalaya, 2022. [Google Scholar]