DETERMINANTS OF CLOVE PRODUCTION IN ZANZIBAR: EVIDENCE FROM VECM MODEL

A Thesis

Submitted to the Master's Study Program of Economics at the Faculty of Economics and Business in partial fulfillment of the requirements for the degree of

Master of Arts (M.A.)

by

Asia Khamis Nyange

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UNIVERSITAS ISLAM INTERNASIONAL INDONESIA

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ABSTRACT

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Cloves are not only a treasured cash crop in Zanzibar; they are an economic life-preserver, keeping export incomes and rural prosperity in place. The production of cloves, once a booming part of the export economy of the archipelago, has continued to shrink, raising serious questions about its root causes. In response to this call, this work explores how climatic factors as well as economic factors shape clove production in Zanzibar. Using secondary time series data from 1980 to 2024, sourced from the office of the chief government statistician Zanzibar, FAO and NOOA, this research used EViews software as a tool for data analysis, while R and STATA were used for graphical presentations. In addition, the analytical approach used descriptive statistics, as well as a Vector Error Correction Model (VECM) to reflect any immediate and long-term impacts. In the short-term analysis, result shows that Zanzibar clove production is primarily influenced by temperature (lag 1), producer price (lag 1), Precipitation (lag 2) and Ocean Nino Index (lag 1). However, several factors such as Producer Price (lag two), Temperature (lag two), Precipitation (lag two), Ocean Nino Index (lag two), Exchange Rate (lag one and two) and Clove export (lag one and lag two) do not have a statistically significant impact. Moreover, in the long run analysis, the study finds that Zanzibar's clove production is significantly determined by most of the factors included in the model which are temperature, Ocean Nino Index, Exchange Rate and clove export. In contrast, the study finds that precipitation and producer price do not have a significant impact on clove production in long run. Overall, the study concludes that clove production in Zanzibar main determined by temperature, Ocean Nino Index, producer price, Exchange Rate, clove export and precipitation. Based on these findings, this paper proposes a climate adaptation plan on clove sector in Zanzibar. These are the establishment of drought tolerant cloves varieties, reinforced agro-extension programs, integrated agroforestry with the use of shade and nitrogen fixing trees like Gliricidia sepium and Albizia lebbeck.

Keywords: *Zanzibar, Clove Production, Climatic factors and VECM*

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

1.1 Research Background

Assuring sustainable patterns of consumption and production is one of the key Sustainable Development Goals (SDG) 12 (Arora & Mishra, 2019). This goal emphasizes the importance of promoting sustainable practice in industries such as agriculture, which play a vital role for supporting economies and livelihoods in developing nations. Clove production is one of the significant agricultural activities in many developing nations, especially in tropical areas. This is because it plays an important role, such as not only contributing to the well-being of farming communities but also improving national economies through exports. Practicing sustainable clove production is crucial since it will help to meet the global demand while ensuring sustainable environmental preservation and improving the livelihoods of the farming communities.

Clove is a perennial tropical plant clove grows and thrives best in coastal environments with typical temperatures between 15 and 30 degrees Celsius, from ocean level to an elevation of 1000 meters above sea level V.S, R., & Manimekalai, V. (2020). Cloves grow best in deep loamy soil that has a high humus content and good drainage. Additionally, it thrives in milder climates with evenly distributed 1500– 3000 mm of annual rainfall. As a tropical crop, cloves rely heavily on climate conditions for planting, flowering, harvesting, productivity, and drying (Djaenudin et al., 2003). The main producers of this spice are the tropical regions, with Indonesia, Madagascar, and Tanzania leading as the top growers and producers. Indonesia dominates the market, accounting for nearly 70% of the world's clove production, followed by Madagascar at 27% and Tanzania.

The demand for this spice continues to increase globally, as evidenced by the growth of the global clove market from a valuation of US$366.7 million in 2022 to US$383.2 in 2023, and is expected to be valued at US$589.5 million by 2033 with a compound annual growth rate (CAGR) of 4.4% (Food, 2023). Despite increasing global demand, clove production is unstable, fluctuating significantly from year to year. For example, production increased from 187,500 tons in 2019 to 196,00 tons in 2020, indicating notable improvements of around 8500 tons. However, this expansion was short-lived, and output dropped sharply to roughly 188,500 tons in 2021, marking a drop of about 7,500 tons from previous year. Additionally, the declining trend continued in 2022, with further declining to 184,000, a decrease of 4,500 tons (FAO, 2023). These trends highlight the challenges within the industry and underscore the needs for intervention to stabilize the production.

The decline in clove production is evident not only on global scale but also within specific regions. Example, Over the past 20 years, clove production in Africa has been on the decline (Suarbawa et

al., 2024). The continent currently accounts for 27% of global clove output, a decrease from the nearly 90% it formerly contributed in the 1834s, when it dominated the market (FAO, 2023). Also, between 2012 and 2023, the average production peaked in 2022 and then fell precipitously in 2023 in terms of value and quantity. This represents a significant decline from the previous year's peak. In comparison to the previous year, this caused its clove market to decline by 3.3%, bringing the market value down to $83 million in 2023 (*Africa: Cloves market report, 2024*).

Tanzania, Africa's second-largest clove producer, exemplifies this downward trend (Pratama & Darwanto, 2019). Currently, it contributes around 12% and 2.89% share Africa and World's clove production respectively, a significant drop from over 80%, when it was the World's and Africa largest producer of clove (World population review data, 2023). Decline in Tanzania share in the clove market is largely due to its reliance on Zanzibar, which supply 99 percent of clove exported by Tanzania. Moreover, (Volza., 2024) noted that share of Tanzania's clove is decreasing due to the decline of the spice trade and natural disasters that hit the islands of Zanzibar (Volza data, 2024). Zanzibar, a semi-autonomous part of the United Republic of Tanzania, is historically known as the Spice Island, where clove cultivation has been a cornerstone of its agricultural sector and a vital component of its economy (Samwel J. KABOTE, 2022). When Zanzibar entered the global clove market in the 1830s, Indonesia lost its dominant position in the world's clove supply. 90% of the global clove market was dominated by Zanzibar in 1834, when 35,000 metric tons were produced there. Up until the 1940s, Zanzibar maintained its virtual stranglehold on the global clove market. Following that, Indonesia once again took the lead in the global clove market, both in terms of imports and production. Since that time, the quantity and value of cloves produced have been drastically decreasing, despite cloves being a high-value spice that has supported Zanzibar's economy for many decades (Samwel J. KABOTE, 2022).

It has been reported that, in Zanzibar, since the 1940s, the quantity and value of cloves produced show a significant and consistent decrease (KABOTE & TUNGUHOLE, 2022a). Between the 1970s and 2000s, Zanzibar's clove production decreased and reached a decline of 84.4% (Hilal 2013). On the same note, Bank of Tanzania (2013) observed that there was 65 percent reduction in production volumes within a decade. Even more, current figures prove this decline. As per the graph, the production of clove in Zanzibar rose by nearly 7000 metric tons to 12,500 MT between 2019 and 2020, which is a positive sign of improvement in short term. Such top did not last, though. The production lowered to approximately 9,300 tons in the year 2021, and then further attained a more pronounced downward trend to 5,200 tons in the year 2022. Production fell even further 23 percent in 2023 to only 4,000 tons, a decline of 68 percent compared to the 2020 high. This pattern suggests the continuous instability and fragility of the clove industry and emphasizes the necessity to have sustainable agricultural policies and stable production approaches in Zanzibar (Zanzibar Statistical Abstract, 2023).

Volatility of clove production in Zanzibar has been occurred due to price, monopoly of the market, inadequate funding, and a lack of participation of the private sector and poverty (Moh'd et al., 2017). Moreover, (government of Zanzibar (2013) stated that the drop in clove production in both Unguja and Pemba is due to clove growers failing to establish new trees. For example, it is estimated that between 1950/51 and 1959/60, Zanzibar had a clove tree population of 5,120,000, with the majority (3,824,000 trees) in Pemba and the remainder (1,296,000 trees) in Unguja. Between 1980/81 and 1989/90, the number of trees decreased by over 44% to 2,854,853. Between 1990/91 and 1999/2000, Zanzibar's clove tree population was projected to be 2,055,495. Zanzibar's clove tree population has declined by around 60% since 1950/51. Clove output has decreased in tandem with tree population fall. It is estimated that the average clove output in Zanzibar was 12,408 tons between 1950/51 and 1959/60, but fell to 6,225 tonnes during the ten-year period 1980/81 to 1989/90. By 1990/91-1999/2000, clove output had dropped to an average of 4,805 tones. Also, one of the main causes of this low productivity is changes in market prices, which leave farmers confused about prices and less inclined to spend money on regular crop maintenance (Assouto et al. 2020). Climate fluctuations, the unpredictability of the three-acre land tenure system, illnesses, inadequate management, and the limited replacement and aging of clove trees have all been blamed for the decline in productivity.

In addition, Hervy et al. (2014) state that declining areas of farms producing cloves, poor utilization of clove processing companies, low prices paid to producers, a shortage of market to Zanzibar clove products are the factors affecting production. Zimmerman et al. (2016) also concluded that Zanzibar cloves production is negatively affected due to climatic conditions like rainfall, where he noted that rainfall affects clove production through vegetative growth as well as clove bud differentiation. In addition, the other factors that are taken seriously as the cause of reduced clove production in Zanzibar are diseases and climate change (Dabek, and Martin, 1987). Moreover, Miraji, M. K. (2013) and Chami (2020) found out that increasing rainfall insecurity is detrimental to clove production in Zanzibar. Moreover, Insect pests and diseases, poor agronomic management, old plants, drought, infertile soil, and lack of knowledge on good agricultural practice has also been attributed to the low clove production (Martin and Dabek, 1988; Baietto, 2014; Das et al., 2018; Riptanti et al., 2019). Competition from other cash crops such as cinnamon, seaweed, chillies, and copra in terms of human, financial resources and land observed by (government of Zanzibar (2013) as another factor that declines the production of cloves in Zanzibar.

Even though a lot of research has been conducted to observe the causes and come up with solutions, clove production in Zanzibar is still declining. Surprisingly, this spice is still considered to yield the highest-quality oil, flavour, aroma and remains to play an important role to Zanzibar's economy, as it accounted for 43.1% of all exports (Zanzibar Statistical abstract, 2023) and contributes 50 percent to the GDP (Tarawalie & Kpana, 2022). Furthermore, it accounts for over 60% of Zanzibar's foreign

exchange earnings (Tembsa & Suda et al. 2020). Additionally, it creates jobs for more than 60% of rural agricultural households and helps the tourism industry grow by bringing in thousands of international visitors through spice tours (Kabote & Tunguhole, 2022b). This shows that growing cloves has the potential to lower poverty and enhance the sustainable standard of living for everyone in Zanzibar.

To illuminate the fact that the clove sector still plays a significant role in the Zanzibar economy, the trends of government revenue from clove exports and clove's share of the total exports in the years 2018 to 2023. Although metrifying in the short term, cloves have continuously helped the country to generate significant export revenue and in the year 2022, income was as high as it has ever been. Although the percentage of total exports made by cloves was low in years 2022 2023 as compared to the share in 2021 2022, the sector continued to provide significant income in terms of revenue, which highlights its economic stability. Such trends prove that cloves are a strategic export commodity and therefore it is important to consider the underling factors that determine its production. Knowing these determinants forms the basis of having knowledge in crafting informed policy interventions that can stabilize and improve the performance of the clove sector in the long term. Thus, this study aims to uncover the reasons behind the decline in production and suggest solution.

1.2 Research Problem

Zanzibar and Cloves are inseparable twins, this is because cloves have long been an essential component of the culture, history, and economy of the Zanzibari people. For many decades since the 18th century, cloves have also been a major contributor to Zanzibar's economy, making up nearly 60% of foreign exchange, it employs 60% of the labour force (URT 2016) and 43.1% of the island's total exports as of 2023 (Office of the Chief Government Statistician in Zanzibar, 2023). Moreover, the island subsidized the Zanzibar Development Budget by more than 80% throughout the 1960s and 1970s due to the large earnings from cloves (Masoud 2017; REPOA, 2018).

The clove sector faces challenges, particularly in production areas, despite the crop's historical and economic significance in Zanzibar. For instance, between the 1970s and the 2000s, the production of cloves decreased by 84.4%. Its export volume also declined, from 89% in 2003 to 60% in 2018. Additionally, recent data shows that production is continuously dropping, dropping 43.9 percent in the previous year and 33% between 2011 and 2022 (Zanzibar Statistical abstract, 2023). To a certain degree, these challenges are impeding the sector's overall development. For instance, Zanzibar's economic growth has decreased from contributing more than 50% of GDP to 27% Nuhu, (2016), and the country has performed poorly in the global market by making a smaller contribution. This decline in clove production is caused by several factors. Bakar, (2015) stated that clove production in Zanzibar is declining due to poor services offered by (Zanzibar State Trading Cooperation- ZSCT is a government monopoly), a lack of land among farmers, insufficient government support, low state prices, and a lack of finance for farmers to adjust their farms.

Moreover, (Nuhu, 2016) observed that Lack of knowledge, an unreliable market for producers and dealers, and inadequate physical infrastructure systems were also found to be obstacles impeding clove production activities in Zanzibar. Also, according to Moh'd et al., (2017) revealed that the absence of private sector involvement, price volatility, a lack of funding and high production costs, and poverty, were additional significant obstacles. Also, diseases and climate change are considered as major sources of clove production decline in Zanzibar (Dabek. A & Martin, 1987).

Chami, (2020) found out that the absence of significant players within the industry like players in production and marketing, and the presence of a strong monopsony marketing system are the main variables affecting the clove sector in Zanzibar. More so, it was established by Janjua et al., (2014) that the type of seeds planted in cloves and the size of land was the most significant factor to the production of cloves in Zanzibar. Also, private sector participation, insufficient finances, high production costs, and poverty had the biggest impact on clove production. In addition to Diseases, inadequate management, a lack of replacement, the monopoly of clove marketing systems that discourage private sector investment, and the insecurity of the three-acre land tenure system could all be major factors in the reduction in clove production and export (Juma. H., 2010). Furthermore, Peter J. Martin (1988) Observed that clove harvests have positive relationship with rainfall from October to February two years before the harvest. In contrast, the study again observed negative relation between clove production and rainfall in July and October to December of the year preceding the harvest, as well as with the harvest the previous year. The study concluded that rainfall affect clove production by affecting vegetative growth and clove bud differentiation.

Despite numerous researches have been carried out to identify the primary reasons for this drop, the study has observed that, there is limited current research that observed the problem in Zanzibar, as majority were conducted a long time ago. Also, all studies conducted failed to use advances statistical techniques to observe the problem, they focused much on descriptive, correlation as well as simple regression analysis. This study intends to close the gap by use of advanced statistical techniques such as time series analysis was used to provide comprehensive dynamics. Thus, the study's conclusions offer information that may direct better clove regulations and procedures, encourage the expansion of the clove industry, and improve the performance of Zanzibar's clove.

1.3 Research Questions

I. What are the effects of producer price on Zanzibar's clove production in the short term and long term?
II. What are the effects of Volume of clove export and exchange rate on Zanzibar's clove production in the short-term and long-term?
III. What policy measures can be implemented to enhance clove production?

1.4 Research Objectives

I. To determine the effects of clove producer price on Zanzibar's clove production in short-term and long-term.
II. To examine the short and long-term effects of Volume of clove export and exchange rate on Zanzibar's clove production.
III. To recommend policy measures can be implemented to enhance clove production.

1.5 Significance Of the Study

1. 5.1 Theoretical Benefits

This research contributes meaningfully to agricultural economics and development literature through the provision of empirical evidence regarding macroeconomic and environmental determinants of clove production based on a Vector Error Correction Model (VECM). This highly rigorous econometric approach provides theoretical insight into dynamic relationships among variables, including climate, world demand, price levels, and patterns of exportation, and how they affect long- and short-term agricultural production. This study fills a gap in sub-regional economic modelling by concentrating on Zanzibar, a special economy greatly dependent on one cash crop, frequently under-represented in international academic literature. The study offers a replicable model that can be applied to other spice- producing regions and enhances comparative studies on commodity-based economies in sub-Saharan Africa and the world.

1.5.2 Practical Benefits

This research is a decision-making tool for politicians, farm planners, and development institutions by identifying the critical ingredients that will improve clove productivity and sustainability. The acquired knowledge can inform planning for climate-resilient agricultural practice, diversification policy for markets, and price stabilization interventions to stabilize the income of smallholder farmers. Exporters and agribusiness investors can gain from better knowledge of production risks and export trends to help them maximize supply chains and marketing efforts. This study encourages environmentally friendly cultivation of cloves, thus helping Zanzibar meet Sustainable Development Goal 12 of sustainable use and production. The study enhances Zanzibar's trading performance and resilience through the alignment of local manufacturing systems with international market demands.

1.6 Outline of the thesis

This proposal is designed in a well-organized manner in order to meet the research objectives as well as to offer detailed information about the critical variables that affect clove production in Zanzibar. Chapter Two provides an extensive literature and a source review including both theoretical and empirical sources and states the conceptual framework which the research is based on. Chapter Three elaborates the methodology of the research incorporating data sources, variable choice as well as analytical tools to be deployed to test the connection between climate and market forces and the resulting clove output. Chapter Four outlines the empirical findings of the study and discusses the results of the study about the research hypotheses and the previous studies' results. Lastly, Chapter Five gives policy recommendations based on the findings and concludes the study with the presentation of important contributions market structures and economic conditions impact on clove productivity. This paper is aimed at exploring the factors influencing production of clove in short term and long term.

CHAPTER II
LITERATURE REVIEW

History of clove production and Justification for Choosing Zanzibar as the Study Area

Zanzibar, a semi-autonomous part of the United Republic of Tanzania consists of two island Zanzibar of two main islands which are found on the East African coast of the Indian Ocean; they include Unguja and Pemba. The region has been known to have good soils, tropical weather and strategic marine location that had in the past placed it as an important trade Centre of spices especially cloves. Clove was introduced in the first half of the 19 th century and it thrived rapidly because of the good environmental background and the market. The Arabs settlers first set up large-scale plantations and the slave labor worked in them and by 1834, Zanzibar had begun to produce almost 35,000 tonnes of cloves and which formed about 90 percent of the total export of cloves in the world. Clover strength persisted through to the 20 th century and by 1922 it was believed to have an estimated three million clove trees on the islands making the crop not just an economic lifeline but a defining characteristic of Zanzibar.

After the Zanzibar Revolution of 1964, the government made significant reforms, among which there was the nationalization of big estates. Small holders were given pieces of around three acres and in 1968, the Zanzibar State Trading Corporation (ZSTC) was founded as the only legit purchaser of cloves and exporter. This was a centralized system which was aimed at maintaining stability in the price regime and safeguarding of farmers income. Nevertheless, the system has over time been criticized as shoring up the weakening role of the private sector making investment and innovation in the sector unattractive. As compared to other developing world countries that had gone through structural adjustment reforms in the 1980s and the 1990s, Zanzibar had maintained the state monopoly in the marketing of cloves further deepening the inefficiency in the value chain.

In spite of the fact that the clove industry is historically strong, there is a significant fall in the production and exports over the last few decades. To give an example, in the 70s-early 2010s, the production declined by more than 65% because of aging trees, low replantation plan, and inadequate investments. Along with the now-vanished contribution of the clove industry to almost 50 percent of regional GDP, the clove industry retains crucial importance on the lives of thousands of rural families. The government pegged the 2007/2008 clove farming with around 8,139 households, although total hectares amounted to nearly 4,972 hectares. Nonetheless, due to declining production and stagnant market arrangements, a number of farmers have since found it hard to sustain their profits. The recent demographic situation in Zanzibar, where the population of the rural area is youthful and increasing, makes the necessity of clove industry revitalization even more strongly apparent. The region is still heavily reliant on farming as a means of income and job-generation particularly in the rural margins where alternative sources of finances are poor. Considering the historical, economic and social importance of

cloves, and the current issues facing the sector, Zanzibar case is pertinent and timely to investigate how climatic conditions and economic conditions impact the production of clove.

2.1 Theoretical Literature

One of the most important steps in understanding the variables influencing clove production is developing a theoretical framework. The next step is to assess earlier research and develop theories. Therefore, the study will lay forth the theoretical foundations upon which this research is based in the first section of this chapter. The literature on the general factors impacting clove production outside of the particular study variables will be reviewed and discussed later in the second section. Examining earlier studies that have a direct bearing on the variables employed in this study—temperature, precipitation, the Ocean Nino Index and clove producer prices—is the main objective of the third phase of the study. The research hypothesis will continue to be refined in the meantime. The conceptual framework will be presented in the last part.

2.2.1 Production Theory

To comprehend and elucidate the elements influencing clove production, the study employs a production theory. The link between inputs and outputs, which is the conversion of factor inputs into outputs, is explained by production theory (C. R. Thomas & Ii, 2013). Given the several input variables employed in the study, it generates accurate estimations of clove output. Moreover, it considers technologies and economic efficiencies as well production function. This theory also describes how a farmer can determine the amount of each product to produce, sell, and how much raw materials, labor, and fixed capital goods will be utilized to reach a certain level of production.

2.2.2 Ricardian Techniques

This technique is one of the methods for researching agricultural production. Kurz & Ricardo (1823) derived this technique to examine on how land values would represent its net productivity. Then followed by Mendelsohn et al. presented this technique in 1994 to find the effects of climate change on agriculture. Several nations adopted and finished this model, including those in America ((Mendelsohn & Reinsborough, 2007); (Ouedraogo, 2006); (KABOTE & TUNGUHOLE, 2022a); (Simtowe & Yi, 2018); (Mishra & Sahu, 2014), and (Lippert et al., 2009)). They predict a land-based approach on land rent (which represents the farm land agricultural productivity) and came up with similar results that soils, climate, and economic situations all affect net agricultural productivity. The following equation describes the approaches (Economics et al., 2019):

$$V = \sum P_i Q_i (X, C, S, G, H) - \sum P_x X$$

Where Pi is a crop i market price, Q_i is the crop I, X represent purchased inputs other than land, C represent climate variables, S represent soil variables, G represent economic variables, H represent water flow and P_x present input prices. According to a previous World Health Organization (WHO) assessment, climate change has had a major influence on current agricultural systems and may have much more dire consequences in the future (World Health Organization report, 2009). Moreover, (Janjua et al., 2014); (Alshahrani & Alsadiq, 2014) concluded that the global agricultural production is affected by climate, either positively or negatively. Variations in agricultural productivity have a detrimental impact on the food supply (Slingo et al., 2005), farmers' income (Zamanian, 2019), and prices, all of which are consequences of climate change (Ray et al., 2012). Furthermore, (Abraha & Savage, 2006) observed that crops are entirely reliant on the climate, and any changes in the climate could have an effect on agricultural output both locally and internationally. Because meteorological factors govern the fundamental processes of crop development and growth, climate change thus readily affects agricultural output (Meza & Silva, 2009). Thus, a proper understanding of the Ricardian approach, and production theory are necessary for this systematic appraisal as it will aid in understanding the impact of factors affecting clove production. In this study, these theories will be applied to explain the main determinants (temperature, precipitation, the Ocean Nino Index and clove producer prices) and their impact on Zanzibar clove production.

2.3 Empirical Literature

Over the years, several studies have been conducted using different types of empirical research to determine the determining factor of clove production with different outcomes that are affected by regional variations, research methods, and variables. In the next section, significant research that offers some understanding of climatic, market, and policy issues conditioning clove productivity is outlined.

2.3.1 Previous studies beyond the study variables: Broader determinants of clove production

The reasons behind the decrease in clove output and its effects on the Pemba-Zanzibar community's sustainable way of life were investigated by (Nuhu (2016). A basic random sampling procedure was used to choose the 90 respondents that made up the study's sample. Additionally, both primary and secondary data were employed in the study. The focus group discussion method was used to interview the respondents and collect the primary data. SPSS was used to analyze secondary data that was acquired from ZSTC, the Zanzibari government body. Additionally, the study used a mixed method in which descriptive techniques were used to analyze the quantitative data. According to the report, clove growing is practiced by both sexes in Zanzibar. The study's findings also show that the factors influencing clove production are ignorance, an unreliable market for growers and traders, and an inadequate physical infrastructure system.

Also, the study's findings observed that clove growing primarily contributes to the social and economic development of the local community in the study area by being used for food, spices, trade, medicine, and income generation. Building upon this, (Baghong et al., 2020) sought to ascertain: the amount of clove produced, farmers' earnings from clove cultivation, and the factors influencing clove production. Both primary and secondary data were used. A straightforward random approach is used to determine the sample. 46 farmers, or 25% of the 306 total population, were included in the samples. Regression employing the Cobb-Douglass production function approach was employed in the data analysis. The result shows that number of plants and their age were the only two factors that significantly affected the production of cloves in Ronggakoe Village; the other three factors—land area, labour, and farming experience—had no discernible impact. Moreover, the study observed that respondent farmers produced 22,285 kg of cloves in total, with an average of 484.46 kg and 1.1 tons/ha produced per hectare.

Meanwhile, Zuweina H, (2013) looked at how the current marketing structure affected the export and production of cloves. It specifically aimed to comprehend how the monopsony structure influenced the choices made by farmers regarding investment and production. To fully comprehend the causes of the notable drop in clove production and the reasons why clove growers decreased their output, primary and secondary data were analyzed. Data analysis was done using a qualitative approach and an examination of the documents. The results showed that the monopolistic system offers advantages and disadvantages for producers' ability to survive. It appears that a producer nation can control the marketing of the commodity in both internal and foreign markets when the state has an effective marketing 48 system through marketing boards. Despite the study's findings that the monopoly market system is inefficient, farmers' choices also impede the production process. Clove production significantly decreased as a result of state control, according to an analysis of the monopsony system's impact on investments and production. It was noted that farmers and investors were deterred by the monopsony system's restricted ability to involve others in the sale of cloves, which caused them to choose more lucrative economic channels. Aside from the monopsony marketing structure, several other issues, such as low farm gate prices set by marketing boards, old clove trees, and low replanting rates, were impeding the growth of clove production. Low extension service availability, which leaves farmers ignorant of how to increase soil fertility and ward off pests and diseases, was another culprit.

Similar market-related challenges were observed in India. Thomas et al., (2023) examined the clove economy in India, paying particular attention to production trends, trade patterns, production costs, and clove agricultural returns. The cost of production and profitability of clove cultivation were estimated using data from a primary survey of 40 clove farms from Tamil Nadu's Kanyakumari and Tenkasi districts and Kerala's Idukki, Kozhikode, and Kollam districts, which are the five clove-growing regions. An estimated Rs 581 was spent on each kilogram of dry cloves during manufacture. Low genetic variety, poor agronomic methods, inadequate management of soil fertility, biotic stress factors, senile plantations,

unstructured markets, and labour shortages during harvest are some of the issues that clove farming faces, according to the report. These issues limit domestic output and make it less profitable. Opportunities for intervention include creating disease-resistant, high-yielding cultivars, improving training and extension services, bolstering pest and disease control strategies, promoting replanting and revitalization of aging plantations, setting up organized markets and price stabilization systems, and resolving labor shortages during harvest. The profitability and sustainability of clove farming in India can be increased, local clove production can be increased, and import dependency can be decreased by addressing these issues and putting recommended initiatives into practice.

In addition, (Martinus. A. et el., 2024) explored research themes related to the technological efficiency of elements that affect clove production. The study was conducted in Nagekeo Regency, 41 farmers were randomly chosen from homes that grow cloves to take part in this study since Jawapogo village is one of the villages in Nagakeo Regency that produces cloves. Cobb-Douglas regression analysis, technological efficiency, and a mixed method were also utilized in the study. The results of Frontier software's technical efficiency estimates indicated that inefficiency in clove production is influenced by the farmer's age and level of non-formal education. Furthermore, the fluctuating number of productive plants has a major effect on clove production. Land area, formal education, plant age, and personnel, however, had no appreciable effect. In addition, Suprihanti et al. (2018) investigated the policy's impact on the clove market and cigarette manufacturing in Indonesia. This study examined data from 1990 to 2016 using a model of a simultaneous equation system evaluated with the 2SLS (Two-Staged Least Squares) approach. The findings revealed that the influence of the clove import policy lowered clove supply while boosting clove demand. Domestic clove prices declined by 3.02 percent in the industry and 3.96 percent among farmers, leading to a 0.31 percent increase in cigarette production. In the long run, clove area will decrease by 0.1%, while clove production will decrease by 0.03%. This technique benefits the cigarette industry more than clove farmers. The long-term drop in clove prices may have an impact on the sustainability of Indonesian clove production and endanger its survival in the future. As a result, farmers and the tobacco business must collaborate to create clove products.

Also, Bay et al. (2020) investigated whether land space, manpower, and capital affected clove production in Woewolo Village, Nagekeo Regency. This study is classified as quantitative research. The study sample of 75 was chosen using a basic random sampling procedure. The primary method of data gathering was to distribute questionnaires to respondents; the secondary method included casual conversations with clove growers and observations of their operations. The data was analysed with SPSS software. The study used a multiple linear regression model to determine the impact of independent variables on clove production. The results show that land area, labour, and capital contribute 35.8% of clove production. Furthermore, the study found that capital, labour, and land area had a considerable favourable impact on clove output. Furthermore, Mea et al., (2021) was to determine whether capital, labour, and land

area affect clove growers' production revenue in Woewolo Village, Nagekeo Regency. This is a type of quantitative investigation. This study's population consisted of all clove farmers in Woewolo Village, which contained 75 samples. Primary data was collected via distributing questionnaires to respondents. According to the Multiple Linear Regression Test, the variables capital (X1), labour (X2), and land area (X3) all have a positive correlation with clove output in Woewolo Village, Mauponggo District. As shown in the statistical test results, it can be confirmed that capital influences clove production due to the attainment of t-test results, especially the t-count value of 2.452 and significance of 0.017 at the 5 % level.

Moreover, Bella et al., (2024) intend to investigate the internal and external factors that influence clove farming development strategies as conservation and ecosystem restoration actions, as well as describe alternative clove farming development strategies as ecosystem conservation and restoration actions in the Bongok Forest, Jetak Village, Montong District, Tuban Regency. The study employs survey and quantitative descriptive approaches. The number of respondents was purposefully limited to five people, including farmer groups and the head of Jetak Village. The data analysis method employs SWOT analysis and a space matrix for sustainability analysis. Alternative clove farming methods based on SWOT matrix analysis include raising clove productivity, improving human resource capabilities in technology and information development, and increasing forest conservation and utilization (SO). Meanwhile, the WO plan is to conduct regular contact with the agricultural department and propose proposals to meet the capital requirements for clove farming. The ST method entails reducing and adapting to weather changes, expanding agricultural extension programs, and hiring qualified professionals in their industries. The second alternate option is for WT to seek information to improve his expertise of clove growing, to invest in agricultural equipment and infrastructure, and to apply for a low-interest bank loan. Based on the findings of calculating internal and external elements, the alternative strategy using the space matrix is in the first quadrant position, meaning the aggressive quadrant, which is constrained by the X and Y axes, both of which have positive values of 0.28 and 0.54.

Moving toward ecological considerations, Bella et al. (2024) described alternative clove farming development strategies as ecosystem conservation and restoration actions and critically examined the internal and external factors that impact these strategies. The study combines quantitative descriptive approaches with survey methodologies. Up to five individuals, including the head of Jetak Village and farmer groups, were purposefully chosen as respondents. For sustainability analysis, the data analysis approach makes use of a space matrix and SWOT analysis. Increasing clove productivity, enhancing human resource capacities in information and technology development, and boosting forest conservation and utilization (SO) are alternative clove farming methods based on SWOT matrix analysis. In the meanwhile, the WO plan calls for frequent outreach from the agricultural department and the submission of bids to the department in order to obtain the necessary funds for clove farming. Increasing agricultural extension programs, adding experienced people to their fields, and mitigating and adapting to weather changes are all

part of the ST strategy. The next alternate tactic is for WT to look for information to learn more about clove farming, equip agricultural infrastructure and equipment, and apply for a low-interest bank loan. The alternate method employing the space matrix is in the first quadrant position, or the aggressive quadrant, which is bounded by the X and Y axes, both of which have positive values, namely 0.28 and 0.54, according to the findings of calculating internal and external components.

Moreover, (Haryana et al., 2021) study set out to develop a plan to increase Indonesian clove production's competitiveness. Secondary data with a qualitative component were employed in this investigation. information gathered from earlier research as well as the Directorate General of Plantations, Data Centre, and Agricultural Information System. After that, the data is examined using a SWOT analysis, which can eliminate vulnerabilities, increase the importance of strengths, and lessen the impact of emerging threats. The SWOT analysis yields a matrix that combines tactics for both external (opportunities and threats) and internal (strengths and weaknesses) components. According to the study's findings, there are several ways to make Indonesian clove production more competitive. These include maximizing clove land, enhancing the quality of processed cloves, growing markets, strengthening farmer institutions already in place, working with major consumer countries' clove processing companies, encouraging organic farming systems in clove plantations, and enhancing the national economy to support clove commodities.

Further reinforcing the role of technical efficiency, (Martinus A.L., Et el., (2024) carried out the study about the clove production decline in In Nagekeo Regency. Given that Jawapogo village is one of the communities in Nagakeo Regency that produces cloves, forty-one farmers were selected at random from clove-growing households to participate in this study. The study also employed mixed methods, technical efficiency and Cobb-Douglas regression analysis were used for analyses. Frontier software uses calculations of technical efficiency, and the result showed that the age of the farmer and non-formal education have an impact on inefficiency in clove production. Moreover, clove production is significantly impacted by the changing number of productive plants. However, manpower, plant age, formal schooling, and land area had no discernible impact.

2.3.2 Empirical studies on the relationship between the study variables and clove production

Climate change is one of several natural phenomena that have a significant impact on agriculture. Winda et al. (2025) intend to find out (1) Clove Plant Productivity in Kramat Village, West Taliabu District, Taliabu Island Regency, North Maluku Province. (2) Adaptation Strategies. Clove Farmers carried out the operation in Kramat Village, West Taliabu District, Taliabu Island Regency, North Maluku Province. The research location was chosen only on the basis that Kramat Village is a clove producer with variable meteorological circumstances that threaten clove productivity. A total of 36 clove farmers responded. The data was analysed descriptively and qualitatively using a Likert scale. The study found that the yield of clove plants in Kramat Village, West Taliabu District, Taliabu Island Regency, was only 106.60 kg/ha/year.

This low productivity is due to climatic changes in heavy rainfall, which occurred in Kramat Village, West Taliabu District, with a yearly range of 1811.9-5118.8 mm. Clove farmers in Kramat Village, West Taliabu District, Taliabu Island Regency, adapted to climate change by using extension services, changing planting times, using fertilizers, selecting resistant varieties, clearing ground cover, forming farmer groups to share knowledge, business diversification, using more efficient irrigation technology, and agroforestry.

In similar vein, Laimeheriwa et al., (2024), present evidence based on science regarding how climate factors affect clove productivity on Saparua Island in the Central Maluku Regency. Data collection in this research was mainly aimed at having climatic data to use in studying rainfalls in regions. The data were analysed through a few methods that comprise regression analysis to determine the effects of the climate factors, together with trend analysis of rainfall changes. The result identified that yearly rainfall in the area with a local unimodal rainfall pattern had an elevation of 11.8 percent. During the dry season (October to March), an increase of rainfall by only 1.3 percent is observed; however, there is a tendency during the rainy season (April to September) to increase by 15.2 percent. The El Nino excessive dry rain events and La Nina extreme wet rain events have been recorded in 19 instances and 14 instances respectively in the Saparua Island area in the last 60 years. Consequently, the research results established that climatic conditions like El Nino, La Nina extremes, and rainfall influence the productivity of the clove plants.

Complementing these findings, the study performed by (Hadun et al., 2016) tested the impact of climatic changes, soil conditions (characteristics and quality) in clove producing areas and the suitability of ground water availability on clove growth and productivity in Indonesia. The method of survey used by the researchers involved the observational methods of data collection by using mini pits and profile pits. The results showed that the number of annual rainfalls received in the area was averagely 2,332.40 mm/year with type and Q value of 0.17391 respectively. Also, in the research, it was revealed that month of drought proved to be particularly advantageous to the growth of clove. Additionally, the study found out that soil with udic moisture regime and hyperthermic soil temperature was best as far as growth and yield is concerned. The research also observed that rainfall is an important factor in growth and it should be at optimal level. On the whole, the results revealed climatic conditions, quality of soil and availability of groundwater influences the growth and yield of cloves.

Earlier empirical work by (Dabek &Martin, 1987), determined the factors influencing the production of clove tree in Zanzibar and Pemba, and also identified factors determining the variability of clove tree production. In the effort to measure the relationship between the study variables, the descriptive statistics and correlation methods were employed. Results of the study revealed that there was a negative value of irregular rainfall and clove production. In addition, Peter J. Martin (1988) conducted research on the biological and environmental factors on the erratic flowering and production of the Zanzibar clove tree. The observational method was applied in collecting data of firsthand sources and the focal point of the

study was concerned with flowering cycles and associated features spread over sustained growing seasons. Comparison was made on the characteristics of flowering and yield regarding the nutrient content, insect applications and weather. The research revealed that the common causes of erratic production were pest damage, nutrient deficiencies, climate periods.

Expanding on the context of Zanzibar, (Chami, 2020) determine the factors that affect the clove industry in Wete-district-pemba, that entails Kisiwani, Gando, as well as Mtambwe wards Zanzibar. The study was in a position to collect primary data through the development of questions and through interviews. The methods utilized were the descriptive statistical and literature survey study of literature design that are desk-based. The study reveals the main methods applied in cultivation of cloves in the study area as pot holing, nursery seedlings, dropping, organic and the shade systems. Findings of the study showed that respondents of three Wete shehias, Kisiwani, Gando and Mtambwe, followed the size of the farm, nature of the land, unpredicted climatic changes, and weather-related clove misery as environmental challenges. Age and experience of potential clove farmer, social status of farmers, number of people in a household, level of education, gender aspects as well as farming experience, on the other hand, are normally used as some of the factors that are a barrier in the society. The following were also identified as institutional and management challenges: organization membership and structure, borrowing capacity, and concerns about the health of clove farmers and environmental degradation; institutional/technology delivery mechanisms: extension services, information access, and prior involvement in and training in pest control practices.

Similarly, Miraji, M. K. (2013) evaluated the impact of meteorological factors on clove production in Tanzania's Pemba Island. The Tanzania Meteorological Agency (TMA) provided the study's meteorological data, and Zanzibar State Trade Corporation (ZSTC) provided the data on clove yield for the years 1992–2011. The arithmetic mean ratio was used to estimate missing weather parameter data, and the single mass curve was used to check for homogeneity. All of the data were determined to be homogeneous throughout time. The meteorological parameters' monthly variations were calculated as a mean pattern and explained. Clove yield and meteorological characteristics were correlated using a lag system, and the findings were reviewed. In order to forecast the clove yield using the meteorological parameters, a regression equation was finally developed using regression analysis. The yield that was produced by the equation (model) was then analyzed. The results of the study show that the yield of cloves decreases as the maximum temperature rises. Additionally, he found a negative correlation between the minimum temperature and clove yield using a scatter plot. The results of the regression model also showed that rainfall had a favorable effect on clove production.

In East Java Province, Ayuka et al. (2025) investigated how production inputs affected clove productivity and production hazards. The research consisted of 937 families of clove farmers in the East Java Province based on the use of secondary data provided by the Household Agricultural Survey of 2014. Production inputs were evaluated in terms of the effect they had on productivity and production hazards of

cloves using Just and Pope Model. The coefficient of variation (CV) is greater than 0.5 and reveals that the risks of the clove cultivation in East Java are high. The various production inputs enhance the productivity of clove such as the fertilizers including the compost fertilizers, insecticides, family labour, and outside labour and plant population. However, TSP fertilizers and irregular rainfall systems discourage the level of production of cloves. Also, the risk of production is reduced using the family labour whereas ZA fertilizers increase the risk of production. The findings also indicate how important it has been to regulate the production inputs so that it can maximize the clove output and reduce the hazards associated with them. The report stated that the government ought to employ effective pest control mechanisms, provide incentives that will ensure the effective use of inputs and develop training programs that will enhance the level of understanding by farmers. The resilience and sustainability of clove farming in East Java will have to be promoted using some strategies. The analysis under this study will aid efforts geared toward stabilizing productivity and mitigating risks in production by offering the stakeholders and policymakers valuable information.

Further exploring production factors, Khamis, B. (2020) compared the clove production and value addition in Tanzania with a case example of Zanzibar State Trading Corporation. The study involved the use of a case study research design and involved both the use of qualitative and quantitative approaches. Forty respondents were selected randomly and sampled among the vendors of clove producers and of the Zanzibar State Trade Corporation (ZSTC). The data collection involved questionnaires, interviews and reviewing of documents. Although the analysis of quantitative data was based on descriptive analysis as the primary source of information, qualitative data analysis was based on comprehensive assessment of supplementary information as the secondary data information. The findings monitored that land size, clove planting, pesticides, and subsidies seeds were the greatest crucial determinant of clove production in Zanzibar. In addition, the lack of private sector participation, low producer price, unavailability of funds, high cost of production and poverty affected the production of clove in the largest negative terms. The outcome also denoted that the clove production and value addition were directly correlated with those various investors and organization.

From a financial perspective, Moh-d et al., (2017) conducted research in Zanzibar to test the best course of actions in order to curbing the financial difficulties that the clove industry is going through. The specific objective of the researchers was to come up with the best solution to the financial problem facing the clove growers in Zanzibar. The study noted that financial factors are significant and have an effect on clove production. The study reviewed and evaluated various existing financial models and subsequently pointed out their shortcomings. The study also observed that many initiatives, strategies, and actions that relevant parties have undertaken to address the decline in clove production have not been successful. As a result, the study proposed the implementation of the Waqf-Muzara'ah-supply chain model to resolve the financial challenges. The Waqf-Muzara'ah-supply chain model advocates for a partnership-based solution

to tackle the issues of high borrowing costs and collateral requirements that hinder farmers' productivity and financial capability. The study therefore concluded that Absence of private sector, low producer price, lack of fund, high production cost and poverty are negatively impact the clove production.

Furthermore, the study by Husnaeni, H. et al., 2022 in North Kolaka Regency was to assess the impact of education, family dependents, farmer status, price, working time, income and hours worked on clove production. 76 respondents were chosen as sample using the Slovin algorithm. Multiple linear regression analysis was used in the study to evaluate how the independent factors affected the production of cloves. The study result shows that clove production negatively impacted by production prices, working hours, and land area—which accounts for 21.6% of the total amount. Moreover, the study concludes that working hours of non-clove farming significantly affect the clove production by 49.5%. Turning to international trade dynamics, Siringoringo, et al. (2023) studied the supply-demand change reaction of Indonesian cloves in the international market. It used time series data since the year 1985 to 2019. The research established a simultaneous equation, in which an econometric design was adopted. analyse data using the two-phase Least Squares technique. The results show real rupiah exchange rate with the United States dollar, price of the Indonesian cloves demanded, Comoros as well as Tanzania output growth of the cloves, real value of the growth of the world cloves t-1 and United Arab conglomeration gross domestic product per capita as being short term responsive factors. However, these factors in long run include harvest area of Indonesian and Madagascar cloves, actual rupiah exchange rate against US dollar, Indonesian clove demand, Comoros, Madagascar, and Tanzania production of cloves, real price of world cloves t-1 and United Arab Emirates GDP per capita.

Further supporting the role of internal and external factors, Fadilah., & Alimah, S. (2025) attempts to determine the internal and external determinants of clove production in Ledug Village in Prigen District in Pasuruan Regency and the formulation of a strategy to increase the revenue and production of clove producers. Type data collection utilises descriptive qualitative data collection, which consists of information collection in natural settings and examination of phenomena. Among the sources acting as the number informants were ten people. The annual income of the clove farmers in Ledug Village is Rp 24,879,452/Ha with Rp 3,807,642/Ha on average per annum as the cost of clove farming. This shows how well the clove producers can be able to develop their land and it is worth conserving. Several internal factors have also helped increase the amount of clove production and these factors have transformed cloves to an industrial raw material such as the availability of huge lands to produce cloves, the availability of manpower which is enough, and long experience of the farmers on the farming of cloves. Minimal equipment, low capital, unpredictable production, dwindling revenue, and a huge number of competitors in the market are examples of internal weakness issues. Quality clove production, the number of businesses that sell clove goods, strong market demand, sufficient transportation infrastructure, and government backing are external factors that present potential. Unpredictable weather and climate, poor pricing for clove

production, illnesses and pests that impact production costs, and fluctuating market circumstances are examples of external danger factors. The correct approach, known as the SO strategy, boosts the revenue of clove farmers. This includes using farmers' experience to sustain their farming operations and enhancing marketing tactics to boost clove farmers' income through mass media.

Moreover, Hasim et al. (2025) have conducted a study to examine what variables positively or adversely influence the effectiveness of agricultural extension (clove growing) in Sidrap Regency. With the aim of realizing this, 140 selected producers of cloves were subjected to structured interviews to ascertain primary data. The binary logistic regression model was used to test how fourteen independent factors affected the dependent variable. As depicted in the research results, the terms, family size, electronic media, mass communication strategy, and clove cultivation material, showed a significant positive effect on the success of the agricultural extension to farming in the clove crop. On the other hand, the parameters of the land area, print media, cosmopolitanism of the farmers, agricultural experiences, and educational levels do not play significant roles but the rest played an adverse role. These findings are a great indicator and eye-opener in promoting and facilitating the effectiveness of extension in clove cultivation. The findings indicate that family characteristics, extension methods of farming as well as methods of information delivery are critical as far as the dissemination of agricultural technology and increasing the effectiveness of agricultural extension are concerned. Based on research results, policy recommendations are drawn to enhance effective carrying out the extension in the clove farming. These comprise heightened farmer education on cultivation of clove, growth and proliferation of mass extension methods and electronic media in extension strategies.

Lastly, (Winda et al, 2025) aims to find out (1) Clove Plant Productivity in Kramat Village, West Taliabu District, Taliabu Island Regency, North Maluku Province (2) Adaptation Strategies Carried out by Clove Farmers in Kramat Village, West Taliabu District, Taliabu Island Regency, North Maluku Province. The determination of the research location was carried out purely with the consideration that Kramat Village is one of the clove producers that has unstable climatic conditions and threatens the productivity of cloves which is the main source of livelihood for farmers. The number of clove farmer respondents was 36 farmers. The data analysis used was a descriptive-qualitative analysis with a Likert scale. The results of the study showed that the productivity of clove plants in Kramat Village, West Taliabu District, Taliabu Island Regency, was only 106.60 kg/ha/year. This low productivity is caused by climatic variations in high rainfall that occurred in Kramat Village, West Taliabu District with a range of 1811.9-5118.8 mm/year.

Table 2.1 Summarizes the previous studies

Author	**Method for data analysis**	**Result**
Laimeheriwa et al., (2024)	Regression	Clove plant productivity is affected by climatic factors such as El Nino, La Nina extreme and rainfall.
(Hadun et al., 2016)	Observational technique	Climatic conditions, moisture regime, hyperthermic soil temperature, and rainfall availability affect clove growth and yield.
(Winda et al, 2025)	Qualitative method and descriptive	Climatic factors such as rainfall and precipitation negatively impact clove production
Miraji, M. K. (2013)	Correlation, scatter plot and Regression	Clove yield decreases as the maximum temperature rises. Additionally, he found a negative correlation between the minimum temperature. Moreover, the results showed that rainfall had a favorable effect on clove production.
(Chami, 2020)	Descriptive and qualitative method	The study's findings revealed that majority of the respondents reported environmental obstacles such as the size of the farm, the nature of the land, unforeseen climate changes, and weather-affect clove production.
(Dabek &Martin, 1987)	Descriptive statistics Correlation techniques	Negative correlation between irregular rainfall and clove production.
Peter J. Martin (1988)	Observational Approach	Pest damage, nutrient deficits, and climate cycles (rainfall change) were the main causes of irregular production.
(Baghong et al., 2020)	Regression	Number of plants and their age were the only two factors that significantly affected the production of cloves
(Martinus. A. et el., 2024)	Regression	Farmer's age and level of non-formal education and number of productive plants have a major effect on clove production. However, land area, formal education, plant age, and personnel, had no appreciable effect.

Moh'd et al., (2017)	Waqf-Muzara'ah-supply chain model	Absence of private sector, low producer price, lack of fund, high production cost and poverty are negatively impact the clove production. The study also observed that many initiatives, strategies, and actions that relevant parties have undertaken to address the decline in clove production have not been successful.
(Chami, 2020)	Descriptive techniques Desk-based survey	The existence of a strong monopsony marketing structure is the primary variables influencing the clove
(Nuhu, 2016)	Qualitative descriptive (correlation)	Clove production is impacted by ignorance, an unreliable market for growers and traders, and an inadequate physical infrastructure system
(Haryana et al., 2021)	SWOT analysis	Clove production significantly increases by maximizing clove land, Enhancing the quality of processed cloves, working with major consumer countries' clove companies, encouraging an organic farming system in clove plantations and enhancing the national economy to support clove commodities.
(Martinus A.L., Et el., (2024)	Regression	Clove production is significantly impacted by the changing number of productive plants. However, manpower, plant age, formal schooling, and land area had no discernible impact.
(Zuweina, 2013)	Document review Qualitative method	The Monopsony market system's inefficiency, farmer decisions, a lack of replanting, the aging of many clove trees, low farm gate pricing, and a lack of extension services are the main causes of the decline in clove production.
Ayuka et el. (2025)	Just and Pope model	Clove production increases due to availability of family labor, external labor, organic fertilizer and plant population. However, TSP fertilizers and unpredictable rainfall patterns decreases clove production
Thomas el al., (2023)	Qualitative method	Clove production declines due to the cost of production, low genetic variability, poor agronomic practices, inadequate soil

		fertility management, biotic stress factors, senile plantation, unorganized market and labor shortages
Mea et al., (2021)	Mixed method Qualitative and Quantitate (linear regression)	Production of clove increases due to availability of capital, labor, and land area.
Pratama et al., (2020)	Policy Analysis Matrix	Clove output is affected by government policies
Hasim et al., (2025)	Mixed method: Qualitative and quantitative (binary logistic regression)	Family size, mass communication approach, electronic media and clove cultivation material significantly and positively affect production of clove. However, education attainment, farming experiences, farmer's cosmopolitanism, print media and land area had a negative significant effect.
(Bella et al., 2024)	Quantitative descriptive method	Clove output increases due to increasing human resource capabilities in developing technology and information, increasing forest conservation and utilization (SO)
(Bay et al., 2020)	Multiple linear regression	land area, labor, and capital positively impact clove yield

Due to the theoretical discussions and empirical evidence described above, the given study posits certain hypotheses to determine the factors influencing clove production in Zanzibar. The literature reviewed has noted that climatic factors and producer pricing play a crucial part in determining agricultural productivity. The variables of the climatic factors, temperature, precipitation and the Ocean Nino Index have also constantly been found to have a direct or indirect negative effect on the production of clove, depending on plant physiological stress or interference of weather patterns. Conversely, good clove producer prices, Volume of clove export and exchange rate act as an incentive to farmers to invest more in cultivation, consequently raising production. Accordingly, the following hypotheses are developed to guide this study's empirical analysis:

1. H_{11}: There is a positive and significant effect from clove producer price towards Zanzibar's clove production in the short-term and long-term
2. H_{12}: There is a positive and significant impact of Volume of clove export and exchange rate on Zanzibar's clove production in the short term and long term.

2.2 Research Gap

Upon reviewing the previously mentioned papers, the study found that much of the earlier research mentioned above relied heavily on cross-sectional primary data analysis with descriptive statistics and multiple linear regression models; however, few of them concentrated on other methods, such as Waqf- Muzara'ah-supply chain model and SWOT analysis to produce conclusions. The need for more reliable time series studies is highlighted by the fact that, despite their value, the approaches employed are unable to capture the dynamics and complex interactions between the factors influencing clove production over time. To bridge this gap, the study used a vector error correction model to track the short- and long-term dynamics of Zanzibar clove production determinants over time.

2.3 Conceptual Framework

The conceptual framework of this study takes into consideration both conceptual ideas and available empirical studies. It is organized based on two kinds of variables: predictor variables and outcome variables. The predictor variables are a set of factors that altogether make the determinants of clove production. The study's conceptual framework aims to ascertain the relationship between independent variables (temperature, precipitation, ocean Niño Index, exchange rate, volume of clove exports and producer price) and dependent variables (Zanzibar clove output). The theoretical and empirical literature described above supports the study's prediction that climatic conditions (temperature, and the ocean Niño Index) hurt clove production. Furthermore, depending on whether producer prices, clove export and exchange rate are high or low, the study anticipates that they will either have either beneficial or a negative effect on clove output. The theoretical literature and earlier research described above also support this anticipated result. Below is the conceptual framework diagram (figure 2.2) of the study.

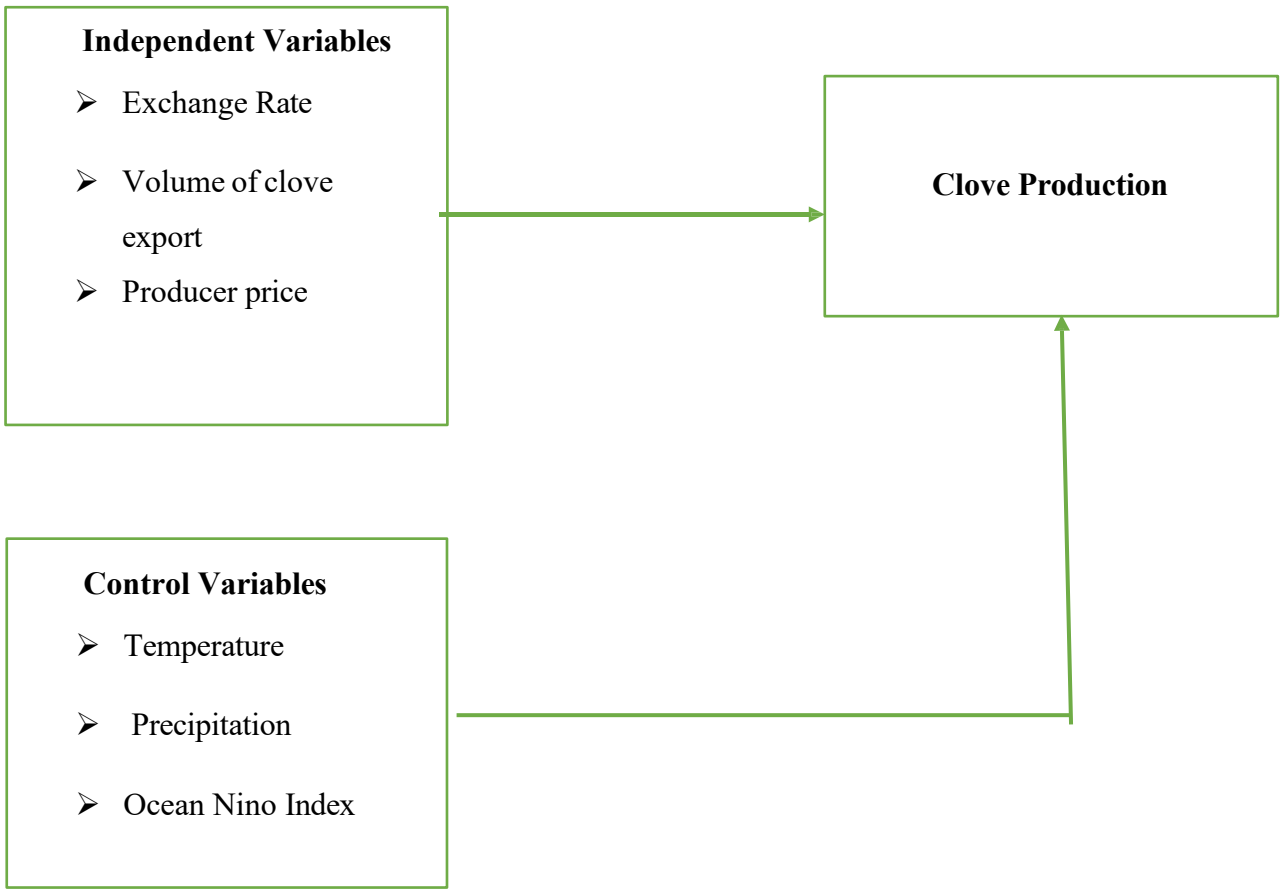

Figure 2.2 Conceptual framework of the study

CHAPTER III
RESEARCH METHODOLOGY

The purpose of this chapter is to detail the techniques and equipment needed for data analysis to explore the factors that influence clove production in Zanzibar. As a result, the first portion of this chapter will cover the research design and methods. The variables chosen for the study, together with the relevant measures and sources, will be discussed in the section that follows. The paper's last section shows how the Vector Error Correction Model (VECM) was used to analyze the factors influencing Zanzibar's clove output in both the long and short term.

3.1 Research Type and Approach

This study is classified as quantitative research since it employed a systematic approach to gather and analyze numerical data in order to identify trends and make inferences. The study also employed a quantitative approach which involves a time series study. This approach is chosen because the study aims to quantify various determinants of clove production in Zanzibar, and because the study questions and hypothesis were addressed by statistical methods. To fulfil the study's objective, descriptive and inferential statistics were used. Inferential statistics help make inferences, whereas descriptive statistics provide a summary of the data's characteristics.

3.2 Research object, subject, data, and data source

The research seeks to investigate the factors influencing clove production in Zanzibar, emphasizing examining the short-term and long-term effects of precipitation, Ocean Nino Index, temperature, producer price, global cinnamon production, exchange rate, and volume of clove export on clove production to identify key influencing factors. The subject of this research entails the elements that affect the production of cloves, while the research object is the actual clove production in Zanzibar. Also, the study used secondary time series data for the period ranging from 1980 to 2024. The data of the study variables, such as clove production, precipitation, temperature, producer price, exchange rate, and volume of clove export, were obtained from the same source, which is the Office of the Chief Government Statistician (OCGS), Zanzibar. While Ocean Niño Index data was obtained from the NOAA Climate Prediction Centre website. The following are the description of the study variables as:

3.1.1 Clove Production

The dependent variable in this study is Clove production, which refers to the growing and harvesting of cloves for the market. In Zanzibar, Zanzibar State Trading Corporation measures clove production based on the total amount of cloves purchased by farmers in regions like Pemba and Unguja. The variable has also been applied in studies done by Bakar, (2015), Suprihanti, (2020), Masoud. M., (2020), and (Chami, 2020) as dependent variable so as to determine the effectiveness of clove sector.

3.1.2 Producer Price

Additional independent variables are; producer price, which is the price the farmer or grower of the clove receives when he has sold it. It is a significant indicator of the economy in the agricultural sector as it shows the impact of the supply and demand, cost of production and market factors outside the industry on the sector (FAO, 2025). Alterations in the producer prices may influence the choices of farmers, their investments, and the size of farms, which makes them paramount to the sustainability of farming. Clove production prices are unstable because of global demand, exportation policies, climate conditions, and speculation of investors (Keil et al., 2009). An increase in producer prices tends to lead to an increase in growing and investing by farmers, whereas a fall in prices leads farmers to work less and face challenge cost, thereby leading to less production of cloves (Yan et al., 2024). Janjua et al. (2014), Yan et al. (2024), Keil et al. (2009), and Nuhu (2016) used this variable as a explanatory variable to determine the effect it bears on the clove production

3.1.3 Volume of Clove Export

The demand of cloves is the overall quantity of cloves which other nations or the global market is prepared to purchase of the cloves producing countries. Given that Zanzibar clove industry relies more on export (rather than the domestic consumption), changes in the export of cloves may impact on the level of production. These variations can be due to variations in trade agreements, the world demand or interruptions in the supply chain. Such variations in exports in turn translates to the overall clove productivity. Due to that, this variable is considered an independent variable in this study. its inclusion allows for a more accurate assessment of how external market forces shape clove output. Previous studies such as those by Pratama et el. (2020), (García et al., 2018), Barreiro-Hurle (2007) and Rist et al. (2011) have similarly identified this variable as a significant factor of agricultural production.

3.1.4 Exchange Rate

The rate, at which one currency can be exchanged to another, is another independent variable incorporated in this paper besides one, which was discussed above. It serves as a benchmark against which other currencies can be compared by the amount of other that can be purchased through a unit thereof. Since the value of the US dollar has consistently increased in recent years, the exchange rate has regained significance in agriculture and is relevant for determining the value of agricultural equipment and output. Anderson and Kristinek (2002) argued that fluctuations in exchange rates will affect Zanzibar's operational costs and the output of the agricultural sector as a whole because the country is heavily dependent on the importation of capital goods like machinery and fertilizers used in the production process. Therefore, including this variable is essential. Mundlak et al. (2002), Imai et al. (2015), and Subramanian and Roy (2001) also used this variable in their studies and found that devaluations of currency rates often increase agricultural output by making products more competitive in local markets.

3.1.5 Control Variables

This research uses climate as a control variable recognizing the fact that climate contributes to the agricultural productivity. Climate is described as the long-term average of weather in a region, including patterns of precipitation, temperature, and wind. Moreover, any natural landscape or phenomenon which influences the climate of an area is supposed to be a climatic factor. These factors are temperature, Ocean Nino index, precipitation and humidity and the speed of the winds which influences the growth and development of the plants largely. Moreover, the aggregate of these factors determines the long-term climate and weather conditions in a location. These factors are also dynamic and unpredictable and often are accompanied by considerable losses in crops Dastogeer et al., (2020). As a result, temperature, precipitation, and Ocean Nino Index were employed as climatic variables in this study and the description of each is provided below as:

Starting with Temperature, this factor plays a crucial role. This also describes how hot or cold an object or environment is. Furthermore, temperature has a significant impact on agricultural productivity, especially when it comes to growing clove plants. The ideal growing temperature for clove plants is between 20°C and 30°C (68°F and 86°F), which promotes strong development and blooming. Any departure from this optimal temperature might cause stress and impair the general health and productivity of the plant, so it is imperative to maintain this range. Production might fall as a result of even slight variations in growth rates and flowering patterns. Conversely, when temperatures rise above 35°C (95°F), clove plants also experience problems such as wilting, flower drop, and decreased fruiting, all of which can have a major effect on yield. Overheating can impact plant development phases, productivity, and clove quality over the long run. In keeping with other research, this study uses temperature as a climatic proxy to assess its influence on Zanzibar output due to its significance. The significance of this climatic factor in agricultural studies has been reinforced by studies by Dabek and Martin (1987), Keil et al. (2009), Martin, P. J., Butler, D., & Dabek (1988), Suprihanti et al. (2020), Seguna (2017), Miraji, M. K. (2013), and Chami (2020) that also used temperature as a proxy to evaluate its effects on clove growth, quality, and production.

Precipitation is another factor that leads to agricultural productivity aside temperature. It is described as any water or water substance frozen and condensed in the atmosphere and re-joins the earth termed as precipitation. It may assume a great variety of forms, including snow, sleet, and rain (Miraji, 2013). Precipitation forms part of the three major processes of the global water cycle; the other two being evaporation and condensation. This is essential in avoiding drying up of the soil which is most important in plant growth and development. In the life cycle of the cloves, germination, flowering and yield are factors affected by precipitation. Clove trees like frequent rainfalls since it allows the plants to grow in deeper roots and ease absorption of nutrients. Waterlogging caused by excessive rain, on the other hand, may hinder root respiration and increase a plant to be targeted by fungal disease (Hadun et al., 2016). Conversely, drought stress which is caused by poor rainfall rates can also affect total clove output, as well as flowering. This

paper, just as others similar to it, Ayuka et al. (2015), Haduni et al. (2016), and Miraji (2013), takes precipitation to serve as a factor of climatic conditions to determine the impacts of climate change on the cultivation of cloves.

Finally, Ocean Nino Index was utilized to consider the wider climatic variation effect. This Index is the difference between the long-term average and the three-month running average of the sea temperature surface as a whole within a part of the ocean (120 West to 170 West longitude in the equator). (Dahlman, L. 2016). This index helps the NOAA to monitor El Ni o and La Ni a which are reverse states of the El Ni o-Southern Oscillation (ENSO) climate phenomena. Also, NOAA says that under the condition of the Oceanic Niño Index +0.5 or higher, when the east-central tropical Pacific has become tangibly warmer than normal, there is an El Niño condition. On the other hand, if the Oceanic Niño Index is -0.5 or below, it indicates that La Niña conditions are present and the area is cooler than normal (Hafiz, Y. 2016). Moreover, NOAA takes into account neutral conditions when there are neither El Niño nor La Niña conditions in the atmosphere or ocean. At times, "neutral" really indicates that atmospheric and oceanic conditions are close to average. On other occasions, however, the ocean has satisfied the parameters for El Niño or La Niña, but not the atmosphere. This condition is also regarded as neutral since ENSO cannot fully disturb the climate unless the ocean and atmosphere are in perfect sync, or "coupled," according to experts. In addition to the Ocean Nino Index, it is a key contributor to climate variability, affects crop-producing regions globally. Several studies have looked at how it affects crop yields both locally and globally. Because of its importance, this study examines the relationship between climatic variability and Zanzibar clove production using the Ocean Nino Index as a proxy. In the same way, previous studies have employed Ocean Nino Index as a climatic indicator in agricultural research, like Yan et al. (2024), Iizumi et al. (2014), Rezza Aji Pratama (2020), and Keil et al. (2009).

Table 3.1 Represent the study variables, units of measurement and descriptions

Variables	**Unit of Measurement**	**Description**
Clove production (CP)	Ratio scale (in Metric tons)	Dependent variable
Producer price (PR)	Ratio scale (Tanzanian shilling)	Independent focus variable
Volume of clove Export	Ratio scale (tons)	Independent focus variable
Exchange rate	Ratio scale (percentage)	Independent focus variable
Temperature (TEMP)	Ratio scale (in Celsius)	Control Variable
Precipitation	Ratio scale (in millimetres)	Control Variable
Ocean Nino Index	Interval scale (Celsius °C)	Control Variable

3.1 Data Analysis Techniques

The study used EViews as an analytical tool that helps in the process of data analysis. Moreover, both descriptive and inferential statistics were used as data analysis methods in this investigation. Descriptive statistics, this method acts as the first stage in comprehending and condensing the clove production, precipitation, Ocean Nino Index, temperature, producer price, exchange rate and volume clove export. It involves the arrangement, depiction and resumption of raw data to produce a collective image. Moreover, the principal objective of descriptive statistics is to present a feasible and concise overview of the primary points of the data. This research explained the characteristics of the study variables using mean, maximum value and minimum value. In addition, in the case of Inferential statistics, the study employs a vector error correction model, to make the inference concerning the factors determining clove production in Zanzibar.

3.2 Estimation of the Vector Error Correction Model

This model is a statistical model that captures both short-term dynamics and long-term relationships among several variables when used to analyze cointegrated time series data. To account for transient departures from the long-term equilibrium relationship, VECM incorporates an error correction term. The notion that any departure from equilibrium will eventually be rectified is reflected in this word (Wang, 2023). The vector error correction (VEC) model is merely a specific instance of the VAR, for variables that are stationary at their differences. It is crucial for comprehending the interaction of co- moving series in econometrics since it offers a means of modelling how variables change over time towards their long-run equilibrium. Therefore, the study employs vector error correction model to measure the short term and long-term impact of the precipitation, Ocean Nino Index, temperature, producer price, exchange rate, and volume of clove export on clove production.

This is a statistical model that reflects short-term dynamics as well as long-term relationships between various variables when it is employed to analyze any cointegrated data on time series. VECM takes into consideration short-term deviations from the relationship with the long-term equilibrium through the correction term. This term has the meaning of the idea that there is an expectation that any disruption to the equilibrium will be resolved with time (Wang, 2023). The vector error correction (VEC) model is just a special case of the VAR, in which the variables are stationary at their differences. It plays a vital role in understanding interactions between co-moving series of econometrics because it provides a method of representing the process under which its directional variables transform in time towards a long-run stability. Thus, the vector error correction model is being applied in the study to determine the short-run and long-run effects of the precipitation, the Ocean Nino Index, temperature, producer price, exchange rate, and volume of cloves export as clove production variables. Different studies have been conducted that employed the VECM model to come up with short-term and long-term results. Such studies include those conducted by

Bonham et al., (2009), (Bonham et al., 2009) and Wang, (2023).

The following are econometric equations that show relations between dependent variable and independent variables in both terms as:

For the long-term equation:

$$CP_t = \alpha + + \beta_1 PR_t + \beta_2 EX_t + \beta_3 ED_t + \beta_4 TEMP_t + \beta_5\ Pre_t + \beta_6 ONI_t\ \varepsilon_t$$

Where: β_1…… β_6 represent the long-term coefficients and ε_t represent error correction term which reflect deviation from the equation. Moreover, CP represent clove production, TEMP for temperature, Pre for precipitation, ONI for Ocean Nino Index, PR for producer price, EX for exchange rate and ED for volume of export.

For the short-term equation:

$$\Delta CP_t = \alpha(\varepsilon_{t-1}) + \sum_{i=1}^{p.} \partial_I \Delta CP_{t-i} + \sum_{i=1}^{p} \infty_{1i} \Delta PR_{t-i\ t-i} + \sum_{i=1}^{p} \infty_{2i} \Delta EX_{t-i} + \sum_{i=1}^{p} \infty_{3i} \Delta ED_{t-\ i} + \sum_{i=1}^{p} \infty_{4i} \Delta TEMP_{t-i} + \sum_{i=1}^{p} \infty_{5i} \Delta Pre_{t-i} + \sum_{i=1}^{p} \infty_{6i}\ \Delta ONI_{t-i} + V_t$$

Where: Δ represent the first differences (short term changes), $\alpha(\varepsilon t\text{-}1)$ represent the error correction term where α is adjustment speed to the long-term equilibrium. Also $\partial I, \infty 1i$ $\infty 6i$ represent short term coefficients. Moreover, Vt represents residual error term, P represent lag order of the model and I represent.

3.2.1 Addressing the Endogeneity Problem

In the realm of econometrics, the relationships between variables can often lead to complexity, such as, certain explanatory variables being correlated with the error term. This phenomenon is known as the endogeneity problem, which can lead to biased and inconsistent estimators, thereby distorting the true causal relationships. In agricultural economics, the simultaneous movement between production and prices is well-recognized, as it generates endogeneity bias. This issue has been exemplified by De Nicola et al. (2014), Höhler & Müller (2021) and Fliessbach & Ihle (2022) who observed the simultaneous movement between production and prices. In the cases of clove production and producer prices, these dynamics suggest that, simultaneous impacts between these variables are likely to occur.

To address the problem of endogeneity (mitigate the risks of reverse causality and omitted variable bias) several studies have been used lagged values, such as Enders, W. (2014), Besley, T., & Case, A. (2000), Kilian, L. (2009) and Wang & Bellemare (2020). However, Bellemare, Masaki, & Pepinsky (2015) argued that while lagging variables can shift the source of bias, it does not full eliminate endogeneity unless strict assumptions about serial correlation are met. Some studies have also, suggested the use of Instrumental variable regression to overcome this problem. However, but this method is not appropriate in this study, as this technique are not suited to analysing both short and long run relationship in time series data, which are the main focus of this research. Due to that, this study employs Vector error

correction model, given that this model is designed for timeseries analyses, it naturally incorporates lagged values to mitigate simultaneity bias and capture dynamics adjustments. Moreover, the study tests the serial correlation of the residuals to provide a more accurate and meaningful interpretation of the factors influencing clove production in Zanzibar as well as reduce the endogeneity problem.

3.3 Pre estimation Assumptions

Before executing the VECM model, several preliminary steps must be taken (pre-estimation), which include multicollinearity, stationarity, lag selection criteria, and the co-integration test. Below are the explanations of the steps as follows:

3.3.1 Multicollinearity

Multicollinearity is the complete correlation between two or more independent variables that exist within a regression model. This problem may lead to biased or even misleading output where a researcher or an analyst tries to determine the extent to which the independent variable can be employed to explain or predict the dependent variable in the statistical model. Also, the multicollinearity may cause a wide confidence interval thus the effect on independent variables of a model may not be reliable about probability. In extreme situations it can lead to the model producing imprecise or misleading parameter estimates. Consequently, regressions ways of thought that there is no strong correlation between independent variables (Gujarati, 2004). In order to make sure that this assumption is valid, this research employed correlation matrix to determine the relationship that exists between independent variables. The process of studying the matrix can allow this study to realize any possible multicollinearity situations and address them with the help of the necessary measures.

3.3.2 Stationarity Test

To establish a causal connection between two or more variables a set of variables should be stationary. A stationary series is one for which statistical characteristics such as mean, variance, covariance, and standard deviation remain consistent over time, or these statistical properties do not depend on time. In other words, stationarity in time series also indicates series that lack a trend or seasonal elements. According to Yuan et al. (2007), a series is considered nonstationary if its mean, variance, and autocovariance are not constant across time. It has been demonstrated that non-stationary data can produce erroneous causality conclusions when used in causality tests (Granger and Newbold, 1974). Due to that this test holds significant importance because it not only produces effective and accurate results but also may help prevent the acquisition of erroneous findings. Thus, unit root tests are used to identify whether trending data should be first differenced or differenced at a higher order to make the data stationary. If a nonstationary series must be differenced d times before becoming stationary, it is said to be integrated of order d, abbreviated as I(d). In this research, the Augmented Dickey Fuller (ADF) test was employed to assess the stationarity of the variables under study (Cheng, S., & Cao, Y. (2019), Sa-Ngasoongsong, (2012), Bekkis, S., &

Benmehaia, A. M. (2024), Tran et al, (2022), and Bukkapatnam, (2015). The data will be considered stationary when the ADF test yields a p-value that exceeds the 0. 05 level of significance; this is due to the fact that under this condition the p-value provides the likelihood of accepting the null hypothesis that the data is stationary or (data do not possess a unit root).

3.3.3 Lag Selection Criteria

Lag is a temporal difference between two observations in a sequence. The choice of lag is crucial in the Vector error correction model because an incorrect selection of lag can result in erroneous outcomes and autocorrelation issues. The process of selecting lag encompasses several criteria such as Hannan- Quinn Information criteria (HQIC), Bayesian Information criteria, SIC, LR, and Akaike Information criteria (AIC). Given that this study spans 45 years, it concentrates on the Akaike Information criterion (AIC) to obtain the maximum number of lags, as AIC is considered the best criterion when the study involves less than or equal to 60 observations (Janjua et al., 2014).

3.3.4 Cointegration

Once all variables have been integrated in the same sequence, this paper will proceed to investigate the presence of long-run correlations among series. Cointegration demonstrates that time series move together in the long run, and the error term resulting from the linear combination of time series quantifies the time series' divergence from their shared long-run relationship, which can be used to forecast their future values (Granger, 1986). Hence, this test examines whether non-stationary variables exhibit a consistent long-term relationship. Moreover, the test holds significance in the Vector error correction model as it guarantees the equilibrium between modelling the long-term model and the dynamic short-term model in non-stationary data. This method includes the maximum eigenvalue test and the trace test to assess the long-term relationship (Kremers et al., 1992). According to the trace statistic, the alternative hypothesis is that co-integration linkages exist, while the null hypothesis is that there are none. Additionally, the alternative hypothesis that there is r + 1 co-integrating relations will be tested against the null hypothesis that there are r co-integrating relations using the maximum eigenvalue statistic. To determine whether there is a long-term association between non-stationary variables, the study employed Rank or Trace test.

3.4 Robustness of the Model result

Robustness refers to the quality of a model, which can stay stable under various adversarial environments such as noise, data distribution changes, or, more fundamentally, the adversarial attacks designed to deceive the model. In a bid to guarantee reliability of results derived in the Vector Error Correction Model (VECM), robustness checks are necessary. These tests confirm that the estimated associations among variables are consistent, stable, and not caused by the model misspecification and outliers. Typical robustness tests of VECM includes residual serial correlation, heteroskedasticity and

model stability (through the eigenvalue stability criterion, i.e., ensuring all eigenvalues are within the unit circle). Therefore, it is an important to check for Robustness in regression analysis for determining the validity of model assumptions and the suitability of the fitted model.

3.4.1 Stability test

The stability test entails identifying the roots of the characteristic polynomial. The study performed a stability test to ensure the model's reliability. This test uses the circle of stability of variance and the table of modulus. For the model to be stable, the modulus value should be lower, and all of the companion matrix's roots' moduli should be less than the unit and within the circle.

3.4.2 Serial correlation

Serial correlation (also known as autocorrelation) occurs when error terms in a time series shift from one period to another. In other words, the error for one time period a correlates with the error for the next time period b. This test validates one part of the model's premise that residuals are independent. It operates by determining if there is a positive or negative correlation between residuals depending on their order in the data. Addressing serial correlation is critical because it can influence the standard errors estimated for model coefficients. The Lagrange multiplier test was utilized in the study to assess whether the residual was independent. The alternative hypothesis that residuals are serially connected will be compared to the null hypothesis of no serial correlation, which states that residuals are not. When the null hypothesis is accepted, this assumption will be fulfilled. This is because the probability value exceeds the significance level of 0.05.

3.4.3 Heteroskedasticity

Heteroscedasticity is the condition in which residual variances differ between observations. The presence of heteroscedasticity can skew statistical inference, resulting in incorrect confidence intervals and test findings. It is crucial to recognize heteroscedasticity since its effect cannot be ignored. The detection of heteroscedasticity is critical indicates the potential need for variable transformation or the usage of models that can integrate non-constant variance. There are two typical tests for determining whether the error term is not of constant variance. The first is the Breusch-Pagan Test, which compares the null hypothesis of constant variance to the alternative of variable variance. The second test is White's Test, which is a broader test that does not imply linearity in the variance. In this study, the White test was used to determine the presence of heteroscedasticity. A conclusion of no heteroskedasticity is achieved when the P-value is exceeds the level of significance, leading to the acceptance of the null hypothesis of constant variance and rejection of alternative hypothesis.

CHAPTER IV
RESULTS AND DISCUSSION

This chapter intends to present the results of the study and provide a significant discussion. To achieve this, the first section explains descriptive statistics of the study variables so as to get insight into their characteristics. Later on, the second section displays the estimation of the Vector error correction model. Finally, the last section presents the discussion of the results.

4.1 Descriptive statistics

Before providing the time series data analysis, this study generates summary statistics to illustrate the characteristics of each variable and show how they behave. With a total of 45 observations for each variable, Table 4.1 below provides a statistical summary of the study's factors. The findings show that the average clove output during the period was around 4,905.935 metric tons, with notable fluctuations reaching a peak of (a maximum value of) 16,052 metric tons and dropping to a low of (a minimum value of) 1463 metric tons over the period. This variability underscores the volatility in clove production, which may be influenced by several factors. Furthermore, the study's findings show that the producer price changed over time, averaging 4507.441 Tanzania Shillings, with a low of 2429.68 Tanzania Shillings and a high of 6534.66 Tanzania Shillings. The constant ups and downs in producer prices indicate market volatility, which may undermine farmers' production incentives and discourage them from investing in long-term agricultural growth. Furthermore, the results demonstrate that the average amount of cloves exported during that time was approximately 4,411.192 tons, with a minimum of 1006.32 tons and a maximum of 12,000 tons. This suggests that there may have been volatility in annual harvest levels, inconsistent demand inside the country, or inconsistent demand globally. Additionally, the findings indicated that the average currency rate at the time was roughly 2,604.46 Tanzanian shillings to US dollars, with a minimum of 1842.813 Tanzanian shillings to US dollars and a maximum of 2852.20 Tanzanian shillings to US dollars.

The Ocean Nino Index, a key predictor of EL Niño episodes, also averaged roughly 0.2296, with a minimum value of -0.8166 and a maximum value of 1.275, according to the results. Furthermore, the data indicate that the precipitation averaged approximately 264.55 for the period, with the lowest and maximum values being 209.20 and 422.84, respectively. Ultimately, the temperature averaged 28.90°C for the period, ranging from a minimum of 25.922°C to a maximum of 34°C, this suggests potential seasonal variations shifts that may influence productivity. Therefore, extreme heat may affect flowering and yield whereas cooler period can act as relief in plant growth. Knowledge on the nature of the variables in the study provides useful information as relates to the dynamics in clove business in Zanzibar. The variability of the study variables proves the complex relationship between the economic and environmental determinants.

Table 4.1 represents summary statistics of the study variables

Variables	Mean	Minimum value	Maximum Value
Clove export	4,411.192	1006.32	12,000
Clove production	4,905.935	1463.65	16,052
Producer price	4507.441	2429.68	6534.66
Exchange rate	2,604.46	1842.813	2852.20
Temperature	28.90	25.92	34
Precipitation	264.55	209.20	422.84
Ocean Nino Index	0.2296	-0.8166	1.275

4.2 Model Pre-estimation Assumptions

This paper conducted some initial tests to ascertain the validity, accuracy, and robustness of the Vector Correction Model (VECM) before its deployment. These pre-estimation procedures are important in making sure that the time series data satisfy the fundamental assumptions of the Vector Correction Model, such as multicollinearity, stationarity, the lag selection criterion, and cointegration are achieved. Besides enhancing the credibility of the interpretation based on the analysis, these checks prevent model misspecification as well. Thus, the Vector error correction model was not performed before undertaking the following diagnostic tests:

4.2.1 Multicollinearity

To establish whether there was a relationship between the independent variables used in the study, the study used a correlation matrix. The method allows one to readily identify whether two variables are moving in the same direction the majority of the time, and this method can be especially helpful in identifying multicollinearity, a condition that can distort regression estimates and result in inaccurate estimates. The results of the correlation in table 4.1 show that all correlation value is less than 0.7 and this shows that there is no significant correlation between any of the variables. This low correlation between predictors is desirable because it lowers the risk of having a multicollinearity, as it ensures that the findings are significant and plain through statistics. This finding shows that each variable acts independently, with no undue influence from others, strengthening the validity of the analysis. By proving variable independence at this stage, the study improves the reliability and interpretability of the following econometric models, allowing for a more species-specific assessment of each factor's unique contribution to clove production.

Table 4.2 represents the Correlation Matrix of the study's variables

	Producer price	Temperature	Precipitation	Ocean Nino Index	Exchange Rate	Clove export
Producer Price	**1**					
Temperature	0.0133	**1**				
Precipitation	0.0101	0.0375	**1**			
Ocean Nino Index	0.0108	0.033	0.0644	**1**		
Exchange Rate	0.089	0.200	0.0046	0.259	**1**	
Clove export	0.366	-0.10	0.099	-0.01	0.118	**1**

4.2.2 Stationarity

The results of the unit roots test in Table 4.3 show that all of the variables which are clove production, producer price, ocean Nino index, temperature, exchange rate, precipitation and volume of the clove export are non-stationary at the levels, as demonstrated by p-values above the 0.05 level of significance. This implies the presence of a unit root in each series, implying that the variables have a stochastic trend and are not mean-reverting to their original shape. However, after applying first-order differencing, all variables become stationary, as evidenced by falling below the 0.05 level of significance. This leads to accepting the alternative hypothesis that the data does not have a unit root. So far, the first and second conditions of the VECM analysis with EViews are valid, namely, the data are not stationary at the level but become stationary at the first difference.

Table 4.3 shows the stationarity result

Variables	**P-value at level**	**P-value at first difference**
Clove Production	*0.0596**	*0.000****
Producer price	*0.061**	*0.005****
Ocean Nino Index	*0.0572**	*0.0004****
Temperature	*0.169**	*0.003****
Exchange Rate	*0.066**	*0.000****
Precipitation	*0.057**	*0.044****
Volume of clove export	*0.062**	*0.0001****

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Values without stars are not statistically significant.

4.2.3 Lag-selection criteria

According to the findings of the lag length analysis, as shown in table 4.4, the optimal lag is two, as it offers the lowest Akaike Information Criterion value. The Akaike Information Criterion value is preferred over other criteria in studies with a small sample of less than or equal to sixty (60) observations, like this study, as it minimizes the chance of underestimation while maximizing the chance of recovering the true lag length. Furthermore, the results show that the majority of the asterisks are in Lag 2, indicating that the majority of the selection criteria, such as the Likelihood Ratio test, Final Prediction Error, and Hannan-Quinn criterion, also chose Lag 2, implying a significant consensus among many metrics. As a result, lag two is regarded as the optimal lag in this model.

Table 4.4 shows the lag-selection result

Lag	**logL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	*-750.17*	*NA*	*6.2e+13*	*48.78*	*49.0780*	*48.87539*
1	*-623.90*	*195.37*	*1.93e+11*	*42.97*	*44.911**	*43.601*
2	*-566.77*	*66.46**	*6.52e+10**	*41.593**	*45.203*	*42.7180**

4.2 Co-integration

To ascertain whether there is a long-term relationship between the variables in the study, it is necessary to assess the presence of co-integration because e all of the variables are integrated of order one, I (1), meaning they become stable after the initial differencing. Cointegration was examined in this study using the Johansen co-integration test, and the findings disprove the null hypothesis that there is no cointegration. At the 5% level of significance, the results, as displayed in table 4.5, disprove the null hypothesis that there is no cointegration. Since the p-values for None, At most 1, and At most 2 are all less than 0.05, the Trace Rank test supports cointegration at the 5% level of significance. According to these results, the variables have up to three cointegrating associations, which means that over time, the variables tend to travel together even in the face of short-term fluctuations. Therefore, the variables are cointegrated if there is at least one p-value less than 0.05. The Vector Error Correction Model (VECM), which is suitable when variables are I (1) and cointegrated, is justified by this conclusion.

Table 4.5 shows Co-integration test result

Hypothesized No. of CE(s)	***Eigen Value***	***Trace Statistic***	***Critical value 0.05***	***Prob.***
*None**	*0.790009*	*226.7806*	*159.5297*	*0.0000****
*At most 1**	*0.751848*	*161.2316*	*125.6154*	*0.0001****
*At most 2**	*0.562344*	*102.6957*	*95.75366*	*0.0153**
At most 3	*0.529431*	*67.99011*	*69.81889*	*0.0693*
At most 4	*0.366560*	*36.33000*	*47.85613*	*0.3799*
At most 5	*0.252302*	*17.15320*	*29.79707*	*0.6287*
At most 6	*0.110061*	*4.941445*	*15.49471*	*0.8150*
At most 7	*0.001050*	*0.044139*	*3.841465*	*0.8336*

*Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively, based on the p-values of the Johansen trace test. "None" and "At most 1" show strong evidence of cointegration at the 1% level.*

So far, all basic preliminary assumptions for the Vector Error Correction Model have been met. First, the correlation matrix verified that there is no problem with multicollinearity because each variable operates independently and is not influenced by others. Second, the unit root tests revealed that while all variables are non-stationary at their levels, they become stationary at the first difference. Third, the Akaike information criteria revealed that two lags were best for capturing the underlying dynamics. Finally, the Johansen cointegration test confirms the presence of a long-term equilibrium relationship between the variables. Given that these critical assumptions are met, the Vector Error Correction Model is considered the best econometric tool for analyzing the short- and long-term effects of producer price, temperature, precipitation, Ocean Nino Index, exchange rate, and clove export on clove production. As a result, the

findings of the model are presented and discussed in the following section:

4.3 Vector Error Correction Model Result

Based on the Vector Error Correction Model output presented in Table 4.6, it turns out that the adjusted R-squared is 0.7071 indicating that approximately 70.71 percent of the total variations in clove production in Zanzibar were explained by the Producer Price, Temperature, Precipitation, Ocean Nino Index, Exchange rate and Clove export. Such a high explanatory power reflects the model's robustness in capturing the dynamics affecting the production of clove. In addition, the study result shows that the coefficient of the error correction term (ECTt-1=-0.8237) is negative and statistically significant at the 5% significance level (t-stat =2.49755> 1.96), which confirms the presence of a stable long-run relationship among variables influencing clove production. This also implies that the adjustment toward the equilibrium takes place by 82.37 percent per annum. Hence, Zanzibar clove production responds rapidly and forcefully to any short-term shocks in its determinants.

Turning to the short-term dynamics, the result shows that, Zanzibar clove production are significantly impacted by temperature at lag 1, producer price at lag 1, Precipitation at lag 2 and Ocean Nino Index at lag 1 this is because their t-statistics (2.1009, 2.10068, 2.14734 and 2.2875 respectively) are greater than t-critical which is 1.96 at 5% level of significance. These findings suggest that in the short run, Zanzibar clove production is sensitive to both market and climatic conditions. Specifically, the coefficient for Temperature at lag 1 is -1.2254, indicating that keeping all other variables constant, each degree Celsius increase in temperature during the previous year results in a decrease of 1.2254 metric tons in clove production in the current period. This illustrates how cloves are at risk from rising temperatures and proves that climate change may have serious effects on farming in tropical regions. Similarly, the coefficient value of the Ocean Nino Index at lag one is -0.3634, suggesting that a unit increase in the previous year in the index leads to 0.3634 metric tons decrease in clove production, holding other factors constant. This result underscores the adverse influence of regional climatic anomalies on agricultural performance, potentially through increased climatic variability.

On the other hand, Precipitation at lag two has a coefficient value of 0.00211, indicating that a one unit increase in precipitation in two years prior leads to 0.00211 metric tons increase in clove production in the current year. This lagged effect reflects the benefits of past weather conditions and accumulated soil moisture on plant development cycles. Importantly, the result observed that the coefficient value of producer price at lag one is 2.1007, suggesting that a unit increase in producer price in the previous year incentivizes production by 2.1007 metric tons in the current year, holding other factors constant. However, not all variables in the short term are statistically significant. The short-run results indicate that Producer Price at lag two, Temperature at lag two, Precipitation at lag two, Ocean Nino Index at lag two, Exchange

Rate at both lag one and two as well as Clove export at both lag one and lag two, do not have a statistically impact on clove production, as their t-statistics are less than t-critical which is 1.96. This finding highlight that the effects of these variables are less immediate or may be absorbed through other mechanisms in the short term.

In the long run analysis, the study finds that Zanzibar clove production is significantly impacted by most of the factors included in the model which are temperature, Ocean Nino Index, Exchange Rate and clove export as depicted in the table 4.7. This significance is due to their t-statistics (7.2622, 5.9566, 14.216, 3.0644 and 5.3115 respectively), all of which are greater than t-critical (1.96) at 5 percent level of significance. Regarding their coefficient values, the study observes that precipitation has a coefficient of -1.860, suggesting that a one-unit increase in temperature in the previous year leads to a reduction in clove production by 1.860 in the current year. Moreover, the coefficient value for Ocean Nino Index, which captures the occurrence and intensity of El Nino conditions, is -0.5554, suggesting that a one unit increase in the Index in the previous year reduces clove production by 0.5554 metric tons in the current year. Given the ongoing concerns about climate change and global warming, these study results raise critical implications for adaptive strategies in Zanzibar.

In contrast, the exchange rate has a positive coefficient which is 1.3022, meaning that a one unit increase in exchange rate in the previous year leads to an increase of 1.302 metric tons in clove production in the current year. Moreover, the most substantial long-run impact for clove export, which carry a large positive coefficient value of 10.735. This study result suggests that a one unit increase in clove export in the previous year results in a 10.735 in clove production in the current year. This strong linkage highlights the export-driven nature of Zanzibar's clove sector, where increased global demand directly incentivizes farmers and producers to scale up production. However, the study found that not all variables are significantly impact the clove production in the long-run. Despite being theoretically relevant, the coefficient for precipitation is not statistically significant at 5 percent level of significance, as indicated by its t-statistic of 1.0275 less than 1.96. Similarly, the producer price which often considered as a key economic driver, also fails to show significance in the long-term as its t-statistic (0.6542) is less than 1.96 at 5% level of significance. These findings suggests that while precipitation and producer price have notable impact in the short-run, their influence dissipates over the longer time horizon.

Table 4.6 represents VECM output, including model summary and short-run result
Adjusted R-squared = 0.7071

Variables	**Coefficient**	**Standard error**	**t-statistics**
CointEq1	-0.8237	0.3298	-2.4975**
D (Producer Price (-1))	1.8658	0.00099	2.10068**
D (Producer Price (-2))	1.5408	1.0620	1.4508
D (Exchange Rate (-1))	0.1498	1.0563	0.1418
D (Exchange Rate (-2))	-0.5211	0.9907	-0.5259
D (Clove export (-1))	6.0195	3.9467	1.5252
D (Clove export (-2))	2.9522	2.9143	1.0129
D (Temperature (-1))	-1.2254	0.5833	-2.1009**
D (Temperature (-2))	-0.4009	0.4884	-0.8208
D (Precipitation (-1))	0.00102	0.00102	1.0018
D (Precipitation (-2))	0.00211	0.00099	2.14734**
D (Ocean Nino Index (-1))	-0.3634	0.1589	-2.2875**
D (Ocean Nino Index (-1))	-0.1816	0.1303	-1.3930

Note: *, **, and * denote statistical significance at the 10%, 5%, and 1% levels, respectively. Values without stars are not statistically significant.**

Table 4.7 represents VECM output including model summary and short run result

Variables	Coefficient	Standard error	t-statistics
Producer Price	-0.3263	0.4988	-0.6542
Exchange Rate	1.3022	0.4249	3.0644***
Clove export	10.735	2.0212	5.3115***
Temperature	-1.8601	0.2561	-7.2622***
Precipitation	-0.00039	0.00038	-1.0275
Ocean Nino Index	-0.5554	0.03907	-14.216***

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Values without stars are not statistically significant.

4.4 Robustness of the Model Result

To ensure the robustness, validity, reliability and to justify whether the model was suitable for the study or not, a series of post-estimation diagnostics tests were conducted. These tests include the serial correlation test, the stability test, and heteroskedasticity. The objective of these diagnostic checks is to confirm that the model's estimations are statistically sound and interpretable for both policy and academic purposes.

4.4.1 Stability Test

The stability of the Vector error correction model in this study was assessed using eigenvalues of the companion matrix. The result of this test, as presented in table 4.8, indicate that all eigenvalues of the companion matrix have moduli less than one, ranging from 0.204166 to 0.847748, confirming the stability of the estimated VECM model. In the context of production of clove, this implies that, after any shorter-term problems, such as those caused by weather, economy, or policies, the clove system will eventually return to its usual, long-term path. This discovery highlights that the clove production system can remain strong despite facing different external issues. In summary, the outcomes of the stability test back up the belief that the VECM model used here is set up correctly and stable. Based on this, the study concludes that the relationships between clove production and the key factors— temperature, Ocean Niño Index, exchange rate, and exports—are not only valid in the short-run but also hold consistently in the long run.

Table 4.8 represent Stability test

Root	**Modulus**
-0.341422 - 0.775956i	0.847748
-0.341422 + 0.775956i	0.847748
-0.460797+0.457980i	0.649676
-0.520035	0.520035
-0.074506-0.364979i	0.372507
-0.074506+0.364979i	0.372507
0.167122-0.117277i	0.204166

Note: 0.204166 to 0.847748, confirming the stability

4.4.2 Serial correlation test

The Lagrange multiplier test was used as part of the model diagnostic tests to look for serial correlation in the model residuals. The results summarized in table 4.9 indicate that the p-value for each lag (p- value of lag one is 0.2556 and lag two is 0.3189) exceed the 0.05 level of significance. This indicates that we failed to reject the null hypothesis of no serial correlation in the model residual. This outcome confirms the absence of serial correlation in the Vector Error Correction Model residual and are independently distributed across time. The absence of serial correlation means that the model has managed to capture all the main features of the data without creating any patterns in the residuals, hence supporting the validity and reliability of VECM estimations and inferences. As a result, the model's outcomes for both the short and long term become more trustworthy and usually help in policy-making and academic studies.

Table 4.9 represent Serial correlation test

Lag	LRE*stat	Prob	Rao F-stat	Prob.
1	75.64868	0.1512	1.202383	0.2556
2	73.18688	0.2020	1.142173	0.3189

4.4.3 Heteroskedasticity

To further validate the robustness of the Vector Error Correction Model, the study employed the White test to check for heteroscedasticity. The results of this test, as predicted in table 4.10, show that the probability value of this test is 0.244, which is greater than 0.05. This implies that the study accepts of the null hypothesis of no heteroscedasticity in the data, meaning that the variance of the residuals remains constant across observations. Therefore, this confirms the reliability and validity of the model's estimates, reinforcing that the residuals are well behaved and that pre-estimation assumptions of the regression model are upheld.

Table 4.10 represents the Heteroskedasticity test

Chi-square	Probability Value
1257.03	0.244

a. Discussion of findings

The primary objective of this research is to examine the determinants of clove production in Zanzibar. The study observes that, in the short term, clove production is significantly influenced by temperature at lag one, producer price at lag one, Precipitation at lag two and Ocean Nino Index at lag one. These results highlight that both market factors and climatic factors play an important role in shaping the immediate fluctuations in the production of clove. However, in the long term, the clove production is significantly influenced by temperature, Ocean Nino Index, Exchange Rate, and clove export. This implies that sustained output is largely shaped by broader and structural factors such as global market trends and long-standing climatic conditions. Due to that, this section is intended to discuss how these factors impact Zanzibar clove production, including whether their effects are positive or negative. Moreover, this section analyses the research findings against previous studies to establish their conformity or differences with existing literature and to draw meaningful insights for policy and practice.

4.5.1 Impact of temperature on clove production

The findings of this study underscore the significant negative impact of temperature fluctuations on Zanzibar clove production, both in the short run and long run. Specifically, higher temperatures in the previous year are found to negatively affect clove production in the current period, with long-term effects proving more severe than short-term impacts. This highlights the sensitivity of Zanzibar's clove sector to temperature fluctuations. Moreover, these findings raise serious concerns about the sustainability of clove farming under projected climate scenarios, particularly for an economy heavily reliant on clove exports like Zanzibar. The future viability of clove farming is at risk, as rising temperatures threaten to harm or reduce agricultural yield, destroy farmer incomes, and erode national export revenues. The negative relationship

between temperature and clove production aligns with findings by Miraji, M. K. (2013) observed that increasing in maximum temperature result in decreasing Zanzibar's clove yield. Using scatter diagram, he further observed that the clove yield and the minimum temperature were negative correlated, suggesting that even cooler periods, if warmer than historical norms, could disrupt clove tree. Similarly, according to the results of the interviews conducted by Chami (2020), the impact of climate change manifested through floods and droughts, as well as increased surface temperatures, has a negative impact on clove production. Clove growers have also noticed increased temperature and rainfall unpredictability since the 1990s, resulting in clove tree death and decreased productivity compared to the pre-1990s period.

Additionally, these results are consistent with more general research on climate change and tropical agriculture. For instance, Das & Sharangi, (2018) pointed out that spice crops are suffering from climate change just as other horticultural and agricultural crops. In particular, high temperatures, rainfall, photoperiods, sunshine hours, and wind have been found to have a negative impact on various physiological growth stages, including flowering, fruit setting, fruit development, seed setting, and the ultimate reproductive or vegetative yield of spice crops. In the same vein, (Maerere and Van, 2014; Suprihanti, 2020) concluded that clove production worldwide tends to decline due to climate changes such as higher temperature and unpredictable rainfall. In addition to (Masoud. M., 2020), suggest that, change of the rainfall pattern and increasing of surface temperature negatively affect clove production in Pemba Micheweni, Wete, Chake Chake and Mkoani districts. The findings' congruence with earlier research by Miraji, M. K. (2013), Chami (2020), and Das, S., & Sharangi, A. (2018) highlights the wider ramifications for Zanzibar's economy and supports the validity of the study's conclusions.

4.5.2 Impact of Ocean Nino Index on clove production

The Ocean Nino index is also determined to exert negative effect on the production of cloves implying that fluctuation of the index the year before causes a downward trend in the production of cloves in the current year. Such a drastic reduction in production of cloves during Ocean Niньo events highlights the extent to which such crops are affected by disturbances in the ocean and the atmosphere. This magnitude of this effect raises great concerns among farmers, clove industry and agricultural authorities as well as the stakeholders. This puts the economic stability of the farmers who rely on clove farming at risk and hence jeopardizing their individual economic statuses and the market structure at large. These results are supported by several studies, e.g. (Iizumi et al., 2014), which held that El Ni o causes rainfall distortions along with extensions of droughts and increases in temperatures, the latter having adverse effects on agricultural yields. Similarly, Pratama, R. A. (2020) observed that during El Nino 2015, dry circumstances caused by El Niño disrupted growth phases during flowering and fruiting, resulting in a 70% decrease in nutmeg and clove yields in Maluku. In the same way, (Keil et al., 2009) found that prolonged dry conditions from El Niño inflict severe damage to crop productions mainly in regions where farmers depend on seasonal rainfall. These findings suggest that climatic variability play significant role in shaping

agricultural outcome. Therefore, this study results reveals signal an urgent call to action for implementing suitable agricultural adaptation to protect sector from climate variability effects.

4.5.3 Impact of volume of clove export on clove production

In this study clove export in the previous year is found to positively influence Zanzibar's clove production in the current year. This positive effect is crucial for Zanzibar because clove make up a large share of its export earnings. When exports grow, farmers earn more and the overall economy improves. This research outcome supports basic agricultural economic theory that show increased market demand from profitable export destinations motivates producers to expand their farming operations for greater profits (Key & Runsten, 1999). Supporting this view, Pratama et el. (2020) observed that production of clove in Indonesia shows strong market-responsive behaviour, with higher export volumes increases trigger farmers to boost production for international demand. Similarly, the paper published by Rist et al. (2011) showed that favorable clove export conditions lead to higher production volumes for cash crops including cinnamon and clove thereby confirming farmers tend to alter their output response to economic stimuli.

These research outcomes reveal how export markets function as fundamental drivers of agricultural growth specifically for clove sectors that depend on exports. For example, rising global consumer interest in cloves motivates local farmers and producers to enhance production levels to fulfil export needs while seizing opportunities in profitable foreign markets. However, relying heavily on exports can be risky. Some previous researches have raised concerns that excessive reliance on export markets causes unstable local production rates, especially when international prices fluctuate. For example, the investigation of black pepper trade in Southeast Asia demonstrates that export demand enhancements led farmers to decrease their production because price instability and elevated competition entered the market (García et al., 2018). Moreover, according to (Barreiro, 2007), observed that developing countries face production instability risks whenever their agricultural exports become overly dependent on international markets.

4.5.4 Impact of producer price on clove production

Producer price in the previous year is found to be a significant and positive predictor of Zanzibar's clove production in short term. This would be an indication that better price of clove farmers would lead to increased production. This slight shift is also in line with an economic theory that states that, the higher the prices given by producers, the more is the agricultural output. Consequently, farmers can be able to commit additional resources (labour), and territory to more marketable crops thus increasing total output. This finding is comparable to those done by the scholars Khamis, B. (2020), Husnaeni, et al., 2022, Moh d et al., (2017) and Febryana et el., 2022. They have found that, the producers that receive lower prices are likely to discourage production of cloves, whereas producer prices that are higher will promote the clove cultivation. Besides, (Kabote & Tunguhole, 2022) found out that one of the largest challenges that affect clove production and exports in Zanzibar is price fluctuation. On top of this, the findings also underscore

the need to have neutral and positive pricing arrangements that enhance sustainable production of the cloves particularly where small-scale farmers collectively control the industry. Similarly, Hery et al., (2014) assert that low pricing of producers and absence of the involvement of the private sector slows down the production of cloves in Zanzibar. Even in the same line of response, Samwel K. (2022) recorded that increases in producer and global market prices promoted domestic production. On the same note, Suprihanti et al., (2018) indicated that a decline in the prices of producers can affect the sustainability of clove production in Indonesia and it can pose a threat to the future existence of the crop.

4.5.5 Impact of Exchange Rate on clove production

The results of the study indicate that rise in the exchange rate of the previous year results in subsequent rise in production of cloves within that year. The fact that clove farming in Zanzibar is mainly done by smallholders who depend on the export earnings implies that when shillings are strong, farmers will receive more shillings with every dollar they make during the sale of cloves which stimulates them to produce more. The producers could respond to the demands by redirecting the resources to the production of cloves when the local currency is strong so that they can maximize returns. This is essential to Zanzibar as cloves sustain livelihoods, identity and the general economy of the island. These findings are justified by a number of studies. As an example, Mundlak et al. (2002) have found that devaluations of exchange rates usually have the effect of boosting agricultural output because the products sold become more competitive in the local markets. On the same note, an influential role of alteration of exchange rates over investment judgments in sectors related to agriculture in the developing countries was displayed by Imai et al. (2015). Their results also reveal that higher exchange rates would enable the farmers to commit more resources towards agricultural production, especially export commodities. Similarly, Kandil (2004), Yaqub (2010), and Bakare (2011) have noted that depreciation of exchange rates causes contractionary effects on agricultural production and therefore, appreciation can even have expansive effects thereby indirectly confirming the results of the research. Likewise, Edwards (1992), Odusola and Akinlo (2001), Adewuyi (2005), and Bahmani-Oskooee and Kandil (2007) reported that exchange rate appreciation can lead to increased output, especially when it improves trade competitiveness.

The results are different according to other studies though. To give an example of this, Yaqub (2013), noted that the different sub-sectors within the agricultural industry respond differently to exchange rate shocks. Similarly, Rakotoarisoa, et al., (2020) found that exchange rate changes had mixed effects, with depreciation sometimes boosting exports but not always production due to high farming costs. These results contradict our finding, as our study shows a positive effect from a stronger shilling. To conclude, although the extent to which the exchange rate changes relate to agricultural output is inconclusive in the literature, this study is part of the growing argument by showing a context-dependent positive impact of exchange rate appreciation on the production of clove in Zanzibar. As opposed to the literature that finds the advantages in depreciation, our results imply that among the smallholder farmers in export- based crops such as cloves,

a higher local currency can lead to a more stable farmer income and can induce higher production.

4.5.6 Impact of precipitation on clove production

This study observes that precipitation has a significantly positive influence on Zanzibar clove production in Zanzibar. This highlights the crucial role of climatic conditions in sustaining productivity, particularly for crops that are sensitive to weather fluctuations. This finding aligns with the study conducted by Miraji et el. (2013) who found that precipitation plays an important role in determining clove yield in Pemba Island, Zanzibar. In his qualitative study, Nuhu, A. A. (2016) also noted that respondents had noticed that clove trees flourished well in prior years when there was sufficient annual rainfall that was conducive to clove growth. Even if you replant clove trees after a short period, 80 percent of them die from dryness because of the recent changes in the weather. In addition to decreasing total output, this also has an impact on the yield of the few trees that do survive. Similarly, Haduni et el. (2016) found that precipitation significantly supports clove growth and yield in Ternate Island, Indonesia. Moreover, Ayuka et al. (2015) noted that in East Java Province, unpredictable rainfall patterns contributed to fluctuations in clove productivity. These research findings demonstrate that precipitation benefits farming; however, proper amounts remain essential for achieving high output performance while preventing negative impacts.

CHAPTER V
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study is to analyze the determinants of clove production in Zanzibar. To archive this, two specific objectives were formulated: (1) to determine the impact of producer price, volume of clove export and exchange rate on Zanzibar's clove production in short-term and long-term and (2) to ascertain the short and long-term effects of climatic variables (temperature, Ocean Nino Index, and precipitation) on Zanzibar's clove production. To facilitate data analysis, this study utilized EViews software as a tool for data analysis and employed the Vector Error Correction Model to determine the short-run and long- run of the factors that impact clove production. The findings can be summarized into two points: In the short-term analysis, result shows that Zanzibar clove production is primarily influenced by temperature at lag 1, producer price at lag 1, Precipitation at lag 2 and Ocean Nino Index at lag.

However, several factors such as Producer Price at lag two, Temperature at lag two, Precipitation at lag two, Ocean Nino Index at lag two, Exchange Rate at both lag one and two as well as Clove export at both lag one and lag two do not have a statistically impact on clove production in the short term. Moreover, in the long run analysis, the study finds that Zanzibar's clove production is significantly determined by most of the factors included in the model which are temperature, Ocean Nino Index, Exchange Rate and clove export. In contrast, the study finds that precipitation and producer price do not have a significant impact on clove production in long run. Overall, the study concludes that clove production in Zanzibar mainly determined by temperature, Ocean Nino Index, producer price, Exchange Rate, clove export and precipitation. These findings highlight the sensitivity of clove farming to climatic and economic factors, emphasizing the need for adaptive strategies to ensure the sustainability of the clove industry in Zanzibar.

5.1 Policy recommendations

` As it was identified in this study, the clove industry in Zanzibar is at great risk especially due to climate related stress like increased temperatures and El NINO. It is also found out, however, that there is a positive and significant value of independent variable (that is, the producer prices and export volume, exchange rates) to clove production in the short-run. In a bid to boost its resilience and long-term sustainability of the sector, the government of Zanzibar and other major stakeholders, such as the Ministry of Agriculture, the Zanzibar State Trading Corporation (ZSTC), and the Commission of Disaster Management, this study are proposed the following recommendations.

Recommendation for strengthening climate resilience in Zanzibar's clove sector

An increasing effort has been expressed by Zanzibar in the quest to combat the climatic vulnerabilities posing threats on the productivity of its key sectors such as cloves through the development of Zanzibar Climate Change Strategy (2014). In its five priority areas, the strategy also considers climate-smart agriculture and better natural resource management to be the most important in ensuring there is promotion of sustainable agricultural practices that improve the resilience in the food and cash crop systems In implementing this strategy, the government has supported the existence of early warning mechanisms with the help of Commission of Disaster Management and Capacity of Tanzania Meteorological authority in enhancing climate output and advisory to the citizens (Omar, M., 2021). The purposes of these interventions are to make sure that farmers have access to information which is timely and reliable and as such losses that are related to climate are reduced. Also, afforestation and sustainable management of the land are encouraged through the strategy, which reduces the occurrence of soil degradation and water evaporation and consequently can protect clove trees against extremes in temperature and irregular rain patterns.

Nonetheless, although these strategic interventions are taking place, the adoption of climate adaptation mechanisms within the clove sector is incomplete and underfunded (Omar, M. K., 2021). The visions of the Strategy in mainstreaming climate resilience have not been completely converted into sector specific action plan, at least in the case of cloves which are a crucial source of export and livelihood to most farmers in Zanzibari islands. This gap is clearly represented in research done by MASOUD, M.S. (2020): the percentage of households that did not receive the warnings related to the upcoming natural disasters was staggeringly high in the clove growing districts with 81(%) percent of the households in Micheweni and Chake Chake not receiving any warnings related to climate hazards and, 76 (%) and 46 (%) percent in Mkoani and Wete respectively. These numbers correspond to similarly high vulnerability indices and these types of differences indicate this does not indicate an effective and equitable outreach within the early warning framework.

Most of the clove-growing regions particularly Pemba have no access to clove plant variety with high drought-tolerance ability, effective irrigation system and information on climate adaptation strategies like mulching, intercropping or agroforestry (Omar, M. K. (2021), Nuhu, A. A. (2016) and (Watkiss, 2012). Although more than 20 climate-affected areas have been recognized and mapped in Zanzibar, there is a lack of progress in rehabilitation and resilience building regimes. The institutional and technological ability is still weak, and adaptation mechanisms like localized forecasting practice, enhancement of climate-resilient seed technology, and real-time contact with farmers are also yet to be maximized (Omar, M. K. (2021). This policy void threatens the viability of clove production, more so as the fluctuation of temperature and parallel precipitation worsens in the area.

To enhance climate resilience, government should put more emphasis on implementing sector-based climate adaptation practices in cloves by utilizing integrated climate-smart agricultural measures. These refer to introduction of drought tolerant varieties of cloves, developing and distributing of better extension service and introduction agroforestry system through the shade and nitrogen fixing tree like Gliricidia sepium and Albizia lebbeck. These measures would not only alleviate heat stress but it will also enhance the soil structure and moisture holding capacity, which can help buffer clove against the increase of temperature variability and El-Nino condition related disruption. Also, there is need to scale up early warning system with localised and timely information particularly in such susceptible areas such as Micheweni and Chake Chake districts so as to empower farmers to make real time adjustment to their farming practices. In leading such initiatives, Zanzibar should look up to Indonesia; the world number one producer of clove, which has effectively adopted strategies on comprehensive climate resilience within its spice industry. Indonesia has initiated and expanded research and distribution of drought resistant variety of cloves by supporting agricultural R&D efforts by the state. In North Maluku, Indonesia, studies have demonstrated that Indonesia has significantly invested in clove varietal research with an aim to facilitate localization and sustainability of clove production over the long run (Darmawan et al., 2021).

It has also embraced extensively intercropping systems which include the use of nitrogen fixing trees to neutralize soil health and climatic stress (Iswandi et al., 2018). Particularly, in 2023, the Climate Smart Indonesia initiative has been launched, which offers the mobile-based early warning alerts including meteorological, pest, and crop records in order to inform decision-making activities among farmers (Ministry of Agriculture Indonesia, 2023). Such interventions give practical examples Zanzibar can consider in enhancing the resilience and sustainability of its clove sector.

Recommendation for Enhancing Price Efficiency and Market Access in Zanzibar's Clove Sector

In Zanzibar, the clove industry is regulated by a state-regulated price structure (guideline) through the Zanzibar State Trading Corporation (ZSTC) which ensures that the farmers receive up to 80 percent of the world prices and it also supplies farmers with free seedlings and soft loans during the seasons (ZSTC, Zanzibar Investment & Business Insights, 2023). Although this strategy has accorded a price floor and infrastructural assistance, there are a number of shortcomings. Sometimes farmers have to face delays in their payments, and the overhead costs that come with ZSTC make the true farm-gate prices even lower, and makes producers unable to get their full share of foreign price rallies (Citizen, 2023; The Citizen, 2024). In addition, the monopolistic system has been condemned in putting a curb on the participation of the private sector and discouraging replanting and modernization (ZACPO, 2020; African Business, 2015). This has made farmers resort to selling in the streets and smuggling to get higher prices and at times, twice what ZSTC pays (LA, 2005).

Though the empirical findings of this paper show that the producer price only affects clove production significantly in the short-term, it does not refute the importance of reforms based on price in the long- term evolution of the sector. The short-run effect in real sense points out that farmers are very sensitive to price information; a behavior that can be taken advantage of. Through addressing existing inefficiency, example tardy payment and absence of competitive pricing, these reforms will help restore confidence by farmers in the formal marketing system, stimulate reinvestment in clove growing, and induce replanting, albeit slowly. Such gains are likely to be long-term in nature as they are incremental in nature. This is in line with the practices of all other countries in the World, like Indonesia, where short-term reforms that tweaked the pricing and digital technologies in the short-run led to sustained increases in agricultural production and farm incomes.

To help enhance the policy structure, several policy reforms are suggested to focus on these challenges in the system. To start with, it is necessary to invest in the modernization of the system of payment. The government ought to establish a real-time online system of auction to payment that is connected to cooperative accounts-management so as to tailor payment completion in not more than seven days to the farmers. Such would help ease financial insecurity and regain confidence by producers on the formal marketing channel. Indonesia has a successful case where e-Agriculture National Strategy is implemented, which integrates digital tools into the payment process to make it more efficient as well as accentuate price transparency among smallholders (FAO, 2023).

Second, the market should be liberated partially to create competition and to raise the farm-gate prices. The government had the ability to license the quality buyers to buy the same with ZSTC via strict terms which included quality assurance, traceability and pricing transparency. This would provide a competition which would serve to cut overhead costs, promote innovation, and enable farmers to negotiate prices. Indonesia offers a compelling case in point, as it does not impose a monopoly but instead, it allows the intervention of privately owned middlemen, like PT HM Sampoerna and Gudang Garam, to purchase cloves directly at the farmer level in order to use it on the manufacture of its kretek cigarettes. This decentralizes the system and allows price negotiation, boosts competition, and results in better farm-gate returns to growers (World Bank, 2023; Science Agriculture, 2025; Grow Sejahtera, 2025). Finally, it must be noted that the recovery of the clove industry in Zanzibar needs to organize a multi-faceted policy strategy that integrates state solutions with the liveliness of the market. The insights of other nations, such as Indonesia, emphasize the importance of the incorporation of digital payment systems, providing a competitive market, and accessing information to farmers. Such reform would boost not only the welfare and the production performance of the farmers but also set the clove sector in Zanzibar to grow sustainably in the international spice market.

Agricultural Export Promotion and Diversification Policy

This policy seeks to enhance Zanzibar's involvement in overseas markets for cloves, keeping in mind that clove exports are a key source of foreign capital and influence incentives to produce, as well as providing security to producers from alien intervention. The government ought to play an active role in bilateral and multilateral trade negotiations to obtain secure market outlets for cloves, particularly from nations with consistent demand. Farmer cooperatives and producer groups need to be made stronger and more empowered with marketing and branding capabilities to compete on export standards to enhance negotiating power and market access. Export credit insurance mechanisms and price stabilization tools will protect exporters and farmers from unexpected price declines or contractual default. Also, promotion of value-added clove oil products, spiced tea blends, and processed clove snacks can diversify export earnings and minimize reliance on raw clove markets. This integrated approach would optimize the economic returns of clove exports while offsetting their built-in risks.

Foreign Exchange Risk Management and Input Subsidy Policy

This policy supports a two-pronged approach to maximize benefits and minimize risks for farmers in the wake of the volatility of exchange rates on clove exports and the cost of inputs. During good exchange rates, the government must facilitate bulk buying of foreign inputs such as fertilizers, pesticides, and farm equipment and make them available via targeted subsidies. At the same time, taking on foreign exchange risk management instruments such as hedging mechanisms or indexed insurance can guard farmers and exporters from unforeseen currency devaluation that shocks input prices or diminishes export profitability. Domestic processing of key farm inputs needs to be incentivized through government assistance of agro-industrial entrepreneurship and innovation to improve long-term reliance on imported resources. Financial literacy training programs, currency risk, and forward contracts can enhance farmers' ability to deal with intricate market dynamics. This overall plan guarantees that Zanzibar's clove business is competitive and robust against global economic downturns

5.3 Limitation of the study

The limitation of this study includes the lack of interaction effects between its independent variables i.e., how the interaction effect between producer price and climatic conditions/exchange rate fluctuations may collectively affect clove production. These interactions can also be ignored, thus concealing more subtle relationships. Secondly, the research is confined to Zanzibar only and this would reduce the scope of the research findings. Applications of the panel regressions in the major countries producing cloves could help future researchers. Such enhanced coverage would be able to compare regions and also bring more understanding of the short-run and the long-run dynamics of the factors influencing clove production.

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