Journal of Economics, Finance and Management Studies

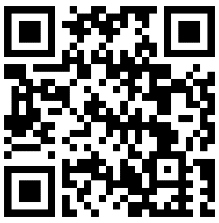
ISSN (print): 2644-0490, ISSN (online): 2644-0504

Volume 07 Issue 08 August 2024

Article DOI: 10.47191/jefms/v7-i8-50, Impact Factor: 8.044

Page No: 5291-5302

Factors Affecting Food Security: A Case of Tanzania



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ABSTRACT: The study examines the factors that affect food security and their implications in Tanzania. The key factors in this study includes population density, temperature, agricultural land, precipitation, carbon dioxide emissions, and exchange rate. Additionally, the study utilized secondary time series data from 1990 to 2022. Also, the study main objectives were to determine the short-term and long-term effect of the key factors on food security by Vector Error Correction model. At a significance level of 5%, the short-term estimation result indicates that the exchange rate is the only factor that significantly influences food security in Tanzania. Other factors like population density, temperature, amount of arable land, precipitation, and carbon dioxide, however, have no discernible short-term effects on food security. Furthermore, all factors have a significant impact on Tanzania's food security at the 5% level in the long-term estimate. Due to that, the study reommends that government should focus on as well as make discission and develop effective policy for the population densitcy, temperature, agricultural land, precipitation, carbon dioxide emissions, and exchange rate, so as to increase food availability, access, and usage for its people. Moreover, more research should also look into other factors that might also have an impact on food security since this study focused on only few variables.

KEY WORDS: Food production index, precipitation, carbon dioxide emissions, food security, exchange rate, population density, agricultural land and temperature

CHAPTER ONE: BACKGROUND OF THE STUDY

This chapter includes introduction of the problems, statement of the problem, research questions as well research objectives: general and specific.

INTRODUCTION

The world's food crisis is having an impact on millions of people. People's acute food insecurity still exists. According to estimates, 691–783 million people worldwide would go hungry in 2022. 2022 observed that 122 million more cases of hunger than 2019 when the midrange population, or roughly 735 million, is taken into account. Although there were 2.4 million fewer hungry people in Latin America and the Caribbean in 2022 than there were in 2019, the number of hungry people there was still 7.2 million higher per year. The fall was mainly caused by South America, which concealed a significant increase in the Caribbean from 14.7 percent in 2021 to 16.3 percent in 2022. Moreover, the percentage of the population in Asia decreased by almost 12 million, primarily in Southern Asia, from 8.8 percent in 2021 to 8.5 percent in 2022. This is still 58 million more than before the outbreak, though. Every subregion had gains, with the exception of Western Asia, where it went from 10.2 percent in 2021 to 10.8 percent in 2022 (FAO, 2023).

An unprecedented level of food crises is currently afflicting Africa. It is anticipated that millions may soon be at risk of experiencing increased hunger. According to the most recent predictions, the percentage of Africans experiencing moderate or severe food insecurity would reach 61% by 2022. This prevalence is significantly higher than the global prevalence of 29.6%, which is more than twice as high. Additionally, according to the updated figures, 24% of the continent's population experienced extreme food insecurity. The regions with the highest rates of moderate or severe food insecurity were Central Africa (78.4%), Eastern Africa (69.2%), and Western Africa (66.4%) (FAO, 2023).

For many years, the rate of food insecurity in Eastern Africa has been the highest of any subregion. One country in Eastern Africa, Tanzania, is expected to witness severe acute food insecurity (IPC Phase 3 or higher) for nearly 900,000 people between November

2023 and April 2024 (or 13% of the 7.1 million residents living in the 21 district councils of Mainland Tanzania that were examined). Within IPC Phase 2 (Stressed), encompassing the remaining 19 district councils, the majority of households are compelled to utilize stress coping mechanisms in order to purchase certain essential non-food items. In addition, most households struggle to provide for their food needs. The district councils of Longido and Monduli are IPC Phase, according to the Tanzania report from 2023.

The Tanzanian Ministry of Agriculture (MoA) released reports on food availability for the 2023–2024 year and food crop production for the 2022–2023 production year, which concludes in June 2023. This data made it possible to determine that 48 district councils spread across 13 regions would experience a shortfall in crop production in 2023–2024. Pests of crops grown in fields and unequal rainfall distribution were two reasons put forth for the low productivity. Throughout Tanzania's growing season of 2022–2023, the main factors contributing to food insecurity were an extended dry spell and irregular rainfall, which had a significant impact on crop and animal productivity, livestock diseases, and pests. The reduced crop yields in Vuli, Masika and Msimu harvest restricted food availability and accessibility because they resulted in financial hardships for contract agricultural laborers (IPCT, 2024).

Insufficient availability to food poses a potential danger of long-term detrimental impacts on productivity. In addition, food insecurity runs the potential of escalating the nation's already-existing political unrest and strife, plunging the nation into perpetual poverty. Numerous studies show the various ways in which Tanzania's food security is impacted by various causes. In Tanzania, household size, area of residence, and income from sources other than agriculture are the socioeconomic components of household food secu The demographic component of household food security in Tanzania is the head of the household's marital status; the socioeconomic components are household size, area of residence, and income from sources other than agriculture (Mwanga, 2019).

Also, the study by (Reincke *et al.*, 2018) shows that although cultivating cassava can help households achieve food security, doing so is hampered by a number of issues such as pests, lack of markets, subpar processing, societal perceptions, and ignorance. Furthermore, a study on the relationships between institutional factors and food security variables discovered that a number of different institutional elements, such as total food production with institutional assistance, had a major impact on family food security (Kingu, H.A., 2015). Additionally, (Arndt C. *et el*., 2012) note that Tanzania's current agricultural methods cannot ensure food security in the face of climate change, in part because they rely on increasingly unpredictable and erratic rainfall. As a result, the purpose of this study was to investigate the factors that influence food security in Tanzania, as well as their short and long-term effects.

STATEMENT OF THE PROBLEM

In order for any nation to prosper and maintain social stability, food security is a prerequisite. In response to that various tactic have been devised to enhance food security in Tanzania. Since 1963, the World Food Programme (WFP) has been operating in Tanzania, collaborating with the government, corporate sector, NGOs, other UN agencies, funders, and other relevant parties to enhance the nutrition and food security of marginalized communities. Moreover, a US$77.4 million project agreed upon by the International Fund for Agricultural Development (IFAD) and the Government of the United Republic of Tanzania would provide much-needed support to 260,000 rural households suffering from the consequences of climate change. Additionally, rural communities receive the resources they require it from the agriculture and fisheries development programme to improve their resilience, productivity, and ability to provide food security and better nutrition.

Despite Tanzania's best efforts, the Integrated Food Security Phase Classification Report, 2023, discovered that 13% of the 7.1 million residents of the 21 district councils in Mainland Tanzania that were studied or 900,000 people suffer from severe acute food insecurity (IPC phase 3 or above). Reports from the Ministry of Agriculture (MoA) on food crop production for the 2022/2023 production year ending in June 2023 and food availability in the nation for the year 2023/2024 were used to identify a shortage of crop production for the year 2023/2024 in 48 district councils distributed across 13 regions. Many causes, such as the uneven rainfall distribution and the existence of agricultural pests in the fields, were pointed out as the reasons for the low yield. These statistics demonstrate that Tanzania is not on track to fulfil the targets of the Sustainable Development Goal 2 on Zero Hunger for 2030, nor the targets of eradicating hunger and all kinds of malnutrition by 2025. Due to that, the study employed Vector Error Correction Model to determine short term and long impact of temperature, precipitation, carbon dioxide emissions, agricultural land, exchange rate and population density on the food security.

General objective

To examine the factors that affect food security in Tanzania.

Research questions

1. What is the short-term impact of (temperature, precipitation, carbon dioxide emissions, agricultural land, exchange rate and population density) on the food security?

2. What is the long-term impact of (temperature, precipitation, carbon dioxide emissions, agricultural land, exchange rate and population density) on the food security?

Research objectives

1. To determine short term impact of (temperature, precipitation, carbon dioxide emissions, agricultural land, exchange rate and population density) on the food security.
2. To determine long term impact of the (temperature, precipitation, carbon dioxide emissions, agricultural land, exchange rate and population density) on the food security.

CHAPTER TWO: LITRATURE REVIEWS

This chapter includes basic concepts of food security, overview of the food security in Tanzania, literature revies part as well as research gap of this study.

Basic concept of food security

Food security is when everyone has physical, social, and financial access to a sufficient supply of wholesome food that satisfies their dietary needs and preferences for leading an active and healthy life, food security has been achieved (FAO, 2001). This applies to all people, regardless of where they live. The availability, accessibility, sustainability, agency, use, and stability are the essential components of food security (HLPE, 2020). Additionally, the significance of the right to food has been acknowledged, and the four previously identified aspects of food security availability, access, usage, and stability have been joined by agency and sustainability. (Clapp *el al.,* 2022)

Overview of food security and nutrition in Tanzania

Finding out how much and what kind of food the households under interview consumed was the goal of the food consumption evaluation. Several attributes were evaluated, such as the household dietary diversity (HDDS), the food consumption score (FCS), the household hunger scale (HHS), and the reduced coping strategies index (rCSI). Using stress management techniques, 16 out of 21 district councils are able to barely meet the barest requirements for food; these councils have food consumption gaps based on FCS and HDDS indicators. IPC Phase 3 is implied in 19 out of 21 districts (or roughly 90%) with a score of between 2 and 3 (moderate food shortage). This information comes from the HHS indicator. A significant number of families in Longido (63 percent), Monduli (38 percent), Manyoni (37 percent), Nzega (35 percent), Singida (35 percent), Bahi (34 percent), and Simanjiro (32 percent) were impacted by food shortages, according to HHS. Reducing meal frequency, regulating portion sizes, and consuming less desired food were among the reduced coping strategies (rCSI) that ten out of twenty-one district councils used to address food limitations in the homes. In Monduli and Longido, where 49% and 48% of respondents, respectively, used coping methods to reduce stress levels in order to meet their food demands, the situation is worse. The percentage of households using livelihood coping strategies varied by region: roughly 54% in Longindo, 45% in Kongwa, 40% in Magu, and over 30% in Babati, Busega, Chamwino, Magu, and Shinanga in response to food crises. To meet their food consumption needs, these tactics included begging, taking out loans to buy food, and buying food on credit (Integrated Food Security Phase Classification Report, 2023).

Current state of food security dimension in Tanzania as:

Food access**,** about 85% of the households in the complete assessment stated that the market was accessible and available to them, and 67% reported that the prices of staple food crops had decreased in September and October of 2023. Prices of staple foods are still significantly higher than the five-year average even after the harvesting season because of strong export demand, limited supply, and expensive production and transportation expenses. The cost of food has an impact on the accessibility of food for those with limited means (Integrated Food Security Phase Classification Report, 2023).

Food availability**,** Food crops and livestock production in the 2022–2023 season performed below average (28 percent) in a number of district councils, including Mkinga, Mkalama, Singida, and Bahi, according to the results of the Integrated Food Security Phase Classification Report, which analyzes the thorough food and nutrition security assessment conducted in October 2023. Several Tanzanian councils, including Babati, Busega, Chamwino, Handeni, Kishapu, Kongwa, Korogwe, Longido, Magu, Manyoni, Maswa, Mbulu, Meatu, Monduli, Nzega, Shinyanga, and Kilimanjaro, reported an average productivity decrease of sixty-one percent.

Food utilization**,** Water, sanitation, and hygiene, as well as dietary preferences, preparation techniques, feeding procedures, storage, and safety, are important aspects that affect how well food is used and stays stable. While a lot of homes demonstrate commendable food preparation techniques, such soapy dishwashing, other crucial areas like feeding habits, storage, safety, and WASH point to less-than-ideal performance in terms of food security. Remarkably, over half of the households surveyed for the study admitted to feeding their young children (those under five) just twice a day. This pattern was seen in families in the district

councils of Busega, Chamwino, Singida, and Maswa. More than 50% of households were found to primarily rely on traditional storage facilities, which increases food losses and negatively impacts food security.

Empirical literature review

There are numerous studies that determined factors influencing food security. The following is a summary of some of the studies that looked at the variables affecting Islamic bank performance:

Different Using data from 40 chosen Sub-Saharan African (SSA) nations between 2000 and 2021, the study (Lefe, Y. D. *et el*., 2024) explores the degree to which climatic variability impacts food security in SSA. Based on its four aspects (availability, accessibility, use, and stability), a food security index is created using Principal Component Analysis (PCA). Precipitation, temperature, and CO2 emissions were the proxies for climate variability. Heteroscedasticity, serial correlation, and cross-sectional dependency were all taken into consideration while using the Panel Corrected Standard Error (PCSE) technique. The empirical findings indicate a negative correlation between temperature and food security and a positive relationship between precipitation and CO2 emissions. (Applanaidu, S. D., & Baharudin, A. 2014) studied the dynamic relationship between food security in Malaysia and several chosen macroeconomic variables, such as GDP, the food price index, biodiesel production, exchange rates, government spending on rural development, and population, using the VAR approach. According to the variance decomposition, the biodiesel output, the exchange rate, and government spending on rural development are the factors that will have the biggest impact on food security in year ten. Results also show that Malaysia's population and the food price index were determined to be important. The other factors, however, do not matter. The variance decomposition also demonstrates that, although it increased until year ten, the first year's shocks to food security were not immediately exacerbated by Malaysian biodiesel production. Furthermore, the results validate that the manufacturing of biodiesel will ultimately have an adverse effect on food security.

Additionally, research was done by (Anwar, N. 2022) to determine the drivers that influence food security in the nation as well as map the areas that are most food insecure in order to build anticipatory solutions. This study uses secondary data from Statistics Indonesia and is quantitative in nature. We employed Clustering Analysis and Non-Parametric Splines Regression to estimate the model. Based on available data, food security in Indonesia is significantly influenced by rice production, purchasing power index, population density, food expenditures, and harvested area. In addition, food security varies from medium to high in most of Indonesia's provinces. The findings demonstrated the necessity of including land, water, and fertilizer availability regulations into Indonesia food chain strategies.

Furthermore, the current study was carried out in Punjab province with intention of investigating the relationship between agricultural farm area, agricultural fam infrastructure, agricultural farming community, agricultural output and food security issues in the context of raising the standard of living for farmers and the rural poor (Pervaiz, B., & Manzoor, M, Q. (2019). During a field survey conducted throughout Punjab for this purpose, data were collected from 300 households using a comprehensive questionnaire using a multi-stage clustered sampling strategy. For better comprehension, the relevance of unique circumstances was taken into account using the structural equation modelling (SEM) technique. The findings demonstrated that safe land management and tenancy increased agricultural output. The level of living in Pakistan was found to have a direct correlation with food security, whereas agricultural output and suitable farm land had an indirect effect.

Moreover, (Gingrich, C. D. et el., 2001) carried performed research on the connection between food security (homegrown food output) and foreign exchange rates in Indonesia and the Philippines. Over the past 20 years, the total amount of grain supplies in both countries have been impacted by cost of food security imports relative to available foreign currency. Furthermore, during the 1997–1998 financial crisis, Indonesia's fall in cereal supplies outpaced that anticipated due to a scarcity of foreign currency. The research indicates that the interplay between foreign exchange availability, food import prices, and domestic food production has a considerable influence on the short-term food security of food-importing nations. Programs for compensatory funding that support food security must to be adaptable to further instances of financial contagion, price hikes, or production shocks.

Food insecurity in Tanzania is mostly caused by a country's dependence on rainfall, insufficient inputs, and limited technological competency. In Chamwino District, the socioeconomic and demographic elements that influence food security status are rather well recognized, although they have not been experimentally studied. According to Assenga, E. A., & Kayunze, K. A. (2020), this study examined the effects of socioeconomic and demographic factors on food security by examining the characteristics of the households surveyed. This cross-sectional study design involved 400 randomly selected houses as the subjects. Four factors related to socioeconomic status and demographics—family size, land size, total annual household income per adult equivalent, and age of household head—were found to have a significant ($p < 0.05$) positive impact on food security through multiple linear regression analysis. The study area's food security is found to be greatly influenced by socioeconomic and demographic characteristics; hence, addressing these aspects may lead to an increase in food security. It is suggested that governmental and private organizations take a more proactive approach to tackling the issue of food insecurity in Chamwino District. The focus of this involvement should be on the demographic and socioeconomic variables that lower food security.

Factors Affecting Food Security: A Case of Tanzania

The research (Kitole, F. et et al., 2024) examines the connection between food security, climatic change, and the frequency of diarrhoea in Tanzania using data from the Agriculture Sample Census (2002/03, 2007/08, 2019/20). In the instrumental variable probit and control function approach models, temperature anomalies are employed as instrumental variables to manage heterogeneity and endogeneity. The findings indicate that there is a strong correlation between the incidence of diarrhea (0.214602, $p < 0.01$) and food security (p-value<0.01, coefficient value of -0.331142) and climate change. These results show that the strain that climate change places on food security makes households more vulnerable to food insecurity, and that the frequency of diarrhea exacerbates health problems. Furthermore, using information from the National Bureau of Statistics' (NBS) 2019–20 agriculture sample census survey, Jennifer Sesabo (2024) investigates the variables influencing food security among Tanzania's smallholder farmers. The study evaluated the main factors influencing food security using a probit regression model and a non-experimental research approach. The findings highlight the importance of a number of variables as significant predictors of food security in Tanzania, including crop storage (-1.473, $p<0.01$), irrigation (-0.906, $p<0.01$), land ownership (-0.070, $p<0.01$), and land ownership by women (-0.909, $p<0.05$).

To ascertain the ways in which houses in the Bukoba District are impacted by socioeconomic, infrastructural, technological, and sociocultural dimensions, Mavole, J.N. et al. (2016) conducted a study. The study was conducted in Tanzania's Bukoba District. The study's primary objectives are to examine the connections between sociocultural components and household food security, economic factors and household food security, technological factors and household food security, and household food security and infrastructure. This study employed a descriptive research design. 150 households' worth of data were gathered through focus groups and organized, standardized interview guides. In the study, primary and secondary data sources were consulted. Primary data were gathered in conjunction with standardized interview guides and focus groups. Sources: Academic journals, government publications, textbooks, internet/online sources, theses, and previously published research projects were the sources of the secondary data. This study found that sociocultural, technological, economic, and infrastructure factors all had an impact on the food security of rural households in Bukoba District. Certain sociocultural factors, such as household size and local attitudes toward bananas, had an impact on food security in rural households. Farmers in the Bukoba district were perceived as being below purr in terms of technology since most of them still relied on antiquated implements like jembe and panga rather than implementing more advanced farming techniques that promote higher yields. Due to the lack of credit institutions, most farmers in Bukoba had difficulty obtaining credit. Furthermore, the majority of the farmers could not afford the interest that was charged on the credit. Additionally, it was noted that the district lacked the common infrastructure frameworks needed to enable maximum food production.

In addition, a study conducted by F. N. Rashid et al. (2024) used data from household budget survey which held in 2017–18 to investigate the factors influencing household food expenditure in Tanzania and its implications for food security. Stage Least Squares (2SLS) model was the technique employed. According to the research, Tanzanian families spend 159,072.80Tsh (roughly US$69.2) on food on average per month. With a 0.72% income elasticity, the relationship between food expenses and the age of the head of the household was non-linear. In addition, the amount spent rises with household size, the sex of the head, education, asset ownership, group membership, and marital status; on the other hand, the cost of food decreases with rural location.

Research gap

The researcher has discovered a substantial gap in previous studies that mainly concentrate on a small number of variables when analysing food security, based on the research described above. This study attempts to provide a thorough understanding of the short and long-term impact complexities within these relationships by using Vector error correction model to analyse the complex interactions among socioeconomic, environmental, and agricultural factors in relation to food security. Moreover, while research in Tanzania mostly focused on how carbon dioxide emissions affect food security as a result of climate change, this study aims to widen the focus by taking precipitation and temperature into account. The study intends to provide a comprehensive evaluation of the numerous implications on the food security in the area by taking these extra factors into account.

CHAPTER THREE: METHODOLOGY

This chapter includes explanation of the data source, variables descriptions as well as data analysis methods.

Source of the data

The data used in this study obtained from World Bank covered 1990-2022, and the study used Vector error correction model to determine if there is short-term and long-term impact of the key variables on food security.

Variable's descriptions

Dependent variable

Food security: According to the Food and Agricultural Organization of the United Nations (FAO), food security is the condition in which all people, at all times, have physical, social, and economic access to enough, safe, and nutritious food that satisfies their

dietary needs and food preferences for an active and healthy life. Food production index, which served as a stand-in for food security in this study. (Applanaidu, S. D., & Baharudin, A. 2014) and (Avi et al., 2023) also use this proxy to gauge food security.

Independent variables

The study employed the following variables as factor variables which are:

Carbon dioxide emissions: emissions from burning fossil fuels and producing cement are classified as carbon dioxide emissions by the World Bank. Among them are the carbon dioxide emissions from gas flaring as well as the burning of fuels, including liquid, gas, and solid. In their study, (Lefe, Y. D. et el., 2024) and (Kitole, F. et el., 2024) employed this variable as an independent variable.

Exchange rate*:* is used to describe the rate set by the federal government or the rate that is allowed by law to be set in the currency market. Using monthly averages that are expressed in local currency units in relation to US dollars, an annual average is computed. To assess their influence on food security, (Gingrich, C. D. et al., 2001) employed this variable.

Population density: It is the midyear population split by the land area in square kilometres, according to the World Bank. The calculation of this ratio is possible for each geographical unit at any given period, contingent on the source of the population statistics. This variable used by (Anwar, N. 2022) as independent variable to determine the food security.

Agricultural land: is used to designate the area of land that is arable, permanently cropped, and open for pasture. This component was utilized by (Avi et el, 2023) to calculate the effect on food

Precipitation: is characterized as any type of water, either liquid or solid, that descends from clouds. This variable was also included in the research by (Lefe, Y. D. *et el*., 2024).

Temperature: The measurement of heat or cold, represented on one or more scales, is called temperature. Additionally, it depicts the direction in which heat energy will naturally flow that is, from a body with a higher temperature to one that is colder. (Lefe, Y. D. *et el*., 2024) also used this variable as factor variable.

Data Analysis Techniques

For the purpose of giving a summary of the descriptive statistics of the variables under investigation, the study employed descriptive analysis techniques in conjunction with time series analysis methodologies to ascertain the variables' short- and long-term effects on food security. To ascertain the immediate and long-term effects of food security in Tanzania, this study employed the Vector Error Correction Model as its time series model.

Vector Error Correction Model

Vector Error Correction Model is a cointegrated VAR model. This idea of Vector Error Correction Model (VECM), which consists of a VAR model of the order p - 1 on the differences of the variables, and an error-correction term derived from the known (estimated) cointegrating relationship. The study will employ this model so as to determine short-term and long-term impact of temperature, precipitation, carbon dioxide emissions, agricultural land, exchange rate and population density on food security. The VECM model in its general form, where p represents the lag of an endogenous variable and r is the rank of cointegration, is as follows:

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + u_t$$

Where, Δ: operator differencing, with $\Delta X_t = X_t - X_{t-1}$, X_{t-1}: Π: matrix coefficient cointegration ($\Pi = \alpha\beta t$; α = vector adjustment, matrix with order (k × r) and β: vector cointegration (long run parameter) matrix [k × r]), ut: vector residual with order (k × 1), Γi: the -i matrix coefficient variable endogenous with order (k × k). This technique includes several steps which are:

Stationarity test

In order to prevent non-stationary data that could produce erroneous findings, the Augmented Dickey Fuller (ADF) test was used to determine whether the study's variables were stationary or non-stationary.

Lag order selection criteria

The number of lags to be used in this study determined using a variety of criteria, but the Akaike Information Criteria is better than other criteria when it comes to small samples of sixty (60) observations or fewer because it reduces the possibility of underestimating while increasing the likelihood of recovering the true lag length. In order to determine the maximum lag length, this study employed the Akaike Information Criteria.

Stability test

The purpose of this test is to determine whether or not the chosen lags are stable. The table of modulus and the stability of variance circle will be used in the stability test. The modulus value must be smaller and all of the companion matrix's roots' moduli must be smaller than one and fall inside the circle for the model to be stable.

Cointegration Test

In order to apply the vector error correction model, Johansen's co-integration test was used to determine whether there is a long-term equilibrium relationship between non-stationary variables.

RESULTS, DISCUSSION AND RECOMMENDATIONS

This chapter includes results, discussion of the result, conclusion and recommendations of the study.

Descriptive statistics

The statistical summary of the study's factors is presented in Table 1 below, with a total of 31 observations for each variable. The results also demonstrate that, with a maximum value of 112.31 and a minimum value of 54.74, the average food production index for the period was roughly 64.056. Over the course of the period, the average value of the agricultural land was 40.181, with a maximum value of 44.616 and a minimum value of 35.21. Additionally, the result indicates that, with a maximum value of 14,960.80 and a minimum value of 1859.50, the average carbon dioxide emissions over the period were approximately 6167.98. A minimum of 1842.813 Tsh to US dollars and a maximum of 14,582.20 Tsh to US dollars were found in the findings, which also show that the average exchange rate for the time was roughly 8440.75 Tsh to US dollars. In addition, the population density averaged 46.289 over the period, with a maximum of 69.659 and a minimum of 29.584. Moreover, the data show that the average amount of precipitation during the time period was roughly 264.55, with minimum and maximum values of 209.20 and 422.84, respectively. Ultimately, the temperature ranged from a minimum of 22.22 to a maximum of 23.40 over the course of the period, with an average of 22.77.

Table 1 show the data summary of the variables

	AGRIC_LAND	CO2	E_RATE	FPI	PD	PRECIPITA...	TEMPERA...
Mean	40.18149	6167.981	8440.744	64.05613	46.28917	264.5595	22.77476
Median	39.86701	5660.000	9159.317	54.74000	44.52416	262.9625	22.81500
Maximum	44.61639	14960.80	14582.20	112.3100	69.65965	422.8400	23.40750
Minimum	35.21110	1859.500	1842.813	35.85000	29.58457	209.2025	22.22250
Std. Dev.	2.897701	4024.266	4169.490	26.89594	11.86425	40.96728	0.308980
Skewness	-0.024008	0.684386	-0.430174	0.521673	0.400491	1.984395	0.107677
Kurtosis	1.676868	2.234220	2.039475	1.727216	2.030276	8.556637	2.237890
Jarque-Bera	2.264271	3.177446	2.147794	3.498544	2.043336	60.22720	0.810120
Probability	0.322344	0.204186	0.341674	0.173900	0.359994	0.000000	0.666937
Sum	1245.626	191207.4	261663.1	1985.740	1434.964	8201.345	706.0175
Sum Sq. Dev.	251.9002	4.86E+08	5.22E+08	21701.75	4222.811	50349.54	2.864058
Observations	31	31	31	31	31	31	31

Inferential statistics outputs

Stationarity test

Table 2 shows that only temperature and precipitation were stationary at the level because at the 5% level of significance, the p value from the ADF unit root test was less than 0.05. Food security, carbon dioxide emissions, agricultural land, population density, and exchange rate, on the other hand, were stationary at the first difference since their p-value was less than 0.05 and greater than 0.05 at level show that they were not stationarity.

The table 2 shows the stationarity out at level and first difference

	P value		
	Level	1 st diff	significance
Variables Name			
Food security	0.992	0.000	significant at 1 diff
carbon dioxide emissions	1.000	0.012	significant at 1 st diff
Temperature	0.041	0.000	significant at both level and 1st diff
Agricultural land	0.704	0.036	significant at 1 st diff
Precipitation	0.003	0.000	significant at both level and 1st diff
Exchange rate	0.706	0.023	significant at 1 st diff
Population density	1.000	0.049	significant at 1 st diff

Lag selection criteria

Akaike Information criterion showed that the maximum lag length was one (1) with the lowest AIC value because AIC outperformed other criterion for a sample of less than 60 observations.

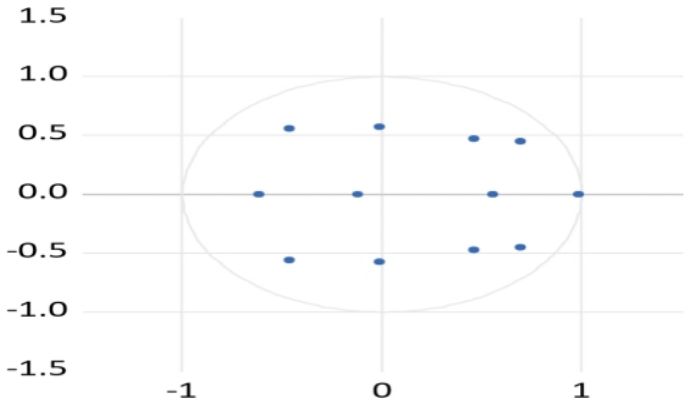
The 3 shows the lag length selected by all criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-946.0133	NA	5.78e+17	63.60089	63.97454	63.72042
1	-696.6083	349.1671*	2.88e+12*	51.24055*	54.60342*	52.31636*

Stability Test

Since this test use of the variance circle's stability and the table of moduli. For the model to be stable, the modulus value must be smaller and all of the root moduli of the companion matrix must be smaller than one and fall inside the circle. Therefore, the chart below demonstrates that modulus values fell within the circle, which supported the model's stability and the chosen lag.

The Chart shows the modulus values in inside the circle



Johansen Cointegration Test

Table 4 shows that there are two co-integration vectors since the Traces statistical value exceeds the Traces critical value. Moreover, the value holds significance at the 5% level of analysis. As a result, the findings supported the existence of a long-term association, indicating that the Vector Error Correction Model is the optimal model for this study.

Table 4 show the result of Johansen Cointegration test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.790493	147.7934	125.6154	0.0011
At most 1 *	0.740063	102.4665	95.75366	0.0159
At most 2	0.593312	63.39430	69.81889	0.1462
At most 3	0.524723	37.30273	47.85613	0.3334
At most 4	0.292894	15.73089	29.79707	0.7310
At most 5	0.177202	5.680211	15.49471	0.7329
At most 6	0.000824	0.023902	3.841465	0.8771

Vector Error Correction Model output

Short term result

From the table 5 below, the fact that the t-statistic is 1.990, which is greater than 1.96, indicates that the factor that significantly has significant effect on food security in the short term was exchange rate. The exchange rate's coefficient value is 0.0007, meaning that at the 5% level of significance, a unit rise in the exchange rate from the prior year will result in a 0.0007 unit increase in the current value of food security. The study conducted by (Gingrich, C. D. et el., 2001) and Ariani R et el., (2023) observed the similar effect. However, as their t-statistic is smaller than 1.96, the results show that temperature, carbon dioxide emissions, agricultural land, precipitations, and population density do not significantly affect food security at the 5% level of significance.

Table 5: summarize short run result, dependent variable is Food Security

	Coefficient	**t-statistics**
Temperature	-2.328	-0.514
Agricultural land	-1.733	-0.387
$C0_2$ Emissions	-0.0005	-0.429
Precipitation	0.0041	0.1766
Exchange rate	0.0007	1.990
Population density	-2.969	-0.397

Long term result

From the table 6 below, the long-term results demonstrate that temperature has a significant detrimental effect on food security because the temperature's t statistic is -5.713, which is greater than 1.96 at the 5% level of significance. This indicates that a one-unit increase in temperature over the previous year will cause the present value of food security to decrease by 381.86 units. The findings align with the research conducted by (Lefe, Y. D. et al., 2024) and Dasgupta, S., & Robinson, E. (2022). Additionally, the data show that agricultural land has a coefficient value of 119.68, meaning that an increase in agricultural land of one unit from the previous value will result in an increase in food security of 119.68 units today. Since the t-statistics was 2.257 which is larger than 1.96 at 5% level of significance this reveals that their effect was significant. This result bear resemblance to the study conducted by Anwar, N. (2022) and Zhidkov, S. A.et al., (2021).

Furthermore, the study reveals that precipitation has significant effect on food security since t-statistics was 2.664 which was larger than 1.96 at 5% level of significance. Also, since the coefficient value of precipitation was 1.2671 meaning that one unit increase in the previous value of the precipitation will increase current value of the food security by 1.2671 units. Similar result was noted by (Lefe, Y.D. et al., 2024). Moreover, the study concludes that the coefficient value of the exchange rate was 0.0154 this means that one unit increase in the previous value of the exchange rate will increase the current value of the food security by 0.0154 units. This effect was significant at 5% level of significance since t-statistics was 1.997 which is higher than 1.96. These findings are consistent with those of Ariani R et al. (2023) and Gingrich, C. D. et al. (2001).

Additionally, as the t statistic value is 3.402, the statistics show that the population density has a negative impact on food security since t value is greater than 1.96, and the population density coefficient value is -77.968, this means that for every unit increase in population density from the previous year, the current value of food security will decrease by 77.968 unit at 5%. This outcome

is consistent with the study by Efendi, N. et el., (2021) and Hall, C., Dawson et el., (2017). Therefore, in general these findings highlight the importance of addressing the challenges posed by population density to ensure adequate food availability and access for the population.

In addition, the coefficient value of carbon dioxide emissions is -0.0103 meaning that carbon dioxide affects food security negatively. Since the t statistic value is 1.999, which is larger than 1.96 at 5%, this conclude that, statistically food security is affected by carbon dioxide emissions over the long run by 0.0103 unit. Similar result observed in the study conducted by Segbefia., E*., et el.,* 2023 but the result is in contrast to the study by (Lefe, Y. D. *et el*., 2024) observed that carbon dioxide emission hasn't significant impact on food security.

Table 6: summarize long run result, dependent variable is Food Security

	Coefficient	t-statistics
Temperature	-381.86	-5.713
Agricultural land	119.68	2.257
CO_2 Emissions	0.0103	1.999
Precipitation	1.2671	2.664
Exchange rate	0.0154	1.997
Population density	-77.968	-3.402

CONCLUSIONS

This paper aimed to assess the factors that affects food security and their impacts in Tanzania. The kay variables used in this study includes temperature, precipitation, carbon dioxide emissions, agricultural land, exchange rate and population density. Also, the data used in this study was obtained from World Bank and the study employed Vector error correction Model to determine the short-term and long-term impact of these key variables on food security. The short-term estimation result indicates that, at a rate of 5%, the only factor that significantly affects Tanzania's food security was exchange rate. However, at the 5% level of significance, the results indicate that factors such as population density, temperature, agricultural land, precipitation, and carbon dioxide emissions do not significantly affect food security in short term. Additionally, the results of the long-term estimation show that, at 5%, the all factors significantly affect food security. However, the study did not include all factors that impact Tanzania food security hence the future researcher can go beyond this factor.

RECOMMENDATIONS

1. Given that exchange rate has a statistically significant positive impact on food security, Tanzania's government should implement the following measures: First, capitalize on the favourable effects of exchange rates by supporting and incentivizing export-oriented agriculture. Second, promote agricultural export diversification to lessen reliance on a single commodity and improve resistance to changes in exchange rates. Thirdly, to guarantee fair markets and competitive prices for farmers involved in export-oriented agriculture, strengthen value chain development and market linkages. Fourthly, give farmers more access to credit and financial support so they can grow their businesses and invest in cutting-edge farming equipment.
2. Since the impact of temperature on food security was negative, this study recommends the government to formulate comprehensive policy approach such as to support climate-smart agricultural practices like conservation agriculture and improved irrigation techniques, also agricultural systems ought to be encouraged in order to reduce resilience on crop that are sensitive to temperature, as well as the financial support for the study and creation of crop and livestock breeds that can tolerate high temperature and promote long-term adaptability
3. Also, the study recommend that government should promote and implement the sustainable expansion and management of agricultural land policies such as provide farmers with security over their land, encourage long-term investments, and boost production, also farmers' proficiency with sustainable land management approaches can be enhanced by using this in conjunction with targeted agricultural extension services. In addition, promoting the coexistence of trees and crops can improve climate resilience, biodiversity, and soil fertility by putting agroforestry methods and land use planning ideas into practice. Additionally, strengthening agricultural cooperatives and facilitating access to markets and funding, smallholder farmers can get additional help in optimizing their land use and productivity. Moreover, the government should collaborate with international organizations and sharing best practices, so as to gain

from the prosperous experiences of other countries in creating and implementing policies for food security and sustainable agricultural land management.

4. The study also suggests that government should consider putting a multipronged plan into actions so as to cut carbon emissions and mitigate their negative consequences on food security by includes promoting the use of renewable energy sources such as wind, solar, and hydroelectric power can help reduce carbon emissions from the energy sector and help shift away from fossil fuels, also by implementing energy-saving measures in industry, transportation, and buildings, moreover the government should engage in international organizations and global climate change accords may also provide Tanzania with financial resources, as well as chances for technology transfer and information exchange.
5. In addition, the study observed that precipitation has a major positive influence on Tanzania's food security; therefore, the study recommends that investments in irrigation infrastructure and better water storage systems be made to guarantee a steady supply of water for agricultural activities, particularly during times of low precipitation. Furthermore, implementing efficient water management techniques, such as rainwater collecting and drip irrigation, can optimize water consumption and minimize waste. also, government should provide farmers with timely information regarding weather forecasts and climate-related concerns, early warning systems can be reinforced and farmers can make better informed decisions. By implementing these policies, Tanzania might potentially enhance food security while reducing its vulnerability to climate-related issues and optimizing the advantages of precipitation.
6. The report also recommends that the government should prioritize policies for adapting to climate change, strengthening connections with the market, developing capacity, fostering knowledge exchanges amidst dense populations, also improving rural infrastructure, investing in agricultural technology and innovation, boosting agricultural productivity, and guaranteeing a resilient and food-secure future for its citizens.

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