International Journal of Food and Agricultural Economics
ISSN 2147-8988, E-ISSN: 2149-3766
Vol. 12, No. 2, 2024, pp. 97-110

DIFFERENTIAL EFFECTS OF MACROECONOMIC INDICATORS ON FOOD SECURITY IN SUB-SAHARAN AFRICAN COUNTRIES

Afees Oluwashina Noah
Department of Economics, North-West University, Vanderbijlpark, South Africa
Email: noahafees@gmail.com , ORCID: 0000-0003-4075-0976

Oladipo Olalekan David
Department of Economics, North-West University, Vanderbijlpark, South Africa
ORCID: 0000-0002-9922-9504

Wynand Grobler
Department of Economics, North-West University, Vanderbijlpark, South Africa
Wynand.Grobler@nwu.ac.za

Abstract:

Global food insecurity has worsened due to COVID-19 and political crises. Persistent regional disparities are evident, with Africa, and specifically sub-Saharan Africa (SSA), bearing the heaviest burden. This study therefore explores the differential effects of macroeconomic variables on both the demand and supply sides of food security and their components, based on cross-country data from 2012 to 2022 for 28 countries, using panel-corrected standard error (PCSE) and system generalized method of moments (SGMM). Descriptive analysis reveals average food security percentages of 48.14% and 44.08% for the demand and supply sides, respectively. The PCSE and SGMM results also show that economic growth, agricultural output, and food trade openness have a similar effect on both the demand and supply sides, while employment in agriculture, population growth, and food price inflation have differential effects. The study recommends enhancing supply-side dimensions due to their lower indices and targeted interventions for short run impacts.

Keywords: *Demand and Supply Sides, Food security, Sub-Saharan Africa, Macroeconomic Drivers*
JEL Codes: *Q110, Q180*

1. Introduction

Ensuring food security is a matter of utmost importance globally. The sufficient availability, utilization, and accessibility of food are not only vital for human survival but also contribute to addressing poverty and hunger across the world, as well as fostering economic development and growth (Adeyeye, 2017). A state of food security is achieved when individuals consistently possess financial, social, and physical means to obtain ample, safe, and nourishing food, meeting their nutritional needs to achieve a healthy and active lifestyle (Nkurunziza, Mchiza & Zembe 2023). Ensuring a satisfactory standard of living is a fundamental right of every individual, encompassing necessities like clothing, food, medical care, housing, and other essential amenities, along with access to food security in situations such as illness, old age, unemployment, widowhood, disability, or other circumstances beyond their control (Morlachetti, 2016). Sustainable food security hinges on a steady supply of sufficient food, well-functioning markets, and households' capacity to produce a combination of homegrown food and income that covers all their basic needs (Fraval *et al.*, 2020).

Nonetheless, global food insecurity has worsened due to COVID-19 and political crises. Recent estimates reveal a troubling increase in the proportion of undernourished people worldwide. Persistent regional disparities are evident, with Africa, and specifically sub-Saharan Africa (SSA), bearing the heaviest burden. In 2021, a staggering 20.2% of Africans faced food insecurity, compared to other regions across the world which are less than 10% (World Bank, 2023). In 2022, 2.4 billion people - mostly women and those in the region - lacked year-round access to sufficient, safe, and nutritious food (FAO, 2023). Therefore, a more effective governance system is needed to address food security, based on understanding the root causes and geographical locations of food insecurity. The issue of hunger is becoming more widespread globally, but the factors causing it among countries are different. Therefore, experts agree that food insecurity often results from regional crises, with sub-Saharan Africa being a major cause for concern (Conceição *et al.*, 2011).

In light of the prevailing challenges, numerous studies have been conducted to probe into the root causes and potential solutions for the escalating food crisis. These inquiries have identified various drivers of food security, encompassing income, agricultural output, trade openness, population growth, climate change, and political crises, among others (European Commission, 2023; Regmi & Meade, 2013; Sassi, 2015; Tossou, 2022; Yobom & Le Gallo, 2024). The significance and actual impact of various drivers of food security have been extensively deliberated. While certain determinants' effects on food security have garnered consensus, the ongoing debate over the metrics of food security remains unresolved. Regmi and Meade (2013) note that the focus of the conversation has largely revolved around the supply side of food security, specifically addressing concerns related to declining productivity growth and the sustainable increase of agricultural productivity. It is necessary to understand the factors that affect food supply capacity to improve food security. However, it is equally important to improve our understanding of the demand-side drivers to achieve this goal (Hobbs, 2020).

The demand-side patterns are analyzed over time to understand how they adjust to various factors such as changes in income, price fluctuations, population shifts, and others. This not only helps to project food needs more accurately, but also provides an understanding of the types of food that buyers are likely to need in the future. Identifying populations at risk and foreseeing emerging trends in food demand are crucial outcomes of research on food demand. Historically, this type of research has been carried out at the country or regional level, leveraging readily available comparable food expenditure data (Hovhannisyan, Mendis & Bastian 2019). Recently, the existence of reliable and extensive datasets across nations has facilitated cross-country analysis of demand, allowing for the exploration of drivers of food security on the demand side at both regional and global levels.

In consideration of these factors, this study examines the fundamental drivers of macro-level food security, specifically distinguishing between its demand and supply sides. Utilizing the most recent cross-country data spanning from 2012 to 2022, the study covers a sample of 28 countries in sub-Saharan Africa. Employing panel-corrected standard error (PCSE) and system generalized method of moment (SGMM) techniques, the empirical analysis examines the fundamental drivers of food security while differentiating between its demand and supply components. This study's primary contribution to the extensive literature on food security lies in its nuanced separation of these two essential components. Furthermore, both the demand and supply sides are subdivided into four foundational pillars of food security. The demand side is further divided into food affordability, safety and quality, while the supply side comprises food availability, sustainability and adaptation. The study systematically examines the impact of these macroeconomic variables on each of these specific components. This differentiation is of paramount significance for shaping effective food policies, providing insights into the areas that should guide interventions at the regional, sub-regional, or country levels. The study's comprehensive approach informs targeted strategies that address the multifaceted dimensions of food security in SSA.

In essence, previous studies have employed various indicators to measure food security, but a common trend involves using only one or two variables as proxies, particularly in SSA. This study addresses this limitation by enhancing the measurement scope by aggregating multiple indicators to provide a more comprehensive evaluation of food security. Recognizing the multi-dimensional nature of food security, which encompasses various key indicators, this study goes beyond the limited use of single or dual indicators. The rationale behind this approach is grounded in the understanding that a singular or dual indicator cannot fully represent the entirety of food security. By incorporating multiple indicators, the study offers a more robust and nuanced assessment of the complex and multifaceted concept of food security.

Moreover, many previous studies on food security in SSA primarily rely on primary data derived from country-specific studies (Akolgo et al. 2024; Jaison, Reid & Simatele 2023; Muringai et al. 2020; Nkhoma, Bosman & Eduful 2019), this research uniquely contributes to the limited body of studies on SSA food security grounded in secondary data. To comprehensively understand the determinants of food security, the study examines the distinct effects of explanatory variables on both the supply and demand sides of food security, along with their sub-components such as affordability, safety and quality, availability, and sustainability and adaptation. This investigation involves assessing whether the explanatory variables exhibit consistent effects on both the supply and demand sides of food security. Notably, empirical literature often focuses on either the demand or supply side of food security individually, rarely exploring both in a single study. While some studies claim to analyze food security by examining only the demand side, the technical accuracy of such claims lies in examining the supply side exclusively. However, the critical concern here is not the terminology used in these analyses but the potential for misleading or confusing interpretations. The key issue revolves around the varying implications attributed to the effect of an explanatory variable on the demand and supply sides of food security.

These are the gaps the present study addresses with the main objective of examining the drivers of the demand and supply sides of food security. The specific objectives encompass investigating the effects of these drivers on their components — affordability, safety and quality, availability, and sustainability and adaptation. Additionally, the study explores the varied impacts of these determinants on the demand and supply sides of food security and their components. The subsequent sections of this study are presented in Sections 2 to 4.

2. Materials and Methods

2.1 Theoretical Framework

This study draws on Malthus (1789) Malthusian and demand theories to underpin the demand side of food security, while the supply side is grounded in production theories such as Solow's Technological Growth Model. Malthus argues that population growth follows a geometric pattern, surpassing the arithmetic growth of food production and leading to a potential Malthusian catastrophe unless effectively managed. Scanlan (2003) emphasizes that adept population management can either reduce or enhance food security. Solow, on the other hand, conceptualizes growth as a production function involving physical capital, labor, and technology. Beyond these theories, key determinants of the demand and supply of food security, along with empirical evidence, guide the selection of variables in the models of this study.

Income emerges as a crucial determinant, with an increase in individual income linked to improved food security, aligning with theoretical and empirical perspectives that associate economic growth with food security (Regmi & Meade, 2013). Agricultural employment also significantly contributes to food production and security, although the gender dimension introduces variability (Sassi, 2015). Considering trade openness, the study acknowledges the global nature of food security, aligning with the economic dependency theory. However, caution is advised to emphasize the importance of balancing domestic production and international factors to prevent over-reliance on other countries' food production, which can be detrimental (Abdullah, Zhang & Matsubae 2021). The role of capital stock is also emphasized, highlighting its contribution to increased productivity and improved living standards (Ashraf & Javed 2023). Agricultural land use is intricately linked to food supply; effective utilization of available lands can significantly impact household food security, while the loss of agricultural land poses threats to food security and agriculture itself (Bonye et al., 2021). An increase in food price inflation is associated with a decline in food security, reflecting the theoretical perspective linking food price volatility to food security (Erokhin & Gao 2020).

The selection of explanatory variables in the demand and supply of food security models, as well as their components, is justified based on their theoretical and empirical support, informing the formulated model to achieve the objectives of this study as follows:

$$FSE_{it} = \alpha_0 + \alpha_1 X_{it} + \varepsilon_{it} \quad (1)$$

where *FSE* is the supply side of food security (measured by the index of food availability and, sustainability and adaptation), *X* represents the explanatory variables that include population (PPN, measured by the population growth), employment in agriculture (*EMP*, measured by the total employment in agriculture), agricultural output (*AGR*, measured by the agricultural sector value-added), economic growth (*EGH*, measured by the GDP per capita), food trade openness (*TOF*, measured by the sum of food export and import expressed as a percentage of GDP), agricultural land (*LAN*, measured by the agricultural land, expressed as a percentage of land area), physical capital stock (*CAP*, measured by the gross fixed capital formation in agriculture, forestry, and fishing), and food inflation (*FOO*, measured by the food price inflation), α_0 is the constant parameter, α_1- α_n are the slope parameters and the coefficients of each explanatory variable, ε is the disturbance term, *i* is for the SSA countries and *t* is the time. Based on the theoretical and empirical justifications, the parameters of employment in agriculture, economic growth, agricultural land, food trade openness, and capital stock are expected to be positive, while food price inflation is expected to be negative. Equation 1, is a replica of the two components of the supply side of food security, as well as the demand side of food security and its components except for the capital and labour that are excluded from the demand side models.

Furthermore, to address potential bias stemming from the endogeneity of specific regressors, the study integrates dynamic panel regression. The applied model is presented in Equation (2):

$$FSE_{it} = \delta_0 + \delta_{1i} FSE_{it-1} + \theta_{1it}\delta + \eta_{it} \quad (2)$$

where FSE_{it-1} represents the first lag of the supply side of food security, Θ_{1it} = *PPN*, *AGR*, *EMP*, *EGH*, *TOF*, *LAN*, *CAP*, and *FOO* with *1 x k* dimension. Taking the first difference of Equation (2) to reflect the unbiasedness and consistency of the models:

$$\Delta FSE_{it} = \delta_0 + \delta_{1i} \Delta FSE_{it-1} + \Delta\theta_{1it}\delta + \eta_{it} \quad (3)$$

2.2 Analytical Techniques

To achieve the objectives of this study, descriptive statistics, correlation analysis, and panel regression analysis statistical techniques were employed. Both panel-corrected standard error (PCSE), and system-generalized method of moment (SGMM) estimations were employed for the estimation of the long and short-run estimations respectively. The justification for choosing these methods is because of their efficiency in dealing with some of the post-estimation problems associated with the alternative methods. In addition, considering the nature of the micro panel data under analysis.

2.3 Data Sources

Secondary data were collected for twenty-eight Sub-Saharan African (SSA) countries from 2012 to 2022. The analytical approach is a panel regression based on the outcomes of unit root and cointegration tests. The stationarity of the data was evaluated through a unit root test, and the presence of long-run relationships among the variables was investigated using a cointegration test. The period of the study is dictated by the data availability and the pursuit of the second goal of sustainable development goals (SDGs). This timeframe also extends the temporal scope of previous research on the topic. Data on food security and its components were sourced from the Economist Impact's Global Food Security Index (GFSI), and both the demand and supply food security index were generated by the authors from the indices of affordability, and safety and quality for the demand, and the availability, and sustainability and adaptation for the supply side. Data on population growth, economic growth, employment in agriculture, and agricultural land was obtained from the World Bank's World Development Indicator (WDI). In addition, data on agricultural output, physical capital stock, food trade openness, and inflation were sourced from Food and Agriculture Organization Statistics (FAOSTAT).

3. Presentation and Discussion of Empirical Evidence

The summary statistics and correlation matrix for the panel series are presented in Table 1. The top section of the table includes the various statistics in the first column, while the second to the tenth columns include the demand side of food security (FDE), the supply side of food security (FSE), economic growth (EGH), agricultural output (AGR), agricultural land (LAN), total employment in agriculture (EMP), population growth (PPN), food inflation (FOO), food trade openness (TOF), and physical capital stock (CAP), respectively.

The statistics in Table 1 show that FDE and FSE averages are 48.14% and 44.08%, respectively, with an average GDP per capita in SSA of $1,457.46. AGR, LAN, and EMP have mean values of 23.66%, 303315.8 per square km, and 53.85%, respectively. PPN and FOO show average values of 2.73% and 9.94%, while TOF and CAP exhibit averages of 56.86% and 22.69%, respectively. The dataset is devoid of outliers, evidenced by the negligible difference between mean and median values across the majority of panel data. The results of the correlation analysis in the lower part of Table 1 show that only EGH and LAN have positive correlations with the demand side of food security at a 5% significance level. Conversely, the remaining variables show negative correlations, except for TOF and CAP. The correlation coefficient values suggest the absence of multicollinearity in the models of this study.

Table 1. Descriptive Statistics and Correlation Matrix

	FDE	FSE	EGH	AGR	LAN	EMP	PPN	FOO	TOF	CAP
Mean	48.14	44.08	1457.46	23.66	302215.8	53.85	2.73	9.94	56.86	22.69
Median	47.30	44.03	883.99	22.93	248503.0	58.74	2.71	6.20	55.87	21.85
Maximum	72.60	61.10	6657.07	61.15	1126648	87.20	3.87	206.47	154.30	52.42
Minimum	31.90	30.15	262.18	1.23	18600.00	14.02	0.39	-15.15	0.08	2.18
Std. Dev.	7.73	5.74	1456.98	12.45	269834.3	17.97	0.55	19.69	25.69	7.25
Correlation matrix										
FDE	1.00 -----									
FSE	0.21 (0.00)	1.00 -----								
EGH	0.67 (0.00)	0.14 (0.02)	1.00 -----							
AGR	-0.37 (0.00)	-0.22 (0.00)	-0.62 (0.00)	1.00 -----						
LAN	0.13 {0.03}	0.03 (0.60)	0.43 (0.00)	-0.14 (0.01)	1.00 -----					
EMP	-0.60 (0.00)	-0.12 (0.03)	-0.70 (0.00)	0.46 (0.00)	-0.17 (0.00)	1.00 -----				
PPN	-0.48 (0.00)	-0.35 (0.00)	-0.58 (0.00)	0.31 (0.00)	-0.06 (0.29)	0.60 (0.00)	1.00 -----			
FOO	-0.17 (0.00)	-0.03 (0.55)	0.04 (0.51)	-0.08 (0.14)	0.40 (0.00)	-0.07 (0.21)	-0.03 0.59	1.00 -----		
TOF	-0.09 0.10	-0.32 (0.00)	-0.13 (0.03)	0.44 (0.00)	0.12 (0.04)	0.20 (0.00)	0.21 (0.00)	-0.09 (0.12)	1.00 -----	
CAP	-0.03 (0.59)	0.12 (0.03)	-0.07 0.2421	-0.07 (0.20)	-0.11 (0.05)	0.12 (0.03)	0.26 (0.00)	-0.26 (0.00)	0.02 (0.73)	1.00 -----

Source: Authors' computation
Note: Demand side of food security - FDE, the supply side of food security - FSE, economic growth - EGH, agricultural output - AGR, agricultural land - LAN, total employment in agriculture - EMP, population growth - PPN, food inflation - FOO, food trade openness - TOF, and physical capital stock – CAP..

The results of the unit root tests are presented in Table 2. Four-panel unit root tests were used to assess the stationarity of the variables. The null hypothesis assumes that the variables have unit roots. The decision on the stationarity of a variable is based on whether the majority of tests support or reject it. The outcomes of the unit root tests indicate that all variables exhibit stationarity in their first difference forms. Notably, only FDE shows stationarity in its first difference form. Based on the analysis, it can be inferred that the series are integrated in different orders.

The study employed the panel Kao Engle-Granger cointegration test to examine whether there is a long-run relationship among the variables. This method was preferred as it can handle multiple regressors. The results, presented in Tables 3a and 3b, suggest that there is indeed a long run relationship among the variables in the models.

Table 2. Panel Unit Roots Test Results

Series	Stationary	PP- Fisher	ADF- Fisher	LLC	IPS	Decision
FDE	Level	137.31*** (0.00)	125.90*** (0.00)	-9.74*** (0.00)	-4.83*** (0.00)	I(0)
	First Diff.	-	-	-	-	
FSE	Level	81.99 (0.01)	57.00 (0.44)	-4.56 (0.00)	-0.43 (0.33)	I(1)
	First Diff.	220.47 (0.00)	95.47 (0.00)	-6.17 (0.00)	-3.02 (0.00)	
EGH	Level	64.63 (0.20)	46.32 (0.82)	-4.44*** (0.00)	1.02 (0.85)	I(1)
	First Diff.	168.87*** (0.00)	128.34*** (0.00)	-8.68*** (0.00)	-4.81*** (0.00)	
AGR	Level	51.98 (0.63)	90.67*** (0.00)	16.99** (0.00)	-3.53*** (0.00)	I(1)
	First Diff.	130.33*** (0.00)	112.42*** (0.00)	-9.74*** (0.00)	-3.78*** (0.00)	
LAN	Level	126.80*** (0.00)	49.89 (0.14)	-0.54 (0.30)	-0.73 (0.23)	I(1)
	First Diff.	141.93*** (0.00)	79.08*** (0.00)	-8.78*** (0.00)	-3.27*** (0.00)	
EMP	Level	149.87*** (0.00)	71.94* (0.07)	-4.13*** (0.00)	-1.02 (0.15)	I(1)
	First Diff.	152.08*** (0.00)	120.45*** (0.00)	-13.26*** (0.00)	-4.59*** (0.00)	
PPN	Level	40.78 (0.94)	68.69 (0.12)	0.21 (0.58)	1.70 (0.96)	I(0)
	First Diff.	79.51*** (0.00)	100.66*** (0.00)	-8.99*** (0.00)	-2.93*** (0.00)	
FOO	Level	94.01*** (0.00)	53.19 (0.58)	0.36 (0.64)	1.07 (0.86)	I(1)
	First Diff.	268.49*** (0.00)	122.73*** (0.00)	-9.49*** (0.00)	-4.59*** (0.00)	
TOF	Level	29.69 (0.08)	41.49 (0.93)	3.20 (0.99)	2.56 (0.99)	I(1)
	First Diff.	173.77*** (0.00)	97.34*** (0.00)	-6.73*** (0.00)	-3.08*** (0.00)	
CAP	Level	41.117 (0.932)	56.209 (0.467)	-3.85*** (0.00)	1.39 (0.92)	I(1)
	First Diff.	166.09*** (0.00)	95.39*** (0.00)	-7.79*** (0.00)	-3.02*** (0.00)	

Source: Authors' computation

Notes: PP-Fisher, ADF-Fisher, Levin-Lin-Chu (LLC), and Im-Pesaran-Shin (IPS). The p-values of the test statistic are in parentheses. The symbols *, **, and *** indicate rejection of the null hypothesis at 10%, 5%, and 1% significance level, respectively. Demand side of food security - FDE, the supply side of food security - FSE, economic growth - EGH, agricultural output - AGR, agricultural land - LAN, total employment in agriculture - EMP, population growth - PPN, food inflation - FOO, food trade openness - TOF, and physical capital stock – CAP.

Table 3a. Panel Kao Engle-Granger Cointegration Test Results

Demand side of food security model	Statistic	p-value
Modified Dickey-Fuller	-4.31***	0.00
Dickey-Fuller	-6.02***	0.00
Augmented Dickey-Fuller	-5.08***	0.00
Unadjusted modified Dickey-Fuller	-6.40***	0.00
Unadjusted Dickey-Fuller	-6.81***	0.00

Source: Authors' computation
Notes: *** indicates rejection of the null hypothesis at a 1% significance level.

Table 3b. Panel Kao Engle-Granger Cointegration Test Results

Supply side of food security model	Statistic	p-value
Modified Dickey-Fuller	-1.18	0.12
Dickey-Fuller	-3.14***	0.00
Augmented Dickey-Fuller	-3.85***	0.00
Unadjusted modified Dickey-Fuller	-2.15***	0.00
Unadjusted Dickey-Fuller	-3.67***	0.00

Source: Authors' computation
Notes: *** indicates rejection of the null hypothesis at a 1% significance level.

3.1 Presentation and Discussion of The Regression Results

Tables 4 and 5 show the outcomes of the analysis on the drivers of the demand and supply sides of food security as well as their components (as dependent variables) in Models 1 to 6, respectively. Additionally, Models 1 to 6 represent the long-run Models for the demand side, affordability, safety and quality, supply side, availability, and sustainability and adaptation of food security respectively, while Models 7 to 12 are their corresponding short run. Table 4 presents the estimations of the panel corrected standard error (PCSE) for the long-run estimations and Table 5 presents the estimations of the system generalized method of moment (SGMM) for the short-run estimations.

The results obtained from the PCSE estimations indicate that economic growth has a positive and statistically significant effect on the demand, affordability, safety and quality, supply, sustainability and adaptation of food security. However, it has a positive but insignificant impact on the availability of food in the long run. Specifically, a one percent rise in economic growth causes the demand, affordability, safety and quality, supply, sustainability and adaptation of food security to rise by 0.04. 0.04, 0.02, 0.01 and 0.02 percent respectively. These results confirm earlier studies conducted by Regmi and Meade (2013), and Zhuang et al. (2022). Its insignificant on food affordability may be attributed to high post-harvest losses that reduce actual availability to the consumers, thereby making it difficult for them to purchase food at an affordable price.

Agricultural output has a positive and significant impact on food availability, safety and quality, supply, affordability, sustainability and adaptation. However, it has no significant effect on the demand for food. The implication of this is that a one percent rise in agricultural output leads to 0.03, 0.01, 0.07, 0.02 and 0.12 percent increase in the availability, safety and quality, supply, affordability, sustainability and adaptation of food security respectively. These findings are consistence with previous studies by Abdelhedi and Zouari (2020), and Zhuang et al. (2022). This suggests that increasing agricultural output will result in a greater food supply, availability, affordability, sustainability and adaptation thereby reducing the cost of food prices in the market, making it affordable for everyone. However, it is important to note that agricultural output does not directly influence the demand for food, the reason for this may be the fact that the availability of food may not necessarily translate to high demand for it, especially if people cannot afford to buy it due to low income or high prices.

Table 4. PCSE Estimation Results

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
EGH	0.04*** (0.00)	0.04*** (0.00)	0.02* (0.09)	0.01** (0.01)	0.02 (0.15)	0.02*** (0.00)
AGR	0.02 (0.61)	0.03*** (0.00)	0.01** (0.04)	0.07*** (0.00)	0.02* (0.09)	0.12*** (0.00)
EMP	0.05*** (0.00)	0.05*** (0.00)	0.03** (0.01)	0.03 (0.16)	0.03 (0.20)	0.08*** (0.00)
PPN	-0.03*** (0.00)	0.10*** (0.00)	-0.07*** (0.00)	-3.44*** (0.00)	-0.07*** (0.00)	-3.42*** (0.00)
FOO	-0.01*** (0.00)	-0.01** (0.03)	-0.01 (0.35)	-0.02 (0.25)	-0.01 (0.46)	-0.02 (0.10)
TOF	0.05*** (0.00)	0.02*** (0.00)	-0.01** (0.01)	-1.67*** (0.00)	-0.04 (0.21)	-2.08*** (0.00)
LAN	-	-	-	0.04*** (0.00)	0.03*** (0.00)	0.06*** (0.00)
CAP	-	-	-	-0.01 (0.87)	0.01 (0.96)	0.01*** (0.00)
Constant	1.77*** (0.00)	1.44*** (0.00)	1.62*** (0.00)	52.26*** (0.00)	1.86*** (0.00)	51.45*** (0.00)
Wald X^2	1456.62 (0.00)	200.21 (0.00)	393.02 (0.00)	974.25 (0.00)	252.19 (0.00)	5927.21 (0.00)
Observations	308	308	308	308	308	308
R-squared	0.49	0.31	0.52	0.62	0.82	0.63

Source: Authors' computation.
Notes: Note that the value in parenthesis ( ) is the p-value. ***, **, and * are 1%, 5%, and 10% significance levels respectively. Also, economic growth – EGH, agricultural output – AGR, agricultural land – LAN, employment in agriculture – EMP, population growth – PPN, food inflation – FOO, food trade openness – TOF, physical capital stock – CAP.

The results further reveal a positive and statistically significant relationship between agricultural employment and the demand for food security, encompassing aspects such as affordability, safety and quality, as well as sustainability and adaptation. However, there is a statistically insignificant relationship between employment in agriculture and the supply and availability of food security. Specifically, a one percent rise in employment in agriculture results in 0.05, 0.05, 0.03, and 0.08 percent increases in the demand, affordability, safety and quality, sustainability and adaptation of food security respectively. These findings are similar to a previous study by Sassi (2015), which suggests that increasing income generated by productive employment opportunities can alleviate poverty and hunger. However, as food demand and other economic activities rise, there is competition between employment in agriculture and other sectors of the economy. The results suggest that the reduction in employment in agriculture is the primary factor contributing to the decrease in food availability in many areas.

Table 5. SGMM Estimation Results

Variables	**Model 7**	**Model 8**	**Model 9**	**Model 10**	**Model 11**	**Model 12**
ΔEGH	0.01 (0.11)	-0.03 (0.35)	0.04*** (0.00)	-0.03 (0.20)	0.08 (0.50)	-0.01 (0.26)
ΔAGR	0.01* (0.07)	0.02* (0.09)	-0.01 (0.15)	0.03** (0.03)	0.02 (0.20)	0.02*** (0.00)
ΔEMP	0.07*** (0.00)	0.02 (0.49)	0.02 (0.84)	-0.02 (0.18)	-0.03 (0.46)	0.02*** (0.00)
ΔPPN	0.02** (0.03)	-0.02 (0.14)	0.01 (0.34)	-0.01 (0.17)	-0.04** (0.04)	-0.01*** (0.00)
ΔFOO	0.01 (0.24)	-0.01*** (0.00)	0.01 (0.44)	-0.01* (0.07)	-0.01 (0.19)	0.01 (0.14)
ΔTOF	0.04 (0.32)	0.02 (0.79)	-0.01 (0.55)	0.03 (0.60)	0.01* (0.05)	-0.02 (0.36)
ΔLAN				0.06	0.03	-0.06**
				(0.18)	(0.98)	(0.04)
ΔCAP				0.02	0.04	-0.01
				(0.64)	(0.46)	(0.70)
FDE_{-1}	0.44***					
	(0.00)					
AFF_{-1}		0.27***				
		(0.00)				
SAQ_{-1}			0.47***			
			(0.00)			
FSE_{-1}				0.81***		
				(0.00)		
AVL_{-1}					0.63***	
					(0.00)	
SAS_{-1}						0.88***
						(0.00)
Constant	1.16***	1.49***	0.62***	0.32	0.31	0.53***
	(0.00)	(0.00)	(0.00)	(0.19)	(0.72)	(0.00)
Wald X^2	591.70 (0.00)	3770.00 (0.00)	1685.06 (0.00)	2089.54 (0.00)	311.05 (0.00)	7478.78 (0.00)
Autocorrelation	-1.62 (0.63)	-0.33 (0.74)	-0.41 (1.00)	-0.99 (0.32)	0.10 (0.92)	-0.35 (0.73)
Sargan test	23.73 (0.99)	22.25 (0.99)	20.88 (1.00)	12.91 (1.00)	21.09 (1.00)	21.34 (1.00)
Observations	280	280	280	280	280	280

Source: Authors' computations.

Notes: Note that the value in parenthesis ( ) is the p-value. ***, **, and * are 1%, 5%, and 10% significance levels respectively. Also, economic growth – EGH, agricultural output – AGR, agricultural land – LAN, employment in agriculture – EMP, population growth – PPN, food inflation – FOO, food trade openness – TOF, physical capital stock – CAP, demand side of food security – FDE, supply side of food security – FSE, food affordability – AFF, safety and quality of food – SAQ, food availability – AVL, food sustainability and adaptation – SAS.

As indicated by the outcomes, there is a positive and substantial relationship between population growth and the affordability aspect of food security. However, it exerts a negative and statistically significant influence on the demand, supply, safety and quality, and sustainability and adaptation of food security. The results imply that a 1% increase in population growth results in a 0.10% upturn in the affordability of food security. Conversely, a 1% decrease in population growth leads to increases of 0.03, 0.07, 3.44, 0.07, and 3.42 percent in the demand, safety and quality, supply, sustainability and adaptation of food security, respectively. The results are consistent with previous research by Scanlan (2003) that highlights the importance of population growth in improving food security. However, it is also found that rapid population growth can strain available resources, such as arable land.

Furthermore, food price inflation is found to be negative in all the indicators of food security but only significant in the demand and affordability of food. This suggests a one percent reduction in food price inflation results in a 0.01 and 0.01 percent increase in the demand and affordability of food respectively. These are consistent with the study conducted by Erokhin and Gao (2020), supporting the fact that rising food prices erode the purchasing power of consumers, especially those with lower incomes. Additionally, the study reveals that food trade openness exerts a positive and statistically significant influence on the demand and affordability of food. In contrast, it has a negative and significant impact on the safety and quality, supply, sustainability and adaptation of food security. This signifies that a one percent rise in food trade openness results in a 0.05 and 0.02 percent upturn in the demand and affordability of food, respectively. However, a one percent decrease in food trade openness leads to a 0.01, 1.67, and 2.08 percent increase in the safety and quality, supply, sustainability and adaptation of food, respectively. These findings are consistent with Abdullah et al. (2021) study and support the notion that food trade openness can aid in diversifying food sources and stabilizing food prices by accessing a variety of products from multiple regions. However, it is crucial to note that an over-reliance on food imports can make countries vulnerable to disruptions in the global supply chain.

The study identifies that agricultural land has a positive and statistically significant impact on the supply, availability, sustainability and adaptation dimensions of food security. This implies that a one square kilometer increase in agricultural land results in 0.04, 0.03, and 0.06 percent increases in the supply, availability, sustainability and adaptation of food security respectively. These findings align with the results reported in the study conducted by Bonye et al. (2021), suggesting that the expansion of agricultural land contributes to fostering self-sufficiency in food production and diminishes reliance on food imports. Moreover, it facilitates the adoption of sustainable land management practices, offering potential resilience against the impacts of climate change on food production. The physical capital stock is also positively correlated and statistically significant in the sustainability and adaptation of food security, although it does not show significance in the supply and availability of food security. This suggests that a one percent increase in physical capital stock results in a 0.01 percent increase in the sustainability and adaptation of food security. This supports the fact that increased capital stock allows for investments in modern and efficient agricultural technologies, machinery, and equipment, thereby, enhancing overall productivity in the agricultural sector.

Furthermore, the SGMM results presented in Table 5 indicate that economic growth exhibits a positive influence only on food safety and quality in the short run. According to the findings, food safety and quality increased by 0.04 percent with an increase in economic growth. Agricultural output also demonstrates a positive impact on the demand, affordability, supply, and sustainability and adaptation of food security in the short run, while showing a negative impact on food affordability. This implies that an increase in agricultural output leads to a 0.01, 0.02, 0.03, and 0.02 percent increase in the demand, affordability, supply, sustainability and adaptation of food security, respectively. Conversely, an increase in agricultural output results in a 0.01 percent decrease in food affordability in the short run.

Employment in agriculture also exhibits a positive impact on the demand, sustainability and adaptation of food security in the short run. This implies that an increase in employment in agriculture leads to a 0.07 and 0.02 percent increase in the demand and sustainability and adaptation of food security, respectively.

The results also indicate that population growth has a positive and statistically significant impact on the demand for food. However, it shows a negative and statistically significant effect on food availability, sustainability and adaptation. This suggests an increase in population growth causes the demand for food to increase by 0.02, while a decrease in population growth causes food availability and, sustainability and adaptation to increase by 0.04 and 0.01 percent respectively. Food price inflation demonstrates adverse effects on both food affordability and supply in the short run. This means that food affordability and supply increase by 0.01 and 0.01 percent as food inflation decreases. Food trade openness has a positive impact on food availability in the short run. That is, food availability increases by 0.01 percent as food trade openness increases. Agricultural land is detrimental to the sustainability and adaptation of food security in the short run. This implies that sustainability and adaptation of food security increase by 0.06 percent as agricultural land use decreases. Moreover, the outcomes indicate that the lag of each food security indicator exhibits a positive and statistically significant relationship. That is, the previous values of each of the indicators have an impact on their present values.

The importance of the factors that affect food security is evaluated through the Wald chi-square statistic. The p-values of all the regressors are significant at a 1% level in all the models, indicating that the models have a strong explanatory power and are a good fit for the data. This means that all the variables are reliable predictors of food security. Moreover, the results of the diagnostic tests for the SGMM, such as autocorrelation and the Sargan test of over-identifying instruments, support the notion that the food security models' instruments are valid and have no endogeneity issues.

4. Conclusion

The findings from the descriptive analysis reveal an average food security percentage of 48.14% and 44.08% for the demand and supply sides in sub-Saharan Africa. Additionally, the breakdown indicates average percentages of 46.38% and 49.87% for affordability, safety and quality, and 44.11% and 44.05% for availability, sustainability and adaptation, respectively. In the long run, the empirical results indicate that increased economic growth enhances various aspects of food security in SSA. Similarly, agricultural output shows a positive impact on all indicators of food security, excluding the demand side. Employment in agriculture also has a positive impact on demand, affordability, safety and quality, and sustainability and adaptation, but it does not affect food supply and availability. Population growth has a negative impact on all indicators of food security, except food affordability, where it has a positive impact. Food inflation has a negative relationship with all indicators of food security, but it only affects the demand and affordability of food security. Food trade openness positively influences the demand and affordability of food security, but it exerts a negative impact on the supply side, safety and quality, and sustainability and adaptation of food security.

Regarding the supply side, the outcomes related to agricultural land and physical capital stock reveal that agricultural land has a positive impact on all indicators, whereas physical capital stock only affects the sustainability and adaptation of food security. These results suggest that economic and population growth have the same impact on the demand and supply sides of food security, while agricultural output, employment in agriculture, food price inflation and trade openness have different effects. In addition, the short-run analysis results also suggest that economic growth, agricultural output, and food trade openness have the same impact on the demand and supply sides of food security, while employment in agriculture, population growth, and food price inflation have differential effects. The previous values of all food security indicators also influence their current values.

Thus, to expedite progress, it is recommended that a concerted effort be directed toward enhancing dimensions from the supply side of food security. Despite each dimension falling below the halfway mark, focusing on these aspects is crucial as they exhibit the lowest indices compared to the demand sides. Also, in the pursuit of the long-run goals of achieving food security, policymakers should strategically target key drivers on both the demand and supply sides. For promoting the demand side, emphasis should be placed on economic growth, employment in agriculture, population growth, food price inflation, and trade openness. Simultaneously, promoting the supply side also requires targeted interventions in economic growth, agricultural output, agricultural land usage, population growth, and food trade openness. Consequently, economic and population growth, along with food trade openness, emerge as pivotal instruments when policymakers seek to enhance both facets of food security concurrently. Finally, recognizing the differential effects of various factors on distinct dimensions of food security, a comprehensive and well-coordinated approach is imperative. Policymakers should adopt an integrated strategy that acknowledges the interconnectedness of economic, social, and environmental factors influencing food security.

Reference

Abdelhedi, I. T., & Zouari, S. Z. (2020). Agriculture and Food Security in North Africa: a Theoretical and Empirical Approach. *Journal of the Knowledge Economy*, *11*(1), 193–210. https://doi.org/10.1007/s13132-018-0528-y

Abdullah, M. J., Zhang, Z., & Matsubae, K. (2021). Potential for food self-sufficiency improvements through indoor and vertical farming in the gulf cooperation council: Challenges and opportunities from the case of Kuwait. *Sustainability (Switzerland)*, *13*(22). https://doi.org/10.3390/su132212553

Adeyeye, S. A. O. (2017). The role of food processing and appropriate storage technologies in ensuring food security and food availability in Africa. *Nutrition and Food Science*, *47*(1), 122–139. https://doi.org/10.1108/NFS-03-2016-0037

Akolgo, J. A., Osei-Asare, Y. B., Sarpong, D. B., Asem, E. F., & Wilhemina, Q. (2024). Examining the nexus between dry season vegetable production and household food security in the Upper East Region of Ghana. *International Journal of Food and Agricultural Economics*, *12*(1), 75–95.

Ashraf, J., & Javed, A. (2023). Food security and environmental degradation : Do institutional quality and human capital make a difference ? *Journal of Environmental Management*, *331*(January), 117330. https://doi.org/10.1016/j.jenvman.2023.117330

Bonye, S. Z., Yiridomoh, G. Y., Derbile, E. K., Ziem, S., Yiridomoh, G. Y., & Derbile, E. K. (2021). ‘ Urban expansion and agricultural land use change in Ghana : Implications for peri-urban farmer household food security in Wa Municipality .’ *International Journal of Urban Sustainable Development*, *00*(00), 1–17. https://doi.org/10.1080/19463138.2021.1915790

Conceição, P., Fuentes-Nieva, R., Horn-Phathanothai, L., & Ngororano, A. (2011). Food security and human development in Africa: Strategic considerations and directions for further research. *African Development Review*, *23*(2), 237–246. https://doi.org/10.1111/j.1467-8268.2011.00283.x

Erokhin, V., & Gao, T. (2020). Impacts of COVID-19 on Trade and Economic Aspects of Food Security : Evidence from 45 Developing Countries. *International Journal of Environmental Research and Public Health*, *17*(5775), 1–28.

European Commission. (2023). *Drivers of food security*. https://commission.europa.eu /document/ download/3e370f0d-fabb-4614-bc98-73caac5b5215 _en?filename=SWD

_2023_4_1_ EN_document_travail_service_part1_v2.pdf

FAO. (2023). The status of women in agrifood systems. In *The status of women in agrifood systems*. https://doi.org/10.4060/cc5343en

Fraval, S., Yameogo, V., Ayantunde, A., Hammond, J., De Boer, I. J. M., Oosting, S. J., & Van Wijk, M. T. (2020). Food security in rural Burkina Faso: The importance of consumption of own-farm sourced food versus purchased food. *Agriculture and Food Security*, *9*(1), 1–17. https://doi.org/10.1186/s40066-020-0255-z

Hobbs, J. E. (2020). Food supply chains during the COVID-19 pandemic. *Canadian Journal of Agricultural Economics*, *68*(2), 171–176. https://doi.org/10.1111/cjag.12237

Hovhannisyan, V., Mendis, S., & Bastian, C. (2019). An econometric analysis of demand for food quantity and quality in urban China. *Agricultural Economics (United Kingdom)*, *50*(1), 3–13. https://doi.org/10.1111/agec.12461

Jaison, C., Reid, M., & Simatele, M. D. (2023). Asset Portfolios in Climate Change Adaptation and Food Security: Lessons From Gokwe South District, Zimbabwe. *Journal of Asian and African Studies*, *00*(0), 1–21. https://doi.org/10.1177/00219096231158340

Malthus, T. R. (1789). *An Essay on the Principle of Population.*

Morlachetti, A. (2016). The rights to social protection and adequate food. In *Human rights-based frameworks for social protection in the context of realizing the right to food and the need for legal underpinnings* (Issue 97). https://www.fao.org/3/i5321e/i5321e.pdf

Muringai, R. T., Naidoo, D., Mafongoya, P., & Lottering, S. (2020). The Impacts of Climate Change on the Livelihood and Food Security of Small-Scale Fishers in Lake Kariba, Zimbabwe. *Journal of Asian and African Studies*, *55*(2), 298–313. https://doi.org/10.1177/0021909619875769

Nkhoma, P. R., Bosman, M. M., & Eduful, M. (2019). Constituting Agricultural and Food Security Policy in Malawi: Exploring the Factors that Have Driven Policy Processes in the Farm Inputs Subsidy Programme. *Journal of Asian and African Studies*, *54*(3), 360–375. https://doi.org/10.1177/0021909618820357

Nkurunziza, M., Mchiza, Z. J. R., & Zembe, Y. (2023). Meals on Wheels: Promoting Food and Nutrition Security among Older Persons in Cape Town, South Africa. *International Journal of Environmental Research and Public Health*, *20*(3). https://doi.org/10.3390/ijerph20032561

Regmi, A., & Meade, B. (2013). Demand side drivers of global food security. *Global Food Security*, *2*(3), 166–171. https://doi.org/10.1016/j.gfs.2013.08.001

Sassi, M. (2015). A Spatial , Non-parametric Analysis of the Determinants of Food Insecurity in Sub-Saharan Africa. *African Development Review*, *27*(2), 92–105. https://sci-hub.se/https://doi.org/10.1111/1467-8268.12126

Scanlan, S. J. (2003). Food Security and Comparative Sociology. *International Journal of Sociology*, *33*(3), 88–111. https://doi.org/10.1080/15579336.2003.11770272

Tossou, J. U. (2022). Effect of Landownership by Women on Household Food Security in Benin. *International Journal of Food and Agricultural Economics (IJFAEC)*, *10*(1128-2022–976), 247–263. http://ageconsearch.umn.edu/record/324831

WorldBank. (2023). *Food security update: World Bank Response to Rising Food Insecurity.* https://doi.org/https://www.worldbank.org/en/topic/agriculture/brief/food-security-update

Yobom, O., & Le Gallo, J. (2024). Food Security and Weather Events: A Multidimensional Analysis in the West African Sahel for 2001–2017. *Journal of Asian and African Studies*, *00*(0), 1–22. https://doi.org/10.1177/00219096231225949

Zhuang, D., Abbas, J., Al-Sulaiti, K., Fahlevi, M., Aljuaid, M., & Saniuk, S. (2022). Land-use and food security in energy transition: Role of food supply. *Frontiers in Sustainable Food Systems*, *6:1053031*. https://doi.org/10.3389/fsufs.2022.1053031