Innovations

Macroeconomic Determinants of Food Security in Sub-Saharan Africa (SSA)

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Abstract: *The study investigates macroeconomic determinants of food security in sub-Saharan Africa. The study made use of secondary data (2001 to 2020) of eighteen (18) sub-Saharan Africa (SSA) countries sourced from World Development Indicator and FAO. Food security, was measured in terms of availability and stability proxied by Food production Index (2006=100) and Per capita food supply variability (kcal/cap/day) respectively. The independent variables are money supply (MS), general government final consumption expenditure (percentage of GDP), and exchange rate, real GDP while the control variables are carbon dioxide emissions, population growth and agricultural productivity respectively. The data were analysed using Autoregressive distributed lag model and granger causality test. The results showed that there is evidence of causality among the variables of interest. The study based on its findings recommended that African leaders should enhance policies to increase money supply given its positive and significant impact on food stability; they should also reduce general government final consumption expenditures given his negative impact on food security. Policies to encourage population growth should be enacted and policy should be put in place to increase exchange rate (Devaluation of local currency) as it will in turn increase food security.*

Keywords: *1.Food security, 2.Real GDP, 3.Broad money supply, 4.ARDL, 5.sub-Saharan Africa*

1. Introduction

Food security problem has been an age long problem in most countries of the world, especially in developing and less developed countries, thus affecting human existence, health, and productivity as well as economic growth. Malnutrition affects almost all African nations, mostly in the form of undernutrition and micronutrient deficiencies (FAO, 2021), which is an indicator of food insecurity. More than 950 million people live in Sub-Saharan Africa (SSA), accounting for about 13% of the world's population.

One out of every four Africans does not have enough food to live a happy and healthy life (Bremner, 2012). Population growth made the amount of undernourished to rise from 182 to 287 million (FAO, 2015).

Although some measures of progress were achieved during the Millennium Development Goals (MDGs) era, the general picture for Africa is mixed, with sluggish progress overall (FAO, 2015). Despite the progress made over the past 25 years, it is apparent that food security poses a major issue in Africa, with more potential for advancement.

Domestic agriculture and food production, as well as food net trade, are influenced by macroeconomic policy. Figure 1 depicts the many pathways via which macroeconomic issues might affect the components of food security.
At household and individual level, income is critical in determining food security. The income distribution may be exacerbated by crises (Lustig 2000), which may also affect other basic needs and non-necessities of life, thus leading to poverty. Growth in the economy, employment and poverty level can combinedly contribute to government revenues, which further, through taxes can indirectly affect the household income, thus impacting food accessibility and by extension, food security. As a result, macroeconomic policies have an impact on food security (Smith & Haddad 2000).

As the scenario with attaining food security at the international magnitude countering hunger and achieving food security in SSA remains a complex set of obstacles, notably is the context of climate change and poor implementation of macroeconomic policies in the region. To this end, much of the development agenda, including macroeconomic policies, have been devoted to solving this perennial problem of food insecurity.

The questions then are:

- To what extent does selected macroeconomic variables (money supply, government expenditure, exchange rate and real GDP per capita) affect Food security in SSA?
- What is the direction of causality among selected macroeconomic variables (money supply, government expenditure, exchange rate and real GDP per capita) and Food security in SSA?

2.0 Empirical Review

Several studies have been conducted to examine macroeconomic variables link to Agriculture. Among these are: Enilolobo, et al. (2012), Udensi (2012), Eyo (2008), Khalid, Iqbal, Aderounmu, Onabote, Ashraf, & Yao-Ping (2021), Enilolobo, Mustapha,and Supo-Orija (2019), Oguntegbe, Okoruwa, Ogheneruemu & Olagunju (2019), Bjornlund and Van-Rooyen (2020), Ogunlesi and Bokana (2018), Akpan, Udoka and Inimfon (2015), Enul and Attah-Obeng (2013), Brownson, Vincent, Emmanuel and Etim (2012), Kareem (2013),Aroriode and Ogunbadejo (2014).
Total government expenditure on agriculture, interest rate, exchange rate, and total loan obtained by farmers from commercial banks are variables that have been identified to positively related to agricultural output. (Enilolobo, et al. 2012; and Udensi, 2012). The macroeconomic environment (such as credit availability, world prices, and technological advancements) also have been found to influence agricultural sector growth in Nigeria (Eyo, 2008) while Khalid, Iqbal, Aderounmu, Onabote, Ashraf, & Yao-Ping (2021) shows that innovation and social inclusion are drivers of food security in West African countries.
Oguntegbe, Okoruwa, Ogheneruemu & Olagunju (2019) through Instrumental Variable Approach, found that an increase in population growth rate reduces food output significantly in Nigeria while Ogunlesi and Bokana (2018) probed the Agricultural Productivity Dynamics in SSA, using the recent Panel ARDL to discover a co-integrating connection between agricultural output and real exchange rate (positive long-run effect), capital, openness, and per-capita income (negative long-run effect). These findings suggest that appropriate macroeconomic policies to maintain the exchange rate, encourage exports, maximize capital utilization, and improve infrastructure availability are recommended in order to stimulate agricultural productivity and spur economic growth in SSA. Also, in Iran, Dehdashti and Mohammadi (2012) discovered the existence of long-run association between income from agricultural sector and

selected macroeconomic variables. In the near term, agricultural prices and agricultural revenue have a positive association while there is a negative link between exchange rates and agricultural revenue. In the short term, the relationship between money volume and agricultural income is projected to be positive, but in the long run, it is expected to be negative.

Bjornlund and Van-Rooyen (2020) looked at why agricultural production in SSA continues low in comparison to the rest of the world from a historical standpoint. The study found that agricultural output in SSA has stayed lesser than the rest of the world in recent years. The study found that sophisticated agricultural systems prevailed in SSA prior to the emergence of European traders, which embraced food security, manufacturing, and trade.

In Ghana, Enul and Attah-Obeng (2013) established that labour force and real GDP per capita led to negative influence agricultural output, while inflation and the real exchange rate has positive influence on agricultural output. This actually contradict apriori expectation for these identified variables. In Nigeria, inflation rate, real total exports, external reserves and external debt have negative relationships with agricultural productivity while per capita real GDP had a positive impact on agricultural production (Brownson, Vincent, Emmanuel & Etim 2012). On the contrary, Kareem (2013) found that FDI, commercial bank loans, interest rates, and the value of food imports have positive relationships with agricultural output. This is similar to the findings of Aroriode and Ogunbadejo (2014) where GDP, commercial loan to agriculture, interest rate, and exchange rate all had positive effects.

Enilolobo, Mustapha and Supo-Orija (2019) discovered that inflation volatility, exchange rate and cost of fund has varying impacts on agricultural output, thus suggesting moderate expansionary monetary policy measures to curtail derogatory impact of the dynamics of inflation rate on agricultural output in Nigeria. Akpan, Udoka and Inimfon (2015) opined that agriculture diversification in Nigeria is driven by long-term inflation, a viable manufacturing sector, agricultural credit among other variables.

In the United States, Baek and Koo (2010) looked at the dynamic link between agricultural revenue and macroeconomic factors. The exchange rate and price of agricultural commodities in the United States were shown to have a bigger influence on net farm income than other factors. The Hungarian agricultural prices reacted to changes in the money supply quicker than industrial prices (Bakues & Ferto, 2015)

From the empirical review above, quit a number of researchers have carried out research similar to this despite the differences in research objectives, temporal and spatial coverage. The emphasis of the researches have been on agricultural output of productivity or growth but not on direct measure(s) of food security. Besides, none of the studies reviewed has been able to look at the impact of each of these macroeconomic determinants on food security in SSA in the short and long run. The present study is up to fill this gap.

3.0 Methodology

3.1 Theoretical framework

In this study, the Cobb–Douglas production function is employed to illustrate the impact of macroeconomic variables on food security in SSA. The Cobb–Douglas production function is stated mathematically as:

$$Y= A L^{\beta 1} K^{\beta 2}$$

Where: Y denoted total output

L represents Labour input

K represents capital input

A denotes total factor productivity

β_1 and β_2 are the output elasticities of labour and capital respectively

3.2 Model Specification

In order to analyze the second research objective of this study, the model of Hanif, Nisa, & Yaseen (2019) who investigated the relationship between food security, macroeconomic variables and environment: evidence from developing countries is adapted and expressed below.

$$FPI = f\,(LGDP, LPOP, LFDI, LFA, LCO2, CRW) \qquad (1)$$

The general form equation adopted from Hanif, Nisa, & Yaseen (2019) is given below:

$$FPI = \beta_O + \beta_{1t}(LGDP) + \beta_{2t}(LPOP_{2t}) + \beta_{3t}(LFDI_{3t}) + \beta_{4t}(LFA_{4t}) + \beta_{5t}(LCO2_{5t}) + \beta_{6t}(CRW_{6t}) + \varepsilon_{it} ---------- (\mathbf{2})$$

Where:

FPI denotes Food Production Index.

LGDP stands for the Log of Gross Domestic Production.

LPOP stands for the Log of Population.

LCO2 stands for the Log of Carbon dioxide.

LFDI stands for the Log of Foreign Direct Investment.

LFA stands for the Log of Food Aid Receipts

CRW stands for the Combustible renewable and waste energy.

β0 is the Intercept, =slope coefficient, εit =Error term, t=1,2,3,4,5……24 (time periods)

I = 1, 2 …...15 (for countries)

In other to achieve the second objective of this study equation two was modified as follow:

$FS_i = f$ (x)

$FS_i = f\,(MEV, AP, CO_2, PG)$………………………………………………........…..**(3)**

i = 1 & 2

Where:

FS_i= food security dimensions

1 = (Availability (FAV)) proxied by "Food production Index (2006=100)"

2 = (Stability (FST)) proxied by "Per capita food supply variability (kcal/cap/day)"

$MEV = f\,(MS, GOVEX, EXR, RGDPPC)$……………………………………........…..**(4)**

Where:

MEV = macroeconomic variable

MS = money supply (Broad money (% of GDP))

GOVEX = General Government final consumption expenditure (% of GDP)

EXR = Exchange rate (Official exchange rate (LCU per US$, period average))

RGDPPC = real GDP per capita (GDP per capita (current US$))

AP = Agricultural productivity proxied by "agriculture, forestry and fishing, value added (% of GDP)

PG = Population growth (annual %)

CO_2= CO_2 emissions in Metric tons

Combining equations 3 and 2, we have

$FS_i = f\,(MS, \text{GOVEX}, EXR, RGDPPC, AP, CO_2, PG)$…………………………..……..**(5)**

Explicitly, equation 5 becomes:

$$FS_i = \beta_{0it} + \beta_1 MS_{it} + \beta_2 \text{GOVEX}_{it} + \beta_3 EXR_{it} + \beta_4 RGDPPC_{it} + \beta_5 AP_{it} + \beta_6 CO_{2it} + \beta_7 PG_{it} + U_{it} \ldots \quad \mathbf{(6)}$$

For food security measured in terms of availability

$$FAV_{it} = \beta_{0it} + \beta_1 MS_{it} + \beta_2 \text{GOVEX}_{it} + \beta_3 EXR_{it} + \beta_4 RGDPPC_{it} + \beta_5 AP_{it} + \beta_6 CO_{2it} + \beta_7 PG_{it} + U_{it} \ldots \quad \mathbf{(7)}$$

For food security measured in terms of stability

$$FST_{it} = \beta_{0it} + \beta_1 MS_{it} + \beta_2 \text{GOVEX}_{it} + \beta_3 EXR_{it} + \beta_4 RGDPPC_{it} + \beta_5 AP_{it} + \beta_6 CO_{2it} + \beta_7 PG_{it} + U_{it} \ldots \quad \mathbf{(8)}$$

Where:

$\beta_{0,}$ is the intercept of the model
$\beta_{1,}$ to β_7= Parameter Estimates
U = Stochastic Disturbance Error Term
i = country
t = time

3.3 Data Analysis Techniques

The data analysis technique comprises two sub-sections namely, pre-test analysis, and estimation technique.

3.3.1 Pre-Test Analysis

Descriptive statistics and unit root test and panel co-integration tests would be conducted before the estimation. In terms of the mean, median, standard deviation, covariance, and number of observations, descriptive statistics would reflect the statistical distribution of the variables utilised in the model. To prevent the issue of spurious regression analysis, the unit root test would disclose the stationary state of the variables employed in the model. The Levin, Lin, and Chu (LLC) test, as well as the Johansen Fisher test, will be used to determine the unit root. The amount of long-run association between the variables will be determined via cointegration.

3.3.2 Estimation Techniques

Autoregressive Distributed Lag (ARDL) model and Granger causality test will be employed as the data analysis techniques.

ARDL Model Specification

Equations (7) and (8) are formulated into the ARDL model as follows.
When FPI is Dependent variable:
For food security measured in terms of Availability:

$$FAV_{it} = \propto_0 + \sum_{i=1}^{p} \propto_{1,i} \Delta(FAV_{t-i}) + \sum_{i=}^{p} \propto_{2,i} \Delta(MS_{t-i}) + \sum_{i=1}^{p} \propto_{3,i} \Delta(GOVEX_{t-i}) + \sum_{i=1}^{p} \propto_{4,i} \Delta(EXR_{t-i}) + \sum_{i=1}^{p} \propto_{5,i} \Delta(RGDPPC_{t-i}) \sum_{i=1}^{p} \propto_{6,i} \Delta(AP_{t-i}) + \sum_{i=1}^{p} \propto_{7,i} \Delta(CO_{2t-i}) + \sum_{i=1}^{p} \propto_{8,i} \Delta(PG_{t-i}) + \beta_1 MS_{it} + \beta_2 GOVEX_{it} + \beta_3 EXR_{it} + \beta_4 RGDPPC_{it} + \beta 5AP_{it} + \beta 6CO_{2it} + \beta 7PG_{it} + Uit1 \quad \textbf{(9)}$$

For food security measured in terms of Stability:

$$FST_{it} = \propto_0 + \sum_{i=1}^{p} \propto_{1,i} \Delta(FAV_{t-i}) + \sum_{i=}^{p} \propto_{2,i} \Delta(MS_{t-i}) + \sum_{i=1}^{p} \propto_{3,i} \Delta(GOVEX_{t-i}) + \sum_{i=1}^{p} \propto_{4,i} \Delta(EXR_{t-i}) + \sum_{i=1}^{p} \propto_{5,i} \Delta(RGDPPC_{t-i}) + \sum_{i=1}^{p} \propto_{6,i} \Delta(AP_{t-i}) + \sum_{i=1}^{p} \propto_{7,i} \Delta(CO_{2t-i}) + \sum_{i=1}^{p} \propto_{8,i} \Delta(PG_{t-i}) + \beta_1 MS_{it} + \beta_2 GOVEX_{it} + \beta_3 EXR_{it} + \beta_4 RGDPPC_{it} + \beta 5AP_{it} + \beta 6CO_{2it} + \beta 7PG_{it} + Uit1 \quad \textbf{(10)}$$

Granger Causality Model Specification

In order to achieve the third objective of this study, the granger causality model for this study is stated as:
For food security measured in terms of availability

$$FAV_{it} = \delta_0 + \sum_{p=1}^{k} \delta_1 FAV_{it-j} + \sum_{p=1}^{k} \delta_2 MS_{it-j} + \sum_{p=1}^{k} \delta_3 GOVEX_{it-j} + \sum_{p=1}^{k} \delta_4 EXR_{it-j} + \sum_{p=1}^{k} \delta_5 RGDP -_{PC}It-j + p=1k\delta 6_{AP}it-j + p=1k\delta 7_{CO}2it-j + p=1k\delta 8_{PG}it-j + \mu \ldots \textbf{(11)}$$

For food security measured in terms of stability

$$FST_{it} = \delta_0 + \sum_{p=1}^{k} \delta_1 FAV_{it-j} + \sum_{p=1}^{k} \delta_2 MS_{it-j} + \sum_{p=1}^{k} \delta_3 GOVEX_{it-j} + \sum_{p=1}^{k} \delta_4 EXR_{it-j} + \sum_{p=1}^{k} \delta_5 RGDP -_{PC}It-j + p=1k\delta 6_{AP}it-j + p=1k\delta 7_{CO}2it-j + p=1k\delta 8_{PG}it-j + \mu \ldots \textbf{(12)}$$

Where:
δ_0 is the intercept; δ_1 to δ_8; are parameter estimates of the granger causality model; µit the error term, whereas it-j represent the country lag lengths; and k, p are periods.

3.4 Sampling Technique

The population of this study is the 48 countries in Sub-Sahara Africa. However, the convenient sampling technique was adopted based on data availability. Using the convenient sampling technique, a total of 18 countries in SSA were selected based on data availability. The selected countries include Angola; Benin; Burkina Faso; Cameroun; Congo; Gabon; Gambia; Ghana; Guinea; Guinea-Bissau; Kenya; Mali; Mozambique; Nigeria; Rwanda; Senegal; South Africa; and Uganda.

4.0 Findings

The stationarity test is examined using the Levin, Lin and Chu (LLC) test. The use of this stationarity statistic is to ensure that none of the variables is integrated at the second differencing level. The results of LLC unit root tests of the variables at levels and first difference are presented in Tables 1.

Table 1: Stationarity Test using LLC Test

VARIABLES	LLC		LLC		STATUS
	LEVELS (0)		1ST DIFF (1)		
	LLC Test Stat	Probability	LLC Test Stat	Probability	
FAV	-4.08582	0.0000	-16.4585	0.0000	I(0)
FST	-2.16171	0.0153	-14.0340	0.0000	I(0)
MS	0.39780	0.6546	-12.8521	0.0000	I(1)
GOVEX	-2.22940	0.0129	-14.7844	0.0000	I(0)
EXR	2.07541	0.9810	-7.29100	0.0000	I(1)
RGDP	-3.35042	0.0004	-12.0467	0.0000	I(0)
AP	-2.29512	0.0109	-15.6867	0.0000	I(0)
CO2	-3.78944	0.0001	-11.6678	0.0000	I(0)
PG	-6.56666	0.0000	-2.88055	0.0020	I(0)

Source: Author's Computation and Compilation (2022)

From the results in Table 1, the Levin, Lin and Chu (LLC) unit root test shows that only money supply (MS) and exchange rate (EXR) variables are not stationary at levels but are stationary at first difference. Since some variables are only stationary at first difference, it implies that there might be a loss in the long-run characteristics of the data series. Nonetheless using the method of cointegration the long-run characteristics can be recovered. The data series were cointegrated and tested for a long-run relationship using the Johansen Fisher Panel Cointegration test.

Since the Unit root tests results showed that not all variables were all stationary at level, the Johansen Fisher Panel Cointegration Analysis was employed to determine the possibility of the existence of long-run relationships among the variables. The results are shown in Table 2 below:

Table 2: Fisher Co-Integrating Test Results

Hypothesized No. of CE(s)	Fisher Stat.* (from trace test)	Prob.	Fisher Stat.* (from max-eigen test)	Prob.
None	22.18	0.9025	22.18	0.9025
At most 1	19.41	0.9608	56.25	0.0051*
At most 2	4.159	1.0000	243.6	0.0000*
At most 3	239.5	0.0000*	294.7	0.0000*
At most 4	341.6	0.0000*	271.7	0.0000*
At most 5	173.8	0.0000*	122.4	0.0000*
At most 6	124.5	0.0000*	124.5	0.0000*
At most 7	236.7	0.0000*	142.8	0.0000*
At most 8	136.8	0.0000*	110.5	0.0000*
At most 9	93.97	0.0000*	93.97	0.0000*

Source: Author's Computation (2022)

Hint: (*) (**) indicate significance at 5% and 10% levels, respectively

The Fisher statistic was used to test for co-integration in the model.The results presented in Table 2 shows that there are at least 7 co-integrating equations from the trace and max-eigen statistics. The performance of the co-integration test is necessary to establish a long-run relationship, hence, there is a long-run relationship among the variables given the above result.

Determination of impact of selected macroeconomic variables on food security in sub-Saharan Africa.

Having done the stationarity test and co-integration test, all necessary conditions have been met to carry out a regression analysis using the Autoregressive Distribute Lag (ARDL) method. Both the short-run and long-run regression results of the autoregressive distributed lag analysis are presented in Table 3 to measure food security in terms of Availability and Table 3 to measure food security in terms of stability.

Table 3 shows the ARDL short-run and long-run estimated impact of the independent variables on food availability in SSA. From the short-run result, the p-values of the independent variables are not statistically significant at the 5% or 10% level of significance, which shows that none of the exogenous variables significantly influence food availability in countries in SSA countries.

Table 3: ARDL Model Estimates Food Security in Terms of Availability

Dependent Variable: D(FAV)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Long Run Equation				
MS	-0.857607	0.124164	-6.907065	0.0000*
GOVEX	0.282844	0.264196	1.070583	0.2859
EXR	0.015940	0.004886	3.262188	0.0013*
RGDPPC	-0.000737	0.000352	-2.094931	0.0377*
AP	-0.584079	0.174926	-3.339009	0.0010*
CO2	0.212475	0.041807	5.082229	0.0000*
PG	5.719401	1.190659	4.803561	0.0000*
Short Run Equation				

ECM	-0.609970	0.097944	-6.227758	0.0000*
D(MS)	0.085928	0.190674	0.450654	0.6528
D(GOVEX)	0.108984	0.395678	0.275437	0.7833
D(EXR)	-0.815581	0.709170	-1.150050	0.2518
D(RGDPPC)	0.006304	0.011879	0.530678	0.5964
D(AP)	1.354410	0.860686	1.573640	0.1175
D(CO2)	3.631573	12.48353	0.290909	0.7715
D(PG)	-26.85559	22.01051	-1.220126	0.2241
C	44.23737	7.505811	5.893749	0.0000*
@TREND	1.254673	0.443914	2.826391	0.0053*
Mean dependent var	2.011071		S.D. dependent var	7.899785
S.E. of regression	6.022535		Akaike info criterion	5.725291
Sum squared resid	6020.974		Schwarz criterion	7.773533
Log-likelihood	-823.5138		Hannan-Quinn criter.	6.540306

Source: Author's Computation (2022)

Hint: (*) (**) indicate significance at 5% and 10% levels, respectively.

The long-run estimates in Table 3 show the long-run impact of the independent variables on the dependent variable. From the table result, the coefficients of Money supply (MS) is negative (-0.85) implying that a unit increase in Money supply results in 0.85 decreases in food security in terms of availability. This effect is statistically significant at 5% level of significance.

The coefficients of Government final consumption expenditure (GOVEX) and exchange rate (EXR) are positive (0.28 & 0.01) implying that a unit increase in any of these variables results in a 0.28 or 0.01 increase in food security in terms of availability respectively. However, only the effect of EXR is statistically significant at 5% level of significance.

Additionally, the coefficients of real GDP (RGDPPC) and Agricultural productivity (AP) are negative and statistically significant at 5% level of significance while that of CO2 emissions and Population growth are positive and statistically significant at 5% level of significance.

Finally, the Error correction term (ECM) in Table 3 which shows the speed of adjustment from short-run and long-run equilibrium, is negative, less than one and statistically significant at 5% level of significance (P=0.000) implying that there is a long-run equilibrium relationship between the dependent and independent variables. The ECM coefficient of -0.60997 indicates that if there is disequilibrium in the system, it takes an average speed of 61% to return from the short-run to the long run. This means that there is a high speed of adjustment from the short-run to the long-run in this model.

Table 4: ARDL Model Estimates Food Security in Terms of Stability

Dependent Variable: D(FST)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Long Run Equation				
MS	0.685477	0.217646	3.149500	0.0019*
GOVEX	-2.957334	0.393675	-7.512125	0.0000*
EXR	0.002482	0.001283	1.934894	0.0545**
RGDPPC	-0.016187	0.003675	-4.404201	0.0000*
AP	-1.027382	0.248731	-4.130498	0.0001*
CO2	-0.029074	0.244124	-0.119093	0.9053
PG	5.215609	7.706935	0.676742	0.4994
Short Run Equation				

COINTEQ01	-0.369330	0.089002	-4.149702	0.0001
D(MS)	1.689835	1.430421	1.181355	0.2390
D(GOVEX)	0.463332	0.875521	0.529207	0.5973
D(EXR)	-0.806524	0.912057	-0.884290	0.3777
D(RGDPPC)	0.020487	0.024273	0.844040	0.3997
D(AP)	2.831085	1.426239	1.985001	0.0486
D(CO2)	59.62673	39.07211	1.526069	0.1287
D(PG)	28.63866	67.24771	0.425868	0.6707
C	27.83048	6.321784	4.402315	0.0000
Mean dependent var	0.198159		S.D. dependent var	13.18721
S.E. of regression	11.29580		Akaike info criterion	6.991039
Sum squared resid	23477.48		Schwarz criterion	8.842124
Log-likelihood	-1064.918		Hannan-Quinn criter.	7.727604

Source: Author's Computation (2022)

Hint: (*) (**) indicate significance at 5% and 10% levels, respectively

Table 4 shows the ARDL short-run and long-run estimated impact of the independent variables on food sustainability in SSA. From the short-run result, the only statistically significant independent variable ($p=0.0489 < 0.05$) is Agricultural Productivity (AP) with a coefficient of 2.83. This implies that in the short-run agricultural productivity positively impacts food stability. All other independent variables are not statistically significant at the 5% level of significance in the short-run.

The long-run estimates in Table 4 show the long-run impact of the independent variables on the dependent variable. From the table result, the coefficients of MS is positive (0.68) implying that a unit increase in Money supply results in a 0.68 increase in food security in terms of availability. This effect is statistically significant at 5% level of significance.

The coefficient of GOVEX is negative (-2.96) and statistically significant at 5% level of significance while EXR is positive (0.002) and statistically significant at 10% level of significance. These results imply that government expenditure does not increase food sustainability but exchange rate increase does.

The coefficients of RGDPPC (-0.016) and AP (-1.02) are negative and statistically significant at a 5% level of significance implying that increases in Real GDP and Agricultural Productivity does not lead to a boost in food sustainability in SSA countries. Furthermore, CO_2emissions (CO2) is also negative but statistically insignificant while Population growth (PG) is positive but also statistically insignificant at 5% level of significance

Finally, the Error correction term (ECM) in Table 4 is negative, less than one and statistically significant at a 5% level of significance (P=0.000) implying that there is a long-run equilibrium relationship between the dependent and independent variables. The ECM coefficient of -0.3693 indicates that if there is disequilibrium in the system, it takes an average speed of 36.93% to return from the short-run to the long run.

According to the ARDL analysis, the selected macroeconomic variables had mixed effect on the food security measures adopted. The short-run ARDL results showed that none of the exogenous variables had a significant impact on food availability (FAV), while only agricultural productivity had a favourable impact on food Stability (FST) in the selected SSA nations. Long-run estimates, however, revealed that money supply (MS), real GDP (RGDPPC), and agricultural productivity (AP) had a statistically significant negative effect on food availability in selected SSA countries. The negative impact of agricultural productivity on food security is in conflict with the findings of Ogundari and Awokuse (2016) and Ogunlesi and Bokana (2018) who asserted that Agricultural productivity contributes positively and significantly to food security. while exchange rate (EXR), CO2 emissions, and population growth (PG) had a statistically significant positive effect. The finding of a positive relationship between population growth and food security is in contrast with the findings of Oguntegbe, Okoruwa, Obi-Egbedi, & Olagunju (2018) who found out that an increase in PG significantly reduces food output when instrumental variable approach was employed. For food security stability (FST), Money supply (MS) and Exchange rate (EXR) had a statistically significant positive impact; while Government Expenditure (GOVEX), real GDP (RGDPPC) and Agricultural productivity (AP) had a statistically significant positive on food sustainability in selected SSA countries. These findings show that macroeconomic variables have a major impact on food security in SSA. These findings support the work of Yaseen's (2019) who recommended that, in order to achieve the aim of food security, there is an urgent need for national and international measures to improve the quality of infrastructure in developing nations.

Evaluation of the nature and direction of causality among selected macroeconomic variables and Food security in sub-Saharan Africa.

Granger causality test is employed in examining the direction of causality between pairs of variables. Causality where present may be uni-directional in either direction or bi-directional. The results of the Panel Granger Causality test are reported in Table 5.

Table 5. Pairwise Granger Causality Results

Pairwise Dumitrescu Hurlin Panel Causality Tests Sample: 2001 2020 Lags: 2			
Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
FST does not homogeneously cause FAV	3.11709	1.12529	0.2605
FAV does not homogeneously cause FST	7.54014	7.73110	1.E-14*
MS does not homogeneously cause FAV	2.74582	0.54834	0.5835
FAV does not homogeneously cause MS	5.47825	4.58486	5.E-06*
EXR does not homogeneously cause FAV	3.67605	1.96009	0.0500*
FAV does not homogeneously cause EXR	6.22804	5.77149	8.E-09*
GOVEX does not homogeneously cause FAV	2.89385	0.78278	0.4338
FAV does not homogeneously cause GOVEX	3.42075	1.56662	0.1172
RGDPPC does not homogeneously cause FAV	5.35142	4.46226	8.E-06*
FAV does not homogeneously cause RGDPPC	4.70005	3.48943	0.0005*
MS does not homogeneously cause FST	4.07414	2.51062	0.0121*
FST does not homogeneously cause MS	4.25348	2.77556	0.0055*
EXR does not homogeneously cause FST	3.87983	2.26443	0.0235*
FST does not homogeneously cause EXR	4.02859	2.48660	0.0129*
GOVEX does not homogeneously cause FST	7.43975	7.54557	5.E-14*
FST does not homogeneously cause GOVEX	3.47232	1.64335	0.1003
RGDPPC does not homogeneously cause FST	7.03197	6.97215	3.E-12*
FST does not homogeneously cause RGDPPC	1.72203	-0.95824	0.3379
EXR does not homogeneously cause MS	4.53786	3.19566	0.0014*
MS does not homogeneously cause EXR	6.39855	5.94438	3.E-09*
GOVEX does not homogeneously cause MS	3.42077	1.53357	0.1251
MS does not homogeneously cause GOVEX	3.06275	1.00670	0.3141

Source: *Author's Computation, (2022)*

Note: *(*) (**) indicates significance at 5% level and 10% level respectively.*

From Table 5 the pair-wise Granger causality tests revealed that food sustainability does not Granger cause food availability (FAV) but food availability Granger cause food sustainability. This, therefore, implies that there exists a unidirectional causal relationship running from food availability to food sustainability.
The table revealed that money supply (MS) does not Granger cause food availability (FAV) but food availability Granger causes money supply. This implies that there exists a unidirectional causal relationship running from food availability to money supply. Also, the result shows that a bidirectional causal relationship exists between food sustainability (FST) and money supply (MS).
Furthermore, a bidirectional causal relationship exists between exchange rate (EXR) and food availability (FAV) as well as between exchange rate (EXR) and food sustainability (FST).
No causal relationship exists between government expenditure (GOVTEX) and food availability (FAV) but there exists a unidirectional causal relationship running from government expenditure to food sustainability (FST).
Finally, a bidirectional causal relationship exists between Real GDP (RGDPPC) and food availability (FAV) but there exists a unidirectional causal relationship running from Real GDP to food sustainability (FST).
The pair-wise Granger causality test demonstrated a unidirectional causal relationship going from food availability (FAV) to money supply (MS), as well as a bidirectional causal relationship between food sustainability (FST) and money supply (MS). The Granger causality tests also demonstrated that there is a bidirectional causal relationship between the exchange rate (EXR) and food availability (FAV), as well as the exchange rate (EXR) and food sustainability (FST). Finally, there is a bidirectional causal relationship between Real GDP (RGDPPC) and food availability (FAV), whereas a unidirectional causal relationship exists between Real GDP and food sustainability (FST).

Conclusion and Recommendations

From the ARDL short-run results, all selected macroeconomic variables are not statistically significant for both measures of Food Security (FAV and FST) except for Agricultural Productivity which significantly impacted food stability positively. However, the long-run ARDL result shows that coefficients of MS, EXR, RGDPPC, AP, CO2 and PG significantly impacted Food Availability (FAV) at the 5% level of significance while MS, GOVEX, EXR, RGDPPC and AP significantly impacted Food Sustainability (FST) at the 5% level of significance. Thus, it can be concluded that macroeconomic variables significantly impact food security in sub-Saharan Africa
The result of the Granger causality test found that both unidirectional and bidirectional causality exist among the selected macroeconomic variable (MS, GOVEX, EXR, RGDPPC, AP, CO2, PG) and the variable used to measure food security (FAV & FST).
From the findings of the study, the following recommendations were suggested:

- Governments should enhance policies to increase money supply given its positive and significant impact on food stability.
- Government in SSA should reduce its expenditures given its negative impact on food security.
- Policies encouraging population growth should be enacted as this will help significantly improve food security both in terms of availability and stability.
- Given that exchange rate has a positive and significant impact on food security (both Availability and stability), policies should be put in place to increase exchange rate (Devaluation of local currency) as this will in turn increase food security. This is because devaluation makes export more attractive in the international market resulting in increased demand and hence increased productivity which will help promote food security.

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