International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2025, 15(3), 587-594.

The Nexus between Exchange Rates and Energy Consumption in Somalia

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Received: 17 October 2024 **Accepted:** 06 April 2025 **DOI:** https://doi.org/10.32479/ijeep.18147

ABSTRACT

This study investigates the nexus between exchange rates and energy consumption in Somalia, a country characterized by its heavy reliance on imported energy and significant economic challenges. Employing time-series data from 1990 to 2021, this research examines how fluctuations in exchange rates influence energy consumption patterns through direct and indirect mechanisms. Variables such as energy consumption per capita, employment in agriculture, land under cereal production, domestic investment, and rainfall are analyzed using an ARDL approach to explore both short- and long-term relationships. The findings highlight that exchange rate depreciation increases the cost of energy imports, thereby reducing affordability and consumption. Additionally, exchange rate volatility indirectly affects energy use by influencing agricultural productivity, investment levels, and rural incomes. While domestic investment and employment in agriculture positively contribute to economic growth and energy demand, the underdevelopment of energy infrastructure and reliance on biomass limit Somalia's capacity to meet rising energy needs. The study emphasizes the need for exchange rate stabilization policies and increased investment in renewable energy to ensure energy security and support sustainable development. These insights provide a foundation for policymakers to mitigate the adverse effects of exchange rate volatility and enhance energy efficiency in Somalia.

Keywords: Agricultural Productivity, Domestic Investment, Economic Development, Renewable Energy, Somalia
JEL Classifications: Q42, Q43, O13

1. INTRODUCTION

Energy consumption is a critical factor in the development and sustainability of any nation, serving as a backbone for economic activities and social well-being. In Somalia, understanding the determinants of energy consumption is particularly crucial given the country's unique economic challenges and opportunities. Among the various factors influencing energy consumption, exchange rates play a pivotal role. The exchange rate, which measures the value of the Somali shilling against foreign currencies, can significantly impact the cost of importing energy resources and technology, thus affecting overall energy consumption patterns (Chen et al., 2019).

The relationship between exchange rates and energy consumption is multifaceted. Fluctuations in exchange rates can alter the cost of energy imports, which Somalia heavily relies on due to its limited domestic energy production. When the Somali shilling depreciates, the cost of importing energy increases, potentially leading to reduced energy consumption as consumers and businesses adjust to higher prices (Ramzan et al., 2022). Conversely, an appreciation of the shilling can lower import costs, making energy more affordable and possibly increasing consumption. This dynamic interplay makes the exchange rate a crucial variable in understanding energy consumption trends in Somalia (Abdi et al., 2024; Balcilar et al., 2020).

Furthermore, exchange rates can influence energy consumption indirectly through their impact on other economic variables. For instance, changes in exchange rates can affect inflation rates, GDP growth, and foreign direct investment (FDI), all of which have implications for energy demand (Dong et al., 2020). A depreciating currency can lead to higher inflation, reducing disposable income and lowering energy consumption. On the other hand, favorable exchange rates can attract more FDI, fostering economic growth and increasing energy needs. Therefore, analyzing the influence of exchange rates on energy consumption necessitates a comprehensive approach that considers these interrelated economic factors (Shah et al., 2022; Ullah et al., 2021).

Somalia's economic landscape, characterized by ongoing recovery and growth efforts, provides a unique context for studying this relationship. The country has been striving to rebuild its economy following decades of conflict and instability, with significant efforts directed towards improving infrastructure, governance, and economic policies (Hamilton et al., 2021). As the country continues to stabilize and integrate into the global economy, understanding how exchange rate fluctuations affect energy consumption can inform policy decisions aimed at ensuring energy security and supporting sustainable economic development. By exploring this relationship, policymakers can devise strategies to mitigate the adverse effects of exchange rate volatility on energy consumption and leverage positive trends to enhance energy access and efficiency (Audi et al., 2024).

Moreover, energy consumption in Somalia is closely linked to its development goals. The country aims to expand its energy infrastructure, increase the share of renewable energy, and improve energy efficiency. Exchange rates can influence these goals by affecting the affordability and feasibility of energy projects (Kruger et al., 2018). For instance, a stronger shilling could lower the cost of importing solar panels, wind turbines, and other renewable energy technologies, facilitating the transition to a greener energy mix. Conversely, a weaker shilling could increase the cost of such imports, posing challenges to achieving these objectives (Newig et al., 2020).

In conclusion, the nexus between exchange rates and energy consumption is a critical area of study for Somalia. As the country navigates its economic path, comprehending this relationship can provide valuable insights into how to manage energy resources effectively in the face of global economic fluctuations. This article aims to delve into the complexities of this relationship, offering a detailed analysis of how exchange rate movements influence energy consumption in Somalia and proposing policy recommendations to address the associated challenges and opportunities. By doing so, it seeks to contribute to the broader discourse on sustainable development and economic resilience in Somalia.

2. LITERATURE REVIEW

Energy consumption, measured in kilowatt-hours (kWh) per capita, is a vital indicator of economic growth and development. In Somalia, traditional biomass sources such as firewood and charcoal constitute over 90% of energy consumption (Warsame and Sarkodie, 2022). Limited access to modern energy infrastructure constrains development, while reliance on imported petroleum products exposes the country to global price fluctuations (Hassan and Warsame, 2024). Exchange rate depreciation further exacerbates energy insecurity by increasing the cost of imported energy, reducing its affordability for households and businesses (Mahmud and Mohammed, 2024).

Studies emphasize the role of energy consumption in fostering economic growth. Using a time-series analysis, (Narayan, 2016) highlighted a significant long-term relationship between energy consumption and GDP in developing countries. Similarly, (Hassan and Mohamed, 2024) demonstrated that positive shocks in energy consumption have a larger impact on Somalia's economic growth than negative shocks. This underscores the need for a stable energy supply, which is intricately linked to exchange rate stability in import-dependent economies like Somalia.

Exchange rate volatility has a pronounced impact on Somalia's energy consumption, given the country's reliance on imported energy products. Exchange rate depreciation increases energy costs, which can hinder industrial and household energy consumption (Abdi and Hashi, 2024). Using the EGARCH model, (Farah, 2024) found that global oil price shocks significantly influence exchange rate volatility in Somalia, creating ripple effects across the economy.

Existing literature also highlights the broader implications of exchange rate volatility. (Bhattacharya and Jeong, 2018) emphasizes that in developing economies, fluctuating exchange rates can undermine energy affordability and deter investment in energy infrastructure. In Somalia, (Mohamud et al., 2024) note that unregulated exchange rate systems amplify these challenges, reducing economic stability and exacerbating energy insecurity.

Land use for cereal crops, measured in hectares, is critical for Somalia's agricultural economy. However, climate variability and exchange rate volatility have negatively affected the sector (Mohamud and Hassan, 2024). Depreciation of the Somali shilling raises the cost of imported agricultural inputs like fertilizers, limiting farmers' ability to adopt energy-intensive technologies (Samatar, 2008).

Studies in similar economies underscore the link between agriculture and energy consumption. For instance, (Qin et al., 2024) highlights that mechanization and irrigation, both energy-intensive, are essential for increasing productivity. (Middlebrook et al., 2019) Found that in Somalia, the lack of affordable energy infrastructure and exchange rate instability hinders agricultural modernization, reducing the sector's potential for growth.

Agriculture remains the largest employer in Somalia, but it relies heavily on traditional practices that limit energy consumption (Samatar et al., 2023). Higher employment in agriculture correlates with lower energy consumption due to the minimal use of mechanized tools (Farah, 2024). Exchange rate volatility further impacts rural incomes, reducing the ability of households to access modern energy services (Newig et al., 2020).

Elliott et al. (2017) found that rural energy access is critical for boosting productivity and living standards. However, in Somalia, the interplay between exchange rate instability and energy poverty perpetuates a cycle of underdevelopment. Addressing these challenges requires targeted interventions to stabilize exchange rates and expand energy access in rural areas.

Domestic investment, represented by gross fixed capital formation, is vital for addressing Somalia's energy and exchange rate challenges (Hassan and Warsame, 2024). Investments in renewable energy infrastructure can reduce dependence on imports, mitigating the impact of exchange rate fluctuations (Aslanturk and Kıprızlı, 2020).

Peltola et al. (2022) highlight that countries with strong domestic investment in energy infrastructure are better equipped to withstand global shocks. In Somalia, (Hassan et al., 2024) emphasize the need for financial reforms to attract investments in renewable energy, which would reduce reliance on imported energy and enhance resilience against exchange rate volatility.

3. METHODOLOGY

The research employed time-series data of Somalia over the period 1990-2021. The data of the study were extracted from the Organization of Islamic Cooperation Statistical, Economic, and Social Research and Training Centre for Islamic Countries (SESRIC) and the World Bank. The variables incorporated in the model are Agricultural output, rainfall, employment in agriculture, land under cereal production, and domestic investment. All variables were converted into natural logarithms. Table 1 summarizes the data description and sources.

3.1. Model Specification

This study used the ARDL model developed by (Pesaran et al., 2001) to analyze short and long-run associations between agricultural output and economic growth. In a variety of ways, ARDL outperforms other cointegration approaches. Firstly, unlike other approaches the ARDL methodology is suitable for small sample sizes (Pesaran et al., 2001; Warsame et al., 2022; Warsame et al., 2023). Secondly, it can estimate the long- and short-term cointegration of the variables, I(0), I(1), or both, depending on the integration order (Hundie, 2021; Hussein and Osman, 2024; Osman et al., 2025; Warsame et al., 2021). Finally, ARDL takes into account the asymmetric function of the bias-corrected bootstrap approach and conditional error correction coefficients, which can be computed to produce trustworthy statistical conclusions about the long-run cointegration of sampled variables (Ali et al., 2022; Hussein and Ali, 2022; Menyah and Wolde-Rufael, 2010; Pesaran et al., 2001).

Table 1: Data description and measurements

Variables	Code	Measurement	Sources
Energy consumption	EC	kilowatt-hours (kWh) per capita	SESRIC
Exchange rate	EXR	Average annual precipitation (mm)	World Bank
Land area cereal crop	LUC	Land area under cereal crops (hectares)	World Bank
Employment in agriculture	EMAG	Percentage of labor force working in the agricultural sector	World bank
Domestic investment	DI	Gross fixed capital formation	World Bank

A linear representation of the relationship between Agricultural output, and explanatory variables of Land under cereal production, Employment in agriculture, Rainfall, and domestic investment in the Somali context is shown in Eq. (1):

$$AGO_t = f(EMAG_t, LUC_t, DI_t, AR_t) \tag{1}$$

Where AGO is Agricultural output, which is the dependent variable of the study, EMAG is employment in agriculture, LUC is land under cereal production, DI is domestic investment, and AR is Annual Rainfall. The above equation explains that Agricultural output is a function of employment in agriculture, land under cereal production, domestic investment, and Annual Rainfall. the preceding equation 1 was transformed into an econometric model as stated below:

$$lnAGO_t = \beta_0 + \beta_1\, lnEMAG_t + \beta_2\, lnLUC_t + \beta_3\, lnDI_t + \beta_4\, lnAR_t + \varepsilon \tag{2}$$

Where ln represents natural logarithmic, AGO_t is the total agricultural production at year *t*, $EMAG_t$ is the labor force working in the agricultural sector at year *t*, LUC_t is the land area crop production at year *t*, DI_t is the domestic investment, meaning Capital invested on agricultural production at year *t*, LAR_t is the total annual rainfall at year *t*, and ε_t is the disturbance term in time *t*. This investigation's primary goal is to carefully examine and clarify the impact of these explanatory variables on agricultural output, focusing on both its long-term and short-term effects. Following the empirical work of (Sarkodie and Adams, 2018) the ARDL cointegration equation can be written as:

$$\begin{aligned}\Delta lnAGO_t &= \varphi_0 + \beta_1 lnAGO_{t-1} + \beta_2 lnEMAG_{t-1} + \beta_3 lnLUC_{t-1} + \\ &\beta_4 lnDI_{t-1} + \beta_5 lnAR_{t-1} + \sum_{i=1}^{\rho}\alpha_1 \Delta lnAGO_{t-1} + \\ &+\sum_{i=1}^{\rho}\alpha_2 \Delta lnEMAG_{t-1} + \sum_{i=1}^{\rho}\alpha_3 \Delta lnLUC_{t-1} + \\ &\sum_{i=1}^{\rho}\alpha_4 \Delta lnDI_{t-1} + \sum_{i=1}^{\rho}\alpha_5 \Delta lnAR_{t-1} + ECT_{t-1}\end{aligned}$$

Where ϕ_0 is the intercept, $\alpha_{1\text{-}5}$ denotes the short-run parameters, $\beta_{1\text{-}5}$ represents the long-run parameters, *p* represents the number of lags, Δ is the operator of the first difference, and ε_t is the error term.

4. RESULTS AND DISCUSSION

The results in Table 2 show the descriptive statistics and correlation matrix of the variables used to define the properties of the raw data. The descriptive statistics provide a deep understanding of the central tendency, dispersion, and shape of the distribution of each variable.

For instance, LEMAG has a mean of 21.93 and a standard deviation of 0.73, indicating that the data is centered around this mean with moderate variability. Skewness and kurtosis provide information about the symmetry and tail heaviness of the distribution, respectively. The Jarque-Bera statistics, along with its associated probability, tests revealed that all variables in the data have a normal distribution. On the other hand, the correlation results in Table 2 showed the pairwise correlations between the variables. Each cell in the table represents the correlation coefficient between two variables. The coefficient correlation ranges from −1 to 1, where −1 indicates a perfect negative correlation, 0 indicates no correlation, and 1 indicates a perfect positive correlation. For example, LAGO and LEMAG have a high positive correlation of 0.87, suggesting a strong relationship between agricultural output and employment in agriculture. Similarly, other correlation coefficients such as the positive correlation between agricultural output and Rainfall (0.50) or the negative correlation between agricultural output and land under cereal production (−0.34) provide insights into the relationships among the variables.

Figure 1 The trend of data series. Legend: LnAGO, LNAR, LNDI, LNEMAG, and LNLUC stand for natural logarithm of agricultural output, average rainfall, domestic investment, employment in agriculture, and land under cereal production respectively.

4.1. Unit Root Test

Stationarity is a crucial assumption in time series analysis, implying that the statistical properties of a series do not change over time. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are commonly used to determine whether a series possesses a unit root, which indicates non-stationarity. The results presented in Table 3 are at the level and the first difference. Some variables are stationary at the level, while others are stationary after differentiation. For example, the domestic investment variable is stationary at the level of the ADF test only, whereas the remaining variables are stationary after the first difference in both ADF and PP tests. However, the test statistics for all variables become substantially negative and exceed the critical values at a 1% level of significance in both ADF and PP tests, implying that all variables become stationary after the differentiation.

4.2. Cointegration Bounds Test

After identifying the unit root and selecting the best lag model, this study tests the F-bound statistics test to determine long-run cointegration among the variables. This employed (Narayan, 2004) Narayan's critical values to determine cointegration among estimated variables. Narayan's critical values can be used with small sample observations that span from 30 to 80 observations and the sample of this study is only 31 observations. However, the result indicates that employment in agriculture, land under cereal production, domestic investment, and rainfall have a long-run cointegration with agricultural output (AGO). Hence, we discard the null hypothesis (no cointegration), and we fail to discard the alternative hypothesis (cointegration). The results in Table 4 show that the Wald *F*-statistics of 3.9 is greater than the critical value of 3.38 at a significance level of 5%, we confirm the existence of cointegration between the dependent variable and explanatory variables.

Table 2: Descriptive statistics of the variables

Variables	LAGO	LEMAG	LLUC	LDI	LAR
Mean	21.93	21.33	18.70	14.44	3.31
Median	21.89	21.29	18.91	14.46	3.46
Maximum	23.01	22.37	20.99	14.93	4.63
Minimum	20.38	19.85	15.29	13.96	1.73
Standard deviation	0.73	0.69	1.90	0.30	1.00
Skewness	−0.40	−0.32	−0.32	−0.06	−0.20
Kurtosis	2.40	2.38	1.70	1.82	1.45
Jarque-Bera	1.34	1.07	2.83	1.87	3.42
Prob.	0.51	0.59	0.24	0.39	0.18
Correlation					
LAGO	1				
LEMAG	0.87	1			
LAR	0.50	0.06	1		
LDI	0.09	−0.57	0.42	1	
LLUC	−0.34	0.13	0.63	0.45	1

Table 3: Unit root test

Variables	ADF	PP
	T-statistics at level	
LNAGO	−0.930	−0.595
LNEMAG	−0.835	−0.369
LNLUC	−1.705	−1.648
LNDI	−4.355***	−1.834
LNAR	−1.118	−0.489
At first difference		
LNAGO	−4.818***	−5.074***
LNEMAG	−4.910***	−5.389***
LNLUC	−6.178***	−5.960***
LNDI	−4.368***	−4.340***
LAR	−4.700***	−4.691***

The critical values are based on Narayan (2004) represents number of parameters.

4.3. ARDL Results with Diagnostics

Since identified that the cointegration of the long-run among the variables existed, the ARDL model was estimated. The results in Table 5 provide insights into the long-run and short-run relationships among the estimated variables. Strong results of long and short-run cointegrations among employment in agriculture, domestic investment, rainfall, land under cereal production, and agricultural output are found. Employment in agriculture, rainfall, and domestic investment positively and significantly affect agricultural output, whereas, land under cereal production negatively and significantly affects the agricultural output of Somalia in the short run only. A 1% increase in employment in agriculture improves agricultural output by 1.02% in the long run and 1.06% in the short run, indicating that employment in agriculture boosts agricultural output in Somalia that results consistent with the previous findings of (Hussein and Ali, 2022; Oyakhilomen and Zibah, 2014) who reported that employment in agriculture boosts agricultural output. Increasing domestic investment by 1% contributes on average 0.48% to agricultural output in the long run and 0.19% in the short run, it means

Figure 1: Time-series plots of logarithmic transformed variables

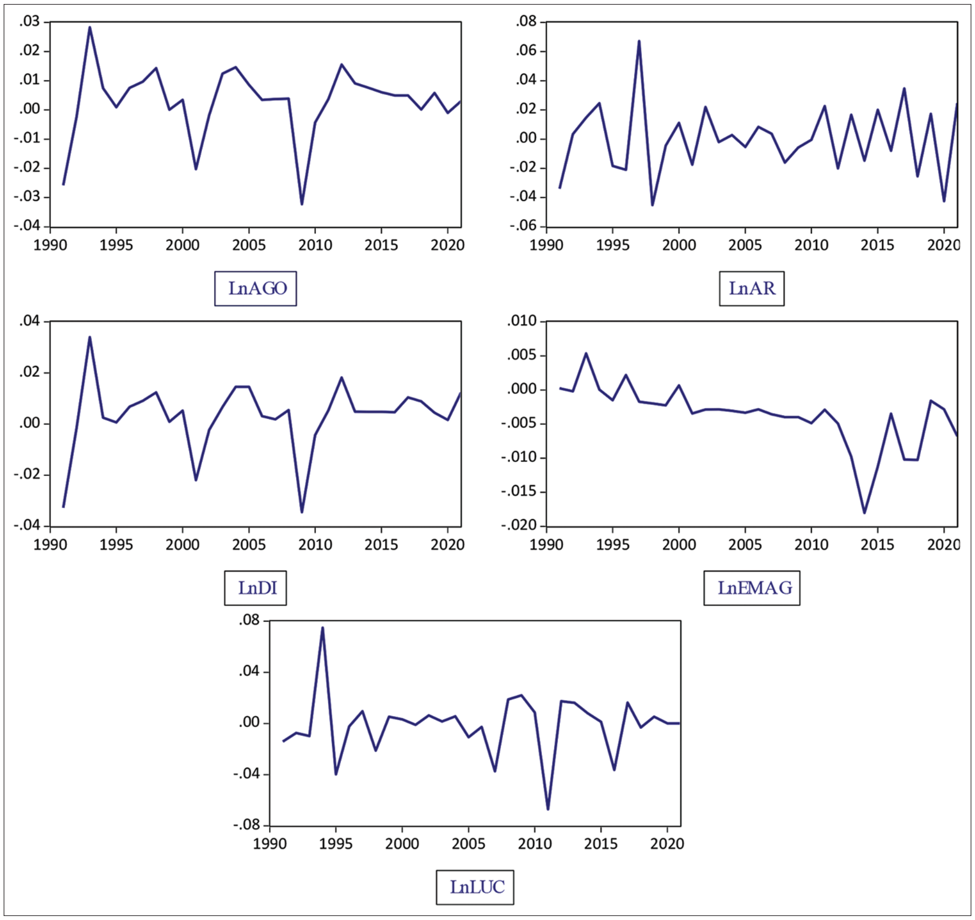

Table 4: F-bounds test

Model	F-statistic	Significance (%)	Bounds test critical values	
			K (4)	
			I (0)	I (1)
LNAGO=*f* (LNEMAG, LNDI, LNLUC, LNAR)	3.902	1	3.06	4.15
		5	2.39	3.38
		10	2.08	3

Table 5: ARDL results

Explanatory variable	Coefficient
Constant	−5.314***
LNEMAG	1.018***
LNLUC	−0.017
LNDI	0.478**
LNAR	0.763***
ΔlnEMAG	1.0632***
ΔLNLUC	−0.109774***
ΔLNAR	1.38037***
ΔLNDI	0.18551****
ECT (−1)	−0.6683***
Ramsey Reset test	0.001***
Breusch-pagan-Godfrey	0.703***
Serial correlation	4.799**
Jarque-Bera	0.288***

***, **, * Indicate significance levels at 1%, 5%, and 10%. Δ represents short run parameters

investments in physical assets such as machinery, infrastructure, and irrigation systems, is another important factor influencing agricultural output. Capital investments enhance the capacity of the agricultural sector to produce more efficiently and sustainably, some scholars (Awokuse, 2008; Huchet-Bourdon et al., 2018; Keho, 2017) agree with the study result. Average rainfall in Somalia contributes to agricultural output significantly, indicating a 1% increase in rainfall increases agricultural output on average by 0.76% in the long run and 1.38% in the short run and this result aligns with previous studies (Fitri, 2022; Okyere and Jilu, 2020; Shiferaw, 2017). However, land under cereal production contributes to agricultural output negatively and significantly, indicating a 1% increase in land under cereal decreases agricultural output by 0.11% in the short run, and this result aligns with previous studies (Fitri, 2022; Okyere and Jilu, 2020; Shiferaw, 2017).

Figure 2: CUSUM test

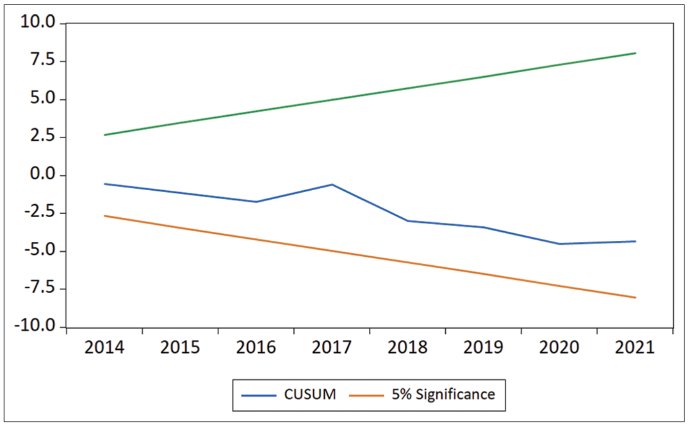

Figure 3: CUSUM squared test

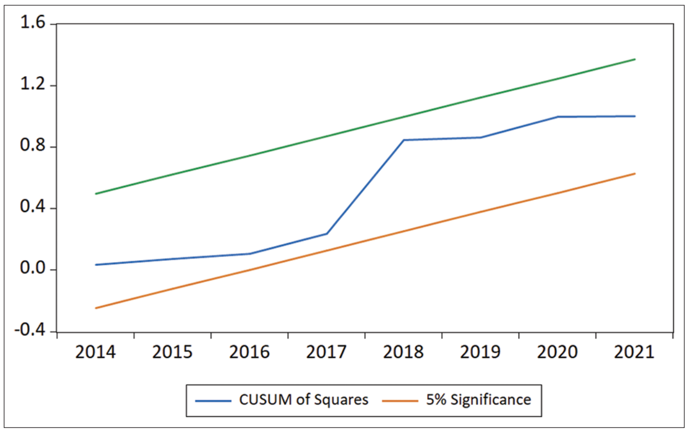

Table 6: Granger causality test

Null hypothesis	F-statistic
LNAR→LNAGO	4.5647**
LNAGO→LNAR	2.9000*
LNDI→LNAGO	1.88514
LNAGO→LNDI	2.0707
LNEMAG→LNAGO	0.40915
LNAGO→LNEMAGO	1.55603
LNLUC→LNAGO	2.08627
LNAGO→LNLUC	2.65017*
LNDI→LNAR	3.2636*
LNAR→LNDI	1.5902
LNEMAG→LNAR	1.7351
LNAR→LNEMAG	2.8010*
LNLUC→LNAR	0.5852
LNAR→LNLUC	3.0103*
LNEMAG→LNDI	2.2161
LNDI→LNEMAG	4.4029**
LNLUC→LNDI	2.7169*
LNDI→LNLUC	1.9574
LNLUC→LNEMAG	0.6968
LNEMAG→LNLUC	2.3751

***, **, * Indicate significance levels at 1%, 5%, and 10%

The ECT is −0.6683, showing the speed of adjustment to equilibrium. This can be explained as 67% of the short-run agricultural output (AGO) imbalance being annually adjusted to equilibrium by repressors. We use the diagnostic and model stability tests listed in Table 5 to validate the estimated models. There is no evidence of non-normality, serial correlation, or mis-specified functional form, indicating that our model is free of diagnostic issues. To test the parameter constancy, the CUSUM and CUSUM square plots are also used. As seen in Figures 2 and 3, both tests demonstrate that the model is stable from 1990 to 2021.

4.4. Granger Causality Test

Granger causality is tested to determine the direction of causality between variables, and the associated results are shown in Table 6. The null hypothesis of that variable 1 does not Granger-cause variable 2 is rejected if the P-value is lower than 5% or otherwise. We observe that average rainfall and agricultural output demonstrate bidirectional causality, with each variable significantly influencing the other, indicating a mutual reinforcement relationship. Additionally, domestic investment and employment in agriculture do not have Granger cause to average rainfall. Also, land under cereal crop, and agricultural output have Granger cause to agricultural production. Finally, unidirectional causality from agricultural output to land under cereal crop, employment in agriculture to domestic investment, highlighting the critical role of human capital in the nation's economic and agricultural development.

5. CONCLUSION AND POLICY IMPLICATION

This study has examined the key determinants of agricultural output in Somalia using annual time series data from 1990 to 2021. The ARDL bounds testing approach was employed to investigate the short-run and long-run relationships between the dependent variable, agricultural output, and the independent variables of employment in agriculture, domestic investment, rainfall, and land under cereal production.

The findings of this analysis provide important insights into the agricultural sector in Somalia. In the long run, the results indicate that employment in agriculture, rainfall, and domestic investment have strong positive impacts on agricultural output. A 1% increase in employment in agriculture, rainfall, and domestic investment is associated with 1.02%, 0.48%, and 0.76% increases in agricultural output, respectively. This underscores the critical role that labor, climate conditions, and capital formation play in driving agricultural productivity in the country.

In the short run, the results are largely consistent, with employment in agriculture, rainfall, and domestic investment all exhibiting positive and statistically significant relationships with agricultural output. Interestingly, the impact of land under cereal production was found to be negative in the short run, suggesting that area expansion of cereal crops may come at the expense of other important agricultural activities in the near term. This highlights the need for a balanced approach to cropland management that considers the tradeoffs between different agricultural sub-sectors.

Overall, the findings of this study provide a robust empirical foundation for understanding the key drivers of the agricultural economy in Somalia. The analysis indicates that policies and interventions aimed at boosting agricultural employment, improving rainfall reliability through irrigation and water management, and incentivizing domestic investment in the sector have the potential to significantly enhance agricultural productivity and output in both the short and long run.

The results of this study offer several important policy implications for strengthening the agricultural sector in Somalia. This includes investing in agricultural labor force development, given the strong positive relationship between employment in agriculture and agricultural output, the government and development partners should focus on policies and programs that enhance the skills, productivity, and working conditions of the agricultural labor force. This could include investments in agricultural extension services, vocational training, and social protection measures for rural workers. It also includes improving climate change resilience, the significant positive impact of rainfall on agricultural output underscores the vulnerability of Somali agriculture to climate variability and change. Policies are needed to support climate-smart agricultural practices, expand irrigation infrastructure, and develop early warning systems to help farmers mitigate the risks of droughts, floods, and other extreme weather events.

The study also suggests incentivizing domestic agricultural investment, the results indicate that boosting domestic capital investment in the agricultural sector can yield substantial productivity gains. The government should consider introducing targeted tax incentives, subsidies, and improved access to credit and finance for farmers and agribusinesses. This could help catalyze much-needed private sector investment in the modernization of production, processing, and marketing activities. Adopting a balanced approach to cropland expansion: While expanding the area under cereal production may provide short-term gains, the negative short-run impact observed in this study suggests the need for a more nuanced approach to cropland management. Policymakers should consider supporting diversified cropping systems and sustainable land use practices that optimize the productivity and resilience of the overall agricultural landscape.

Limitations of the study include lack of sub-sectoral analysis. This study has examined agricultural output as an aggregate measure, without disaggregating the analysis by specific sub-sectors (e.g., crops, livestock, and fisheries). Future research should consider exploring the drivers of output at the sub-sector level. In addition, the study focuses on specific independent variables, other potentially influential factors such as technological advancements, input subsidies; government spending on agriculture, rural infrastructure, and international aid are crucial for agricultural development but are not included in the current model. Future studies could assess the impact of adopting new agricultural technologies such as improved seed varieties, irrigation techniques, and mechanization. Furthermore, the study is specific to Somalia, and while this provides valuable insights for the region, the findings may not be generalizable to other countries with different socio-economic and environmental contexts. Finally, Future research should investigate the long-term impacts of climate change on agricultural output, including more detailed analyses of temperature variations, extreme weather events, and adaptive strategies.

6. ACKNOWLEDGMENT

The author expresses sincere gratitude to the Center for Graduate Studies at Jamhuriya University of Science and Technology (JUST) for providing an intellectually stimulating environment that supported this research. Special thanks are extended to the supervisors and colleagues who offered insightful feedback during the study. Additionally, the author appreciates the World Bank and SESRIC for access to their data repositories, which were instrumental in completing this work.

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