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Foreign Aid's Role in Somali Agriculture: A Detailed Empirical Study

Abdikadir Ahmed Mohamed*, Mahdi Mohamed Omar, Abdikani Yusuf Abdulle

Faculty of Economics and Management, Jamhuriya University of Science and Technology, Mogadishu +252, Somalia

Corresponding Author Email: adaadir887@gmail.com

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ABSTRACT

Somalia is one of the countries where political instability and poor infrastructure have led to a decline in agricultural production, prompting foreign aid donors to encourage overall development and agricultural production. Our study focuses on the effect of foreign aid on crop production in Somalia, employing the ARDL model to analyze time-series data from 1985 to 2022. The study found that the development of food aid negatively affects crop production due to its timing and dependency but shows an insignificant effect in the short run. Humanitarian aid shows no significant effect in either the long or the short run. Climate change variables showed an immediate and long-run effect on crop production, with rainfall indicating a positive effect and temperature negatively affecting crop production. This study recommends better timing management of aid, improved water management, and effective utilization of rainfall.

1. INTRODUCTION

According FAO [1], global crop production continues to face significant challenges related to climate change and resource limitations, which impact food security and agricultural sustainability. Despite these challenges, USDA [2] reports substantial growth in global crop production owing to advancements in agricultural technologies and improved farming practices.

The UN's request for $46.4 billion to assist 180.5 million people highlights the immense need for humanitarian aid worldwide [3]. A significant portion of this aid is directed toward regions experiencing food insecurity and agricultural crises caused by conflicts and extreme weather conditions [4]. Foreign aid allocated to agricultural development typically funds the construction of irrigation systems, roads, and storage facilities to enhance agricultural production and reduce postharvest losses [5].

In 2024, the United States, a major donor, allocated approximately $50 billion to foreign aid [6]. Major recipients of this aid include countries in the Middle East and Africa, where it is often used to support agricultural projects and improve food security [5].

In Somalia, a significant portion of foreign aid is directed towards improving agricultural resilience in the face of recurring droughts and floods [7]. This aid is crucial for sustaining the livelihoods of Somali farmers and pastoralists, who are frequently affected by these climate extremes [1, 8]. These funded projects include programs to treat livestock, which helps prevent the spread of diseases and ensures better productivity [9]. Furthermore, USAID allocates funding to promote modern farming techniques by providing training to farmers. This training aimed to increase crop production and manage resources more efficiently [10]. These efforts are part of a broader strategy to build long-term resilience and food security in Somalia [11].

The research gap of this study is that, while foreign aid and agricultural studies are abundant globally. However, there is a lack empirical studies that specifically examine the Somali context, which is characterized by complex socio-political dynamics, recurring droughts, and varying forms of aid. A focused empirical investigation on Somalia could provide valuable localized insights and contribute to the literature on foreign aid's impact in fragile states.

The purpose of foreign aid to Somalia was to improve agricultural production. The idea is to support farmers, leading to greater agricultural production so that food security is improved, hunger is eliminated or reduced, and farmers become more self-sufficient [12, 13]. Regardless of the large amount of foreign aid, the current status of local farmers remains inferior to what is expected [14]. This suggests that the timing of foreign aid is causing involuntarily suppression of local crop production. Instead of empowering farmers and enhancing agricultural practices, aid often fosters dependency as farmers become less inclined to improve or invest in crop production when aid is readily available. Additionally, the distribution of aid frequently coincides with critical planting periods, diverting attention and resources away from fields. Consequently, there is a pressing need to reassess the design and delivery of foreign aid to ensure it supports rather than hinder the growth of Somalia's agriculture. This study aims to analyze data spanning four and a half decades to understand the lasting impacts and trends of aid and its effects on agriculture and crop production. While many studies have explored the connection between aid and agricultural output, few have specifically focused on crop production in Somalia.

During this period, significant events unfolded in Somalia's history, such as the breakdown of the government in 1991, periods of internal strife, and subsequent efforts to stabilize and rebuild. The amount of assistance provided to Somalia increased from $0.47 million in 1985 to $1.26 billion in 2017. Foreign aid in Somalia has fluctuated over time, dropping to its lowest in 1996, gradually increasing until 2010, and rising again since 2017 [15]. By examining data across these three decades, this study aims to capture the long-term effects and patterns of foreign aid, especially those directly affecting agriculture and crop production.

Many studies have focused on the relationship between foreign aid and agricultural production, but few have specifically addressed crop production in Somalia. This study exists for the following reasons. Unlike the study by Aidaa et al. [16] which focuses on one district in Somalia, this article covers the entire country using secondary data. Second, the research examines two types of aid—development food aid and humanitarian aid—along with climate variables, such as rainfall and temperature.

Furthermore, this study contributes to the existing literature by using the Autoregressive Distributed Lag (ARDL) model to analyze the long-run and short-run effects of foreign aid on crop production in Somalia. Conducting an empirical analysis enhances our understanding of the immediate and enduring impact of aid on agricultural production in Somalia.

The remainder of the paper proceeds as follows: a Review of Literature, Study Methodology, Results and Discussions, and Conclusions and Policy Recommendations.

2. REVIEW OF LITERATURE

Chenery and Strout [17] proposed the Two-Gap Model, emphasizing the widespread deficiency of savings and foreign resource inflows in emerging countries. These two essential factors are requisite for investment [18, 19]. This model posits that foreign aid might alleviate these limits by supplying essential funding for agricultural initiatives, thereby enhancing crop yield. This assistance might be allocated to investments in agricultural infrastructure, technology, and human capital, vital for enhancing productivity in nations such as Somalia. Conversely, the Solow-Swan Growth Model proposed by Solow [20] and Swan [21], posits that aid supporting investments can lead to economic growth. Strategically distributed foreign assistance for agricultural infrastructure, including irrigation systems, storage facilities, and seed technology, can directly enhance farm productivity. The model highlights the significance of capital accumulation and technological progress in fostering long-term prosperity, particularly pertinent to Somalia's agricultural sector. Moreover, Sachs [22], in his Big Push Theory, recommends extensive aid interventions to escape the poverty trap, particularly in agriculture, highlighting the necessity for significant investment in agricultural infrastructure and technologies. Collier [23], in his analysis of fragile states, contends that aid must be tailored to the individual context, addressing the distinct obstacles encountered by nations such as Somalia, where political instability and environmental issues hinder agricultural development. Incorporating these viewpoints would enhance the theoretical framework of our study, explicitly connecting foreign aid to agricultural change in vulnerable circumstances.

Foreign assistance is seen as a strategic allocation of resources towards constructing agricultural infrastructure, including irrigation, storage facilities, and seed technologies. Such targeted funding can directly impact farm yields. While several studies have addressed the relationship between foreign assistance and growth [24-26], few have focused specifically on the agricultural sector and crop output. These studies have revealed the complex dynamics of aid effectiveness. Ssozi et al. [27] noted the crucial importance of governance and economic freedom in the effective use of Official Development Assistance (ODA) in a study conducted in Sub-Saharan Africa. Their findings indicate a positive connection between ODA and agricultural productivity, providing significant insights into the broader regional context, including Somalia. However, they caution against relying solely on country-level and aggregate data, advocating for targeted, country-specific studies, which my research aims to conduct in Somalia. Alabi [28] utilized the Generalized Method of Moments (GMM) to investigate the impact of foreign agricultural aid on GDP and productivity, revealing a positive relationship. Similarly, Waya [29] explored the relationship between foreign agricultural aid and growth in Nigeria and found that such assistance contributes to agricultural development, whereas corruption negatively affects it. Both studies encountered issues with multicollinearity and sampling in large databases. These findings underscore the importance of good governance, which may obscure specific conditions in Somalia. Notably, Fang [30] conducted a study using fixed effects models to analyze the impact of OECD agricultural aid. The study showed that bilateral aid had a significant positive effect on agricultural GDP in Sub-Saharan Africa. However, Fang [30] observed no substantial influence of multilateral aid, highlighting the importance of governance and trade dependency in aid policy formulation. This is particularly relevant in Somalia, where governance issues may affect aid effectiveness. A broader perspective was presented by examining the effectiveness of aid in the food manufacturing industry across various economies from 1990 to 2019 [31]. Djokoto argues that sector-specific foreign aid significantly promotes production and productivity, thereby highlighting the potential benefits of targeted aid interventions. However, these findings cannot be directly applied to the Somali context because the study was broad. On the other hand, Dhahri and Omri [32] found that agricultural foreign aid (AFFA) significantly enhances agricultural output, with a 1% increase in AFFA leading to a 0.63% rise in production. They also emphasized the need for synergies among foreign direct investment, social infrastructure aid, and agricultural finance and food assistance (AFFA), along with effective social protection mechanisms to achieve enhanced agricultural productivity and improved rural livelihoods. However, relying on generalized regional data may overlook context-specific deviations at the country level. To address this gap, this study focuses on Somalia's specific conditions to examine the long-term relationship between foreign assistance and crop production.

In Somalia, Aidaa et al. [16] investigated the impact of foreign aid on the crop production intentions of farmers in Afgooye District. The authors argued that food aid reduced production in the district by creating psychological dependency, which might have undermined farmers' economic capacity. Therefore, further empirical studies are needed to evaluate the actual impact of aid on crop production in Somalia.

These studies have demonstrated the various ways in which foreign aid impacts agricultural development by considering governance and economic conditions. Although positive impacts have been highlighted, corrupt practices and lack of good governance are some of the setbacks that must be overcome to make aid more effective. There are also weaknesses in data collection. To build on this, the current study will use World Bank data to determine the influence of foreign aid on crop production in Somalia and identify measures to avoid these problems while addressing specific country context factors. It is anticipated that this approach will facilitate the formulation of policies aimed at enhancing agricultural productivity and ultimately contribute to overall socioeconomic growth in Somalia.

3. METHODOLOGY

3.1 Data

This study utilizes time-series data from the World Bank and SESRIC, which were selected based on data availability, reliability, historical importance and study context, as well as the need to capture both short-term volatility and long-term trends in Somalia's economic indicators. The dataset covers the period from 1978 to 2022 and includes the dependent variable, crop production (CP), and independent variables such as food aid (FA), humanitarian aid (HA), rainfall (RF), and temperature (TP). All data were transformed into logarithms for the analysis to ensure consistency and accuracy. The data preprocessing techniques used to handle missing data, outliers, and transformations in analyzing foreign aid and agriculture in Somalia can vary depending on the dataset and research objectives. However, there are certain traditional approaches that researchers may take into account. Within this study, Imputation techniques or removal of missing values can be employed when there are missing variables. Logarithmic transformations are beneficial for addressing skewed distributions or linearizing correlations between variables. The choice of methodologies should be based on the data's distinct characteristics and the inquiry's goals. Furthermore, there are no outliers present in this investigation.

Below, Table 1 provides a description of the data sources and measurements for the variables used in the study, additionally, Figure 1 shows the trend of the data series:

Table 1. Description of data

Variables	Measurements	Sources
Crop production	Crop production index shows agricultural production for each year relative to the base period 2014-2016.	World Bank
Development food aid	US Dollar, Millions, 2021	SESRIC data
Humanitarian aid	constant price	SESRIC data
Rainfall	Average annual precipitation (mm)	World Bank
Temperature	Average annual temperature in (°C)	World Bank

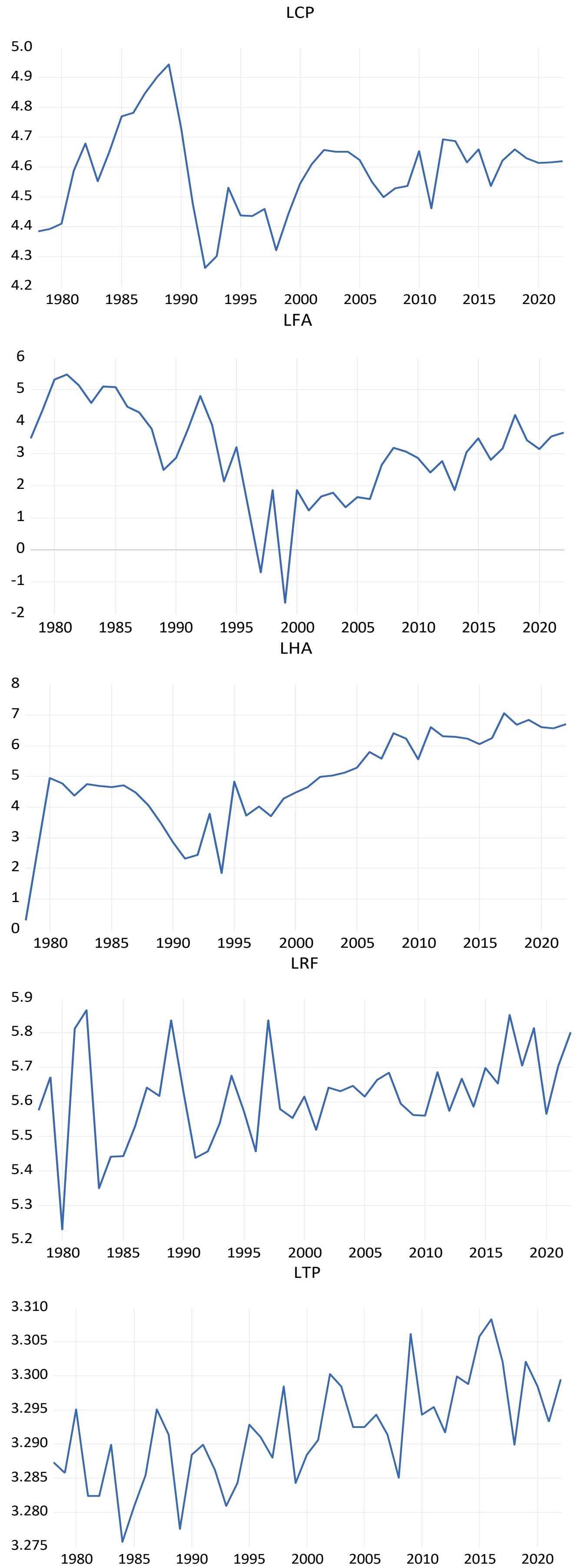

Figure 1. The trend of data series. Legend: LCP, LFA, LRF, LTP, stand for natural logarithm of crop production. Food aid, humanitarian aid average rainfall, average temperature, respectively

3.2 Estimation techniques

The study employs the Autoregressive Distributed Lag (ARDL) model to gain a deeper understanding of the relationships between these variables. The ARDL model is valuable when the variables in your dataset have diverse orders of integration. Specifically, some variables are stationary at levels (I(0)), while others are stationary at the first difference (I(1)), and none are integrated at the second difference (I(2)). Within the scope of your research, foreign assistance variables (such as development food aid and humanitarian help) and agricultural output variables (including crop and livestock production) may display varying levels of integration. ARDL enables the incorporation of variables into a single model without converting all variables into first differences.

The model below was also transformed into logarithms for analytical consistency.

Model specification

$$LCP_t = \beta_0 + \beta_1 LFA_t + \beta_2 LHA_t + \beta_3 LRF_t + \beta_4 LTP_t + \varepsilon_t \quad (1)$$

LCP represents the logarithm of crop production, *LFA* denotes the logarithm of development food aid, *LHA* signifies the logarithm of humanitarian aid, *LRF* is the logarithm of mean rainfall, and *LTP* is the logarithm of temperature. β_0 is a constant term, while β_1 to β_4 are the elasticities to be estimated. ε_t represents the error term, and *t* denotes the years, indicating the time dimension. Moreover, the study suggests that development food aid (LFA), humanitarian aid (LHA), and rainfall (LRF) all have a favorable and important influence on crop production (LCP) in Somalia. Conversely, temperature (LTP) is expected to impact agricultural yield adversely. These hypotheses aim to investigate the connections between foreign aid, climate variables, and agricultural products, emphasizing the distinct roles these elements have in influencing agricultural output in Somalia.

The model predicts that there are linear relationships between the dependent and explanatory variables.

$$\Delta LCP_t = \alpha_0 + \beta_1 LFA_{t-1} + \beta_2 LHA_{t-1} + \beta_3 LRF_{t-1} + \beta_4 LTP_{\ t-1} + \sum_{i=0}^{q} \Delta\alpha_1 LFA_{\ t-k} + \sum_{i=0}^{p} \Delta\alpha_2 LHA_{t-k} + \sum_{i=0}^{q} \Delta\alpha_3 LRF_{t-k} + \sum_{i=0}^{q} \Delta\alpha_4 LTP_{\ t-k} \quad (2)$$

where, α_0 is the constant, α_1 to α_3 are the coefficients of the short-run variables, β_1 to β_4 are the elasticities of the long-run parameters, *q* indicates the optimal lags, *p* shows the optimal lags of the explanators, Δ is the first difference sign showing short-run variables, and ε_t is the error term. The ARDL co-integration method begins with bound testing. The null hypothesis, denoted as H0: $\beta_1=\beta_2=\beta_3=\beta_4$, posits that the variables do not exhibit co-integration in the long term, while the alternative hypothesis, denoted as H1: $\beta_1\neq\beta_2\neq\beta_3\neq\beta_4\neq 0$, suggests that the variables are co-integrated in the long term.

The role of foreign aid in augmenting agricultural productivity is well-documented. In fact, according to studies such as Dalgaard et al. [34], there is prima facie evidence that foreign aid can have a very positive impact on agricultural development, particularly if it is well targeted at agricultural inputs and infrastructure.

Rainfall is a climatic factor that directly influences agricultural productivity. A study Lesk et al. [34] revealed that agricultural outputs are sensitive to changes in rainfall; thus, there is a need to include it in any research on agricultural economics. Temperature also has a significant impact on crop growth and yield. In a 2009 study [35], revealed quadratic and heterogeneous effects of temperature on different crops, making the temperature variable very important for research studies on agricultural productivity.

First, we perform the ARDL bounds test to check for cointegration to ensure that there is a long-term relationship between the variables. In case of cointegration, we will proceed with the estimation of the ARDL model to establish the short and long-term effects of foreign aid, rainfall, and temperature on crop production. In doing so, we run a number of diagnostic tests to check for any autocorrelation, heteroscedasticity, or general stability of our model to ensure its reliability. These tests increased the robustness and credibility of the findings.

4. RESULTS AND DISCUSSION

4.1 Descriptive statistics

Table 2 presents descriptive statistics for the log-transformed variables: crop production (LCP), food aid (LFA), humanitarian aid (LHA), rainfall (LRF), and temperature (LTP).

Table 2. Descriptive statistics

	LCP	LFA	LHA	LRF	LTP
Mean	4.582769	3.009918	4.867564	5.61677	3.291834
Median	4.614625	3.142858	4.838106	5.61687	3.291833
Maximum	4.943355	5.474747	7.052825	5.866695	3.308351
Minimum	4.261693	-1.660731	0.300105	5.230574	3.275634
Std. Dev.	0.147382	1.493834	1.504342	0.133419	0.005942
Skewness	0.099928	-0.74336	-0.777692	-0.303853	0.089803
Kurtosis	3.114265	4.052641	3.454836	3.521851	2.567243
Jarque-Bera	0.099374	6.221983	4.923928	1.203067	0.411632
Probability	0.951527	0.044557	0.085267	0.547971	0.813983
Sum	206.2246	135.4463	219.0404	252.7952	148.1325
Sum Sq. Dev.	0.955739	98.18771	99.57401	0.78323	0.002535
Observations	45	45	45	45	45

The mean LCP was 4.582769, with a median of 4.614625, indicating right skewness. LFA and LHA showed significant variability and skewness, with LFA ranging from -1.660731 to 5.474747 and LHA from 0.300105 to 7.052825. The high standard deviation of LHA (1.504342) indicated a wide variation. LTP showed minimal variability and slight positive skewness, whereas LRF was relatively symmetrical around its mean. Skewness and kurtosis values highlight outliers and heavy tails, particularly in LCP and LFA. The Jarque-Bera test indicated significant deviations from normality for crop production and food aid, suggesting caution with statistical methods assuming a normal distribution. This analysis informs the selection of appropriate analytical techniques for further research. Implementing unit root tests, such as the Augmented Dickey-Fuller test, ensured the accurate modeling of the dynamics of these variables.

4.2 Unit root test

The unit root test results presented in Table 3 are crucial for determining the stationarity of the variables used in the study, namely, log-transformed crop production (LCP), food aid (LFA), humanitarian aid (LHA), rainfall (LRF), and temperature (LTP). The tests were conducted both at the level and after the first differencing, with configurations for intercept only, and both trend and intercept.

Table 3. Unit root test

Variables	Level		First Difference	
	Intercept	Trend & Intercept	Intercept	Trend & Intercept
LCP	-2.929734	-3.515523	-3.592462***	-4.186481***
LFA	-2.931404	-3.518090	-3.592462***	-4.186481***
LHA	-2.931404	-3.518090	-3.592462***	-4.186481***
LRF	-3.588509***	-4.180911***	-3.621023***	-4.226815***
LTP	-3.588509***	-4.180911***	-3.600987***	-4.198503***

Note: ** stands for significance at 5% and*** symbolize is significance 1%.

The test statistics indicate that at the level, all variables except LHA with a trend and intercept do not reject the null hypothesis of a unit root, suggesting non-stationarity. However, after the first differencing, all variables showed significant test statistics (indicated by **) at the 5% level, rejecting the null hypothesis of a unit root and confirming stationarity. This transformation indicates that the variables are integrated of order 1 or I(1).

Given that all key variables achieve stationarity after first differencing and appear to be I(1), the next step in the analysis involves checking for cointegration among the variables, assuming that they have a long-run equilibrium relationship. Because the variables are I(1), the Autoregressive Distributed Lag (ARDL) approach to cointegration becomes appropriate. The ARDL method is advantageous because it can be applied regardless of whether the underlying variables are purely I(0), purely I(1), or a combination of both. Moreover, the ARDL model does not require variables to be strictly stationary at levels, which aligns well with our dataset where the variables are stationary after first differencing.

The F-statistics from the bound tests, as shown in Table 4, offer essential insights into the cointegration relationships among the variables being examined. The ARDL approach was used to determine if the lagged long-run parameters collectively equal zero. The Wald F-test score of 6.087992 suggests significant long-run correlations between the variables. This implies that foreign aid, rainfall, and temperature impact agricultural production not only in the near term but also in the long term.

The ARDL bound test confirms the presence of a long run relationship among these variables, emphasizing the interdependence of agricultural output with foreign aid and climate factors in Somalia. These findings highlight the need to consider both international assistance and climatological factors when assessing the factors influencing crop productivity over time. Long-term equilibrium relationships indicate that changes in foreign aid, rainfall, and temperature have long-term impacts on agricultural productivity, necessitating the implementation of durable and persistent methods to challenge the issues encountered by Somalia's agricultural sector.

These findings establish a strong basis for more in-depth analysis and policy suggestions, specifically regarding the development of foreign aid programs and climate adaptation initiatives that aim to improve agricultural resilience and productivity.

4.3 Cointegration test

Table 4. F-statistics Bound tests

Critical Value (%)	I (0)	I (1)
10%	3.03	4.06
5%	3.47	4.57
2.5%	3.89	5.07
1%	4.4	5.72
ARDL F-statistics	**Wald F-stat 6.087992****	

Note: the critical values, at the 5% significance level, are based on Narayan (2005).

4.4 ECM and short run estimation

The errors Correction Model (ECM) findings and short-run estimation in Table 5 for the Autoregressive Distributed Lag (ARDL) model yield valuable insights into the effects of foreign aid and climate variables on crop output in Somalia. The coefficient for food aid (LFA) is somewhat negative. However, its lack of statistical significance indicates that, in the short term, the development of food aid does not have a significant impact on crop productivity. It is possible that food mostly helps to stabilize consumption rather than directly improve agricultural productivity. Alternatively, the effects of food aid may take time to manifest and become increasingly apparent in the long term.

Similarly, the coefficient for humanitarian help (LHA) is positive but not statistically significant. This implies that although humanitarian aid might provide immediate assistance and assistance during times of crisis, its impact on enhancing short-term crop productivity is negligible. This discovery suggests that the aid provided mainly focuses on immediate needs rather than on improving agricultural capabilities in the short term.

Conversely, rainfall (LRF) has a large and positive effect on crop productivity, confirming the important function of sufficient rainfall for agricultural output in Somalia's climate-sensitive agricultural sector. This outcome emphasizes the susceptibility of Somalia's agricultural output to fluctuations in precipitation. Enhancing water management and irrigation has the potential to greatly assist the sector, particularly in places susceptible to drought.

The study found that temperature (LTP) significantly and negatively impacts crop output, further highlighting the harmful consequences of increased temperatures on agriculture. This highlights the difficulties presented by increasing temperatures and the necessity for climate adaptation techniques to lessen the negative effects of climate change on crop production.

The ECM term is statistically significant, as evidenced by its negative coefficient, which suggests a gradual and consistent adjustment toward long-term equilibrium after experiencing short-term shocks. This discovery implies that although Somali agriculture displays a certain level of resilience, it may require a significant amount of time to completely recuperate from external disruptions. These findings suggest that foreign aid has a small impact on short-term agricultural outcomes, while climatic factors, including rainfall and temperature, have a large influence. Therefore, it is important to prioritize climatic resilience and long-term development methods while enhancing Somalia's agricultural productivity rather than relying only on short-term relief initiative.

Table 5. ECM and short run estimation

Variable	Coefficient
LFA	-0.004623
LHA	0.009537
LRF	0.307176**
LTP	-1.606022**
ECM	-0.009102**

Note: ** denote significance at the 5% level.

4.5 Long run estimation

The results obtained from the long-term estimation in Table 6 provide significant insights into the influence of foreign aid and environmental factors on crop productivity in Somalia. The discovery that food aid (LFA) has a statistically significant adverse effect on crop productivity, as indicated by a coefficient of -0.006068, gives rise to worries regarding the unintended repercussions of food aid. The adverse impact can be ascribed to the synchronicity of food assistance delivery during harvest season, diminishing the need for domestically grown foods. Moreover, providing food assistance can establish a pattern of reliance, wherein farmers may become dependent on external aid rather than cultivating their land, thus worsening Somalia’s historically weak agricultural output. This is especially pertinent in the Somali context, where the agricultural sector encounters notable obstacles, such as inadequate infrastructure, insecurity, and erratic rainfall patterns. Aidaa et al. [16] have documented similar results in their research investigating the influence of foreign aid on agricultural output in the Afgooye district, and their study emphasizes the wider regional consequences of relying on food assistance.

The coefficient for humanitarian help (LHA) is 0.122897. However, it lacks statistical significance, suggesting that it has little impact on crop production over a prolonged period. This is unsurprising, given that humanitarian aid generally focuses on resolving urgent problems, such as scarcity of food or forced migration, rather than fostering agricultural advancement. According to Al Daccache et al. [38], there is a consistent absence of direct impact on crop production from humanitarian aid. This is because humanitarian aid prioritizes survival and emergency relief rather than long-term agricultural development. Within the Somali context, this indicates that humanitarian aid is crucial in addressing crises but does not directly contribute to enhancing agricultural output.

Additionally, rainfall (LRF) noticeably impacts crop output, as indicated by a coefficient of 0.341137. Considering Somalia’s reliance on rainfall and the lack of extensive irrigation infrastructure, it is unsurprising that this outcome is anticipated. The fluctuation in rainfall can substantially impact the productivity of crops, given that most farming in Somalia relies on rainwater for irrigation. The results are consistent with the findings of Warsame et al. [37], who showed that climate variability, namely changes in rainfall patterns, has significantly impacted agricultural production in Somalia. The importance of rainfall underscores the susceptibility of Somali agriculture to climate change, emphasizing the necessity for policies that improve water management and build resilience to drought.

The temperature coefficient (LTP) of -8.84E-10, which is harmful and statistically significant, highlights the detrimental impact of increasing temperatures on Somali agriculture. Elevated temperatures can result in soil deterioration, diminished water accessibility, and crop heat stress, all of which decrease agricultural efficiency. This is particularly relevant in Somalia, where rising temperatures and extended periods of drought have already significantly impacted the agricultural industry. Attiaoui and Boufateh [38] reached similar findings in their study on cereal farming in Tunisia, indicating that elevated temperatures hurt agricultural productivity in arid areas. In the specific context of Somalia, this discovery emphasizes the immediate necessity for climate adaptation tactics, including cultivating crops that can withstand drought, enhancing irrigation methods, and allocating resources towards sustainable agricultural practices.

Ultimately, these long-term outcomes emphasize the complicated relationship between foreign assistance, environmental conditions, and farming efficiency in Somalia. Food aid and humanitarian help have little or no negative long-term impacts on crop output, although climate variables such as rainfall and temperature have significant implications. For Somalia’s agricultural sector to flourish, it is imperative to diminish reliance on external assistance, bolster climatic adaptability, and prioritize sustainable agricultural advancement designed to address the country’s distinct environmental obstacles.

Table 7 provides the diagnostic and stability tests for the critical validation of the regression model used. The results indicate the absence of serial correlation and heteroskedasticity. The F-statistics of 0.473706 and 0.560092, along with high p-values of 0.7036 and 0.8778, demonstrate that the residuals are independent and uniformly dispersed across the different levels of the independent variables. Furthermore, the normality test confirmed that the residuals of the model were normally distributed, with an F-statistic of 2.361352 and a probability of 0.342429. These results confirm that the model's assumptions hold true, enhancing the credibility of the regression outputs. The absence of these statistical issues substantiates the robustness of the model, making it a reliable tool for examining how various factors influence crop production.

Table 6. Long run

Dependent Variable Is Crop Production CP	
Variable	Coefficient
LFA	-0.006068**
LHA	0.122897
LRF	0.341137**
LTP	-8.84E-10**

Note: ** denote significance at the 5% level.
Original work by the authors

Table 7. Diagnosis and stability tests

Diagnostic Results		
	F-statistic	**Prob.**
Serial Correlation	0.473706	0.7036
Heteroskedasticity	0.560092	0.8778
Normality	2.361352	0.342429

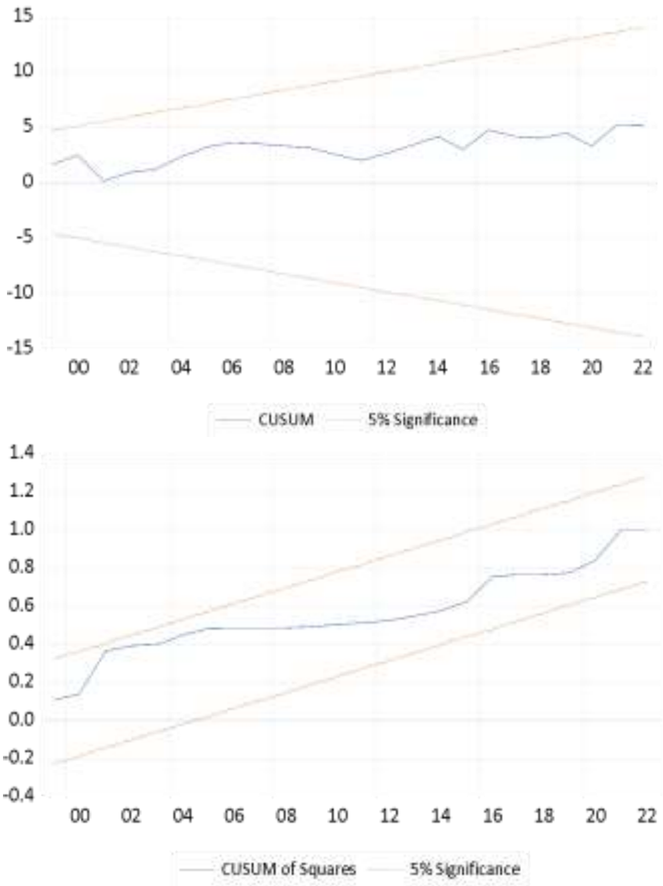

Figure 2. CUSUM and CUSUM of Squares

The results from Figure 2, which present the CUSUM and CUSUM of Squares tests, indicate the stability of the regression model used in the study over the sample period. Both tests show no significant deviations outside the 5% significance boundaries, demonstrating that the model parameters remain consistent and do not undergo substantial changes over time. This ensures that the conclusions drawn from the model are valid, supporting its use in policy analysis and decision-making in agricultural economics.

5. CONCLUSIONS AND POLICY RECOMMENDATIONS

5.1 Conclusions

This study exam the effect of foreign aid on crop production, using development aid (FA) and humanitarian aid (HA) with climate variables Rain fall (RF) and temperature (TP) using ARDL, data are from world bank spans from 1985 to 2022 to analyze both short run and long run impact.

This finding indicates that food aid has a negative effect on crop production in the long run; because of the timing of the aid, it also creates dependence but does not show significance in the short run, humanitarian aid is insignificant both in the short and long run. Rainfall shows positive immediate and long-run impacts on crop production, highlighting the critical dependency of Somalia's agricultural sector on rainfall, aligning with the findings of previous studies that emphasize the sensitivity of agricultural outputs to climatic variations, but temperature shows the opposite: higher temperatures tend to dry out the soil, reducing water availability and adversely affecting agricultural productivity, consistent with established research on temperature impacts on agriculture.

The diagnostic results show that the residuals are normally distributed, and there is no serial correlation or heteroscedasticity. The CUSUM and CUSUM square tests indicated the stability of the model over the study period, which enhanced the reliability of the study.

5.2 Policy recommendations

Based on the findings, several policy recommendations can be made for enhancing crop production in Somalia. First, it is crucial to revamp and streamline aid distribution. Aid programs should prioritize fostering self-reliance and resilience among farmers, rather than continuing dependency. This can be accomplished through focused interventions that enable farmers to reduce dependence on external assistance and enhance their capacity for independent agricultural sustainability. Moreover, optimizing the timing and targeting of food assistance is essential to ensure it strengthens rather than interferes with the agricultural cycle.

A comprehensive strategy should prioritize enhancing infrastructure and accessibility to agricultural technology. Improving water management systems is essential for optimizing rainfall and guaranteeing sufficient water supply for crops during arid conditions. They entail establishing effective irrigation systems to diminish reliance on precipitation and using techniques for rainwater collection and storage for agricultural purposes. Promoting the development of climate-resilient crops capable of enduring drought and temperature variations is essential for the sustainability of Somalia's agriculture.

Agroforestry practices, including cultivating shade-providing trees, can safeguard crops from excessive heat, retain soil moisture, and alleviate the impacts of temperature fluctuations. Furthermore, augmenting agricultural extension services to provide farmers with training in water management, crop selection, and sustainable agricultural methods will be advantageous. Facilitating these services will allow farmers to use more efficient and robust techniques, hence improving overall yield.

Investing in initiatives that promote infrastructure, education, and healthcare in agricultural regions is essential for fostering an environment conducive to agricultural progress. These measures can diminish Somalia's dependence on foreign aid and enhance the resilience of its agricultural industry in the face of economic adversities. By executing these specific ideas, Somalia can cultivate a more sustainable and self-reliant agriculture industry.

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