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The Impact of Climate Change on Economic Growth in Somalia

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ABSTRACT

This study examines how Somalia's economic growth is impacted by climate change. We employ time series data from 1991 to 2022 and the ARDL (Autoregressive Distributed Lag) model to investigate the impact of temperature, CO_2 emissions, and rainfall on real GDP both in the short and long terms. The findings reveal a significant negative impact of climate change on Somalia's long-term economic growth. However, the short-term effects seem less pronounced. Based on these results, the study recommends focusing on emission reduction through sustainable practices and renewable energy, alongside developing adaptation strategies for managing rainfall variability and promoting drought-resistant agriculture. Additionally, long-term planning that incorporates climate change considerations and fosters international collaboration is crucial. While limitations like data accuracy and the exclusion of other influencing factors exist, the study offers valuable insights for policymakers and future research directions to further explore this complex relationship.

1. INTRODUCTION

Climate change represents a significant global challenge, impacting both environmental integrity and national economies worldwide [1]. Studies show a potential decrease in global GDP per capita, especially for poorer nations near the equator, heavily reliant on agriculture [2]. Sub-Saharan Africa (SSA) is particularly vulnerable due to its dependence on agriculture and lack of economic diversification [3]. Since it employs a significant portion of the population (between 70 and 80 percent), contributes substantially to the GDP (30%), and generates at least 40% of the region's income from exports, agriculture plays a critical role in this specific environment [4]. Furthermore, Somalia exemplifies this vulnerability. Water shortages put livelihoods at risk, as 94% of the population lives in poverty. Marine ecosystem disturbances provide extra risks to coastal populations [5]. The intricate interplay between the climate of Somalia and its economic structure is a fundamental element that should not be disregarded. Recurrent shocks, including a prolonged drought from 2020 to 2023, disrupted Somalia's growth, devastating crops, livestock, and exports. Somalia's development has been severely hampered by climate change, leading to widespread destruction of crops, livestock, and exports [6]. Somalia has challenges with poor economic growth, high rates of poverty, and vulnerability to climatic shocks despite initiatives like the HIPC (Heavily Indebted Poor Countries) Completion Point to combat poverty and provide jobs. These problems are made worse by climate change, endangering public health, food security, and economic stability.

This paper explores the intricate connection between Somalia's economic expansion and changing climate. We start with a thorough review of existing research followed by an analysis of Somalia's climate patterns. We then employ the ARDL Model time series technique using data from 1991 to 2022 to examine the connection between real GDP and factors like rainfall, annual CO_2 emissions, and average air temperature. Finally, we synthesize the findings and provide recommendations for policies and interventions that promote sustainable development and climate resilience in Somalia.

2. LITERATURE REVIEW

Theoretical and empirical studies consistently underscore a connection between climate change and economic growth. Investigation on Lebanon exemplifies this approach, showcasing the negative influence of climate change on economic growth through variables like carbon dioxide emissions and deforestation [7]. Research by Fankhause and Tol [8] emphasize the geographically uneven economic consequences of climate change. While some regions might experience short-term benefits, most, particularly developing countries with limited adaptive capacity, are expected to face long-term negative impacts. Rising temperatures and extreme weather events emerge as recurring threats across various studies, including those by Newell et al. [9] who highlight the detrimental impact of hot temperatures on GDP, especially in agricultural economies.

Research indicates that climate change has an adverse effect on economic progress in both the immediate and long-term, particularly in countries with limited financial resources and a significant dependence on natural resources. Studies suggest that climate change has a negative impact on the economic development of E7 nations, including China, India, and Brazil, due to rising temperatures and unexpected alterations in rainfall patterns [10]. Climate change has led to varied economic outcomes among ASEAN states. Carbon dioxide emissions have a harmful impact on economic growth, although certain factors like foreign direct investment and trade openness can mitigate some of the adverse consequences [11]. Middle-income nations, responsible for over 50% of global greenhouse gas emissions, have significant challenges in balancing climate policy with their economic growth goals. The adoption of carbon pricing and the withdrawal of fossil fuel subsidies might possibly hinder sustainable development and poverty reduction initiatives due to the resulting increase in energy costs [12]. Climate change has more pronounced socio-economic impacts on developing nations, especially those in South Asia. This highlights the need for comprehensive strategies that target the reduction of these effects [13]. Climate change in Africa has a considerable negative impact on GDP per capita. Even a one-degree increase in temperature results in huge economic losses in both the short and long term [14].

Studies focusing on Sub-Saharan Africa (SSA) by Alagidede et al. [15-17] paint a concerning picture for the region. Its heavy reliance on climate-sensitive sectors like agriculture and limited capacity to adapt leave it highly vulnerable. These studies identify potential consequences such as reduced agricultural yields, food insecurity, and infrastructure damage caused by extreme weather events, all of which pose a significant threat to economic growth.

Research on specific countries within SSA offers valuable insights into the diverse risks posed by climate change. Elshennawy et al. [18] analyze Egypt's vulnerability due to its low-lying Nile Delta and dependence on Nile River water flow, highlighting the economic consequences of climate change on agriculture, labor productivity, and sea-level rise. Similarly, studies by Ali [19] on Ethiopia's challenges with rainfall variability and, and the study of Tebaldi and Beaudin [20] on the impact of rainfall fluctuations on Brazilian states' economies showcase the agricultural sector's particular sensitivity to such variations. These studies emphasize that the specific risks posed by climate change will vary depending on a region's unique characteristics. Arndt et al. [21] examine the long-term consequences of unchecked emissions o Malawi's agriculture, infrastructure, and hydropower generation. Zhao and Liu [22] explore the differential effects of temperature across Africa's diverse climate zones, underlining the need for regionally tailored strategies. This highlights the importance of considering Somali's a specific climate zone and tailoring adaptation strategies accordingly. Kamanda et al. [23] examine the correlation between Africa's economic growth and CO_2 emissions, highlighting the necessity of policies that tackle both environmental preservation and economic development to achieve sustainable growth. Kareem et al. [24] examine the impact of climatic change, population growth rate, and economic growth on Nigeria by employing unit root tests and ARDL models. The Error Correction Model (ECM) was employed to analyze the population increase rate. The findings indicated that the rate of population increase at birth and the net migration had a favorable and negative effect on economic growth, respectively. Furthermore, a one-way relationship was discovered between the crude mortality rate and economic growth, as well as between life expectancy at birth and economic growth.

Warsame et al. [3] explore how climate change and institutional quality affect economic growth in Somalia. They analyze data from 1985 to 2017 and find that rainfall and strong institutions have a positive long-term effect on growth, while rising temperatures have a negative impact. This suggests that strengthening institutions and adopting climate-resilient strategies are crucial for Somalia's sustainable development.

The broader research findings on climate change and economic growth hold significant relevance for Somalia. Natural disasters including floods, cyclones, and droughts are common in the nation and seriously impede efforts to expand the economy. Its problems are made worse by Somalia's preponderance of extremely susceptible industries, like agriculture and animal rearing. While the reviewed studies provide valuable insights, a critical gap exists in our understanding of the specific relationship between climate change and economic growth in Somalia.

3. METHODOLOGY

3.1 Data analysis

This investigation utilizes annual data and spans the years 1991 through 2022. Since the primary problem was the availability of the data, we took availability into account while determining the time frame. A variety of data sources were consulted, with the Statistical, Economic, and Social Research and Training Center for Islamic Countries (SESRIC) providing real GDP data. The country-level temperature and precipitation data were obtained from the Climate Change Knowledge Portal (CCKP) of World Bank, while the global data on carbon dioxide emissions was sourced from Our Global Database.

The study evaluates the real GDP as a dependent variable, while the study utilizes various independent variables, specifically Annual Precipitation (RAIN), Annual CO_2 emissions (CO_2), and Annual Average Mean Surface Air Temperature (TMP), to examine their associations with the dependent variable.

The selection of climate change indicators such as temperature, CO_2 emissions, and rainfall in Somalia is based on their significance in comprehending and evaluating the effects of climate change. Temperature monitoring is essential for comprehending the process of glacier melting, influencing the occurrence of droughts, and altering agricultural production. Measuring CO_2 emissions facilitates the identification of human activities that contribute to climate change, therefore guiding policymakers in promoting sustainable development. Analyzing rainfall helps in comprehending climatic variability and patterns, facilitating the development of climate-resilient approaches in agriculture, water resource management, and disaster planning.

However, it is crucial to recognize the constraints associated with the accuracy comprehensiveness, and uniformity of the data. This might have influenced the analysis and the generalizability of the findings.

3.2 Estimation techniques

The study used Unit root tests to identify patterns, and determine if variables are stationary or require differentiation. The Augmented Dickey-Fuller (ADF) test will be used to determine if variables are stationary, and the Akaike Information Criterion (AIC) will be used to estimate the Autoregressive Distributed Lag (ARDL) model, which allows for examination of long-run and short-run relationships between variables in both stationary and non-stationary time series. Finally, the model's validity will be assessed using diagnostic tests like autocorrelation, heteroscedasticity, and normality tests, providing a systematic method for analyzing climate change and economic growth in Somalia, considering data's time series properties and diagnostic checks.

Following the empirical work of Warsame et al. [3] and Ali et al. [25], the ARDL cointegration equation can be written as:

$$\Delta \mathrm{LGDP_t} = \alpha_0 + \beta_1 \mathrm{LRAIN_{t-1}} + \beta_2 \mathrm{L}CO_{2\,t-1} + \beta_3 \mathrm{LTMP_{t-1}} + \sum_{i=0}^{p} \Delta\alpha_1 \mathrm{LRAIN}_{t-k} + \sum_{i=0}^{p} \Delta\alpha_2 \mathrm{L}CO_{2\,t-k} + \sum_{i=0}^{q} \Delta\alpha_3 \mathrm{LTMP_{t-k}}$$

The variables in this example are: α_0 is the constant; α_1–α_3 are the coefficients of the short-run variables; β_1, β_2, and β_3 are the elasticities of the long-run parameters; Δ is the first difference sign that shows the short-run variables; ε_t is the error term; q indicates the explained optimal lags; p shows the optimal lags of the explanators.

The ARDL co-integration approach initiates with bound testing and then proceeds to perform regression analysis using Ordinary Least Squares (OLS). The null hypothesis, H0: $\beta_1=\beta_2=\beta_3=\beta_4$, states that the variables do not show co-integration in the long term. On the other hand, the alternative hypothesis, H1: $\beta1\neq\beta2\neq\beta3\neq\beta4\neq0$, proposes that the variables are co-integrated in the long term. The null hypothesis was assessed using the Wald-F statistics and critical values. If the Wald F statistics surpass the upper bound critical values, the null hypothesis is rejected, demonstrating a persistent relationship between the variables. If the Wald F statistics do not exceed the upper bound critical values, then the null hypothesis is accepted, indicating that there is no long-term relationship between the variables.

The following can be used to quantify the empirical specifications for the model:

$$\mathrm{LGDP_t} = \beta_0 + \beta_1 \mathrm{LRAIN_t} + \beta_2 \mathrm{L}CO_{2\,t} + \beta_3 \mathrm{LTMP_t} + \varepsilon_t$$

where, $\mathrm{LGDP_t}$ the dependent variable, and $\mathrm{L}CO_{2\,t}$, $\mathrm{LTMP_t}$ and $\mathrm{LRAIN_t}$ are the explanatory variables in year t, ε_t is the error term, and β_0, β_1, β_2, and β_3 are the elasticities to be estimated.

4. RESULTS AND DISCUSSION

4.1 Unit root tests

The primary objective of analyzing time series data is to ensure that the variables exhibit stationarity, as they may be affected by a unit root problem that might lead to misleading results. The test is employed to ascertain the presence of a unit root problem in the variables. The null hypothesis of the Augmented Dickey-Fuller (ADF) test indicates the presence of a unit root issue, whereas the alternative hypothesis indicates its absence.

The presented Table 1 displays the results of unit root tests run on different variables. These tests are employed to determine whether a time series variable is stationary or has a unit root, indicating non-stationary. The table has two levels of testing: "Intercept" and "Trend & Intercept". The "Intercept" column presents the outcomes of the unit root tests without accounting for a trend, while the "Trend & Intercept" column includes a trend component in the unit root test. Additionally, the table displays the variables being analyzed: "LGDP", "LCO_2", "LTMP", and "LRAIN".

The findings derived from the ADF results in Table 1 reveal that the variables LTMP and LRAIN are stationary at level, meaning they are integrated of order one and do not show any systematic patterns over time. LGDP and LCO_2 are stationary at first differences, meaning they have a constant mean and variance over time after taking the first difference, The outcomes of the ADF test establish that all variables are integrated in a first order and second order, which means mixed results. The next step entails determining the ARDL co-integration among variables.

4.2 VAR lag order selection criteria

The optimal delays for the ARDL model were established using the widely employed Akaike Information Criterion (AIC). The ideal lag length selection for the unconstrained Vector Autoregressive (VAR) model is presented in Table 1, utilizing metrics such as LogL, LR, FPE, AIC, SC, and HQ. The AIC criterion identified the first lag as the optimal lag for the model.

4.3 Cointegration tests

To investigate an unconstrained model, the study used the Autoregression Distributed Lag (ARDL) technique cointegration test. In order to assess the joint hypothesis that the lagged long-run parameters are all equal to zero, it uses the F-test (Table 2). The results are displayed in Table 3 that is provided below. The findings corroborate the statistical demonstration of the variables' long-term cointegration. The results show that, at the 5% significance level, the computed F-statistics of 11.43032 are more than the critical value, which is 3.67. The results indicate a long-term relationship between climatic change and economic expansion in Somalia; comparable study conducted in other nations produced similar conclusions [25, 26].

4.4 ECM and short run estimation with diagnosis

Table 4 shows that Prob. (0.3809) of ECM was statistically insignificant, revealing no short-term correlation between climate change and economic growth.

The study reveals that rainfall has a negative impact on short-term economic growth; Excessive rainfall can lead to flooding and infrastructure destruction which can affect negatively on economic growth. A positive correlation was found between CO_2 emissions and economic growth in the short term, but this association was not statistically significant. This suggests that the direct effect of CO_2 emissions on economic growth may not be evident throughout the study period. The study also found a positive but insignificant relationship between temperature and economic growth in the short run, suggesting that temperature fluctuations may not immediately affect economic growth. However, prolonged temperature rises can significantly impact sectors like agriculture, energy, and human health.

Table 1. Unit root test

VARIABLS	ADF			
	Level		First Difference	
	Intercept	Trend and Intercept	Intercept	Trend and Intercept
LGDP	0.166261	-3.106490	-4.334495***	-4.270947**
LCO_2	-1.837577	-3.005897	-4.396358***	-4.636218***
LTMP	-3.618660**	-5.293061***	-8.340838***	-8.201542***
LRAIN	-4.794319***	-6.413944***	-10.14779***	-9.972417***

Notes: *, **, *** indicate significance at 10, 5 and 1 per cent respectively
Sources: Computed by authors (2024)

Table 2. Lag length selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	158.8181	NA	3.87e-10	-10.32121	-10.13438	-10.26144
1	256.2368	162.3644*	1.72e-12*	-15.74912*	-14.81499*	-15.45028*
2	269.5537	18.64375	2.19e-12	-15.57025	-13.88881	-15.03234

* Indicates lag order selected by the criterion

Table 3. F-statistics bound tests

	Lower Bound I (0)	Upper Bound I (1)
10%	2.37	3.2
5%	2.79	3.67
2.5%	3.15	4.08
1%	3.65	4.66
ARDL F-statistics	Wald F-stat 11.43032**	

Notes: *** 1% significance level, **5% significance level, *10% significance level
Sources: Computed by authors (2024)

Table 4. ECM and short run estimation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D (LRAIN (-1))	-0.031401	0.121598	-0.258234	0.7983
D(LCO_2(-1))	0.304703	0.335603	0.907928	0.3726
D (LTMP (-1))	1.193081	2.077253	0.574355	0.5709
ECM (-1)	0.041999	0.047087	0.891947	0.3809

Sources: Computed by authors (2024)

4.5 Diagnosis and stability tests

Table 5 presents the findings of the diagnostic examination; the results of the tests of the validity and stability of the model are presented.

Table 5. Diagnostic results

Diagnostic Results		
	F-statistic	Prob.
Serial Correlation	0.2622	0.2039
Heteroskedasticity	0.5562	0.5401
Normality	2.105195	0.349030

Sources: Computed by authors (2024)

The Jarque-Bera statistic was used to test for normality, with the result of the probability value of 0.349030% for the residuals in the regression; therefore, we accept the null hypotheses that the data is normally distributed. The ARCH statistic test was used to test for Homoscedasticity with the result of the probability chi-square value of (0.5401) for the residuals in the regression; therefore, we accept the null hypotheses that the data is Homoscedasticity. And the LM serial correlation test is used to detect the presence of serial correlation in a regression model. The probability chi-square value equal 0.2039; therefore, we accept the null hypotheses which indicates there is no serial correlation in the regression model.

The findings indicate that the ARDL model does not exhibit any issues related to serial correlation, heteroscedasticity, model misspecification, or concerns regarding normality.

Moreover, the stability of the coefficients in the ARDL model is verified for the entire sample period by employing the CUSUM and CUSUM-square tests. A visual depiction of these results is available in Figure 1 and Figure 2.

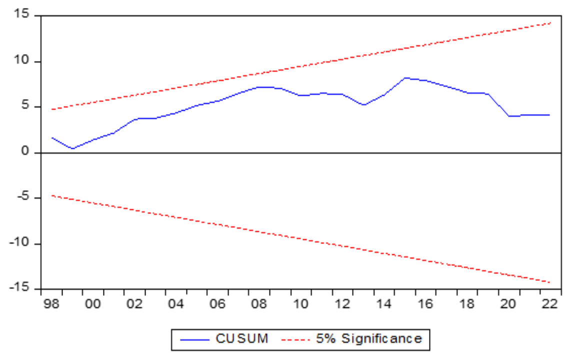

Figure 1. CUSUM test

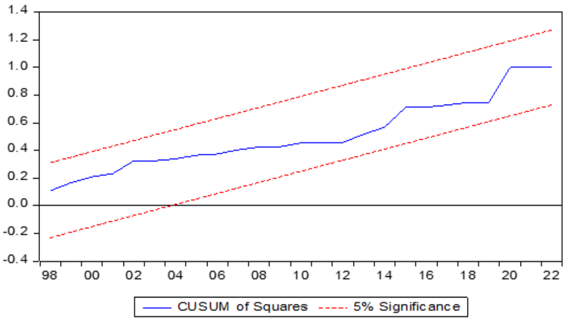

Figure 2. CUSUM squares test

5. CONCLUSION AND POLICY IMPLICATIONS

Somalia's infrastructure, resources, and agricultural yield have been significantly impacted by climate change since 1991. This study employed time series data from 1991 to 2022. The estimation applied Autoregression Distributed Lag (ARDL) model to examines the short and long run relationship between climate change, and other independent variables. The econometric model includes: unit root test, Akaike Information Criterion (AIC), cointegration tests using f-statistics bound tests, ECM short run tests and diagnosis tests. The ADF test confirms that LTMP and LRAIN at level, with unit roots. Other variables, like LGDP and LCO_2 are stationary at first differences, with unit roots of order two, which means the outcomes are mixed with first order I (0) and I (1). The AIC criterion identified the first lag as the optimal lag for the model. ARDL f-statistics bound test finding demonstrated there is existence long run relationship between climatic change and economic growth in Somalia. Diagnostic tests confirmed the model's reliability by demonstrating the absence of serial correlation, heteroscedasticity, and normality issues. Additionally, CUSUM and CUSUM of squares tests confirmed the model's stability. These findings align with research from other countries, lending credence to the results.

Based on the empirical findings, the study suggests that Somalia should invest in renewable energy, reduce greenhouse gas emissions, improve water management, and drought-resistant agriculture, and implement infrastructural development to mitigate the economic effects of climate change. It also recommends long-term planning and collaboration with decision-makers to incorporate climate change forecasts into economic development plans, implement robust infrastructure projects, and promote sustainable business practices.

The study utilized data from various sources, but it is crucial to acknowledge the limitations in terms of accuracy, completeness, and consistency. This might have affected the analysis and how widely the findings can be applied. The study focused on climate change variables, but other factors like political instability, policy changes, technological advancements, and global economic trends can also influence economic growth. A more comprehensive understanding might require incorporating these additional variables in future research.

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