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Towards Sustainable Environment in Somalia: The Role of Urbanisation and Energy Consumption

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ABSTRACT

In this study, we investigated the role of the urban population and energy consumption on environmental degradation in Somalia. The study used the ARDL model and Granger causality test with time-series data from 1989 to 2021. The study found that increasing the urban population and domestic investment positively influenced environmental degradation in the short and long run. If the urban population increases, environmental damage will increase as they use more carbon dioxide emissions. Similarly, increasing domestic investment also contributes to environmental degradation. The study also found a causal effect between the urban population and domestic investment, while the urban population and energy consumption caused domestic investment. Moreover, there was a bidirectional causal effect between urbanization and energy consumption. Based on these results, policymakers are recommended to prioritize the development of urban planning and regulatory institutions that focus on environmental consciousness to guide sustainable urban growth. This should include measures to control pollution, preserve green spaces, and promote energy-efficient practices. Furthermore, targeted policies are needed to support domestic investment while ensuring it aligns with environmental preservation goals. Incentives for adopting eco-friendly industries and technologies can be explored to balance economic growth with environmental protection.

Keywords: Energy Consumption, Urbanisation, Environmental Quality, Domestic Investment, Somalia
JEL Classifications: C22, Q41, Q53, R11

1. INTRODUCTION

Regarding urbanization, the beginning of the twenty-first century marked a historical transformation, with half of the world's population currently residing in urban regions or centers (Muhammad et al., 2021). This tremendous shift has significantly strained both individual life and the natural environment (Jermsittiparsert, 2021). Environmental sustainability is humanity's most pressing issue (Khan and Hou, 2021; Tawiah et al., 2021). Human activities harm the environment and the availability of basic human needs such as food, water, shelter, clean energy, and pollution-free air. Rising demand for clean energy, infrastructure, water, nutrition, and other services stresses the environment through increasing emissions, depleting resources, and distorting economic and environmental systems (Ahmed et al., 2019).

The most noticeable global environmental change event occurring at both geographical and temporal dimensions is land use and land cover change (Muluneh, 2010). Urban growth, the loss of natural plants, and the presence of open spaces are issues that most big cities deal with due to urbanization and development-related activities (Burchell and Mukherji, 2003). Rapid and uncontrolled urbanization contributes to environmental issues, uncomfortable living circumstances, and the haphazard expansion of cities (Gebregergis et al., 2016). The significant rise of cities in Africa, Asia, and Latin America throughout the previous century, combined with a lack of attention on urban regulatory institutions for environmental protection, has contributed to significant environmental deterioration(Gebregergis et al., 2016). According to (UN-HABITAT, 2011), major urban environmental and biodiversity difficulties will emerge shortly due to substantial population expansion in such locations (global south) due to their underdeveloped, formal administration and planning institutions. The increasing environmental deterioration and its wide-ranging effects, which range from health issues to poverty, the problem of climate change, and global warming, have attracted much attention (Weber and Sciubba, 2019). According to a studies conducted by (IPCC, 2001; Solomon et al., 2007), there is a connection between the worldwide trend of urbanization, the emission of greenhouse gases, and the changing ecological temperature. This issue severely impacts the marginalized populations of Asia, Africa, and Southern Europe.

Somalia is regarded as one of Africa's fastest-urbanizing countries. Its urban population is projected to be 6.45 million, accounting for 45% of the overall population. It is also increasing at a rapid yearly average rate of 4.2%. According to the UN Department of Economic and Social Affairs, Somalia's urban population will surpass the rural population by 2026 (Dyfed and Luciana, 2019). (Aubrey & Cardoso, 2019). On the other hand, Somalia faces significant challenges, including widespread poverty, food insecurity, and vulnerability to environmental shocks (Pape & Karamba, 2019).

Urbanization and environmental degradation represent two intertwined facets of contemporary global challenges, and their dynamics hold particular significance in the context of Somalia. In the Horn of Africa, Somalia has experienced remarkable urbanization over recent decades. This phenomenon is driven by factors such as population growth, conflict-induced displacement, and economic aspirations, which have transformed the landscape and socio-economic fabric of the country. However, this rapid urbanization has not occurred in isolation but is intricately linked with environmental degradation, which is multifaceted and driven by various factors. Land degradation is one of the most pressing concerns, including desertification and soil erosion. Prolonged droughts and deforestation exacerbate these problems, leading to Somalia's loss of arable land and food insecurity (FAO, 2019). Somalia's coastal areas are also vulnerable to environmental degradation, with overfishing, habitat destruction, and pollution threatening marine ecosystems and livelihoods (UNDP, 2017). The growing urbanization in Somalia offers considerable environmental issues, prompting an in-depth examination of the urbanization-environmental nexus. As the country's urban population, domestic investment, economic growth, and energy consumption increase, they contribute to environmental deterioration. Therefore, this study aims to examine urbanization and environmental nexus in Somalia using the ARDL model.

2. LITERATURE REVIEW

Urbanization, characterized by the growth of cities and the shift of populations from rural to urban areas, is a global phenomenon driven by industrialization and economic development. This process has far-reaching implications for energy consumption, domestic investment, and environmental degradation. Here, we review key findings from the literature regarding these interrelated factors.

Previous research has shed light on the intricate relationship between urbanization and environmental degradation, revealing bidirectional causality (Iheonu et al., 2021; Warsame et al., 2023). Studies conducted by (Uttara et al., 2012; Yang and Khan, 2022) have corroborated these findings by highlighting the detrimental effects of urbanization on the environment. Concentrating people and economic activities in urban areas increases pollution, waste generation, and resource consumption. These factors contribute to environmental degradation, including air and water pollution (Castro et al., 2021). The Environmental Kuznets Curve (EKC) theory, proposed by Beckerman (1992) offers insights into the complex dynamics between urbanization and environmental quality. The EKC hypothesis suggests that in the early stages of urban development, characterized by increased economic activity and industrialization, environmental degradation tends to rise due to the depletion of natural resources and the accumulation of waste. This phase often exhibits a positive association between per capita income and per capita environmental deterioration. However, as economies progress, factors such as improved technology, service-oriented industries, and information dissemination contribute to a reduction in environmental degradation (Angshuman, 2014). Thus, urbanization, as a driver of economic growth, can influence the environment in a manner consistent with the EKC theory.

Another critical factor in the urbanization-environmental nexus is domestic investment, which plays a pivotal role in a nation's economic development. Domestic investment involves channeling resources into one's own companies and goods, fostering economic growth, and driving the economic cycle. (Liu et al., 2019) investigate the impact of domestic investment on the environment in China. The authors aimed to determine whether domestic investment, often considered a catalyst for economic growth, has a positive or negative effect on the environment. They empirically analyzed the relationship between China's investment patterns, industrial structures, and environmental quality. The research sheds light on the environmental implications of economic activities fueled by domestic investment, providing valuable insights into the environmental challenges associated with rapid economic development and industrialization in China. Bekoe et al. (2023) investigated the relationships among domestic investment, energy consumption, carbon dioxide (CO_2) emissions, and economic growth in Ghana. Employing a multivariate time series analysis, the study examines the dynamic interactions between these variables to better understand their collective impact on sustainable development. The findings highlight the significance of domestic investment as having hostile relations with CO_2 emissions in the long and short run, while energy consumption has a positive relation with environmental degradation. The study underscores the importance of Ghana's sustainable investment strategies and energy policies to achieve economic development while minimizing environmental degradation.

Energy consumption, an integral part of urbanization, contributes to environmental degradation. Energy consumption encompasses using energy for various purposes, including powering homes, industries, and transportation systems. However, this consumption often results in environmental harm, including greenhouse gas emissions, air pollution, habitat destruction, and water contamination (Mufutau Opeyemi, 2021).

Energy consumption, particularly from non-renewable sources show a positive impact on CO_2 emissions in the long run (Khan and Khan, 2024; Salari et al., 2021), Other studies have also revealed that energy consumption and economic growth cause CO_2 emissions in the short and long run (Acuña-Ascencio et al., 2024). The study conducted by Abbasi et al. (2024) examined the association between energy transition, fossil fuel energy, green innovation, and the economic complexity index on CO_2 emissions and the ecological footprint in the United States using the ARDL model. Their empirical evidence indicated that energy transition and fossil fuel energy contribute to increased CO_2 emissions and ecological footprint. At the same time, green innovation has a mitigating effect on these environmental impacts, though only in the long term.

Studies employing the ARD model, such as the one conducted by Saudi et al. (2019), have established a positive and significant impact of energy consumption on environmental degradation, highlighting the importance of sustainable energy practices in urban areas. Kongkuah et al. (2022) investigated the relationship between energy consumption, economic growth, and environmental degradation in China. They use rigorous empirical analysis to investigate whether the increase in energy consumption during economic growth contributes to environmental deterioration, as demonstrated by environmental quality indicators. This research significantly contributes to the ongoing discussion about the environmental impact of energy utilization and economic growth, providing valuable insights into the challenges that rapid industrialization and urbanization pose to China. The study informs policymakers and researchers about the potential trade-offs and policy interventions necessary to balance economic development with environmental sustainability. A study conducted by Aslan et al., (2024) investigated the intricate relationship between economic policy uncertainty, renewable energy consumption, economic growth, and CO2 emissions in G7 countries. The authors found that energy consumption has led to an increase in CO_2 emissions in these countries. Additionally, they identified a U-shaped relationship between economic growth and emissions in G7 countries. Their study emphasizes the urgent need for consistent and transparent energy policies to facilitate the shift to renewable energy sources and alleviate the impacts of climate change.

The urbanization process profoundly influences the environment, with research indicating both positive and negative interactions. The EKC theory sheds light on the evolving dynamics between urbanization and environmental quality as economies progress. Additionally, the role of domestic investment and energy consumption in shaping the urbanization-environmental nexus is crucial, underscoring the need for sustainable urban development practices to mitigate environmental degradation in rapid urbanization. Further examination of these interrelationships in specific regional contexts, such as Somalia, is essential to inform effective policy measures and promote environmental sustainability.

3. METHODOLOGY

3.1. Data

This study investigates the role of urbanization and environmental degradation in Somalia, using yearly time series data from 1989 to 2021. World Bank and SESRIC are the data sources used in this study. To investigate how urbanisation, which contributes to economic growth, affects the environment, we have used the ARDL model, which is considered one of the best models for short and long-term analysis and suitable for urban population and energy consumption (Bentzen & Engsted, 2001; Nasrullah et al., 2021). Environmental degradation is the dependent variable of this study, and we have measured it using deforestation (percentage of arable land). Meanwhile, the proportion of the urban population to the total population has been considered an independent variable to measure urbanization. We have also used Gross Fixed Capital Formation, measured by domestic investment at current prices, and per capita primary energy consumption (kWh/person) to measure energy consumption as independent variables.

3.2. Economic Modeling

Our main objective in this study is to specify a linear relationship between urban population (UP), domestic investment (DI), and energy consumption (EC) on environmental degradation (ED), as we express in equation 1:

$$ED=f(UP,EC,DI) \tag{1}$$

The regression model in Equation 1 indicates that environmental degradation is a function of urbanization, domestic investment, and energy consumption. In Equation 2, we transformed the regression model into the regression equation.

$$ED_t = \beta_0 + \beta_1 UP_t + \beta_2 EC_t + \beta_3 DI_t + \varepsilon_t \tag{2}$$

Where ED_t represents environmental degradation, UP_t is the urban population, EC_t is the energy consumption, and DI_t is the domestic investment. β_0 is the intercept. β_1, β_2, and β_3 are the coefficients representing the long-run effects of urban population, domestic investment, and energy consumption on environmental degradation, respectively. ε_t is the error term.

In equation 3, all the variables in this study were used in log form to avoid diagnosis problems such as misspecification, heteroscedasticity, and autocorrelation (Hassan and Mohamed, 2024; Warsame et al., 2022; Warsame et al., 2023).

$$LED_t = \beta_0 + \beta_1 LUP_t + \beta_2 LEC_t + \beta_3 LDI_t + \varepsilon_t \tag{3}$$

This study is going to utilize the Autoregressive distributed lag model (ARDL) and Granger causality to analyze the long-run and short-run effects of Urban population, Domestic Investment, and Energy Consumption on Environmental Degradation and Granger causality to identify the causal relations between the estimated variables. Before using ARDL, we have to test whether all variables are stationary at level I(0) or deference I(1). After ensuring consistency of stationarity by using the Augmented Dickey-Fuller (ADF) unit root test, we can employ the ARDL model. Thus, Equation 4 can be expressed as follows:

$$\Delta LED_t = \beta_0 + \beta_1 \Delta LED_{t-1} + \beta_2 \Delta LUP_{t-1}$$
$$+ \beta_3 \Delta LEC_{t-1} + \beta_4 \Delta LDI_{t-1} + \sum_{i=1}^{p} {}_i \Delta \text{LED}_{t-1}$$
$$+ \sum_{i=1}^{q} \gamma_i \text{ÄLUP}_{t-1} + \sum_{i=1}^{r} \delta_i \text{ÄLEC}_{t-1} + \sum_{i=1}^{s} \theta_i \text{ÄLDI}_{t-1} + \mu ECT_{t-1} \tag{4}$$

Where Δ is the first difference operator; *p, q, r,* and *s* are the lag lengths for each variable, which you can determine empirically or through model selection criteria; β_0 is the intercept; ECT_{t-1} is error correction term; β_1, β_2, β_3, β_4, and α_i, γ_i, δ_i, θ_i, are the long run and short run coefficients of the model, respectively.

4. EMPIRICAL RESULTS

4.1. Descriptive Statistics

The variables in Table 1 have interesting descriptive statistics that provide valuable insights. LNED has a right-skewed distribution with a mean of −0.496 and a leptokurtic shape with a high kurtosis of 6.886, indicating heavy tails. In contrast, LNUR has a nearly symmetric distribution with a mean of 15.132, resembling a platykurtic shape with a kurtosis of 1.723. LNENC, with a mean of 5.719, demonstrates a right-skewed distribution similar to LNED, with a kurtosis of 5.993. LNDI has a left-skewed distribution with a slightly negative skewness of −0.400 and a mesokurtic shape, having a mean of 19.919. According to the Jarque-Bera tests for normality, LNED and LNENC deviate from normality, while LNUR and LNDI approximate normal distributions. Moving to the correlation matrix n the backside of Table 1, LNUR shows a weak negative correlation (−0.074) with LNED, suggesting a slight inverse relationship between urban population and environmental degradation. LNENC has a moderate positive correlation (0.459) with LNED, indicating that higher energy consumption tends to coincide with increased environmental degradation, and LNDI has a negative relationship (−0.263) with LNED, indicating that higher domestic investment tends to coincide with decreased environmental degradation. On the other hand, LNUR has a strong positive correlation (0.871) with LNDI, revealing a robust relationship between urban population and domestic investment. Additionally, LNDI displays a moderate negative correlation (−0.720) with LNENC, implying that greater domestic investment may coincide with lower energy consumption.

Table 1: Descriptive statistics and correlation

Variables	LNED	LNUR	LNENC	LNDI
Mean	−0.496	15.132	5.719	19.919
Median	−0.494	15.151	5.713	19.939
Maximum	−0.051	15.892	6.459	20.941
Minimum	−0.734	14.484	5.357	18.662
SD	0.123	0.450	0.230	0.555
Skewness	1.026	0.100	1.389	−0.400
Kurtosis	6.886	1.723	5.993	2.629
Jarque-Bera	26.557	2.298	22.929	1.069
Probability	0.000	0.317	0.000	0.586
Correlation				
LNED	1.000			
LNUR	−0.074	1.000		
LNENC	0.459	−0.801	1.000	
LNDI	−0.263	0.871	−0.720	1.000

4.2. Unit Root Test

When analyzing time series data, it is crucial to ensure the stability of the variables as a unit root problem may impact them, leading to false results. Phillips-Perron (PP) and Augmented Dickey-Fuller (ADF) tests are commonly used to determine the presence of a unit root issue. The null hypothesis of these tests assumes that a unit root exists, while the alternative hypothesis argues otherwise. Rejecting the null hypothesis of non-stationarity occurs when a variable's t-statistic is higher than the assigned crucial t-value. This leads to the conclusion that the data are stationary. The unit root test results presented in Table 2 indicate that all the sampled variables are stationary at the first difference (1). However, some have a unit root problem at level I (0).

Table 2: Unit root test

Test type	At LEVE variables			
	LNED	LNUR	LNENC	LNDI
PP				
With Constant	−4.327***	1.326	−3.632**	−0.261
With Constant and Trend	−4.864***	−13.448***	−4.652***	−2.765
ADF				
With Constant	−4.893***	0.334	−3.604**	−0.908
With Constant and Trend	−2.254	−6.094***	−4.489***	−3.172
	At First Difference Variables			
	d (LNED)	d (LNUR)	d (LNENC)	d (LNDI)
PP				
With Constant	−6.307***	−3.903***	−4.875***	−5.895***
With Constant and Trend	−6.316***	−3.999**	−5.051***	−5.492***
ADF				
With Constant	−6.418***	−4.813***	−4.902***	−4.849***
With Constant and Trend	−6.398***	−4.571***	−5.051***	−4.793***

(*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%

4.3. Bounds Test

Once our data has been confirmed as stationary, it becomes critical to determine whether any long-term connections exist between LED, LUR, LEC, and LDI. In this study, we have utilized the Bounds Test, specifically the F-Bounds Test, to accomplish this. According to the results found in Table 3, the F-statistic value (12.57) surpasses the lower and upper critical values at various significance levels (10%, 5%, and 1%). This indicates that we can confidently reject the null hypothesis, which suggests no cointegration between the estimated variables in this study. We acquire evidence supporting a long-term relationship between the estimated variables by rejecting the null hypothesis at these significance levels.

Table 3: Bounds test

F-bounds test				
Test statistic	Value	Sign if.	I (0)	I (1)
F-statistic	12.56510***	10%	2.72	3.77
K	3	5%	3.23	4.35
		1%	4.29	5.61

(***) indicates the level of Significant at the 1%

4.4. ARDL Outcomes

Since we indicated using the ARDL model by Bound test, our next important step was determining and explaining the effects of LUR, LEC, and LDI on LED. The findings in Table 4 provided the short

Table 4: ARDL long and short run outcomes

Variable	Short run			Long run		
	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.
LNUR	0.150***	3.331	0.003	0.338	3.788***	0.001
LNENC	0.044	0.560	0.581	0.098	0.582	0.565
LNDI	−0.080***	−2.854	0.008	−0.180	−2.930***	0.007
ECM_{t-1}				−0.444***	−7.487	0.000
Diagnostic Tests						
R^2	0.851					
R^{-2}	0.822					
LM Test	1.000 (0.606)					
Heteroscedasticity Test	1.995 (0.850)					
Normality Test	0.491 (0.782)					

(***) indicates the level of Significant at the 1%

and long run between the estimated variables of the study. The results from the ARDL model indicate that the urban population (LUR) has a positive and significant impact on environmental degradation in the short and long run. Suggests that a higher value of LUR is associated with an increase in environmental degradation on average 15% in the short run and 33% in the long run, while other things were constant. Energy Consumption (LENC) indicates no relationship between LENC and environmental degradation in the short and long run since it is insignificant. Domestic Investment (DI) has a negative with a significant effect of no environmental degradation both in the short and long run, which indicates a higher value of LDI is associated with a decrease in environmental degradation of the model on average −8% in the short run and 18% in the long run, while other things were constant. ECT_{t-1} refers to the error correction term lagged by one period. This term captures the adjustment process towards long-run equilibrium. A significant and negative coefficient implies that environmental degradation adjusts towards its long-run equilibrium value in the short run. The ECT value of 0.44 suggests that the variables are cointegrated, indicating that the model can adjust at a speed of 44% to achieve long-term equilibrium in environmental degradation due to the explanatory variables. This finding highlights the model's ability to accurately capture the impact of LUR, LENC, and LDI variables on environmental degradation. Additionally, the study conducted a soma diagnosis. The outcomes in the backside of Table 4 explain that there is no heteroscedasticity or autocorrelation and that data is normally distributed. Additionally, Figures 1 and 2 indicate that the ARDL coefficients remained stable throughout the observed period, as confirmed by the CUSUM and CUSUM-square tests.

Figure 1: CUSUM test

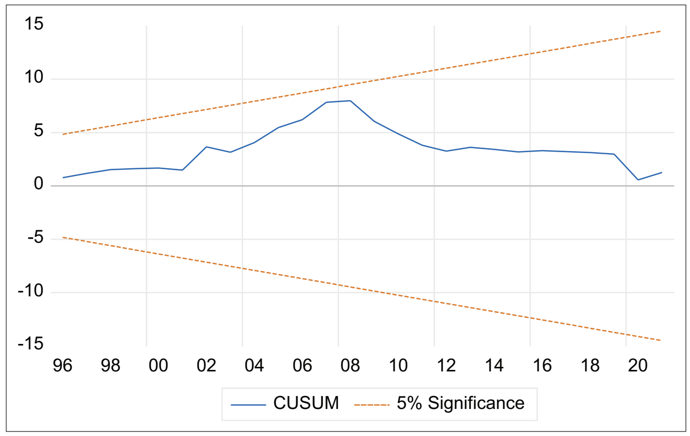
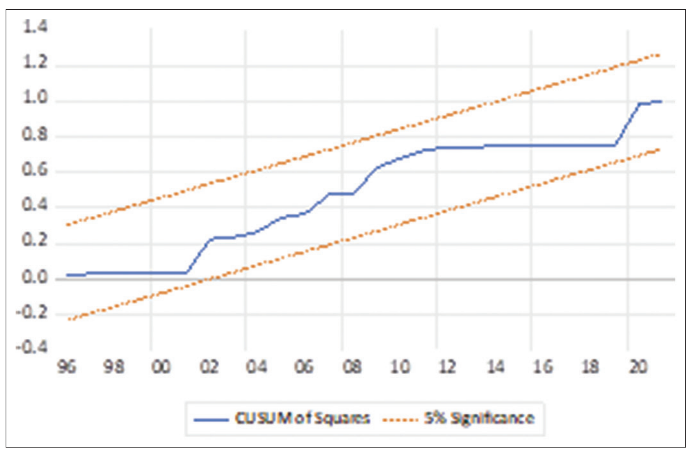


Figure 2: CUSUMSQR test



4.5. Granger Causality test

Table 5 presents the results of a Wald Test for causality among the estimated variables in this study. The outcomes showed that Urban Population has a unidirectional causal effect on LNED and LNDI, implying that changes in urban population influence environmental degradation and energy consumption. LNUR also has a bidirectional causal effect on LNENC. It means increasing urbanisation causes more energy consumption, which causes urbanisation. Energy Consumption has a unidirectional causal effect on LNDI (at the 5% significance level). This suggests that changes in energy consumption influence domestic investment. In contrast, LNENC does not exhibit a significant causal effect on LNUR and LNED. However, Domestic Investment has a statistically significant unidirectional causal effect on LNED (at the 1% significance level). This implies that changes in domestic investment influence environmental degradation. Environmental Degradation has a statistically significant unidirectional causal effect on LNENC (at the 1% significance level). This suggests that changes in environmental degradation influence energy consumption. However, LNED does not exhibit a significant causal effect on LNUR and LNDI. The results indicate that urban population and domestic investment cause environmental degradation, while urban population and energy consumption cause domestic investment. Additionally, energy consumption is influenced by environmental degradation. Finally, there is a bidirectional causal effect between urbanization and energy consumption.

Table 5: Wald test causality

Dependent variables	LNED	LNUR	LNENC	LNDI
LNED	1.000	6.178***	0.313	8.144***
LNUR	0.038	1.000	3.846**	0.341
LNENC	12.005***	26.220***	1.000	0.154
LNDI	2.298	2.769*	3.599**	1.000

(*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%

According to this study, growing urban population and domestic investment had a favorable short-and long-term impact on environmental deterioration. Warsame et al., (2023) discovered that urban population had a favorable impact on both short and long-term environmental damage. As the urban population grows, so does the need for housing, transportation, and infrastructure, resulting in increased energy consumption and CO_2 emissions. Liu et al.,(2019) discovered causal linkages between the urban population and domestic investment, as well as between the urban population and energy consumption. Gasimli et al., (2019) discovered that energy use causes carbon emissions in both the long and short term, providing further evidence for these connections, Furthermore, the bidirectional causal relationship between urbanization and energy consumption emphasizes these components' interconnectedness. According to a study conducted by (Verbič et al., 2021) energy usage has not alleviated the issue of the environment. There is unidirectional causation going from urbanization to energy consumption, according to (Zhao and Wang, 2015).

5. CONCLUSION

The rapid urbanization experienced by Somalia, like many other regions around the world, has significant implications for its environment. As urban centers grow, driven by population expansion and economic aspirations, the delicate balance between urbanization and environmental sustainability becomes increasingly critical. Our study has shed light on the intricate interplay between urbanization, domestic investment, energy consumption, and environmental degradation in the Somali context. Urbanization has substantially influenced environmental degradation, with urban population growth contributing to increased environmental pressure. However, the relationship is not one-dimensional, and the impact of domestic investment and energy consumption plays a pivotal role. Domestic investment has emerged as a critical factor, with evidence suggesting it can reduce environmental degradation. This finding underscores the importance of sustainable investment strategies to achieve economic growth while minimizing environmental harm. Energy consumption, integral to urbanization, poses a dual challenge. On one hand, it fuels economic development and urban growth, but on the other, it significantly contributes to environmental degradation. Policymakers must balance energy usage and environmental sustainability, emphasizing adopting sustainable energy practices to mitigate adverse effects. Our study has also highlighted complex causal relationships among these variables, with urbanization and domestic investment causing environmental degradation, while urbanization and energy consumption influence each other. These findings emphasize the need for a holistic and integrated approach to urban planning and environmental management in Somalia.

In light of these conclusions, we offer several recommendations. Firstly, Somali policymakers should prioritize the development of environmentally conscious urban planning and regulatory institutions to guide sustainable urban growth. This includes measures to control pollution, preserve green spaces, and promote energy-efficient practices. Secondly, there is a need for targeted policies that encourage domestic investment while ensuring it aligns with environmental preservation goals. Incentives for eco-friendly industries and technologies can be explored to balance economic growth and environmental protection. Thirdly, energy policies should focus on adopting renewable and clean energy sources, reducing reliance on fossil fuels, and minimizing their environmental impact. Investments in energy-efficient infrastructure can further contribute to sustainability. Lastly, further research into Somalia's regional and localized environmental challenges is essential to develop context-specific strategies for mitigating environmental degradation. Collaboration between government bodies, researchers, and international organizations is crucial to address these challenges comprehensively.

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