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GREENHOUSE GAS EMISSIONS AND HUMAN DEVELOPMENT: IMPLICATIONS FOR CLIMATE CHANGE IMPACTS IN AFRICA

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ABSTRACT

This study examined the effects of greenhouse gas (GHG) emissions on human development, particularly focusing on its impacts on the human development in Africa. The paper first discussed the trends in global GHG emissions and human development, and subsequently adopted the ARDL estimation technique to examine the effects of GHG emissions on human development in Africa from two perspectives. This involved examining and comparing the effects of GHG emissions from African countries and that from the rest of the world (ROW) on the human development in the region at two periods in time. Results showed that GHG emissions from Africa and from the ROW are increasing. Moreover, both have the same effects on human development in Africa in two periods in time. These effects were positive and significant in the short run, and negative and significant in the long run. The former implies that as GHG emissions increase in the short run, human development improves. Conversely, the latter means that as GHG emissions increased in the long run, human development retards. The comparative analysis showed that, in the short run, GHG-emitting activities from the ROW have benefited African countries much more than what they can produce for themselves. However, GHG-emitting activities from the ROW emit GHGs larger than that emitted in Africa in the long run which causes climate change with undesirable consequences that undermine human development in Africa. Finally, various strategic mitigation procedures and adaptive measures were recommended.

Contribution/Originality: This study is one of the few studies which have investigated the activities in Africa that have the most greenhouse gas emissions. The study contributes to the existing literature by using the ARDL estimation methodology to examine the effects of GHG emissions on human development in Africa from two perspectives.

1. INTRODUCTION

Humans must utilize energy sources in production processes for economic development. As such, using affordable and sustainable energy is critical to the development of any country. In the process of engaging in these economic activities, greenhouse gases (GHG) are emitted into the atmosphere, which consequently threaten the balance between economic development and the environment.

Environmental conservation is essential for sustaining human well-being. The importance of the planet in the pursuit of sustainable development is evident in the UN's resolution in the 2030 Agenda for Sustainable Development, where various nations committed to take urgent actions on climate change in order to support the needs of the present and future generations [1]. One important and sustainable way to satisfy the needs of the present generations without putting the needs of future generations at risk is by maintaining a favorable climate.

The Earth's climate is influenced by the interaction between the air, water, and land and the atmosphere through gaseous exchange. Over time, this exchange affects the climate; and when the climate behaves in an unusual manner over an extended period of time, it begins to change. Climate change, therefore, is the change in the state of the climate due to the changes in the mean and/or the change in how the properties of the climate vary over an extended period of time [2]. These changes can occur due to natural causes or by human's activities.

Climate change is perceived to be a human development issue that undermines the development of human potentials, their capabilities, and their freedom. It threatens the existence of humans and their ability to function freely [3]. In order to respond to the threats of climate change, the UN, through its climate change conferences, has established since the mid-1990s a number of binding commitments from various governments to reduce GHG emissions. This implies that people's survival and the socioeconomic structure of any economy would likely, to a large extent, be affected by climate change.

Natural causes of climate change can be due to the changes in solar energy and properties of natural gas – and volcanic eruptions [4]. However, the recent climate changes cannot be due to natural causes alone; anthropogenic activities have a greater contribution to the way the climate has changed. Human activities (e.g., burning of fossil fuels and land use changes) led to high concentrations of GHG to accumulate in the atmosphere. Accordingly, this atmospheric condition endangers human lives and threatens human development because it would degrade the ecological support systems that humans depend on. This is contrary to the goals of the development process.[1]

African countries along with the rest of the world (ROW) have contributed to global climate change for their own pursuit of economic development. Despite the minute contributions of the region to climate change, Africa has been one of the most adversely affected regions in the world [5]. In fact, it has been identified as one of the most vulnerable region to the impacts of climate change [6, 7].

Different and coordinated measures have already been initiated by governments around the world to curb the causes and to reduce the negative effects of climate change. Despite these efforts, the continuous effects of these anthropogenic activities that pollute the atmosphere have direct and/or indirect debilitating effects on the human development in the African region. Thus, this research sought to:

i. Identify the activities in Africa that have the most GHG emissions.

ii. Determine the effects of GHG emissions from Africa and that from the ROW on the human development in the region.

iii. Examine the implications of climate change impacts on human development in Africa.

Several studies have analysed the linkage between GHG emissions and climate change and how this affects growth and development in Nigeria, Africa, and the Asia-Pacific region. Most of these studies, however, did not examine these variables using time series data on GHG emissions. This study enriches the existing literature by examining GHG emissions and growth and development through time series data analysis. The present study may also be the first of its kind to examine the effects of GHG emissions on human development from two perspectives: (1) determining and comparing the effects of GHG emissions from both African countries and the ROW on human development in Africa and (2) determining the said effects at two periods of time – the short-term and the long-term. There is no generally acceptable duration for the short term and the long term. The present study refers to the short term from day 1 to 5 years; and the long term from 6 years and above.

The study can better inform researchers, governments, international organizations and non-governmental organizations in Africa on the various anthropogenic activities that contribute to the GHG emissions in the African

[1]Note that the ultimate goal of the development process is to improve the welfare of people in Africa. Improving human welfare include efforts to maintain clean air, ensure adequate supply of water and food, and preserve biodiversity.

region, and how the emissions from the ROW affect the well-being of people in Africa. Such insights will help stakeholders to identify and accordingly develop the appropriate measures in order to mitigate the impacts of climate change in Africa.

2. REVIEW OF LITERATURE

In the 19th century, some scientists viewed that the high concentrations of carbon dioxide (CO_2) that has accumulated in the atmosphere can cause a "greenhouse-effect" that can affect the temperature of the planet. Arrhenius [8] the father of climate change, calculated the CO_2 emissions from industries and viewed that these emissions would eventually result in global warming and would increase global temperatures by 5℃–6℃. Conversely, some scientists dismissed this idea.

In the early 20th century, industrial and manufacturing activities rapidly increased as machineries developed significantly [9]. Then Callender [10] argued that the level of CO_2 emissions due to industrial activities would eventually lead to increased global temperatures; however, most scientists dismissed his arguments as unreasonable.

In the 1950s, some scientists argued for the possibility of a global warming. Accordingly, Keeling [11] measured the level of atmospheric CO_2 and alerted the scientific community of the possible contributions of anthropogenic activities to greenhouse effect. Thereafter, researchers began investigating how the level of atmospheric CO_2 have changed overtime and also identified the factors that have influenced this change. They found that the concentration of accumulated CO_2 in the atmosphere plays crucial role in changing the climate; if this remains unchecked, they claimed that this would have a detrimental effect on the future generations.

Although most scientists focused on atmospheric CO_2, some also discovered that other gases (e.g., methane [CH_4] and nitrous oxide [N_2O]) that had been emitted through human activities also contribute to global warming. In the mid-1970s, they realized that these same gases are capable of damaging the Earth's atmosphere; however, the sources of these gases and how their interactions were found to be complex and uncertain at that time. Thus the body of knowledge on this issue made little impact on policy.

Contemporary scholars have studied how climate change affects humans and their development processes. Akanbi, et al. [3] investigated the interrelationships between climate change, human development, and economic growth in Nigeria using a generalized Cobb-Douglas production function and then extended the neoclassical growth model to include CO_2 emissions in the analysis. The study showed that CO_2 emission supported GDP, albeit the effect was not significant, and concluded that climate change imposes numerous constraints that incapacitate human development and economic growth. Meanwhile Mobolaji, et al. [12] investigated the impact of climate change on the economic development of Sub-Saharan African countries, and their results showed that CO_2 emissions have a positive and significant relationship with the growth rate of the real GDP per capita. The study implied that the higher CO_2 emissions indicated activities in the industrial sector that affect economic development. The study concluded that climate change impacted positively on the economic development of African countries.

Asogwa, et al. [13] examined the effects of economic greenhouse gases emissions on economic growth in both Nigeria and South Africa using the panel data econometric analysis. The study revealed that the various greenhouse gases emissions from economic activities in both countries posed negative externality on the effective labour productivity in the countries except waste emission and emission from energy sector. More so, greenhouse emissions from the industrial and agricultural sectors had negative effects on the output productivity. Waste and energy sector emission showed a positive externality on the effective productivity in Africa.

Ejuvbekpokpo [14] examined the impact of carbon emissions on economic growth covering 1980 to 2010. The study used the variables gross domestic product, emissions from fossils fuel, gas fuels, liquid fuels and solid fuels. Using the ordinary least squares analysis, the study revealed that carbon emissions have negative impact on economic growth in Nigeria. More so, the study revealed that all sources of carbon emissions in Nigeria except solid fuels, had significant impact on economic growth in Nigeria.

Asongu [15] examined the effect of CO2 emissions on inclusive human development in 44 Sub-Saharan African countries from 2000 to 2012. The study categorized countries into income levels (Low income versus versus Middle income); legal origins (English Common law versus French Civil law); religious domination (Christianity versus Islam); openness to sea (Landlocked versus Coastal); resource-wealth (Oil-rich versus Oil-poor) and political stability (Stable versus Unstable). Using the fixed effects and Tobit regressions, the marginal and net effects were negative and positive for 'CO2 emissions per capita' and 'CO2 emissions from liquid fuel consumption' respectively. Conversely, for CO2 emissions from electricity and heat production, the marginal impact and net effects were positive and negative respectively. The study revealed that CO_2 emissions negatively affected inclusive human development.

Matthew, et al. [16] examined the long-term effect of GHG emissions on health outcomes in Nigeria applying the autoregressive distributed lag (ARDL) technique to a set time series data from 1985 to 2016. The study showed that human activities increased the level of atmospheric GHG. Furthermore, the ARDL estimates showed that a one-percent increase in GHG concentration reduces human life expectancy by 0.0422%.

Mondal [17] examined the implications of population growth and climate change on the sustainable development of Bangladesh using an exploratory research design. According to the study, the population of Bangladesh almost doubled between 1980 and 2015. The country accounted for around 2.2% of global population in 2013 and contributed only 0.19% of the total global carbon dioxide emissions. Subsequently, Urama and Ozor [18] used Pearson correlation to determine the relationships between the following variables: population size and CO_2 emissions, population size and GDP, and CO_2 emissions and GDP. The study discovered that all the variables mentioned were positively correlated to each other.

Urama and Ozor [18] examined the role of climate change adaptation in the condition of water resources in Africa. They viewed that flooding, drought, sea level rise, drying up of rivers, poor water quality of surface and ground water systems, and other distortions affect ecosystems and communities. Moreover, these distortions pose economic and social effects on human health and food security. Olaniyi, et al. [19] also examined the impact of climate change on the environment. In particular, they analysed the effects of human activities and the effects of natural phenomena on global warming, climate change, and the environment.

The study by Ettah and Ubi-Abai [20] examined the effects of human-induced climate change on human development in Nigeria using the error correction model. They discovered that excessive GHG emissions coming from the economic activities have debilitating effects on the core indicators of human development. However, their model captured the GHG emissions from Nigeria, and neglected the effects of GHG emissions from the ROW on human development.

A region's climate is not only affected by the activities of the people living in that region; it can also be influenced by those in other regions of the world. This study sought to fill this gap by analysing the effects of GHG emissions on human development in Africa from two perspectives. This involves examining and comparing the effects of the GHG emissions coming from African countries and those from the rest of the world on human development in Africa at two periods in time.

3. RESEARCH METHODOLOGY

This study used a model that is based on the greenhouse effect theory, which states that CO_2 and other noxious gases are emitted into the atmosphere due to human activities. These emissions have led to global warming, which has consequently changed the climate. Accordingly, such changes have implications for human development.

The empirical model used GHG emissions as the core independent variable, and this was then split into two kinds: GHG emissions from Africa and those from the ROW. The study used the human development as the dependent variable. Other independent variables were also included to make the model robust. The population of Africa was included since it is the people who engage in activities that release GHGs into the atmosphere. Another variable that was included is the African countries' policies on environmental sustainability, which is important in supporting human development. The external sector variable, the gross international aid disbursement for environmental protection in Africa was also considered in the analysis. Equation 1 specifies the functional form of the model:

$$HDI = f(SAE, RWE, PIESR, POP, GODA) \quad (1)$$

Where:

HDI	=	human development index.
SAE	=	GHG emissions from Africa.
RWE	=	GHG emissions from the ROW.
PIESR	=	policy and institution environmental sustainability rating.
POP	=	population growth of Africa.
GODA	=	gross official development assistance for environmental protection in Africa.

3.1. Data Description and Sources

Human Development Index (HDI) is a statistical tool that measures the key dimensions of human development. Its indicators include people's ability to have a long and healthy life, being knowledgeable, and having a decent standard of living. Moreover, HDI measures socioeconomic development [21]. Accordingly, the present study used HDI as a proxy for human development in Africa; the HDI data were obtained from the *2018 Human Development Report* of the United Nations Development Programme.

In this study, the GHG emissions from Africa (SAE) are referred to as the lump sum of CO_2, N_2O, CH_4, and other noxious gases (e.g., perfluorocarbons [PFC] and sulfurhexafloride [SF6]) that accumulate in the atmosphere due to anthropogenic activities from the African region. On the other hand, GHG emissions from the ROW (RWE) are the lump sum of the same gases mentioned above coming from the GHG-emitting activities from the ROW, excluding those from Africa. In short, RWE are the global GHG emissions less SAE. [2]

Most of the CO2 emitted into the atmosphere come from the burning fossil fuels and from manufacturing cement. During such activities, CO_2 are produced when solid, liquid, and gas fuels are consumed during the process. Most of the CH_4 released into the atmosphere come from producing, handling, transmitting, and burning of fossil fuels and bio-fuels. Meanwhile, N_2O emissions come mostly from agricultural biomass burning, industrial activities, and livestock management. Meanwhile, PFCs are used as substitutes for chloroflurocarbons in the manufacturing of semi-conductors. They are by-products of aluminium smelting and uranium enrichment. SF6 is used largely to insulate high-voltage electric power equipment.

The Policy and Institution Environmental Sustainability Rating (PIESR) is used to assess the extent environmental policies are able to foster protection and sustainable use of natural resources and pollution management. Population growth (POP) is the annual growth of all residents regardless of legal status or citizenship in Africa. Lastly, gross international aid disbursement (GODA) refers to the donor aid that international organizations disburse for environmental policy and administrative management, biosphere protection, biodiversity conservation, site preservation, flood prevention/control, environmental education or training, and environmental research development in Africa.

[2]In this paper, SAE pertains to the GHG emissions coming from the activities of the different economic sectors in Africa, whereas those that come from the rest of the world is called RWE.

3.2. Data Analysis Technique

The functional model was estimated using a dynamic model for the following reasons:

1. The current year when the GHG emitting activities are done may be influenced, to a large extent, by the previous years of productive activities. This is an auto-regressive process.
2. GHGs are released into the atmosphere humans engage in productive activities for socioeconomic progress. This release of gas consequently increases atmospheric temperature and change climatic patterns.
3. The effects of the continuous release of GHG into the atmosphere due to economic activities are spread or distributed over a period of time. This is a distributed lag process.

Hence, this study adopted the ARDL bounds dynamic model. The ARDL model was presented by Pesaran and Shin [22] which was extended by Pesaran, et al. [23]. ARDL helps to avoid problems associated with determining short time series data [24]. Moreover, the ARDL model test for long-run relationships among the variables regardless of whether the underlying variables are I(0) or I(1). The model tests this relationship through the F-bounds test. Accordingly, Equation 2 specifies the short-run ARDL model:

$$lnHDI_t = \beta_0 + \beta_1 lnHDI_{t-k} + \beta_2 lnSAE_t + \beta_3 lnSAE_{t-k} + \beta_4 lnRWE_t + \beta_5 lnRWE_{t-k} + \beta_6 PIESR_t + \beta_7 PIESR_{t-k} + \beta_8 POP_t + \beta_9 POP_{t-k} + \beta_{10} GODA_t + \beta_{11} GODA_{t-k} + ECM_{t-k} + U_t \quad (2)$$

Where:

$\beta_0 \ldots \beta_{11}$ = short-run coefficients.

t-k = lags.

ECM = adjusting coefficient of the error correction.

The appropriate lag for the short-run model was determined using a lag-selection criterion. The long-run ARDL model is specified in Equation 3:

$$lnHDI_t = \beta_0 + \beta_1 lnSAE_t + \beta_2 lnRWE_t + \beta_3 PIESR_t + \beta_4 POP_t + \beta_5 GODA_t \quad (3)$$

There are diagnostic checks to ensure that the ARDL model is robust, including cointegration test, the normality test, test for autocorrelation, and heteroskedasticity test.

3.3. A Priori Expectations

It is expected that SAE would have positive effects on the human development in Africa both the short and long runs. This is because the goals of GHG-emitting economic activities are to generate income, reduce poverty, provide health care facilities, create jobs, and promote other activities that support human development in Africa. RWE is expected to be positively related to the human development in Africa in the short run, but would be negatively related in the long run. This is because most of the outputs of the productive activities from the ROW are exported to Africa through international trades.

For example, the technological devices, machineries, and other industrial products from the ROW have benefited African countries such that they have helped the different economic sectors in the region to create employment, generate income for the populace, reduce poverty, provide healthcare facilities, etc. However, the processes involved in producing such output release GHG into the atmosphere. If GHGs continue to accumulate in the atmosphere due to these economic activities, then global temperature would further increase; this would actually have an effect on global climatic conditions in the long run. Accordingly, climate change would have debilitating effects such as sea level rise, flooding, heat waves, health-related effects, and other negative consequences that affect human development in Africa.

The climate change-related policies and institutions established by the different governments in Africa are expected to have a positive effect on human development, as these policies will ensure that pollutants are effectively managed. Moreover, the protection and sustainable use of natural resources will protect the general well-being of people as they engage in activities to develop themselves.

Likewise, it is expected that population growth in Africa will affect human development either positively or negatively depending the circumstances. On the one hand, as population grows, more people will engage in productive activities, leading to faster growth and development. On the other hand, as more people engage in productive activities for growth and development, more GHGs will be released into the atmosphere. Overtime, these continuous GHG emissions will change climatic patterns, which will have negative consequences for human development.

Lastly, the aim of the gross official development assistance for environmental protection in Africa is to protect the environment and rehabilitate the environment as well. These disbursements are expected to have a positive relationship with human development.

4. RESULTS

4.1. Trend Analyses

CO_2 is one of the GHGs emitted into the atmosphere as a result of economic activities. Table 1 shows the various economic sectors in Africa that have contributed to CO_2 emissions since 1980. The share of CO_2 emissions from the *electricity and production* sectors to total fuel combustion showed increasing trends from 1980. The upward trend reached peak in 2004. The share declined to 55.05% in 2012, and slightly increased to 55.09% in 2016.

The share of CO_2 emissions to total fuel combustion from the *manufacturing and construction* sectors sector steadily declined from 30.96% in 1980 to 11.20% in 2008. Thereafter, the share increased to 12.44% and 12.45% in 2012 and 2016 respectively.

Table-1. CO_2 emissions from different economic sectors in Africa (% of total fuel combustion).

Year	Electricity & Production	Manufacturing & Construction	Residential Buildings, Commercial & Public services	Transportation	Other Sectors
1980	39.8843	30.9561	6.00759	20.0651	3.08332
1984	47.7101	23.804	6.14835	19.8401	2.47703
1988	48.5757	23.3066	6.14333	19.4222	2.53346
1992	52.3156	18.06	6.54657	20.9136	2.1672
1996	55.4791	15.3082	5.95789	20.3847	2.87284
2000	56.6019	14.2677	5.2694	21.1255	2.74059
2004	58.2777	13.3273	5.91195	20.6801	1.80099
2008	58.0021	11.2040	7.93475	20.6957	2.16858
2012	55.0469	12.4439	5.7767	23.3896	3.34224
2016	55.0945	12.4506	5.7834	23.3243	3.35099

Source: Chhibber and Laajaj [25].

The *residential buildings, commercial and public services* sector contributed 6% of total fuel combustion in 1980. The share of CO_2 emissions to total fuel combustion reached peak at 7.93% in 2008, and fluctuated downwards in 2012 (5.78%) and 2016 (5.78%) respectively.

CO_2 emissions contributed by the *transportation* sector fluctuated downward since 1980 until 1992, which represent 20.91% of total fuel combustion. The share reduced in 1996 and increased to 21.13% in 2000. Subsequently, the share increased to 23.39% in 2012 and maintained such increase in 2016. The share of CO_2

emissions from *other sectors* to the total fuel combustion fluctuated downwards since 1980. The share increased in 2012 and 2016 respectively.

In summary, Table 1 emphasized that CO_2 emissions from the *electricity and production* sector, *residential buildings, commercial and public services* sector, *transportation* sector and *other sectors* in Africa have increased despite its fluctuations since 1980. These fluctuations have likely impacted human development in Africa.

Aside from CO_2, other GHGs are also released into the atmosphere as a result of economic activities. Accordingly, Table 2 presents a four-year interval analysis of N_2O, CH_4 and other GHG emissions such as Hydrofluorocarbons (HFC), Perfluorocarbons (PFC) and Sulfurhexafloride (SF6) in Africa.

Table-2. GHG emissions in Africa, by type of GHG.

Year	Thousand Metric Tons of CO_2 Equivalent					
	Nitrous emissions	% growth of nitrous emissions	Methane emissions	% growth of methane emissions	Other GHGs: HFC, PFC and SF6	% growth of other GHGs
1980	397,866.06	0	553,508.08	0	1,683,225.37	0
1984	323,450.90	-18.70	485,630.49	-12.26	1,384,738.77	-17.73
1988	302,593.62	-6.45	480,854.56	-0.98	1,268,758.59	-8.38
1992	505,907.48	67.19	719,489.89	49.63	2,324,616.07	83.22
1996	385,157.39	-23.87	618,830.20	13.99	1,528,956.07	-34.23
2000	377,534.67	-1.98	645,133.74	4.25	3,267,730.81	113.72
2004	373,649.64	-1.03	664,668.06	3.03	3,007,525.32	-7.96
2008	579,087.35	54.98	860,949.23	29.53	3,176,673.31	5.62
2012	557,857.50	-3.67	851,188.32	-1.13	3,014,792.11	-5.10

Table 2 shows that N_2O, CH_4, HFC, PFC and SF6 emissions reduced from their initial values in 1980 until 1992 where there were positive growths in emissions. Thereafter the GHG emissions reduced until 2008 where they reached peak with positive growth rates respectively. Other GHGs reduced in 2012. In summary, Table 2 implies that aside CO_2, other GHGs are emitted from economic activities in Africa which can pose significant effect for human development in both the short term and long term.

Meanwhile, Figure 1 and Figure 2 examine the trends in SAE and GHG emissions from the ROW. The trends show that SAE and GHG emissions from ROW fluctuated upwards from 1980 to 2016.

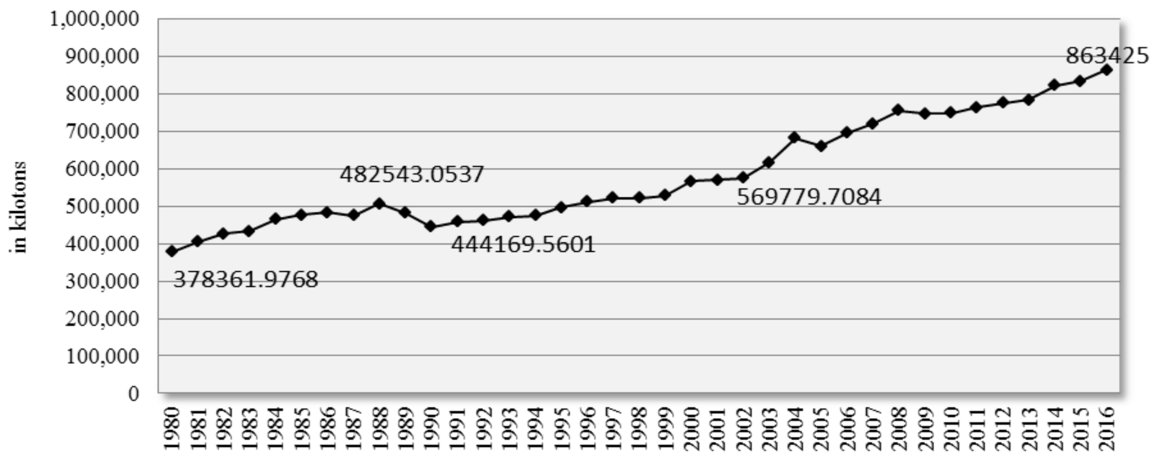

Figure-1. GHG emissions from activities of different economic sectors, Africa.

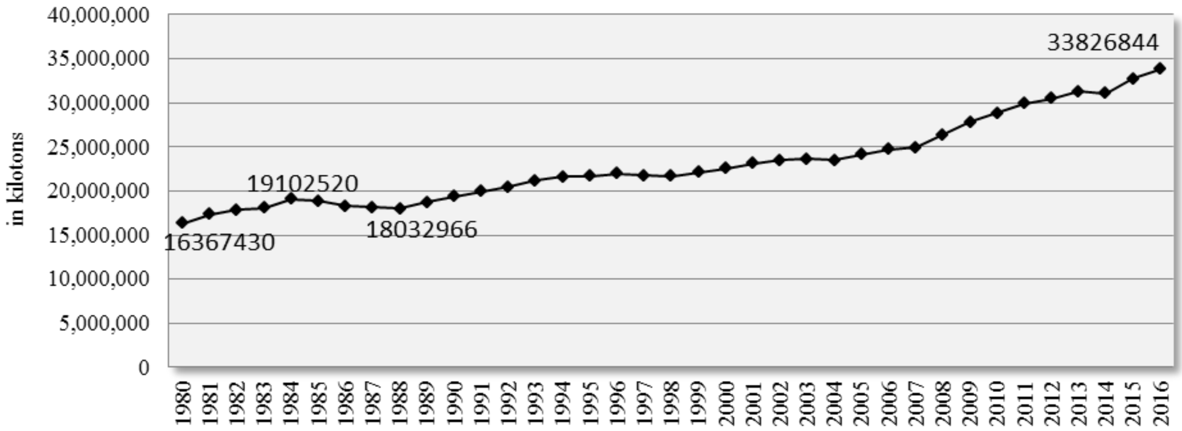

Figure-2. GHG emissions from activities of the different economic sectors, ROW.

The implication of Figures 1 and 2 is that SAE from economic activities as well as economic activities from the ROW has been increasing over the years. Accordingly, the increase in economic activities has supported human development on the one hand, and contributed to increase in global temperatures that can cause climate change on the other hand.

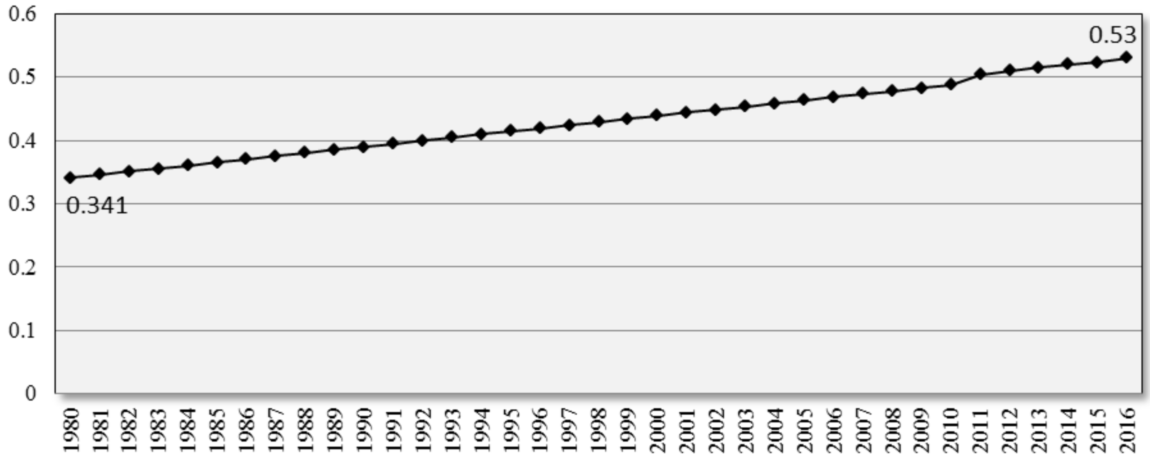

Figure-3. HDI in Africa.

Source: UNDP [26].

Figure 3 presents the trend in HDI in Africa, and shows that people's well-being in the region has steadily improved since 1980. HDI measures the level of literacy, life expectancy, and standard of living of people-as measured by their per capita income. This upward trend indicates that the people living in the region have become more capable in raising their standard and in conserving the environment.

Economic activities in the region have increased over the years, which imply that GHG emissions from the different economic sectors have likewise increased. However, the World Bank [5] views that Africa's contributions to climate change (as indicated by SAE) are minute as compared with that of the ROW. Therefore, the next sections will compare the effect of Africa's contributions to climate change on human development in the region with that of the ROW using the ARDL model.

4.2. Diagnostic Tests for the ARDL Model

The autocorrelation test, heteroskedasticity test, normality test, F-test and the F-bounds test for co-integration were conducted to ensure robustness of the ARDL model. The diagnostics tests are displayed in Table 3.

The Durbin-Watson statistic of 1.94 implies that the model does not have serial correlation in the errors. The observed r^2 estimate of the White's heteroscdasticity test (10.11) shows that the model has equal spread in the variance of the error. The probability value of the Jarque-Bera (JB) normality statistics (0.92) shows that the model follows the normal distribution. The F-bound estimate of 7.74 is higher than the lower bound (2.39) and upper bound (3.38) at the 5% level of significance. This shows that long-run relationships exist among the variables in the model.

Table-3. Diagnostics tests for the ARDL model.

Diagnostic Tests		Estimate
Durbin Watson's test for autocorrelation		1.94
White's heteroscedasticity test	Obs*r^2	10.11 (0.97)
Jarque-Bera normality test	Jarque-Bera statistic	0.17 (0.92)
F-bounds test for cointegration	F-bound	7.74
	Lower bounds (5%)	2.39
	Upper bounds (5%)	3.38
Adjusted r^2		272.19
F-statistics		(0.00)

Note. Figures in bracket are probability values.

The adjusted r^2 (0.79) implies that the 79% of the variation in HDI is explained by the variations in SAE, RWE, and the control variables in the model. The error term accounts for the remaining 21%. The probability value of the F-statistic (0.00) shows that the model is significant at the 5% level.

4.3. The ARDL Regression Analysis

The diagnostic checks indicate that the ARDL model is robust for analysis. Table 4 shows how SAE and RWE have affected human development in Africa. The results show that the past HDI values in Africa have positive and significant effect on the current HDI values. This implies that the economic activities in the region in the past years have significantly affected the present efforts of the people in Africa for development.

Table-4. Short-and Long-run ARDL regression results.

Dep. Variable: HDI	ARDL Regression Output			
InDep. Variables:	Short run Coef.	Long run Coef.	Short run (P-value)	Long run (P-value)
D(HDI(-1))	0.789885	-	0.0007*	-
D(HDI(-2))	0.376966	-	0.0051*	-
SAE	0.022417	-0.028381	0.0054*	0.0064*
RWE	0.209367	-0.181219	0.0000*	0.0000*
POP	3.457709	-0.164530	0.0368**	0.0358**
PIESR	0.208360	0.197520	0.1658	0.1057
GODA	1.833912	0.064996	0.0161**	0.0000*
CointEq(-1)*	-2.324547	-	0.0000*	-

Note. *, **, and *** are those values that are significant at the 1%, 5%, and 10% levels, respectively.

Moreover, the results show that SAE has a positive and significant effect on human development in Africa in the short run, with an average value of 0.022417. This implies that a unit increase in SAE has improved human development by 0.02 on average. However, SAE negatively affects HDI in Africa (−0.028381), which is in contrast with the short-run positive effect of SAE on human development in Africa (0.022417). As earlier explained, the activities in the different economic sectors have positive effects on human development since such activities can improve health, education, and living standards of the people living in Africa. However, the continuous increase in GHG emissions as a result of these activities will eventually undermine these improvements.

SAE is not the only thing that affect Africa's climate; RWE also plays a role in climate change. The results in Table 4 further show that there is a positive relationship between RWE and human development in Africa

(0.209367). Hence, an increase in RWE will increase HDI by an average of 0.21. This implies that RWE has a significant and positive effect on human development in Africa in the short run. The implication is that most of the products, such as automobiles, machinery, equipment, etc. used in the different sectors in Africa are imported from other regions. The processes involved in producing these commodities emit significant amount of GHGs into the atmosphere. For example, the cars from Europe and the electronic equipment from Asia are exported to African countries. These benefit the people in the short run, as they use these products to engage in other activities for their development. However, in the long run, RWE has a negative effect on human development in Africa (−0.181219). Comparably, this is not the case in the short-run positive relationship between RWE and HDI in Africa (0.022417). This implies that as RWE continues to increase in the long run, then climatic conditions in Africa is affected such that the effect is detrimental to human development in the region. In other words, RWE serves as pollutants that impede human development in Africa in the long run.

The results in Table 4 also compare the short-run effects of SAE and RWE on the HDI in Africa. The short-run effect of SAE on human development is 0.022417, whereas that of RWE is 0.209367. This implies that the short-run effect of RWE on human development in Africa is ten times that of SAE. In simple terms, this result means that GHG-emitting activities that produce the technological devices, machineries, and other industrial products from the ROW have benefited African countries much more than what they can produce for themselves.

Just like the comparison between the short-run effects of SAE and that of RWE on human development in Africa, the same applies in the long run. The long-run effect of SAE on human development in Africa is −0.028381, whereas that of RWE is −0.181219. This implies that the effect of RWE is approximately nine times that of SAE in the long run. To illustrate, the process of producing technological devices, machineries, and other industrial products from the ROW emit GHGs larger than that emitted in Africa. These GHGs heat up atmospheric temperatures that cause climate change. The resultant effects are flooding, drought and other undesirable events that undermine human development in Africa. For example, a study by the World Bank [5] showed that the drought due to the 1997/1998 El Niño and the 1998–2000 flooding caused by La Niña in Kenya resulted in damages, which consequently reduced GDP by 10%–16% during the affected years. In 2000, United Nations International Children's Emergency Fund [27] found that the flood event in Mozambique killed hundreds of people. In Ethiopia, the heavy flood events that occurred in May 1968, August 1994, May 2005 caused damages costing millions of US dollars. Moreover, Dechatu River overflowed during these flood events, which caused hundreds of human casualties and displacement [26].

Flooding is not the only impacts of climate change, but severe drought. Examples are evident in Angola, Lesotho, Malawi, Mozambique, Swaziland, Zambia, and Zimbabwe. These countries experienced food shortages after some years of drought and flooding in some areas. The unfortunate scenario has rendered Zimbabwe the most vulnerable country—a region which used to be considered as the breadbasket of Southern Africa [5]. Moreover, United Nations International Children's Emergency Fund [27] stated that over 8 million people in the Horn of Africa (Kenya, Djibouti, Ethiopia, Eritrea, and Somalia) were on the brink of starvation as a result of severe drought, crop failure, and loss of livestock. After a critical analysis of gas produced and burned in Nigeria, Umo [28] asserted that gas burning causes serious environmental damages, increases temperature in the area, triggers acid rain, reduces agricultural production, and endangers human and marine life amongst others.

Other variables were included in the analysis to ensure the robustness of the model. Population growth in Africa has a significant and positive effect human development in the short run (3.457709). This implies that as the African population grows, the number of people engaging in economic activities increases. However, the significantly negative relationship (-0.164530) between Africa's population growth and development is a cause for concern in the long run. This result evidently shows that the growing demands for goods and services due to Africa's high population rate contribute to climate change. In the struggle for survival, humans engage in GHG-emitting economic activities to the detriment of their long-term well-being.

Meanwhile, the policies and institutions in African governments that promote environmental sustainability also supported human development in the short run (0.208360) and long run (0.197520); however, the relationships were not significant. Lastly, the coefficient of the variable *gross official development assistance for environmental protection* was significant and positive in the short run (1.833912) and in the long run (0.064996). These imply that an increase in aid disbursements to protect and revive the environment have been more effective for human development in the short time period (1.83 on average) than in the long time period (0.06 on average).

5. SUMMARY AND CONCLUSION

This study identified the different GHG-emitting activities of different economic sectors and described the trends in GHG emissions from Africa (SAE) and from the rest of the world (RWE). Accordingly, the pictorial analysis showed that SAE and RWE are increasing. Definitely, the increasing trends have implications for human development in Africa.

The study further examined the effects of GHG emissions on the human development in Africa from two perspectives. One is the effect of SAE on human development in Africa, whereas the other is the effect of RWE on human development in Africa. The results of the ARDL model estimation showed that both SAE and RWE affect human development in the same way. The increases in SAE and RWE as a result of the increase in economic activities are positive and significant in the short run; in the long run, however, the effect becomes negative. The comparative analysis showed that, in the short run, GHG-emitting activities that produce technological devices, machineries, and other industrial products from the ROW have benefited African countries much more than what they can produce for themselves. However, GHG-emitting activities that produce technological devices, machineries, and other industrial products from the ROW emit GHGs larger than that emitted in Africa in the long run. These GHGs heat up atmospheric temperatures that cause climate change, which result to flooding, drought and other undesirable events that undermine human development in Africa.

The study concludes that GHG-emitting activities from Africa and the ROW has proven to support human development, but the continuous increase in global GHG emissions has led to changes in climatic patterns, which consequently undermines human development in Africa.

Based on this conclusion, the following recommendations are given:

1. Africa is a developing region. As far as human development is concerned, the region must engage in economic activities for socioeconomic development. Accordingly, there bounds to be GHG emissions in the future in different sectors of African economies. However, changing the people's lifestyle is important to reduce GHG emissions to safer levels. The electricity and production sectors should produce more energy-efficient electronics. People living in residential buildings and people engaging in commercial and public services should purchase more energy-efficient gadgets. More importantly, turn lights off when leaving the apartment and unplug appliance that are not in use. These efforts will reduce the overloaded capacity of electric grids in the continent. With respect to the transportation sector, energy-efficient modes of transportation should be encouraged. Moreover, people should purchase fairly used vehicles with hybrid engines and electric cars. These will reduce GHG emissions from combustion engines.
2. The manufacturing and construction sectors should adopt improved cement-making processes to build energy-efficient buildings. Improved agricultural practices to encourage yields and forest management should be encouraged.
3. The different economic sectors rely on different energy sources for their production. In order to reduce GHG emissions, these sectors can make use of renewable energy sources such as wind power, solar thermal power or alternative energy sources such as biofuels and nuclear power, instead of solely relying on those GHG-emitting energy sources.

4. Although mitigation procedures are being put in place, climate change adaptation measures should be adopted to seek new opportunities to cope with the consequences of climate change.
5. Lastly, the rest of the world, especially those countries that emit GHGs the most, should come together and agree on the best mitigation and adaptive strategy to reduce the effects of GHG emissions on human development. These include putting in place measures to reduce GHG emissions in different sectors of their economies; increasing official development assistance for environmental protection, especially for African countries that meet international standards and fund eligibility requirements; and investing in projects that are energy-efficient such as investing in firms that practice carbon capture and storage. These will reduce GHG emissions to safer levels and enable sustainable economic development.

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