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Dynamic Heterogeneous Analysis of Pollution Reduction in SANEM Countries: Lessons from the Energy-Investment Interaction

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Abstract

This scientific enquiry examines the role of capital investment in the energy-pollution model in SANEM countries. The methodology is based on the Pooled Mean Group (PMG), which is appropriate for a heterogeneous panel. Findings reveal that energy use negatively impacts CO_2 emissions in Algeria, South Africa, Morocco, and the panel, in the short-run; however, it positively impacts CO_2pollution in Nigeria, Egypt, and the panel, in the long-run. Again, investment exerts a positive effect on CO_2 in South Africa and Algeria, whereas it is negative in Nigeria, Egypt, and Morocco. Capital investment also expands short-run pollution in the panel, but it reduces long-run pollution. Lastly, the energy-investment interaction reduces the panel's CO_2pollution in the short-run and long-run, as well as, in Morocco, Egypt, Nigeria, and South Africa, except in Algeria. Thus, we conclude that capital investment is crucial in the energy-pollution nexus and suggest cooperation in attracting low-carbon emitting investments to the region.

Keywords: Capital Investment; Carbon Emissions; Energy Use; Energy Policy; Africa.

JEL Classification: Q32; Q48; Q53; F23; O55.

1. Introduction

The pace of economic growth in SANEM emerging African nations (i.e. South Africa, Algeria, Nigeria, Egypt, and Morocco) call for concern about its environmental effect. The Annex 2 classification of Africa by the UNFCCC[2]due to its low industrial production and contribution to the global CO_2 emissions necessitates this study. So, we demonstrate that Africa's G5 requires more efforts for reducing pollution than some industrialised nations due to their production and pollution capacity. Usually termed as SANE[3] countries, the recent strides by Morocco in terms of GDP and coal production despite not depending on crude oil production are remarkable, necessitating the modification of SANE to SANEM. For example, Egypt, South Africa, Algeria, and Nigeria are heavily dependent on petroleum, while Morocco is coal-dependent with a massive amount of coal-fired plants. Therefore, since pollution control through the capital investment channel is the focal point of this study, the need to focus on SANEM. Again, SANEM nations are fast-growing, are hugely fossil fuel energy-dependent with a large volume of gas flaring, and can be termed as Africa's G5 nations with over half of the continent's GDP. For instance, Nigeria, Algeria, and Egypt ranked high globally concerning gas flaring. In 2013, evidence shows that Nigeria ranks 4th, and accounts for flared gas of 9.3 billion cubic meters (bcm), Algeria ranks 7th (behind the US) with gas flaring of 8.2 bcm, and Egypt ranks 14th with gas flaring of 2.4 bcm (World Bank, 2016). In 2014, Algeria overtook Nigeria and was ranked 6th with 8.7 bcm, Nigeria was ranked 7th with 8.4 bcm, and Egypt was ranked 14th with 2.8 bcm. In 2015, Algeria remained in 6th position with 9.1 bcm, Nigeria remained in 7th with 7.7 bcm, and Egypt moved to the 13th position with 2.8 bcm (World Bank, 2016). So, CO_2 emission is a big issue

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[2] United Nations Framework Convention on Climate Change. The 2018 edition was held in Katowice, Southern Poland, between 2nd and 14th November 2018 while the last edition was held in Bonn, Western Germany, between 17th and 27th June 2019.

[3] South Africa, Algeria, Nigeria, and Egypt- According to Oshikoya (2015), SANE is termed as Africa's G4 nations with about one-third of the continent's population, one-fifth of its landmass and over half of its total GDP.

among the emerging African nations. This means that environmental pollution in Africa is a big problem, and SANEM countries need to set the template for pollution control in the region. The Paris Agreement signed by the major polluting countries did not include African nations in its Annex 1 list but only as Annex 2 countries, with no specific emissions' reduction target. This makes African nations a bit relaxed; hence, the need for this study in SANEM African nations.

In the same vein, fossil fuel energy use is an essential driver of Green-House Gases (GHGs) globally. According to Bhattacharyya (2011), today's global energy system is almost entirely dependent on oil and gas, coal, and other fossil energy sources, which all account for about 80 per cent of the worldwide energy use. Interestingly, Zhang & Cheng (2009) gave credence to this by confirming that pollution in China is unidirectionally caused by primary energy use, Lean & Smyth (2010) confirmed similar result for ASEAN nations, while Eregha & Mesagan (2017) found same in energy-dependent African countries. This situation has become synonymous with non-renewable energy-dependent nations. Available evidence from BP Statistical Review (2020) depicts that in 2015, Algeria's fossil fuel energy use is 99.6% and its CO_2 emission was 136.4 million tonnes (MT), Egypt's fossil fuel energy is 95.7%, and its CO_2 emissions was 211.4 MT, and South Africa's fossil fuel energy use is 96.5%, while its carbon emissions stood at 421.8 MT. This brings to the fore the argument that fossil fuel energy use has a strong association with carbon emissions. Moreover, environmental pollution has been traced to the use of inappropriate investment technology in the Less Developed Countries (LDCs) because several emission-laden firms relocate from the Developed Countries (DCs) because of stringent environmental regulations. Thus, their relocation to African countries might have contributed to increasing pollution, thereby making them specialists in producing the dirty goods[4] themselves. Also, the inflow of highly-emitting multinational firms to the LDCs gives rise intensifies further the concept of polluter haven (seeBlomquist & Cave, 2008; Letchumanan & Kodama, 2000;Mesagan, 2015; Mesagan & Adeniji-Ilori, 2018). It implies that capital investment is a critical pollution-driving factor in the LDCs, and determining its role in the pollution control models of SANEM African nations,is very crucial at this time. We also control for capital investment since it can be used to offset pollution problems (see, Sims, Rogner & Gregory, 2003; Tang & Tan, 2015; Mesagan, Isola & Ajide, 2019).

Since transmission channels are crucial in studying the energy-emissions nexus, coupled with the impreciseness that characterises the related literature, this study is expedient. One of such channels is capital investment, which empirical research has often omitted. This study, therefore, is not only crucial but is also timely since the Paris Agreement aims to reduce global warming below 2^0C while also limiting it to an additional 1.5^0C. The rationale for the study cannot be overemphasised as SANEM African nations are among the fastest-growing emerging economies. They also consume a massive amount of fossil fuel energy with their attendant pollution crisis. Therefore, our broad focus centres on determining the impact non-renewable energy use on pollution via the channel of capital investment in SANEM nations. We specifically examine the effect of energy use on CO_2 emissions, analyse the impact of capital investment on CO_2 emissions, and then examine the possibility for reducing pollution from energy use through the channel of capital investment in SANEM nations. The paper makes three original contributions. First, it ascertains the role of capital investment in reducing pollution in an often-neglected region, which are classified by the UNFCCC as Annex 2 countries with no specific emissions' reductions target. Second, it analyses the

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[4] These are polluted goods which comprise carbon emissions, particulate emissions and other green-house-gases

importance of capital investment as a mediating channel in the energy-pollution link. Third, it employs the PMG framework, which is dynamic and also appropriate in analysing heterogeneous panel data. Again, the approach is suitable for obtaining country-specific results and overall panel estimates, thereby aiding our quest to provide pollution reduction policies for SANEM and the entire African continent. Aside from section 1, the remaining part of the study includes the literature review, which appears in section 2 and stylised facts in section 3. Others include research methodology, which is presented in section 4, findings are presented in section 5, while conclusion and policy implications are presented in section 6.

2. Literature Review

A plethora of literature has beamed searchlight on the energy-emissions relationship by controlling for certain intervening variables in their pollution abatement models. For instance, Stolyarova (2013) focused on 93 countries between 1960 and 2008 and found a short-run association between energy and air pollution whereas energy mix and output growth exerted negative and positive impact correspondingly on pollution. Halicioglu (2009) extended the study to Turkey by including foreign trade in the model covering 1960 to 2005. It found the existence of two types of long-run nexus among the regressors. In the first type, trade, income and energy use determined CO_2 emissions while in the second, only energy use and foreign trade enhanced CO_2 emissions. Recently, Mesagan *et al.* (2019) focused on BRICS by controlling for investment between 1992 and 2014.They observed that income growth and electricity use worsened the environment while capital investment augmented fossil fuel electricity use to improve environmental quality. Shahbaz *et al.* (2013) analysed Indonesia by controlling for financial development and trade between 1975Q1 and 2011Q4. Findings confirmed that energy use and income worsened CO_2 emissions, while trade and financial development significantly reduced CO_2 emissions. Bento and Moutinho (2016) analysed the situation in Italy between 1960 and 2011 and found that foreign trade increased long-run emissions while renewable electricity generation lowered both short- and long-run emissions. Similarly, Dogan and Seker (2016) focused on the major renewable energy nations by disaggregating energy use into non-renewable and renewable. They found that energy from fossil fuel increased pollution, whereas renewable sources of energy, trade, and financial development reduced the pollution of carbon. Mesagan and Nwachukwu (2018) examined the Nigerian case by controlling for financial development between 1981 and 2016 and confirmed that energy use and financial development significantly determined pollution while urbanisation and investment were not significant in the model.

Moreover, for studies examining the causal relationship between air pollution and its determinants, Soytas, Sari & Ewing (2007)focused on the US economy. They observed that in the long run, energy granger caused air pollution while neutrality relationship was found between output and pollution, meaning that income did not provide solution means for curbing environmental hazards in the country. Halicioglu (2009) extended the study to Turkey and found the existence of a bi-directional relationship between energy use, pollution, foreign trade, and income. Again, while examining the Chinese case from 1960 to 2007, Zhang and Cheng (2009) found unidirectional causality from energy consumption to CO_2 emissions and from growth to energy consumption in the long run. However, the neutrality hypothesis was found between energy consumption, carbon pollution and growth. Lean & Smyth (2010) focused on five ASEAN nations from 1980 to 2006.Findings revealed that electricity consumption and CO_2 unidirectionally caused output growth in the long-run, but for short-run,CO_2 unidirectionally caused electricity use. Furthermore, it found support for the EKC in the five ASEAN nations considered. Shahbaz *et al.* (2013) confirmed a mutual causal nexus between CO_2 emissions, output growth, and energy use, but financial development unidirectionally caused emissions of CO_2.

Moreover, Cowan,Chang, Inglesi-Lotz, & Gupta(2014) focused on BRICS by analysing panel data covering 1990 to 2010. They found neutrality relationship between income and electricity consumed in China, India and Brazil, found bidirectional causality in Russia, and that income unidirectionally caused electricity consumed in South Africa. Again, they found the neutrality hypothesis for carbon emissions and income in both India and China and found feedback effects in South Africa, Brazil, and Russia. Lastly, the study did not find any causal evidence between electricity use and CO_2 in South Africa, China, Brazil, and Russia, but in India, electricity unidirectionally caused emissions from CO_2. Bento and Moutinho (2016) found that foreign trade unidirectionally caused fossil electricity generation and CO_2 emissions. It also found evidence of unidirectional causal relationship running from income and non-renewable to renewable electricity generation in Italy. Li *et al*. (2017) analysed the Chinese case between 1965 and 2015 and confirmed feedback between output, coal consumption and gas consumption, as well as between CO_2 emissions and coal consumption. Also, the study observed that a unidirectional causal relationship was found from coal to oil and gas, and from oil and income to CO_2 emissions. Mesagan and Nwachukwu (2018) found feedback hypothesis between pollution and energy use, the neutrality hypothesis was found between financial development, investment and pollution, while output and urbanisation unidirectionally caused pollution.

3. Stylised Facts on Emissions Reduction in SANEM African Countries

3.1 Volumes of Gas Flaring Globally

In Table 1, we present the volumes of gas flared by the top 20 nations globally and evidence shows that three of the SANEM nations (i.e. Algeria and Nigeria) made it to the top ten placing 5th and 7th respectively while Egypt is in 13th position. In Table 1, evidence shows that Algeria, Nigeria and Egypt are highly ranked in terms of gas flaring, and this portends a severe issue for the African continent if output also rises in like manner using environmentally unfriendly machines. The main problem is that Algeria's gas flaring that stood at 8.7 bcm in 2014 increased to 9.1 bcm in both 2015 and 2016. The volume dropped slightly to 8.8 bcm in 2017 before rising again to 9.0 bcm in 2018. For Nigeria, gas flaring volume stood at 8.4 bcm in 2014, and then slightly dropped to 7.7 bcm and 7.3 bcm respectively in 2015 and 2016. This could not be sustained as gas flaring rose to 7.6 bcm in 2017 before plunging to 7.4 bcm in 2018. For Egypt, gas flaring stood at 2.8 bcm from 2014 up till 2016 and then dropped slightly to 2.3 bcm in both 2017 and 2018.

Table 1: Top 20 Countries' Gas Flaring (billion cubic meters, bcm)

SN	Countries	2014	2015	2016	2017	2018	2017-18 Change	2014-18 Change
1.	Russia	18.3	19.6	22.4	19.9	21.3	1.4	3.0
2.	Iraq	14.0	16.2	17.7	17.8	17.8	0.0	3.8
3.	Iran	12.2	12.1	16.4	17.7	17.3	-0.4	5.1
4.	United States	11.3	11.9	8.9	9.5	14.1	4.6	2.7
5.	**Algeria**	**8.7**	**9.1**	**9.1**	**8.8**	**9.0**	**0.2**	**0.3**
6.	Venezuela	10.0	9.3	9.3	7.0	8.2	1.2	-1.7
7.	**Nigeria**	**8.4**	**7.7**	**7.3**	**7.6**	**7.4**	**-0.2**	**-1.0**
8.	Libya	2.9	2.6	2.4	3.9	4.7	0.8	1.8
9.	Mexico	4.9	5.0	4.8	3.8	3.9	0.1	-1.0
10.	Angola	3.5	4.2	4.5	3.8	2.8	-1.0	-0.7
11.	Oman	2.6	2.4	2.8	2.6	2.5	-0.1	-0.1
12.	Saudi Arabia	1.9	2.2	2.4	2.3	2.3	0.0	0.3
13.	**Egypt**	**2.8**	**2.8**	**2.8**	**2.3**	**2.3**	**-0.1**	**-0.5**
14.	Malaysia	3.4	3.7	3.2	2.8	2.2	-0.6	-1.1
15.	Indonesia	3.1	2.9	2.8	2.3	2.1	-0.3	-1.0
16.	Kazakhstan	3.9	3.7	2.7	2.4	2.0	-0.4	-1.9
17.	China	2.1	2.1	2.0	1.6	1.8	0.3	-0.3
18.	Congo DR	1.3	1.2	1.1	1.1	1.6	0.4	0.3
19.	Turkmenistan	2.0	1.8	1.8	1.7	1.5	-0.2	-0.5
20.	Gabon	1.5	1.6	1.6	1.5	1.4	-0.1	-0.1

Source: *Authors' Compilation from World Bank (2019)*

Table 1 suggests that Algeria is 5th behind the United States, Nigeria ranks 7th behind Venezuela, and Egypt ranks 13th behind Saudi Arabia. The fact that three of these five nations rank in the top 20 among the most gas flaring countries globally means that CO_2 emissions in SANEM is massive and requires attention. Except for South Africa and Morocco, Algeria, Nigeria, and Egypt do not even feature in the Climate Action Tracker (CAT), which provides an independent scientific assessment to track the climate action of various countries since 2009 towards achieving the Paris Agreement of keeping global warming below 2^0C and limiting warming to 1.5^0C. Similarly, for South Africa and Morocco that are missing in Table 1, their levels of coal consumption rank among the highest globally. Evidence from Table 2 shows that between 2014 and 2018, South Africa's coal consumption ranks 5th globally while Morocco, which ranked in the 40th position in 2014 moved to the 33rd position in 2018. Also, while several nations recorded decreases in coal consumption between 2014 and 2018, both South Africa and Morocco recorded increases to the tune of 0.01 and 0.05 exajoules respectively. A similar trend is also observed between 2017 and 2018 with South Africa and Morocco recording respective increases of 0.04 and 0.03 exajoules of coal consumption.

Table 2: Top 20 Countries' Coal Consumption (Exajoules)

SN	Countries	2014	2015	2016	2017	2018	2017-18 Change	2014-18 Change
1.	China	81.8	80.1	70.1	79.3	79.9	0.60	-1.90
2.	US	18.0	15.6	14.3	13.9	13.3	-0.60	-4.70
3.	India	16.2	16.6	16.9	17.5	18.6	1.10	2.40
4.	Japan	4.99	5.03	5.02	5.10	4.99	-0.11	0.00
5.	**South Africa**	**3.75**	**3.52**	**3.78**	**3.72**	**3.76**	**0.04**	**0.01**
6.	Russia	3.67	3.86	3.74	3.51	3.63	0.12	-0.04
7.	South Korea	3.53	3.58	3.41	3.61	3.63	0.02	0.10
8.	Germany	3.33	3.29	3.20	3.01	2.90	-0.11	-0.43
9.	Poland	2.07	2.04	2.07	2.08	2.08	0.00	0.01
10.	Indonesia	1.89	2.14	2.23	2.39	2.84	0.45	0.95
11.	Australia	1.88	1.95	1.94	1.88	1.84	-0.04	-0.04
12.	Taiwan	1.71	1.64	1.67	1.70	1.70	0.00	-0.01
13.	Kazakhstan	1.55	1.43	1.42	1.52	1.70	0.18	0.15
14.	Turkey	1.51	1.45	1.61	1.65	1.71	0.06	0.20
15.	Ukraine	1.49	1.14	1.36	1.08	1.15	0.07	-0.34
16.	UK	1.25	0.97	0.46	0.38	0.32	-0.06	-0.93
17.	Vietnam	0.87	1.10	1.19	1.19	1.59	0.40	0.72
18.	Canada	0.82	0.83	0.78	0.78	0.65	-0.13	-0.17
19.	Thailand	0.75	0.73	0.75	0.75	0.80	0.05	0.05
20.	Brazil	0.73	0.74	0.67	0.70	0.70	0.00	-0.03
xx	**Morocco**	**0.17(40th)**	**0.19(37th)**	**0.18(38th)**	**0.19(36th)**	**0.22(33rd)**	**0.03**	**0.05**

Source: *Authors' Compilation from BP Statistical Review (2020)*

3.2 Dissecting the Energy Policy and Emissions situation in SANEM Countries

We examine the energy policies of various countries in SANEM and their pollution abatement strategies in this section. For South Africa, in August 2018 through its Integrated Resource Plan (IRP), sets the energy sector a new focus. Some of the latest direction revolves around moving from coal to gas and renewable energy and also end nuclear power expansion in the country. According to CAT (2019), the revised plan is expected to shift the coal-dominated energy policy of the country by decommissioning about 35 GW of coal-fired state-owned plant and utility giant Eskom by the end of 2050. The revised energy plan also sets to increase renewable energy generation from gas, solar and wind by the year 2030. About 8.1 GW from winds and gas and 5.7 GW from solar are considered for electricity generation without any additional nuclear procurement by 2030. Considering the CAT (2019) assessment, South Africa's 2018 revised IRP can bring the country closer to meeting the upper part of its 2030 Nationally Determined Contribution (NDC) target, which is in tandem with the Copenhagen Accord that proposed reducing emissions below the business-as-usual (BAU) levels (i.e. including land use, land-use change and forestry [LULUCF], by about 42% in 2025, and 34% in 2020). While this is a step forward in transforming the country's energy sector, the climate action tracker still rates the country's NDC target as highly insufficient owing to the fact even if all goals are achieved; warming will only range between 3^0C and 4^0C, which is still far below the Paris agreement of 2^0C. The situation is worrisome in SANEM nations if South Africa's effort is still highly insufficient despite being one of the few countries with emissions reduction targets.

For Morocco, the country's National Energy Strategy sets to achieve the Paris agreement by setting an ambitious target of generating 42% from renewable energy by 2020 and then increase it to about 52% by 2030. According to CAT (2019), Morocco is close to meeting the 2020 renewable target and is also at an advanced stage of planning to achieve its 2030 objective. This is because the country's NDC has a goal to lower its GHGs emissions by 17% below the BAU levels by 2030. Besides, the country hopes to reduce further GHGs emissions by 42% below BAU levels by 2030 if it can secure adequate international support. Moreover, the Moroccan NDC is targeting 13% unconditional emissions reductions and 34% conditional reduction below BAU levels by 2030 while excluding the GHGs reduction contribution from agriculture, forestry, and other land use (AFOLU). With expert assessment from climate action tracker, Morocco’s energy policy target aimed at ambitiously expanding its hydro, wind, and solar energy is close meeting the country’s unconditional NDC goals, hence, compatible with reducing emissions to 1.5^0C of the Paris Agreement (CAT, 2019). The challenge, however, is that to achieve its conditional targets by 2030, since coal-powered plants are still the country might have to implement additional policy strategies being expanded despite the minimum coal reserves in the country.

Regarding the three other nations, Nigeria has demonstrated some levels of commitment to achieving the Paris agreement by taking a pro-active approach towards cleaner energy by 2030. According to the country's Federal Ministry of Environment (2019), its NDC aims to reduce emissions of GHGs unconditionally by 20% and 45% respectively, with international support. The country has also developed a Sectoral Action Plan (SAP) to fast track its NDC implementation in five sectors like transport, agriculture and land use, energy, power, as well as, oil and gas. Moreover, for promoting cleaner energy by 2030, it established ‘the green bonds’ initiatives to channel funds away from carbon-intensive ventures towards low-carbon opportunities. Its plan to increase its on- and off-grid renewable energy received a slight boost by installing 5 MW of large-scale solar plant in 2018, which it expects to triple by

2020.Evidence from UNFCCC (2019) suggested that Algeria's emissions reduction goal ranges from 7% to 22% below the BAU level by 2030. The country's NDC goal is consequent on international assistance via technology, capacity building and finance while the 7% emissions reduction target is set to be achieved through national means. Its energy actions include generating 27% of renewable energy by 2030, high-performance lighting generalisation, reducing gas flaring to less than 1% by 2030, increasing natural gas and liquified petroleum share in fuel consumption, and providing thermal insulation of buildings between 2021 and 2030. Lastly, according to the UNFCCC (2019), Egypt proposes to build institutional and technical capabilities of several units in the energy sector in issues of climate change and then promote efficient energy usage in the country. It also plans to increase renewable energy and more efficient and locally appropriate fossil fuel technology with less emission together with increasing nuclear power. Since the energy policy of Nigeria, Algeria, and Egypt are not contained in the climate action tracker, their progress could not be tracked appropriately.

4. Research Methodology

With the theoretical proposition of Environmental Kuznets Curve (EKC) and following the models specified in Andreoni and Levinson (2001), Stern (2004), Dogan and Seker (2016), and Mesagan & Olunkwa (2020), we specify the econometric model for examining pollution reduction in SANEM while accounting for capital investment. Using capital investment as a mediating channel to reduce GHGs emissions is vital due to the technique effect that environmentally friendly technologies create. So, even if energy use is emission-laden, capital investment can augment it to neutralise the threats of CO_2 emissions as suggested in the pollution hallo theory. To this end, we employ the PMG proposed by Pesaran, Shin & Smith (1999). Consequently, this approach is more appropriate irrespective the size of cross-section (N) and time series (T) as against the GMM approach, which is only suited to large N and small T dimensions (Pesaran & Smith, 1995; Eregha & Mesagan, 2020).

Hence, considering the panel auto-regressive distributed lagmodel in equation (1):

$$a_i(L)y_{it} = b_i(L)x_{it} + d_i z_{it} + e_{it} \tag{1}$$

For country$i$, where$i = 1,..,N$. The parameter for country $i$in the long-runbecomes: $\theta_i = \frac{b_i(1)}{d_i(1)}$ and the panel Mean Group estimator becomes$\theta = N^{-1}\sum_{i=1}^{N}\hat{\theta}_i$. In the PMG framework, long-run estimates remain similar across the cross-section, while they differ in the short-run. Thus, the panel-ARDL unrestricted condition for$i = 1,2,\ldots N$ cross-section, and $t = 1,2,\ldots T$series for the explained variable $y$is given as:

$$y_{it} = \sum_{j=1}^{q}\omega_{ij}\, y_{i,t-j} + \sum_{j=0}^{p}\gamma_{ij}'\, x_{i,t-j} + \mu_i + \varepsilon_{it} \tag{2}$$

Where, $x_{ij} = kx1$ vector of regressors for countries$i\ and\ \mu_i$ represent the fixed effects.

We then present the model as a re-parameterized vector error correction process in Eq (3) as:

$$\Delta y_{it} = \theta_i\left(y_{i,t-1} - \varphi_i' x_{i,t-1}\right) + \sum_{j=1}^{q-1}\omega_{ij}\,\Delta y_{i,t-j} + \sum_{j=0}^{p-1}\gamma_{ij}'\, x_{i,t-j} + \mu_i + \varepsilon_{it} \tag{3}$$

Where, $\theta_i{}'s$ capture the parameters of error correction, and$\varphi_i{}'s$capture their corresponding long-run estimates.

This PMG framework permits the intercepts, adjustment speed, and short-run estimates, to differ across the sample, while the long-run estimates are similar across the group. To conduct the panel unit root test (PURT), we use both the heterogeneous and homogenous tests, whereas the Friedman cross-sectional dependence (CD) test, Frees' test, as well as the Breusch-Pagan LM of Pesaran & Chudik (2014) are employed to confirm the presence of CDs among SANEM countries. We then use the Pesaran CD test to determine whether the 1stgeneration PURTs are appropriate in this study. Considering empirical models in studies like Andreoni & Levinson (2001), Stern (2004), Dasgupta, Laplante, Wang, & Wheeler(2002), Dogan & Seker (2016), and Mesagan, Omojolaibi & Umar(2018), the regressors are selected. They include capital investment (CI) proxied with the gross capital formation per gross domestic product, fossil fuel energy use per person (EN), the interaction of fossil fuel energy use and capital investment (ENCI), income per person (Y), and carbon emissions per person (CO_2). Others include net foreign direct investment inflows (FDI), and trade openness (TO) to the SANEM countries between 1981 and 2017. Trade openness is measured with the aggregation of exports and imports as a ratio of the GDP. The World Bank's World Development Indicators (WDI, 2019) provided the source of various data.

5. Results and Discussion

5.1 Results

To determine the presence of multicollinearity among the covariate variables, we present Table 3. Evidence in Table 3 suggests weak correlation coefficients among the covariate variables. The relatively high ones include energy use and capital investment, which is just 52%, energy-investment interaction and capital investment, which is 60%, and energy-investment interaction and energy use, which is 59%. These variables are estimated in a separate model (i.e. Model IV) to confirm robustness of the other results (in Models I-III). Also, since the rule of econometrics permits their inclusion because their correlation coefficient is far from perfect, we control for them in Model IV. So, having confirmed that our models are free from perfect multicollinearity problem, we proceed with the estimation.

Table 3: Bivariate Correlation Matrix of Variables

	CI	***CO_2***	***EN***	***ENCI***	***FDI***	***TO***	***Y***
CI	1.0000						
CO_2	0.0015	1.0000					
EN	0.5210	0.3705	1.0000				
ENCI	0.6001	0.1204	0.5908	1.0000			
FDI	-0.3125	-0.2691	-0.3373	-0.3206	1.0000		
TO	0.3367	-0.0303	0.1702	0.3521	0.2955	1.0000	
Y	0.1528	0.4916	0.3830	0.2479	-0.2870	0.0742	1.0000

Source: Authors' Compilation

To confirm the stationarity of the regressors, we present Table 4. Both homogeneous PURT of Levin, Lin & Chu (2002) as well as Breitung (2000), and heterogenous PURT of Im, Pesaran & Shin (2003) are used for this purpose as elucidated in section 4.

Table 4: Stationarity Test

Variables	**Heterogeneous PURT**						**Homogeneous PURT**			
	Levels			**First Differences**			**Levels**		**First Differences**	
	ADF	**PP-Fisher**	**IM *et al* (2003)**	**ADF**	**PP-Fisher**	**IM *et al* (2003)**	**Breitung (2000)**	**Levin (2002)**	**Breitung (2000)**	**Levin (2002)**
CI	22.3**	25.2***	-2.33**	75.6***	229***	-8.49***	-3.71***	-0.40	-4.71***	-8.53***
CO_2	10.3	9.25	-0.17	45.3***	115***	-5.39***	-2.05**	0.84	-6.69***	-5.58***
EN	17.5	16.8	-1.61	56.0***	140***	-6.53***	-0.24	-1.73*	-5.45***	-6.87***
ENCI	24.7***	23.5***	-2.56***	72.3***	230***	-8.17***	-3.56***	-1.22	-9.06***	-6.46***
FDI	18.6**	33.0***	-1.89**	79.2***	634***	-8.81***	0.27	-0.65	-4.27***	-5.19***
TO	11.7	13.5	-0.49	60.1***	154***	-6.92***	-0.71	-0.72	-3.37***	-6.37***
Y	6.49	4.43	0.61	26.8***	95.1***	-3.08***	0.18	-1.34	-2.84***	-1.64**

Note: *** 1% significant, ** 5% significant; IM *et al.* (2003)=Im, Pesaran & Shin; Levin =Levin *et al.* (2002).

Evidence in Table 4suggests that at levels, we accept the unit root hypothesis, which means that the panel data are not stationary at levels. We then apply the first difference and found that all the regressors are stationary. The meaning is that the null hypothesis of the existence of unit roots is rejected at the first difference. Thus, we conclude that all the panel covariate variables are found to be stationary at their first differences, but not at their level forms.

Table 5: Panel Cointegration Result

Between-Group		Within-Group		
	Values		**Values**	**Weighted Values**
Group rho	1.51	Panel v-Stat.	-3.96***	-2.93***
Group PP	-3.34***	Panel rho-Stat.	2.83**	1.11**
Group ADF	-1.83***	Panel PP-Stat.	-3.19***	-2.92***
		Panel ADF-Stat.	-1.86**	-1.68**

Note: ***, ** indicates 1%, 5% significance level.

As provided in Pedroni (1999), we present the between-group and within-group results in Table 5.Within-group panel cointegration result pools the autoregressive coefficients across the different sample in computing the statistics' values, whereas the between-groupuse the individual country's estimated means to generate its values.The result in Table 5, therefore, shows that the study rejects the no cointegration null hypothesis considering the within- and between-dimensions altogether. The fact that the group rho of the between-group is insignificant is not strong enough to change the rejection of the null hypothesis. It thus means that long-run association exists among all the covariate variables. This result is also corroborated by the sign of the various error correction terms of the estimated Models I-IV presented in Table 6.

In Table 6, we present the result of the panel estimates, while that of the individual countries is presented in Table 7. In both tables, we present four models to confirm the consistency of the estimated results. In Model I, we show the impact of energy use and other regressors on carbon emissions, while in Model II, we present the impact of capital investment and the other regressors on carbon emissions.

Table 6: Baseline Estimates for the panel, lag lengths are chosen with AIC (max lag = 1)

Regressors	**Dependent Variable:ΔCO_2**		**Model 1: ARDL (1,1,1,1,1,1)** **Model 2: ARDL (1,1,1,1,1,1)** **Model 3: ARDL (1,1,1,1,1,1,1)** **Model 4: ARDL (1,1,1,1,1,1,1,1)**	
	I	**II**	**III**	**IV**
		A. Long-run Estimates		
Y	0.00008	0.00056*	0.00024	0.00042*
	(0.00023)	(0.00033)	(0.00035)	(0.00024)
Y^2	0.13675	-0.55338	-0.28819	-0.94755***
	(0.37670)	(0.34368)	(0.68781)	(0.24486)
EN	0.29037***	-	0.30907***	0.09958**
	(0.06899)		(0.08469)	(0.04179)
CI	-	-0.00658	-0.02417	-0.27188***
		(0.01205)	(0.02637)	(0.10344)
ENCI	-	-	-	-0.00307***
				(0.00116)
FDI	-0.04686	-0.12775***	-0.24411**	0.04245**
	(0.04541)	(0.04446)	(0.11358)	(0.01887)
TO	0.00802	0.00549	0.03935*	0.00118
	(0.00727)	(0.00503)	(0.02013)	(0.00318)
		B. Short-run Estimates		
ECT	-0.23406**	-0.20151***	-0.15056**	-0.25366**
	(0.10585)	(0.06207)	(0.09158)	(0.10222)
ΔY	-0.00079	0.00005	0.00108	0.00053
	(0.00104)	(0.00163)	(0.00161)	(0.00112)
ΔY^2	3.40439	-2.51006	-4.60912	-0.04889
	(3.61135)	(4.17957)	(4.59897)	(2.41894)
ΔEN	-0.24765	-	-0.23791	-0.10974
	(0.24236)		(0.25759)	(0.38852)
ΔCI	-	0.00611	0.01237	1.26250
		(0.00644)	(0.01238)	(1.08908)
ΔENCI	-	-	-	-0.01442
				(0.01216)
ΔFDI	0.00871	0.02112	0.02091	-0.00818
	(0.01265)	(0.01601)	(0.01852)	(0.01376)
ΔTO	-0.00445	-0.00296	-	-0.00396
	(0.00278)	(0.00249)	0.00523(0.00355)	(0.00299)
Constant	-5.58578**	2.26459**	-3.96401*	-5.06943**
	(2.46930)	(0.90176)	(2.25909)	(2.21613)

***Note:** ***, ** & * stand for 1%, 5% & 10% significance levels. Every Modelhas a country-specific term that is constant;( )displaysstandard error for each coefficient.*

Source: *Authors' Compilation (2020)*

Moreover, Model III presents the joint effects of energy consumption and capital investment on CO_2 emissions, while Model IV presents the result for the entire model by controlling for the interaction between capital investment and energy use. Evidence from Table 6 shows that energy use positively and significantly impactsCO_2 emissions in the long-run, thereby making energy consumption a major driver of pollution in SANEM. Meanwhile, in the short-run, energy use has a negative but insignificant effect on pollution across all the estimated models. A satisfying result is that capital investment exerts a short-run positive impact on carbon emissions but lowers CO_2 emissions in the long-run. The role of capital investment becomes noticeable when the interaction term is included in Model IV. The interaction term exerts a negative impact in both short- and long-run. Evidence suggests that while it insignificantly reduces short-run emissions, it significantly reduces long-run emissions at 1%. The meaning is that capital investment is not only beneficial in reducing CO_2 emissions in SANEM but can also be used to augment energy use to reduce air pollution in these countries. Again, it intuitively means that the long-term impact of capital investment as a channel in lowering carbon emissions in SANEM is unusually massive compared to the short-run. The panel models are not spurious as the ECT terms are significantly negative, confirming cointegration and convergence of short-term misalignments back to the long-term.

We use Table 7 to display the short-run individual nation’s result for the same Models I-IV. Table 7 reveals that in South Africa, energy use negatively impacts carbon emissions in models I, III and IV, while capital investment positively impacts CO_2 emissions. However, the interaction term significantly and negatively affects the emissions of CO_2 in South Africa. This means that on its own, South African energy use is beneficial in lowering CO_2 emissions while investment domiciled in the country worsens the CO_2 emissions' situation. However, the capital investment could augment energy use to reduce CO_2 emissions in the country.

Table 7: Country-Specific Estimates, lag lengths are chosen with AIC (max lag = 1)

Regressors	**Dependent Variable:ΔCO_2**		**Model 1: ARDL (1,1,1,1,1,1)** **Model 2: ARDL (1,1,1,1,1,1)** **Model 3: ARDL (1,1,1,1,1,1,1)** **Model 4: ARDL (1,1,1,1,1,1,1,1)**	
	I	**II**	**III**	**IV**
		South Africa		
ECT	-0.54311*** (0.12086)	-0.35330*** (0.11843)	-0.49057*** (0.10769)	-0.17470* (0.10612)
ΔY	-0.00471 (0.00434)	-0.00572 (0.00585)	-0.00675 (0.00449)	-0.00233 (0.00506)
ΔY^2	17.7658 (15.1370)	18.9281 (17.8709)	22.7394* (13.6404)	7.61728 (15.4119)
ΔEN	-0.04104 (0.09319)	-	-0.04355 (0.08827)	-1.35535*** (0.28088)
ΔCI	-	0.03103 (0.03601)	0.06175** (0.02728)	5.55740*** (1.23579)
$\Delta ENCI$	-	-	-	-0.06245*** (0.01401)
ΔFDI	0.02262 (0.03803)	0.04161 (0.04198)	0.06071 (0.04140)	-0.02271 (0.03462)
ΔTO	-0.01106 (0.01508)	-0.00925 (0.01739)	-0.01499 (0.01399)	-0.00624 (0.01479)
Constant	-10.6794*** (3.60708)	5.30102** (2.26090)	-11.6251 (5.76272)	-2.42552 (1.62056)
		Algeria		
ECT	-0.31489*** (0.12019)	-0.30945** (0.12641)	-0.17366* (0.09922)	-0.13039** (0.09061)
ΔY	0.00066 (0.00514)	0.00220 (0.00557)	-0.00129 (0.00579)	0.00432 (0.00546)
ΔY^2	-1.61942 (9.33599)	-3.90312 (10.1272)	2.04297 (10.4467)	-7.62814 (10.0467)
ΔEN	-1.21637** (0.55971)	-	-1.26788** (0.58743)	-1.08432 (3.97532)
ΔCI	-	0.00589 (0.01280)	0.00152 (0.01295)	-0.08154 (11.8740)
$\Delta ENCI$	-	-	-	0.00090 (0.11897)
ΔFDI	0.05081 (0.08331)	0.07297 (0.08864)	0.06848 (0.08854)	0.04556 (0.09212)
ΔTO	-0.01069 (0.00806)	-0.00798 (0.00854)	-0.01290 (0.00863)	-0.01413 (0.00865)
Constant	-9.05073** (3.89649)	3.13281 (2.03476)	-5.93173 (3.92866)	-2.56189 (1.79396)
		Nigeria		
ECT	- 0.03247*(0.04033)	-0.22168*** (0.07560)	-0.03172*** (0.02470)	-0.01933** (0.01548)
ΔY	-0.00085 (0.00081)	-0.00061 (0.00073)	-0.00088 (0.00079)	-0.00090 (0.00076)
ΔY^2	0.63885 (0.63964)	0.52767 (0.54838)	0.65796 (0.61712)	0.65339 (0.59199)
ΔEN	0.01038 (0.01291)	-	0.00501 (0.01334)	0.04689** (0.02386)
ΔCI	-	-0.00332 (0.00441)	-0.00120 (0.00484)	-0.04179 (0.03611)
$\Delta ENCI$	-	-	-	-0.00213 (0.00177)
ΔFDI	-0.01478** (0.00609)	0.00364 (0.00681)	-0.01225** (0.00617)	-0.01441** (0.00575)

ΔTO	-0.00125 (0.00122)	-0.00136 (0.00117)	-0.00152 (0.00127)	-0.00179 (0.00132)
Constant	-0.24812 (0.35036)	1.76917 (1.13078)	-0.34866 (0.41460)	0.33141 (0.26574)
		Egypt		
ECT	-0.31827** (0.12486)	-0.09896*** (0.05975)	-0.09021** (0.06330)	-0.48428*** (0.12170)
ΔY	0.00081 (0.00271)	0.00382 (0.00255)	0.00313 (0.00240)	0.00110 (0.00197)
ΔY²	0.34807 (2.52480)	-2.63811 (2.26752)	-2.24629 (2.23888)	-0.49617 (1.86959)
ΔEN	0.00490 (0.05474)	-	0.02426 (0.05826)	0.25258* (0.15324)
ΔCI	-	-0.00047 (0.00808)	-0.00216 (0.00848)	0.88858 (0.56846)
ΔENCI	-	-	-	-0.00941 (0.00606)
ΔFDI	0.00118 (0.01364)	0.00394 (0.01327)	0.00909 (0.01464)	-0.01735 (0.01356)
ΔTO	-0.00232 (0.00272)	-0.00032 (0.00289)	-0.00213 (0.00327)	-0.00143 (0.00252)
Constant	-8.99458** (3.89577)	0.90079 (0.69420)	-3.00090 (2.42066)	-10.1193*** (3.59412)
		Morocco		
ECT	-0.03852* (0.02276)	-0.02417** (0.03423)	-0.03339** (0.01747)	-0.49825*** (0.12439)
ΔY	0.00023 (0.00047)	-0.00057 (0.00077)	0.00038 (0.00057)	0.00045 (0.00060)
ΔY²	-0.11132 (0.43341)	-0.36426 (0.70300)	-0.20239 (0.51474)	-0.39081 (0.53960)
ΔEN	-0.00386 (0.00752)	-	-0.00551 (0.00765)	-0.02180 (0.05066)
ΔCI	-	-0.00257 (0.00370)	-0.00239 (0.00353)	-0.09372 (0.14338)
ΔENCI	-	-	-	-0.00101 (0.00168)
ΔFDI	-0.01629* (0.00833)	-0.01656** (0.00768)	-0.02117** (0.00864)	-0.03197*** (0.00967)
ΔTO	0.00308** (0.00152)	0.00409** (0.00188)	0.00440** (0.00186)	0.00377* (0.00193)
Constant	1.03897* (0.58619)	0.21911 (0.30238)	1.08639** (0.54681)	-10.1758*** (3.25386)

Note: ****, ** & * stand for 1%, 5% & 10% significance levels. Every Model has a country-specific term that is constant; ( ) displays standard error for each coefficient.*
Source: *Authors' Compilation (2020)*

The Algerian result in Table 7confirms that energy consumption negatively and significantly impacts carbon emissions across all the four Models at 5%. The implication is that energy consumption is beneficial for lowering carbon pollution in Algeria. Like the situation in South Africa, capital investment positively affects emissions in Algeria. However, unlike the situation in South Africa, the interaction term is positive, and capital investment is insignificant. For Nigeria and Egypt, energy consumption positively impacts CO_2 emissions.

In both Nigeria and Egypt, this positive sign runs across Models I, III and IV while in Morocco, energy use also negatively impacts CO_2 emissions like the Algerian and South African cases. Furthermore, capital investment in Nigeria, Egypt and Morocco also exerts a negative influence on carbon pollution. It thus means that capital investment in the three countries is beneficial in reducing CO_2 emissions. Most notably, in Nigeria and Morocco, capital investment reduces emissions with or without the inclusion of the interaction term. Even in Egypt, where the inclusion of both energy use and the interaction term make the capital investment to positively impacts CO_2 emissions, the energy-investment interaction is still able to lower the country's CO_2 emissions. It thus follows that capital investment can provide the needed impetus to reduce carbon emissions in situations where fossil fuel energy use is harmful to the environment. Regarding the suitability of all models, their error correction terms are significantly negative, implying long-run relationship and convergence of the various models.

We present CD tests for the four models in Table 8. The CD tests make it possible to ascertain if the nations are cross-sectionally dependent. Thus, all the CD tests and their usage in the paper remained as explained in the methodology section.

Table 8: CD Results

Null Hypothesis: Countries are cross-sectionally independent								
Tests	**I**		**II**		**III**		**IV**	
	Stat.	**Prob.**	**Stat.**	**Prob.**	**Stat.**	**Prob.**	**Stat.**	**Prob.**
Breusch-Pagan LM test	24.071	0.0074***	58.428	0.0000***	24.360	0.0067***	24.286	0.0069***
Pesaran CD test	1.168	0.2430	-1.462	0.1439	1.166	0.2435	0.997	0.3185
Frees test	0.168	0.0017***	0.684	0.0000***	0.173	0.0013***	0.187	0.0005***
Friedman test	43.804	0.0000***	22.498	0.0002***	44.337	0.000***	44.405	0.000***

**** Indicates 1% level of significance*

The CD results in Table 8implies that the null hypothesis that countries are cross-sectionally independent is rejected since the Friedman, Frees, and the Breusch-Pagan LM tests are all significant at 1% across the four models. Although Pesaran CD agrees that countries are cross-sectionally independent as it is insignificant, the null hypothesis is still firmly rejected. Hence, we confirm that cross-sectional dependence exists in SANEM. The implication remains that the energy and pollution reduction policies that each of these emerging African nations implement have a far-reaching impact on SANEM as a whole. This is not surprising because CO_2 emission has a transboundary effect and will, therefore, require a joint effort from these countries. Lastly, the 1st generation PURT is adequate in the paper since Pesaran CD confirms that SANEM nations are cross-sectionally independent.

5.2 Discussion of Results

This empirical result shows that for the short-run coefficients, fossil energy use negatively affects pollution in Algeria, South Africa, Morocco, and the panel. However, energy use positively impacts pollution in Nigeria, Egypt, and the panel in the long-term. The intuition is that energy use in South Africa and Algeria enhances the reduction in CO_2 emissions. It intuitively means that South Africa's revised energy plan to increase renewable energy generation from solar and wind by the year 2030 and move away from coal to decommissioning about 35 GW of the coal-fired state-owned plant by the end of 2050 is attributable to this progress. We can attribute the Algerian result to the efforts it has invested in generating 27% of renewable energy by 2030 and the provision of thermal insulation of buildings between 2021 and 2030. Also, the energy impact on emission in Morocco is expected since the climate action tracker has already rated its emissions reduction energy plan as compatible with the agreed Copenhagen accord. Interestingly, out of 32 nations tracked, only one country and Morocco have such rating. The country's ambitious plan informs this of generating 42% renewable energy by 2020 and upgrading to 52% by 2030, thereby drawing it closer to its 2020 target and is currently at advance stage to achieving its

2030 target. This result reflects in the panel as energy lowers short-run pollution, but increases it over the long-run. It means long-term planning is required in SANEM to sustain the short-run gain. Meanwhile, for Nigeria and Egypt, energy use compounds the CO_2 emissions situation. This is attributable to both countries' less ambitiousness in their energy-pollution reduction targets because their efforts are still very rudimentary compared to their counterparts. The rational meaning is that energy consumption in Algeria, South Africa, and Morocco is more efficient in reducing pollution compared to those in Nigeria and Egypt. Hence, the short-run panel result and those of Algeria, South Africa and Morocco negate the findings of Shahbaz,Hye, Tiwari & Leitão(2013) and Lean & Smyth (2010) but are in sync with the result of Dogan & Seker (2016).

Furthermore, results show that investment positively impacts pollution in South Africa and Algeria but is negative in Nigeria, Egypt, and Morocco. Also, in the panel, capital investment increases short-term CO_2 emissions but reduces it in the long-term. It intuitively means that investment domiciled in Nigeria, Egypt and Morocco can help to decrease emissions, whereas, for South Africa and Algeria, capital investment did not reduce emissions. It implies that as capital investment increases in Nigeria, Egypt and Morocco, outputs increase vis-à-vis, the technique effects that are generated and emissions reduced. Whereas, capital investment expansion in South Africa and Algeria only triggers output increase, and the composition effects produced expands the pollution level. For the panel, capital investment's impact on pollution corroborates the EKC proposition by causing the output to increase short-term pollution and reduce it over the long-term. Again, energy-investment interaction in SANEM as a whole is negative in both short and long terms; also, negative in Morocco, Egypt, Nigeria, and South Africa, but positive only in Algeria. The meaning is that short- and long-run emissions reduction in SANEM and countries like South Africa, Nigeria, Egypt, and

Morocco can be achieved through the capital investment channel. Moreover, despite being positive in the Algerian model, its inclusion is still able to enhance the capacity of both energy and capital investment in reducing pollution. This result is attributable to the enormous investment that several of these countries are putting into the energy sector. For instance, Algeria is currently investing in expanding the share of liquified petroleum in its fuel consumption to achieve its aim of reducing gas flaring to less than 1% by 2030. It means that the energy-investment interaction provides support for the pollution Hallo theory, which opined that investment could be used to neutralise the threats of emissions (see, Gray, 2002; Copeland and Taylor, 2004).

6. Conclusion

The paper analysed the role of investment in the energy-pollution model in SANEM nations using the dynamic heterogeneous panel approach for 1981 to 2017. The study is driven by the need to: (i) assess the energy policies that Africa's G5 nations (i.e. SANEM) have drawn up in their quest to achieve the Copenhagen Accord of lowering global emissions below 2^0C and limiting it to 1.5^0C; and (ii) determine how crucial capital investment in their pollution abatement model is. Hence, we employed variables like the real GDP per capita, fossil fuel energy use, capital investment, CO_2 emissions, foreign direct investment, trade, and the energy-investment interaction term. Empirical results showed that energy use negatively impacted CO_2 emissions in Algeria, South Africa, Morocco, and the panel in the short-term, it positively impacted pollution in Nigeria, Egypt, and the panel in long-run. Again, capital investment positively determined pollution in South Africa and Algeria, but it exerted a negative impact on pollution in Nigeria, Egypt, and Morocco. Whereas, investment increased pollution in the panel, in the short-term but reduced it over the long-term. Lastly, the energy-investment interaction reduced both long- and short-run pollution in the panel, lowered CO_2

emissions in Morocco, Egypt, Nigeria, and South Africa, except in Algeria. Sequel to these findings, we conclude that capital investment is very crucial in the energy-pollution nexus in SANEM African countries.

We, therefore, recommend that since investment contributes to the rising emissions in South Africa because many firms still generate energy from coal, it should consider down-sizing completely coal-generated power, significantly reduce the use of natural gas, and then increase its renewable energy target beyond 2030. It can also adopt ambitious 2050 goals beyond its revised 2018 IRP to put the country in line to achieve its Paris Agreement. With a similar result, Angola can adequately screen its technology inflow and increase the 7% emissions reduction target meant to be nationally achieved. It can also raise its 2030 renewable energy generation from 27% to about 40%. This will improve its ambitiousness and signal its readiness to meet its Paris agreement target. Moreover, Morocco can sustain its present pollution reductions efforts and achieve its conditional targets even before 2030 by quickly de-emphasising investment in coal-powered plants, which are still being expanded in the country. For Nigeria, the country's approach towards cleaner energy by 2030 is still rudimentary without much vigour. Its NDC target of 20% unconditional GHGs emissions reduction by 2030 should be hastened by improving renewable energy in its energy mix. For instance, while its plans to increase its on- and off-grid renewable energy is a right step, the country's installation of 5 MW of large-scale solar plant in 2018 with the hope of raising it to 15 MW by 2020 is inadequate considering its large population. Therefore, to propel energy use for reducing GHGs emissions, hydro and solar energies should receive massive investments through its green bonds' initiatives, and fossil fuel energy should be drastically reduced. Lastly, since Egypt also has similar energy situation with Nigeria, it should be more proactive by setting specific emissions reduction target and implement more ambitious energy policies. It can explore foreign technical assistance in making its nuclear power generation a reality to achieve its 2030 target. Thus, Africa's G5 nations must cooperate and seek institutional and technical support from their foreign partners in attracting low-carbon emitting technologies to the region. If these policies are well implemented, the current level of pollution in the selected African nations will reduce. It would also set the template for improving environmental quality in the entire African region.

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