

Urbanization and environmental unsustainability: an ecological footprint analysis for Nigeria.

Urbanización e insostenibilidad ambiental: un análisis de huella ecológica para Nigeria.

Aderinto, E.R.

Department of Economics, Lead City University, Ibadan, Oyo State, Nigeria. E-mail: esthercareer@yahoo.com
Mobile phone: +2348021473839

ABSTRACT

The earth's limited natural resources and assimilation capacity, coupled with increased production and consumption activities of a rapidly growing population has made the global environment unsustainable. This study therefore analyses the empirical relationship between urbanization and environmental unsustainability in Nigeria by employing the ecological deficit obtained from the ecological footprint as a measure of environmental unsustainability. The study contributes to empirical literature on the subject matter by employing the STIRPAT model as against the Environmental Kuznets Curve (EKC) model employed by most studies for Nigeria. Secondly, the study differs from others that have used carbon dioxide emissions (CO₂) as a measure of sustainability(unsustainability) of the environment by employing the difference between biocapacity per capita and ecological footprint per capita otherwise regarded as ecological surplus (deficit) as a measure of environmental sustainability (unsustainability). Time series data spanning from 1981 to 2019 was used and the STIRPAT framework was adopted. Autoregressive Distributed Lag Technique of estimation was employed for the long and short run estimates, while the results are validated with the Dynamic Ordinary Least Square Technique (DOLS) as well as the Fully Modified Ordinary Least Square Technique (FMOLS). Short and long run results revealed that urbanization significantly has negative effects on environmental unsustainability. However, working population has a positive effect on environmental unsustainability in the long run, However, in the short run, per capita income and working population have positive effects on environmental unsustainability. The study therefore recommends responsible consumption and production activities that will improve environmental quality.

Keywords: Ecological deficit, Environmental Unsustainability, Population, Urbanization.

RESUMEN

Los limitados recursos naturales y la capacidad de asimilación de la tierra, junto con el aumento de las actividades

de producción y consumo de una población en rápido crecimiento, han hecho que el medio ambiente mundial sea insostenible. Por lo tanto, este estudio analiza la relación empírica entre urbanización e insostenibilidad ambiental en Nigeria utilizando el déficit ecológico obtenido de la huella ecológica como una medida de insostenibilidad ambiental. El estudio contribuye a la literatura empírica sobre el tema al emplear el modelo STIRPAT frente al modelo de curva de Kuznets ambiental (EKC) empleado por la mayoría de los estudios para Nigeria. En segundo lugar, el estudio se diferencia de otros que han utilizado las emisiones de carbono (CO₂) como una medida de la sostenibilidad (insostenibilidad) del medio ambiente al emplear la diferencia entre la biocapacidad per cápita y la huella ecológica per cápita como medida de excedente (déficit) ecológico. de sostenibilidad ambiental (insostenibilidad). Se utilizaron datos de series de tiempo que abarcan desde 1981 hasta 2019 y se adoptó el marco STIRPAT. La técnica de estimación de retardo distribuido autorregresivo se empleó para las estimaciones de largo y corto plazo, mientras que los resultados se validaron con la técnica dinámica de mínimos cuadrados ordinarios (DOLS) y con la técnica de mínimos cuadrados ordinarios totalmente modificados (FMOLS). Los resultados a corto y largo plazo revelaron que la urbanización tiene efectos negativos significativos sobre la insostenibilidad ambiental. Sin embargo, la población activa tiene un efecto positivo sobre la insostenibilidad ambiental a largo plazo. Sin embargo, a corto plazo, la renta per cápita y la población activa tienen efectos positivos sobre la insostenibilidad ambiental. Por tanto, el estudio recomienda actividades de consumo y producción responsables que mejoren la calidad ambiental.

Palabras clave: Déficit ecológico, Insostenibilidad ambiental, Población, Urbanización.

INTRODUCTION

Global warming, extreme weather conditions and continuous environmental degradation have aroused interest on issues of environmental sustainability (Shahbaz et al., 2016). The Sustainable Development Goals (SDGs) were designed to ensure a sustainable future for all, of which the environment contributes in no small way. The SDGs are a collection of seventeen goals geared towards poverty reduction, climate resilience, environmental degradation, peace and justice (United Nations, 2020), with about six of these goals being focused on the environment.

In achieving sustainable development, expansion in population plays a very crucial role but could have a deteriorating effect on the environment especially when it exceeds a nation's productive capacity. Population growth influences the production and consumption activities of countries across the world and in view of this, exerts pressure on the existing earth resources (land, water, air amongst others), thus contributing a great deal to climate change and posing a threat to environmental sustainability. Similarly, the composition of a country's population determines the extent to which resources are utilized and consumed. This is so because a working population contribute more to the production and consumption activities of a country.

Global population is increasing consistently and it has been predicted that by 2030, about 60% of global population will be concentrated in urban centres. It has also been projected that a larger percentage of this increase in urban population, about 90 to 95% will be emerge from low- and middle-income countries in Asia and Africa, of which India, China and Nigeria are predicted to take the lead. The reason for this is not farfetched, as people tend to migrate to cities for an improved standard of living. The resulting effect of this will be an increase in resource consumption followed by a high emission rate that will pose a threat to the environment.

As defined by Global Footprint Network (2017), environmental sustainability refers to human interaction with the environment in a responsible way that reduces degradation or depletion of natural resources. It seeks to ensure that the environmental needs of today are met without leaving lesser units of environmental resources for the future generation. Human's consumption of environmental resources beyond the earth's regenerative capacity could be very detrimental. Given an increasing population, the supply-demand gap of these resources could be widened. In this regard, the ecological footprint (EFP) measures the supply of natural resources as well as human demand on the environment and is therefore an appropriate measure of sustainability. However, in evaluating the EFP as a measure of environmental sustainability, biocapacity (BC) is an important indicator. Borucke et al. (2012) posits that biocapacity is a measurement of people's ecological budget or nature's regenerative capacity that is calculated by biologically productive land and sea areas as given in EF calculations.

The EFP measures the required ecological assets for production and absorption of generated waste from the use of technology and resource management. The EFP analysis indicates whether a country has an ecological deficit or surplus. When it exceeds a nation's biocapacity, such country is regarded to have an ecological deficit. This is because such a country is consuming more environmental resources than it is producing. Similarly, an ecological surplus occurs when the EFP of a country is lower than its biocapacity. The implication of an ecological deficit is that environmental resources are being depleted. According to Bagliani et al., (2008), ecological deficit indicates environmental unsustainability while ecological surplus is a prerequisite for environmental sustainability.

Since the 1970s, global consumption of natural resources has increased by 50 percent. However, this does not match up with the available resources as this has been recorded to have decreased by over 30 percent since then. A global average ecological footprint of 2.75 global hectares per person was recorded in 2016 with a corresponding global average biocapacity of 1.63 global hectares per person (Global footprint, 2018). It can be inferred from Global Footprint (2018), that the world recorded an ecological deficit of 1.1 global hectares per person in 2016. However, to ensure environmental sustainability, ecological footprint should be smaller than biocapacity.

Over the years, Nigeria has recorded an ecological deficit. In 2017, the country's EFP was 1.0 gha with a biocapacity of 0.6 gha, thus recording a deficit of 0.4 gha (Global Footprint Network, 2018). With a teeming population, this implies an increase in the production and consumption activities of the country which may have

deteriorating effects on the environment. Given the threat of climate change and its potential effect on economic activities, it has been projected by Chindo and Abdulrahim (2018) that about 6% to 30% decline in the Gross Domestic Product of Nigeria by 2050 may be owing to climate change if proper mitigation measures are not put in place.

This study therefore examines the effect of urbanization on environmental unsustainability in Nigeria. The study contributes to empirical literature on the subject matter in two ways. The study employs the STIRPAT model as against the Environmental Kuznets Curve (EKC) model employed by most studies for Nigeria. Secondly, the study differs from others that have used carbon dioxide emissions (CO₂) as a measure of environmental sustainability(unsustainability) as it employs the difference between biocapacity per capita and EFP per capita otherwise regarded as ecological surplus (deficit) as a measure of sustainability (unsustainability) of the environment.

MATERIALS AND METHODS.

Data employed for this study spans from 1981-2019. Data employed include ecological deficit as a measure of environmental unsustainability, which is obtained by subtracting biocapacity per capita from EFP per capita, urban population growth, active working population, per capita income, energy consumption used as a proxy for technology, financial development, sourced from World Development Indicator and ecological footprint sourced from Global Footprint Network.

Two main models have been employed in literature to analyse the population- environment nexus vis-à-vis the IPAT (Impact, Population, Affluence, Technology) model and the Environmental Kuznets curve (EKC) model. The IPAT model founded by Ehrlich and Holdren (1971) posits that environmental quality (I) is determined by population (P), affluence (A) measured by GDP per capita and technology (T).

$$I = P \cdot A \cdot T \text{-----} \quad (1)$$

The theory submits that as population increases, environmental quality decreases due to increasing demand for land and other resources (Ehrlich & Holdren, 1971). Similarly, an increase in affluence also increases environmental degradation. However, technology could have positive or negative effects as it could either improve or worsen the environment depending on how it is employed (Commoner, 1972). This model has however been criticized for generating proportionate impact of environmental change by changing one factor and simultaneously holding others constant (Fan et al, 2006).

To overcome the limitation of the IPAT model, a stochastic form of the model was developed, which is the Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model which can be estimated using regression techniques (Dietz & Rosa, 1994). The STIRPAT model allows for the analysis of the non-proportionate impact of a variable on the environment. This model still retains the ecological foundation of the IPAT model as it hinges on the Structural Human Ecology theory. It is however more flexible than the IPAT model by giving room for other theoretically relevant variables to be included into the model (Dietz & Rosa, 1994). Similarly, the model does not confine itself to any particular measure of environmental impact and as such allows for the use of environmental indicators like EFP (Dietz et al., 2007; Rosa et al., 2004; York et al., 2003a).

This study therefore adapts the STIRPAT model as developed by Dietz and Rosa (1994) and as adapted by Janson and Johnson (2017). Thus, the model for this study is specified in form of a linear-log model given that the difference between biocapacity per capita and EFP per capita (ecological deficit) used as a measure of environmental unsustainability is a negative series. The model for the study is given as:

$$EST_t = \beta_0 + \beta_1 \ln UP_t + \beta_2 \ln GDP_t + \beta_3 \ln E_t + \beta_4 \ln WP_t + \beta_5 \ln FIN_t + \mu_t \quad (2)$$

Where EST_t is environmental unsustainability, $\ln UP_t$ is the natural logarithm of urban population growth rate, $\ln GDP_t$ is the natural logarithm of GDP per capita used as proxy for affluence, $\ln E_t$ is the natural logarithm of energy consumption used as proxy for technology, $\ln WP_t$ is the natural logarithm of active working population, $\ln FIN_t$ is the natural logarithm of financial development and μ_t is the error term.

The study adopts the Autoregressive Distributed Lag (ARDL) technique and its cointegration approach i.e. bounds test is used to establish the presence (absence) of long run relationship between the variables. This approach has some advantages over others in the sense that it is applicable for series that exhibit a mixed order of integration i.e. $I(0)$ and $I(1)$ variables. Similarly, the ARDL technique estimates simultaneously the long-run and short-run parameters of the model. The ARDL model to be estimated is represented below:

$$EST_t = \beta_0 + \sum_{i=1}^n \beta_1 \Delta \ln UP_{t-1} + \sum_{i=1}^n \beta_2 \Delta \ln GDP_{t-1} + \sum_{i=1}^n \beta_3 \Delta \ln E_{t-1} + \sum_{i=1}^n \beta_4 \Delta \ln WP_{t-1} + \sum_{i=1}^n \beta_5 \Delta \ln FIN_{t-1} + \alpha_1 \ln UP_{t-1} + \alpha_2 \ln GDP_{t-1} + \alpha_3 \ln E_{t-1} + \alpha_4 \ln WP_{t-1} + \alpha_5 \ln FIN_{t-1} + \mu_t \quad (3)$$

Where β_1 to β_5 are the short run coefficients and α_1 to α_5 are the long run coefficients of the variables. The Bound test for cointegration will be used to determine whether there is long-run relationship between the variables of interest. The co-integration test will be tested at 5% level of significance. If co-integration is established, the long-run and short-run models of ARDL specification in Equation (3) are estimated as:

$$EST_t = \beta_0 + \sum_{i=1}^n \beta_1 \ln UP_{t-1} + \sum_{i=1}^n \beta_2 \ln GDP_{t-1} + \sum_{i=1}^n \beta_3 \ln E_{t-1} + \sum_{i=1}^n \beta_4 \ln WP + \sum_{i=1}^n \beta_5 \ln FIN_{t-1} + \mu_{2t} \text{-----}$$

----- (4)

$$EST_t = \beta_0 + \sum_{i=1}^n \beta_1 \Delta \ln UP_{t-1} + \sum_{i=1}^n \beta_2 \Delta \ln GDP_{t-1} + \sum_{i=1}^n \beta_3 \Delta \ln E_{t-1} + \sum_{i=1}^n \beta_4 \Delta \ln WP_{t-1} + \sum_{i=1}^n \beta_5 \Delta \ln FIN_{t-1} + \Phi ECM_{t-1} + \mu_t \text{-----}$$

----- (5)

Where ecm is the error correction representation in equation (5) and Φ is the speed of adjustment.

Lastly, as a robustness check for the ARDL long run results, the study adopts the Dynamic -Ordinary Least Square (DOLS) and Fully Modified Ordinary Least square (FMOLS) techniques. These techniques can also be used for variables with a mixed order of integration and as such is adopted to validate the ARDL long run estimates.

RESULTS AND DISCUSSION

1.1. Unit Root Test

The Augmented-Dickey Fuller (ADF) and Phillip Perron (PP) tests are employed in a bid to ascertain the unit-root properties of the data.

Table 1. Unit Root Test Result

Source: Author's Computation (2021)

Variable	ADF Test Statistic at level (I ₀)Trend only	PP Test Statistic at level (I ₀) Trend only	ADF Test Statistic at first difference (I ₁). Trend only	PP Test Statistic at first difference (I ₁). Trend only
Environmental unsustainability	-1.927	-1.341	-3.458**	-3.458**
Urban population growth	-9.891*	-8.850*	-----	-----
Gdp/capita	-1.107	-0.889	-3.366**	-3.297***
Energy use	-2.788	-2.675	-5.704*	-6.743*
Active working population	1.823	-1.349	-4.329*	-2.776
Financial development	-1.100	-1.043	-5.609*	-6.064*
Critical values				
1%	-4.226	-4.219	-4.244	-4.226
5%	-3.536	-3.533	-3.544	-3.533
10%	-3.200	-3.198	-3.205	-3.198

Note: *, ** and *** indicate significance at 1%, 5% and 10% levels respectively.

Results shown in table 1 reports unit root test for all our variables. ADF results show that variables exhibit a mix order of integration. This justifies our choice of ARDL methodology as variables exhibit a mix of integration order 1(0) and 1(1).

1.2. Bounds Test for Cointegration

For the Bounds test, the F-statistic value is compared against the two critical value bounds (upper and lower bounds) developed by Pesaran et al. (2001). If the calculated F-statistics value is greater than the upper bound at 5 percent, then cointegration is established.

Table 2. Bound Test Result Source: Author's Computation (2021)

F-Statistic	7.843*		
Critical Values	1%	5%	10%
Lower Bound	3.29	2.56	2.22
Upper Bound	4.37	3.49	3.09

Note: * indicates significance and rejection of the null hypothesis of no co-integration at 1% significance level.

Table 2 reported above shows the Bound-Test for linear co-integration. This approach is used for testing whether or not there is co-integration among the variables employed. Since the calculated F-Statistic (7.843) is greater than the upper bound at 1%, 5% and 10%, we therefore establish long-run relationship.

1.3. ARDL Results

The short and long-run estimates for all variables are presented using the ARDL framework.

Table 3. ARDL Result

Dependent Variable: EST				
Variable	Coefficient	Standard Error	T-Statistics	Probability
LONG RUN ESTIMATES				
LNGDP	-0.306	0.065	-4.737	0.001*
LNWP	1.979	0.528	3.749	0.005*
LNUP	-0.386	0.096	-4.012	0.003*
LNE	-0.832	0.337	-2.467	0.036**
LNFIN	-0.136	0.066	-2.055	0.070*
C	-29.100	7.433	-3.914	0.003*
SHORT RUN ESTIMATES				
DLNGDP	0.137	0.065	2.112	0.064***
DLNWP	6.053	3.123	1.938	0.085***
DLNUP	-0.184	0.079	-2.340	0.044**
DLNE	-0.217	0.082	-2.626	0.027**
DLNFIN	0.192	0.048	4.038	0.002*
ECM	-1.684	0.176	-9.565	0.000*
R -Squared.	0.982			
Adjusted R-Square.	0.934			
DW Statistics.	2.316			
Normality test	0.658			
Breusch-Pagan-Godfrey (Heteroskedasticity).	0.664			
Breusch-Godfrey (Serial Correlation)	0.153			

Source: Author's Computation (2021)

Note: *, ** and *** indicate probability value at 1%, 5% and 10% respectively.

Results shown in table 3 reveals that in the long run, per capita income influences ecological deficit negatively and significantly. This means that a percentage increase in per capita income will reduce ecological deficit by 0.003 units. Similarly, in the long run, active working population has a positive and significant effect on ecological deficit at 1 percent. A percentage increase in active working population will therefore increase ecological deficit by 0.019 units. This conforms with a-priori expectation as it is assumed that an increase in working population will increase consumption and demand on the environment.

Urban population growth has a negative relationship with ecological deficit at 1 percent. A percentage increase in urban population growth rate will reduce ecological deficit by 0.0038 units. Energy use has a negatively significant relationship with ecological deficit at 5 percent as a percentage increase in energy consumption will reduce ecological deficit by 0.008 units. In the same vein, financial development has a negative and significant relationship with ecological deficit at 5 percent as a percentage increase in financial development will reduce ecological deficit by 0.001 units.

Short run analysis show that per capita income has a positive relationship with ecological deficit at 10 percent. A percentage increase in GDP per capita will therefore increase ecological deficit by 0.001 units. This conforms with long run results and a-priori expectation. Similarly, active working population positively determines ecological deficit at 10 percent with a percentage increase in active working population increasing ecological deficit by 0.06 units. This conforms with a-priori expectation and corroborates long run findings. Urban population growth rate has a significantly negative relationship with ecological deficit at 5 percent in the short run. A percentage increase in urban population growth rate in the short run will reduce ecological deficit by 0.001 units. Energy consumption has a negative and significant relationship with ecological deficit at 5 percent with a percentage increase in energy consumption, reducing ecological deficit by 0.002 units. Financial development positively determines ecological deficit at 1 percent significance level with a percentage increase in financial development increasing ecological deficit by 0.001 units.

The speed of adjustment from short-run to long –run equilibrium given any shock in the model is about 168 percent given by the error correction term. To ensure the reliability of the results, some post-estimation diagnostic tests were done. Normality, heteroskedasticity and serial correlation test results show that the null hypotheses for all these tests could be rejected. This shows that the results are free from all these econometric problems. Similarly, cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests for stability of the model are reported.

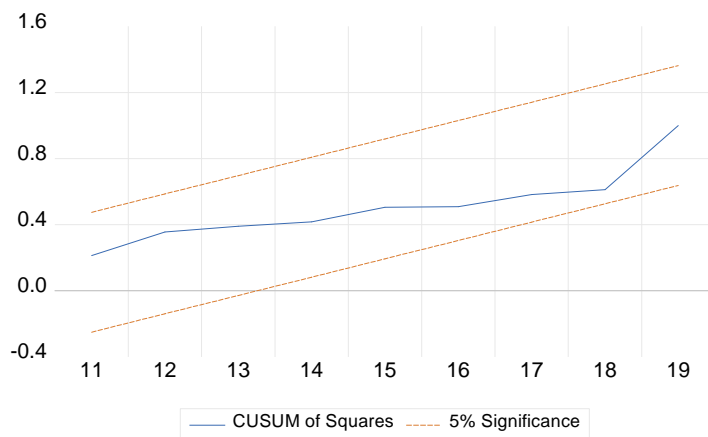


Figure 1: Cusum of Squares test. Source: Author's Computation (2021)

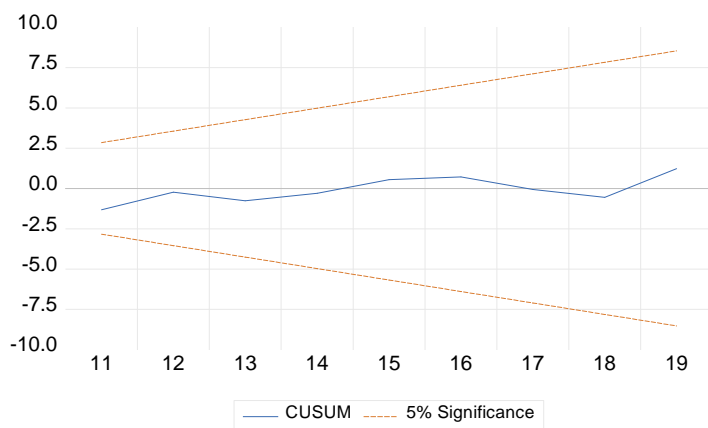


Figure 2: Cusum test. Source: Author's Computation (2021)

Results illustrated in Figures 1 and 2 show that the model is stable as the residuals are within the critical bounds at 5% significance.

1.4. Robustness Check

To validate the long run ARDL result, DOLS and FMOLS results are presented below.

Table 4. FMOLS Results

Dependent Variable: LNEST				
Variable	Coefficient	Standard Error	T-Statistics	Probability
LNGDP	-0.235	0.020	-11.660	0.000*
LNWP	1.429	0.159	8.976	0.000*
LNUP	-0.456	0.064	-7.083	0.000*
LNE	-0.387	0.085	-4.509	0.000*
LNFIN	-0.103	0.030	-3.425	0.001*
C	-21.458	2.574	-8.336	0.000*

Source: Author's Computation (2021)

Note: *, ** and *** indicate probability value at 1%, 5% and 10% respectively.

The FMOLS result presented in table 4 conforms with the ARDL long run estimates. Per capita income, working population, urban population growth, energy consumption and financial development have negative relationship with ecological deficit and are all statistically significant at 1 percent. Active working population on the other hand has a positive relationship with ecological deficit at 1 percent.

Table 5. DOLS Results

Dependent Variable: LNEST				
Variable	Coefficient	Standard Error	T-Statistics	Probability
LNGDP	-0.166	0.028	-5.878	0.000*
LNWP	0.795	0.233	3.410	0.004*
LNUP	-0.335	0.070	-4.769	0.000*
LNE	-0.133	0.167	-0.719	0.437 ^{ns}
LNFIN	-0.013	0.038	-0.335	0.742 ^{ns}
C	-12.383	3.389	-3.653	0.002*

Source: Author's Computation (2021)

Note: *, ** and *** indicate probability value at 1%, 5% and 10% respectively, ns= not significant.

From this DOLS analysis in table 5, energy consumption and financial development do not significantly determine ecological deficit but have negative relationship with ecological deficit as indicated by the long run ARDL results. Per capita income and urban population growth, are seen to have negatively significant relationship with ecological deficit at 1 percent. Only active working population has a significantly positive effect on ecological deficit.

CONCLUSION AND POLICY RECOMMENDATION

The study analysed the effect of urban population growth on environmental unsustainability in Nigeria from 1981-2019 by employing the STIRPAT model within an ARDL estimation framework. Ecological deficit was used as a proxy for environmental unsustainability given that the nation's EFP overshoots its biocapacity since the 1970s. Long run results were also validated with the DOLS and FMOLS estimation techniques. Long run results revealed that of all the variables employed, only active working age population has a positive effect on ecological deficit, thereby increasing the unsustainability of the Nigerian environment. Other variables like per capita income, urban population, energy consumption and financial development were seen to exert negative effects on ecological deficits against a-priori expectations.

However, short run ARDL estimates reveal that per capita income, active working age population and financial development have positive effects on ecological deficit. This conform with a-priori expectation. The working age population is the share of total population in every economy with the largest consumption level. Their consumption pattern will therefore exert a great pressure on the environment since current consumption level is not environmentally sustainable. Similarly, an increase in per capita income increases consumption level though marginally as not all the increase in income is expected to be spent on consumption according to the Keynesian theory. Financial development implies an increasing level of production in the country which has its deteriorating effect on the environment.

The study therefore recommends that responsible consumption and production activities that are environmentally friendly should be encouraged in line with sustainable development goals. This should extend to food and other agricultural products, buildings, transportation and energy. In the same vein, since energy consumption has been seen not to be a positive contributor to ecological deficit, it then means that technology is becoming more environmentally friendly and as such the government should continue in its pursuit of favorable energy policies that will further improve environmental quality in terms of renewable energy and energy efficiency measures.

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