

Study on Quality of Air and Economic Development in: an argument for sustainable India

Prerana K Jain

PhD Scholar

Department of Economics

IBS Hyderabad

The ICFAI Foundation for Higher Education

Donthanapally, Shankarapalli Road, Hyderabad

Telangana

prerana.kjain20@ibsindia.org

Abstract

In this study, from 1990 to 2019 (Time series data) is used to find the link or effect between air pollution and economic development in India which is examined by Autoregressive Distributed Lag (ARDL) methodology. No₂ (Nitrous oxide) emissions and Co₂ (carbon di oxide) emissions were employed for Quality of Air (Air pollution) and the Gross Domestic Product served for economic Development (GDP). Empirical evidence indicates that emissions of Co₂ and No₂ have insignificant and inverse impact on the Gross domestic product, respectively, GFCF (Gross fixed capital formation) i.e., Domestic Investment have a significantly beneficial effect on economic development (GDP). Based on the results it is advised the adoption and proper execution of additional regulations like tax on usage of carbon di oxide for some specific industries releasing substantial level of greenhouse emissions. Additionally, funds raised from this type of tax ought to be used to fund initiatives that would increase in the employment opportunities and economic development of the country

Introduction

Air pollution related diseases have an unhealthy impact on economic Development through decreased productivity, a reduction in the labour force, increased health care costs, and lost welfare. In the literature on public health, the cost-of-illness method is the principal method used to calculate the financial impact of disease outcomes, particularly those caused by air pollution. The important Goals for Sustainable Development which are Goal 3- Good health and Well-being, Goal 6- Clean water and sanitation, and Goal 11-sustainable cities and communities emphasise the need for an adequate standard of living while preserving a decent environment. The realisation of green development and sustainable development is determined by the interaction between economic activities and environmental pollution in various economies.

In many nations, the use of unsustainable agricultural methods causes long-term harm to the cultivation. Therefore, the Government have to consider the necessity for a healthy environment and choose appropriate solutions for sustainable development when establishing and executing policies.

According to the literature, most economies in the world have developed economically as a result of the efficient utilisation of energy systems. The pollution caused by Co₂ and No₂ emissions such as fossil fuels burning, fertilised soil and wastage of animals have a negative effect on the environment globally. This is due to the fact that activities like production and construction, particularly the use of fossil fuels, have a negative impact on the environment, which has led to environmental deterioration, worse health outcomes, and a reduced life expectancy.

What fuels economic development is productivity. Without economic expansion, progression is challenging, if not impossible. It is therefore necessary because it is linked to an increase in welfare.

Over time, economic development boosts a nation's output and income by increasing the economy's productive capacity. Economic development is one of the macroeconomic priorities that cannot be abandoned in a developing nation like India. All economic sectors in a nation have to use more energy to achieve economic development.

India's transport sector contributed 286 metric tonnes of CO₂ emissions in 2021. Before India's transportation-related CO₂ emissions began to rise and are expected to peak at 286 metric tonnes in 2021, they saw a decline and hit a low of 43 metric tonnes in 1973, contributing to global warming. Fossil fuel consumption and the disposal of animal faeces both have negative effects on the environment's quality and the health of humans. The National Air Quality Monitoring Program (NAMP) is being carried out by the government of India monitors Sulphur Dioxide (SO₂), Nitrogen Oxides (NO_x), Particulate Matter (PM), and Nitrogen Dioxide (NO_x) are the four principal air pollutants in 312 cities and towns of 29 states and 6 union territories of India

Literature Review

SI No	Title	Author	Results	Publication And Period
1	Comparative investigation of the Development, poverty, and inequality trilemma in Sub-Saharan Africa and Latin American and Caribbean Countries	Bosede Ngozi Adeleye Obindah Gershon Adeyemi Ogundip Oluwarotimi Owolabi Ifeoluwa Ogunrinola Oluwasogo Adediran	This study makes the claim that the linkage between inequality in income and the prevalence of poverty dampens the beneficial effects of economic development and supports the claim that the degree of inequality diminishes the benefit of inclusion. Therefore, one of the key factors affecting poverty is income disparity.	https://doi.org/10.1016/j.heliyon.2020.e05631
2	Working Paper on Environmental pollution, economic development and institutional quality: Exploring the nexus in Nigeria	Samuel Egbetokun, Evans S. Osabuohien, Temidayo Akinbobola, Olaronke Onanuga, Obindah Gershon Victoria Okafor	Using ARDL model they see the link between environmental pollution and economic development. The results determine the objective of the green development of developing economies. The results shows that Carbon di oxide and suspended particulate matter (SPM) which implies the green development objective can be achieved in Nigeria with some attention and also studies that other pollution indicators does not give more significant effect on Economic Development. Hence, it is suggested that Nigeria have to strengthened to reduce environmental pollution for achieving economic development.	Forthcoming: Management of Environmental Quality

3.	An empirical examination of the Environmental Kuznets Curve hypothesis for carbon dioxide emissions in Ghana: an ARDL approach	Daniel Kwabena Twerefou Frank Adusah-Poku William Bekoe	Ghana's economic development and the relationship between several pollutants, using time series data 1970 to 2010 and by using the ARDL and Bounds Testing methodology, this paper seeks to have close gap by addressing two key problems. Their findings show that trade openness and energy use are long-term, beneficial drivers of Carbon di oxide emissions. As a result, it is suggested that trade liberalisation policies be enhanced to ensure the adoption of greener products and technology. Likewise, investing in cleaner energy sources may help to reduce CO2 emissions.	DOI: 10.1515/environ-2016-0019 Environ. Socio.-econ. Stud., 2016, 4, 4: 1-12
4	Renewable Energy Consumption Shocks on CO2 Emissions and Economic Development of Nigeria	N Ezenwa V Nwatu O Gershon	The study looks at the relationship between Nigeria's CO2 pollution, usage of renewable energy, and economic development. The study applied the vector error correction model (VECM) to the annual data for the years 1990–2015 in order to test for co-integration using the Johansen technique, which is clear. The findings show the relationship between use of renewable energy (REC) and economic development (GDP). While GDP have inverse impact on REC in the short run, REC positively influences GDP both in the short and long terms.	Published under licence by IOP Publishing Ltd IOP Conference Series: Earth and Environmental Science, Volume 665, International Conference on Energy and Sustainable Environment 23-25 June 2020, Covenant University, Nigeria
5.	Impact of energy consumption and environmental pollution in malaysia	Muhammad Aminu Haruna Suraya Mahmood	The purpose of the study is to look into energy use impacts environment both immediately and over time, as well as government efforts in Malaysia to address the impact. The data from 1980 to 2017 (time series) are analysed using the autoregressive distributive lag (ARDL) method developed in this paper. The findings demonstrate that both long- and short-term environmental effects of energy consumption are present, and that government spending is insufficient to address the issue. The study suggests switching to energy friendly use i.e., investing in renewable energy.	Energy economics letters, Asian Economic and Social Society, vol. 5(1), pages 31-43.

Data

The secondary data from 1990 to 2019 of India (time series data) are used in study. The World Development Indicator was used to gather the information.

Variable source	
Gross Domestic Product (GDP)	World Development Indicator (WDI)
Nitrous oxide emission (NO2)	World Development Indicator (WDI)
Carbon dioxide emission (CO2)	World Development Indicator (WDI)
Gross Fixed Capital Formation (GFCF)	World Development Indicator (WDI)

Methodology

The link between Economic Development and environmental sustainability is captured by the ARDL model, according to its specifications the functional form is showed by mathematical formula:

$$LGDP = f(LCO2, LGFCF, LNO2) \quad (4.1.)$$

Where,

LGDP = Log of GDP (Gross Domestic Product)

LCO2 = Log of CO2 (Carbon dioxide) emissions

LGFCF = Log of GFCF (Gross Fixed Capital Formation)

NO2 = Log of NO2 (Nitrous Oxide) emissions.

From the eq.4.1 in the Autoregressive Distributed Lag equation:

$$DLGDP = b_0 + \sum_{j=0}^r b_1 \Delta LCO2_{t-j} + \sum_{j=0}^s b_1 \Delta LGFCF_{t-K} + \sum_{j=0}^v b_2 \Delta LNO2_{t-l} + \varphi_1 LGDP_{t-1} + \varphi_2 LCO2_{t-1} + \varphi_3 LGFCF_{t-1} + \varphi_4 LNO2_{t-1} + e_2 \quad (4.2)$$

Here, the lag components of second half of the eq.4.2 are present in long-run, the various variables in eq.(4.2) will be present in the short run. Error code e_2 is used. The parameters for the variables are b_i ($i=1,2,3$) in long run and φ_1 ($i=1,2,3,4$) in short runs. The ideal lag time will be obtained by using Akaike knowledge gathering criteria. The eq. (4.2) that accounts for error correction equation;

$$DLGDP = b_0 + \sum_{j=0}^r b_1 \Delta CO2_{t-j} + \sum_{j=0}^s b_1 \Delta GFCF_{t-K} + \sum_{j=0}^v b_2 \Delta NO2_{t-l} + b_5 ECM2_{t-1} + e_2 \quad (4.3)$$

Where, $ECM2_{t-1}$ = Error correction term

Results

Descriptive Statistics

The variables analysis and presentation of the summary (Descriptive statistics) are present in below Table 5.1. All the variables are around the mean values are specified by their small standard deviation (SD) values less than the mean value. Once more, minimum values of the variables are lower than their mean values. On the other hand, the maximum values of several of the variables are more important than their corresponding means.

Table 5.1 The mean, standard deviation, maximum and minimum values of the variables

Variable	Obs	Mean	Std. Dev.	Min	Max
loggdp	30	4.714723	.1812701	4.455015	5.026262
logco2emis~s	30	6.07741	.204914	5.750956	6.390281
loggfef	30	13.19106	.3143498	12.7199	13.6638
logno2emis~s	30	5.305107	.0826799	5.161907	5.419146

Augmented Dickey Fuller Test

When dealing with time series, the unit root model for a stochastic system can be cause with statistical inference. The process has a unit root if one of the roots in the equation describing its properties is 1. The non-stationary phase will not always follow a pattern. The mean is permanently impacted by the unit root phase in the presence of a shock (that is, it does not converge over time). When the root of the process characteristics is more than one, the process is said to be explosive. Numerous techniques can be used to test a unit root. Two of these are the Philips Perron test procedure and the Augmented Dickey-Fuller unit root test method is used in this work. The following model is estimated using the ADF unit root test:

$$\Delta y_t = \beta + \delta t + \theta Y_{t-1} + \sum_{i=1}^q \gamma_i \Delta Y_{t-1} + e_t \quad (4.4.)$$

Where,

Δ = First order Difference

Δy_t = the time series variable(t)of current period

β = Estimation of Drift

δ = One time trend co-efficient, t

θ = test parameter

q = AI (Akaike information criterion) is used to check the maximum time lag empirically

It is empirically questionable whether not to include β or δ . Thus, there are three scenarios that can appear from ADF test:

- (i) model includes the series has drift but still no trend (β can be included but no δ)
- (ii) Model includes both trend and drift (including both β or δ)
- (iii) Model does not have both drift and trend (exclude both β and δ)

ADF test with null hypothesis is $H_0: \theta = 0$ (which means y_t is nonstationary), as opposed to the alternative $H_a: \theta < 0$. (which means y_t is stationary). If we reject the null hypothesis, it means the absence of a unit root. The test will be administered in cases where H_0 is not rejected in it.

$$\Delta \Delta y_t = \beta + \delta t + \theta \Delta y_t + \sum_{i=1}^q \gamma_i \Delta \Delta y_{t-1} + e_i \quad (4.5.)$$

Here variables remain as previously obtained, but at this time the series is twice differentiated which is indicated as the second order difference, $\Delta\Delta$ and the test parameter is the coefficient on the first order difference- one lag of y , Δy_{t-1} .

In level form of log GDP is stationary, the results of the Augmented Dickey-Fuller test give the corresponding t statistics at the level is more than the 5 percent critical value in absolute terms. The level forms of the variables for log all independent variables are not stationary i.e., the level which should be lower than the 5 percent critical value. The unit root null hypothesis is not rejected for all the independent variables. In this instance, these variables were initially differentiated before being put to the test in a model with two-lag length drift. The independent at first difference were stationary which was 5%. The ADF test was more significant at 5 percent at first difference than the absolute values. Log of Co₂, No₂ and GFCF with order 1 are formed using with ADF unit root model, whereas the log of GDP is with order 0 is also formed.

Table 5.2 The ADF (Unit Root Test)

Variable	Augmented Dickeyfuller Levels		Model Used	Lags Order	$\sim I(d)$
	Levels	1st order difference			
LogGDP	-0.1403*	-	Drift	2	I(0)
LCO ₂	-0.00696	0.510998*	Drift	2	I(1)
LNO ₂	0.253966	0.1085649*	Drift	2	I(1)
LGFCF	-0.00933	-0.182023*	Drift	2	I(1)

The optimal lag lengths were determined by Akaike's Final Prediction Error (FPE) and Akaike's knowledge criterion, where * denotes a 5percent significance level and the rejecting null hypothesis that a unit root exists. The 5 percent critical level of ADF values is -1.714 and -1.319 at 10% critical value. The ADF model which includes a drift model.

The Link Between India's Economic Development and Air Pollution

The error correction model was used to examine the Link between Quality of air and India's economic progress (eq. 4.3) was computed. However, in order to corroborate the variables' level effect, a test for the level form Link between the variables in eq. (4.2) is first carried out using cointegration.

Evaluating the variables through the ARDL Model for level form relationships (level effects)

It was determined using the Pesaran, Shin, and Smith (2001) Bounds test is used to know that the variables in ARDL eq. (4.2) exhibits connection (cointegration). Table 5.3 below displays the test's results.

Autoregressive Distributed lag Model for Error Correction

Estimates were made for the EC model is demonstrated through Akaike Information Criterion. Because the combination of variable are of set I(0) and I(1) series and they do not comprise the I(2) series, so Autoregressive Distributed lag Model is best suited for the present research. Since no variable is I, not even one variable is susceptible have this structural break. Therefore, a structural break variable does not need to be included in the model. In short-run and long-run coefficient EC estimates are shown in Table 5.4, using ARDL model of equation (4.3).

Table 5.4: Estimation of the Autoregressive Distributed lag Model for Error Correction - (For equation 4.3)

```
e (lags) [1,4]
      loggdp  logco2emis~s      loggfef  logno2emis~s
r1          1          0          2          1

. ardl loggdp logco2emissions loggfef logno2emissions,lags(1 0 2 1) ec btest

ARDL(1,0,2,1) regression

Sample:      1992 -      2019                Number of obs   =      28
                                         R-squared       =      0.6032
                                         Adj R-squared   =      0.4644
Log likelihood = 111.47469                Root MSE       =      0.0053
```

	D.loggdp	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
ADJ	loggdp						
	L1.	-.2295173	.0810201	-2.83	0.010	-.3985223	-.0605123
LR	logco2emissions	1.838732	.4006364	4.59	0.000	1.003019	2.674445
	loggfef	-.0967433	.1870575	-0.52	0.611	-.4869383	.2934517
	logno2emissions	-1.862448	.605116	-3.08	0.006	-3.124698	-.6001985
SR	loggfef						
	D1.	.1334842	.063469	2.10	0.048	.0010901	.2658783
	LD.	.0876182	.0568534	1.54	0.139	-.030976	.2062124
	logno2emissions						
	D1.	.6627966	.2091573	3.17	0.005	.2265021	1.099091
	_cons	1.080421	.4556161	2.37	0.028	.1300223	2.030819

Fstatistic: 4.885

Durbin-Watson d-statistic(8, 28) = 2.188987

All the variables used in the test are logged variables (GDP, CO2 Emissions, No2 emissions and Gross fixed expenditure)

The adjustment coefficient are also known as the error correction coefficient, is significant, which have negative sign, and the range between the values 0 and 1. The technology automatically corrects around -2.29% of the errors produced annually in succeeding years at an adjustment pace of -0.2295173 per year. That translates to shift to equilibrium at a rate of -2.29% annually. Convergence is a typical process.

The outcome demonstrated a long-term t-statistic of -3.28 and a nitrous oxide emission coefficient of -1.862448. Since the t-value of -3.28 > 2 (greater) with the probability value of 0.006 which is less p-value at 5% level that is (0.05). Hence it has the significant impact. From the estimation we can know that in short run the p-value of 0.02 and the t-value of 3.17 of NO₂ emissions in short run is significant effect of NO₂ on India's gross domestic product.

Similar results of coefficient of CO₂ in long run were found, with t-value of 4.59 and coefficient of 1.838732 which indicates the long-term economic impact of carbon dioxide emissions is positive. In specifically, rising carbon dioxide emissions cause a 1.83 percent long-term increase in the country's GDP. Additionally, outcome showed that CO₂ with t-value of 4.59 > 2, indicating impact on Gross Domestic Product in long run. Further evidence of impact's comes from the p-value of 0.000 which is > (0.05) crucial value 5% hence, we can say that gross domestic product of India is significantly impacted by CO₂ emissions.

In long run the coefficient of GFCF creation had a considerable inverse impact on the GDP, with coefficient of -0.0967433 and t-values of -0.52. This indicates that gain in GFCF output results in a long-term decline of 9.6% in GDP. Whereas in short run GFCF (domestic investment) has a considerable positive impact on GDP, as indicated by the coefficient of 0.1334842, t-value of 2.10 and p-value 0.048. The proportion or percentage of total variation in the dependent variable which is explained by independent variables is called as coefficient of determination (R²). It also serves as a measure the goodness of fit of the data i.e., how well the model fits the data. R² value of 0.4955, the variables explained 49.55 percent of the variation in India's GDP. The relevance of the "F" value of 4.885 is significant thus, the null hypothesis, in which the variables taken as a whole have insignificant impact on GDP, is thus rejected. Which is supported by the p-value of 0.004. Because of this variable has a large effect on India's GDP. The Durbin-Watson statistic of 2.188987 indicates the absence of autocorrelation.

The Residuals of Regression

The Residuals were detected through the Recursive and OLS of Dependent variable in the regression were also observed and plotted are shown in figure 5.1 and Figure 5.2

Figure 5.1: Recursive of LGDP

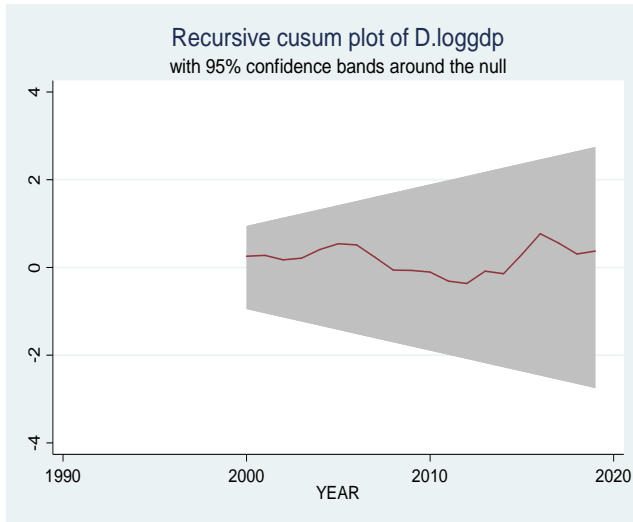
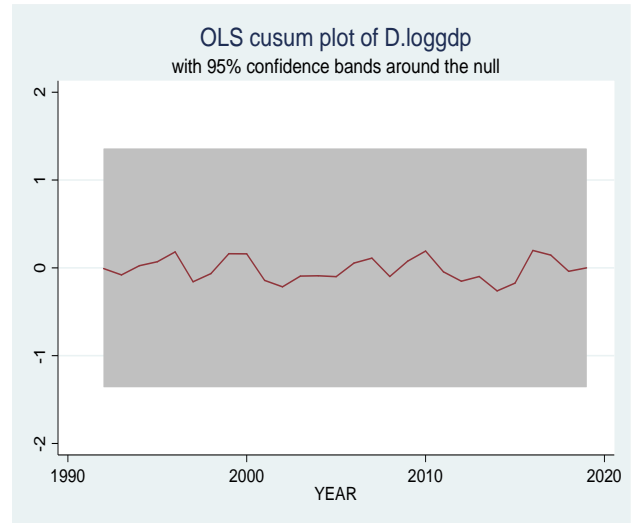


Figure 5.2: OLS of LGDP



This is to verify that the residuals are in line with the model's random error. As seen in Figure (5.1 & 5.2), the residuals have a consistent distribution across the range and follow a symmetrical pattern. A good match is shown by the residuals' asymmetrical and unpredictable structure, which regularly extends down the 0-horizontal axis. As a result, the model is regarded as being accurate for all fitted values. The presence of nonlinearity and structural change was also examined using the recursive residuals (CUSUM) method. The CUSUM test plots the total of the recursive residuals. If there is any moment where the sum exceeded the bound if the sum crosses a critical bound there will be structural break in the model.

The CUSUM-OF-SQUARES test measures how many number of squares are present. It displays the overall sum of square of residuals as a proportion of entire squared residual value shown in the Figure (5.3)

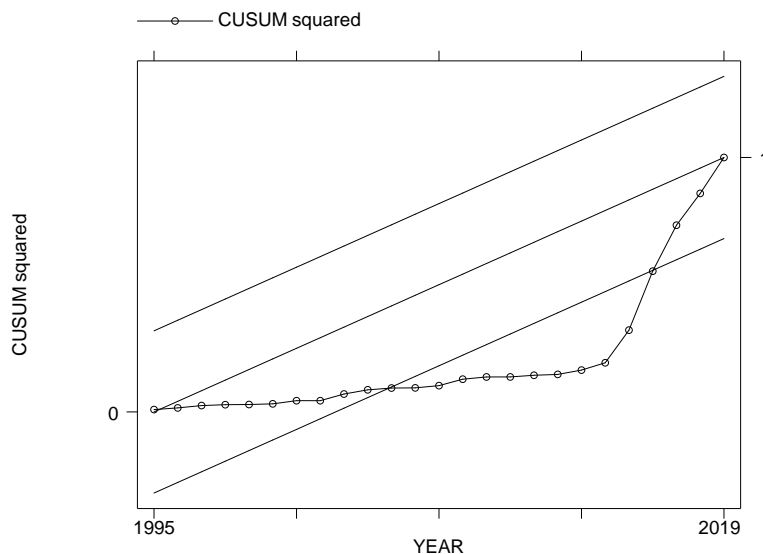


Figure 5.3: The CUSUM test (Cumulative sum of square test) of recursive) in 4.7 model:

According to Figure 5.2's CUSUM-OF-SQUARES, it's possible that parameter constancy persisted during the whole study period. With the exception of the CUSUM of recursive residual which occurred slightly outside critical line boundaries, thus there is stability in the calculated parameters so the recursive mistakes are inside them.

Conclusion and Discussions

This study demonstrated the link between Quality of air(air pollution) and economic development in India. The ARDL technique was used to examine this connection. While NO₂ and CO₂ emissions have insignificant and inverse impact on India's economic development, GFCF is positively and significantly impacting economic development. As a result, GDP grows together with gross fixed capital formation.

It is critical to talk about the consequences for India's industrial and environmental policies of sustainable economic growth, particularly with regard to achieving SDGs 3, 6, and. Infrastructure for energy supply is a significant opportunity for raising India's gross capital formation, and India must exert more effort in this area if it is to experience sustained economic development and meet its Nationally Determined Contributions (NDCs) to combating climate change. India's primary sources of air pollution are energy consumption, transportation, and production. Therefore, it is advised that the government push the development of green infrastructure, such as hydrogen projects, and adopt pertinent laws to encourage such investments in India.

Indian enterprises would have had cheaper costs and higher revenues. In other words, there was a chance to obtain back a sum that was equal to either 150% of India's healthcare budget or 50% of all tax revenue received annually. India's economy and businesses benefit from cleaner air thanks to less absenteeism, increased on-the-job productivity, increased consumer traffic, and decreased premature death

Sustainable practises must be incorporated into the control measures used to combat air pollution. For instance, the primary focus of air pollution control should be taken on environmentally friendly transportation options like BRTs, metros, trams, cycle lanes, and well-connected pedestrian facilities. These options can further ensure that private vehicles are used as little as possible, lowering air pollution levels. To encourage people to choose an effective public transportation system over a reliance on private vehicles. Similar to how tough policies like congestion pricing and pollution trading, which have significantly lower emissions should be implemented. In addition to this, the government needs to encourage the usage of e-cars, e-bikes, and hybrid vehicle types will automatically reduce dangerous emissions.

References

- Estimating emissions from the Indian transport sector with on-road fleet composition and traffic volume – Apoorva Pandey and ChandraVenkataraman- DOI: 10.1016/j.atmosenv.2014.08.039
- Air pollution trends over Indian Megacities and their Local-to-global Implications- B.R .Gujar, Khaiwal Ravindra, Ajay s Nagpure – Science, Technology and Environment Journal
- International Journal of Energy Economics- Economics and policy Greenhouse Gas Emissions and Health outcomes in Nigeria-ARDL technique

An overview of global greenhouse emissions and emission reduction scenarios for the future policy - Anderson, J., Fergusson, M., Valsecchi, C. (2008)-Department of Economics and Science Policy. Brussels, Belgium:

Economic development and greenhouse gas emissions.- European Parliament. Ansuategi, A., Escapa, M. (2002),.- Ecological Economics, 40(1), 23-37. Behera, S.R., Dash, D.P. (2017)

World Bank

<https://www.worldbank.org/en/country/india/publication/catalyzing-clean-air-in-india>

The effect of urbanization, energy consumption, and foreign direct investment on the carbon dioxide emission in the SSEA (South and Southeast Asian) region. Renewable and Sustainable Energy Reviews, 70, 96-106

Narayan, Paresh Kumar & Narayan, Seema, 2008. "Does environmental quality influence health expenditures? Empirical evidence from a panel of selected OECD countries," Ecological Economics, Elsevier, vol. 65(2), pages 367-374, April.

Does tourism affect economic development in Indian states? Evidence from panel ARDL model- lingaraj mallick, ummalla mallesh, jaganath behera- Theoretical & Applied ..., 2016

Impact of FDI, crude oil price and economic development on CO2 emission in India: - symmetric and asymmetric analysis through ARDL and non -linear ARDL approach- Neenavath seeru- Environmental Science and Pollution Research volume 29, pages42452–42465 (2022)