©*The Pakistan Development Review*
55:4 Part II (Winter 2016) pp. 589–604

Environmental Pollution and Sustainable Development in Developing Countries

MUNAZAH NAZEER, UZMA TABASSUM and SHAISTA ALAM

Environmental Pollution is cost of economic growth via increased industrialisation, urbanisation, mechanisation, use of fertiliser and pesticides in agriculture and mismanagement to dump human waste, especially in developing countries, where environmental laws usually are relatively less strict. Hence growth and pollution are positively linked in developing countries expectedly. Sustainable development may be defined as continuous increase in the socio-economic standard of living of a country's population, normally accomplished by improving the quality of its physical and human capital. The research's foremost objective is the generation of environmental pollution index that incorporate various production and consumption side indicators that are majorly responsible for pollution. While, the at-most objective of the study is to examine the causal relationship between the generated pollution index and human development through a panelcausality analysis using a panel of 32developing countries over the period 2000-2013.

*JEL Classification:*Q2, Q3, Q4, O13
*Keywords:*Pollution Indices, HDI, Renewable Energy, Panel Causality, Sustainable Development

1. INTRODUCTION

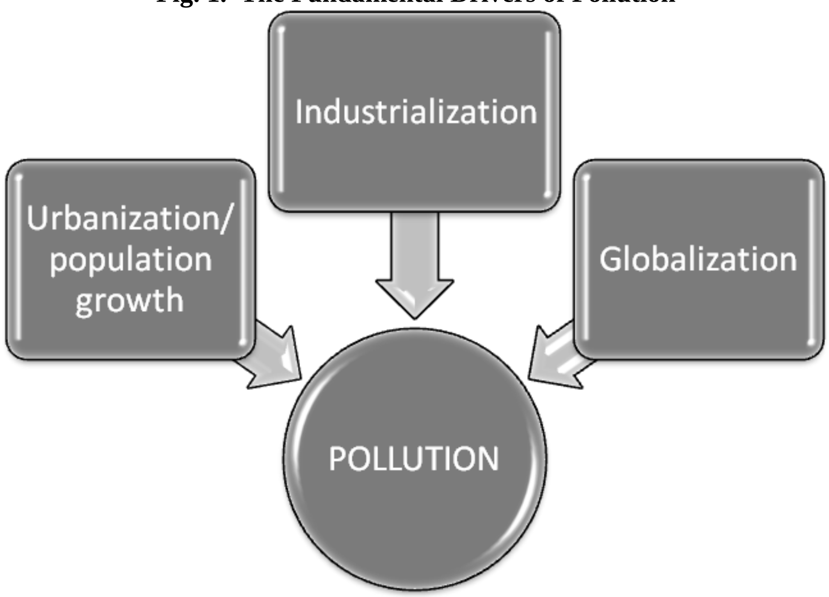
The haste of globalisation, urbanisation and industrialisation has led to severe environmental concerns in developing countries. Over the past few decades the natural resources have depleted remarkably resulting from accelerated pace of economic and social transformation. Economic and social changes such as natural growth of population, migration from rural to urban areas, increase in mechanisationhave transformed the country's natural resource base, both as a source of factor inputs and as a by product of pollution associated with economic activity. The continuously accelerated and unabated environmental degradation in the country is dangerous for sustainability of human development that is the foundation for long-term economic development. Especially in developing countries the impact of environmental pollution is more rigorous, leading to ill health, increase disabilities and mortality rate annually [Greenstone and Hanna (2014)]. Developed nations have advanced technologies and resources to combat pollution consequently they experienced relatively fewer health risks and the probable repercussions of climate change.

Munazah Nazeer <munza_83@hotmail.com> is MPhil Scholar, Applied Economics Research Centre (AERC), Karachi. Uzma Tabassum is Research Associate, Applied Economics Research Centre (AERC), Karachi. Shaista Alam is Senior Research Economist, Applied Economics Research Centre (AERC), Karachi.

Environmental pollution may destabilise development process and competitiveness of developing nations whose economies depends on natural resources. Economic development and human development efforts are increasingly constrained by environmental concerns, including degradation of forest and fisheries, lack of fresh water resources, and poor human health as a result of air and water pollution [Banister (1998); Chu and Yu (2002)]. Intensified crop and livestock production combined with misdirected incentive have contributed to increased production of chemical and organic waste, natural resource and biodiversity loss and soil erosion. Inadequate clean water supply, explosive growth in population, and artificial method of cultivation are the most severe environmental problem in many developing countries. Environmental degradation is costing developing countries 3 to 10 percent of the country's GDP in a sample of 20 countries representing about forty percent population of developing countries. Moreover, environmental experts believe that the environmental degradation cost might cross about Rs.450 billion so far [World Bank (2012)].

Fundamentally, there exist three major driver of pollution namely industrialisation, urbanisation and globalisation surging the level of air, water and noise pollution. This link can be seen from Figure1.

Fig. 1. The Fundamental Drivers of Pollution



Source: Author's presentation of fundamental drivers of pollution.

Industrialisation is the first fundamental cause of pollution. Among other things, industrialisation set in motion the widespread use of fossil fuels (oil, gas and coal) which are now the main sources of pollution. Industrial pollution contribute majorly in emitting waste gases like carbon monoxide, sulphur oxides, and nitrogen oxides which are the waste products of industry and end up in the air as well as dumping of industrial waste into water, endangering human life. Such industries include petroleum refineries, metal smelting, iron and steel mills, grain mills, and the flour handling industry**.**

Urbanisation is the second fundamental cause of pollution. With population numbers literally exploding around the world, the demand for food and other goods goes up. This demand is met by expanded production and use of natural resources which in turn leads to higher level of pollution. On the other side of the coin consumption demand of these produced good is higher for higher concentrations of people which in turn are associated with higher waste generation.

The process of urbanisation and emergence of urban centre involve concentration of economic activities which in turn require human capital that leads to concentration of people in a geographically smaller area. For supporting such growing economic activities and human concentration, infrastructure is inevitable but once the availability of infrastructure fall short to accommodate the urban demand, problems of poverty, high prices, low grade and unmaintained housing, congestion, environmental degradation and low living standards will begins to take hold. Urbanisation is characterised by industrialisation, population growth, high rises and slums resulting in rising demand for production and consumption for goods and services which yield more and more waste generation from production and consumption polluting the urban environment.

Globalisation is another cause of pollution. Globalisation has become an effective facilitator of environmental degradation. Developing countries are usually lenient to implement laws and regulations on environmental protection Weng, *et al.* (2009). With this benefit and easy availability of cheap labour, investors or owners of dirty industries move their industries to such 'pollution havens' rather than installing them in more regulated markets [Eskeland and Harrison (2003)].

Hence industrialisation, population growth and globalisation are the roots of the gigantic pollution tree. Rising pollution not only affects human life directly but also indirectly by affecting what humans need from Mother Nature to continue their survival. Pollution directly affect human environment via increased emission of various gases depleting of ozone layer that repel high frequency ultraviolet radiations. All these result as an obstacle in sustainable development. Indirectly, degradation of environment is leading to destroy the natural habitat that provide basic survival needs for human such as increasing water pollution is leading to loss of marine output and species (fishes, herbs etc.), deforestation is causing low tree food production and soil erosion is lowering agricultural yield. What industries would process or stock-out if natural resources are exhausted! High pollution levels are more likely the case with developing countries with low or no environmental regulations. This becomes the rationale behind this study.

The focal objective of the study is to explore the causal relationship between pollution and sustainable development in a panel dataset using indices of pollution and development for 32 developing countries over a period of 14 years from 2000 to 2013. For this purpose the study estimates a dimension index of pollution with the combination of various production and consumption side indicator based on secondary sources of data, while for reflecting development we use Human Development Index (HDI).

This study is unique in the sense that it adds in the existing literature the construction of a combined pollution index. For this combined pollution index production and consumption based pollution indices are also generated using various production and consumption side variables. Moreover, none of the literature reviewed relates so generated pollution index to human development index. Further this study explores the causal relationship between pollution and sustainable growth in a panel analysis.

The rest of the paper is organised as follows. Section 2 states sources of environmental pollution, Section 3 presents review of empirical literature while Section 4 describes the research plan along with methodology and dataset. Empirical results are reported in Section 5 and finally the research is concluded in the last section.

2. SOURCES OF ENVIRONMENTAL POLLUTION

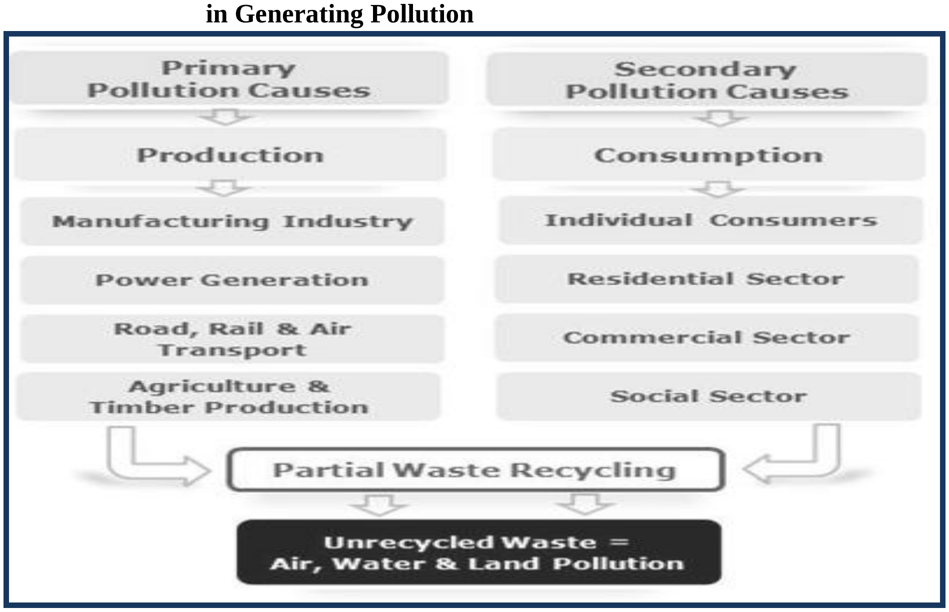
Environment enters as an input into the production function of many goods. For example steel cannot be manufactured without using environment as a dumping ground for pollution. Let *E* denote the input of environment into the production function, the production function now becomes

$$Y = Af(K, L\ E) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

If the firm uses a little *E*, that is equivalent to disposing only a small amount of pollution; a large *E* would correspond to dumping a large amount of pollution. Production of output now involves *L*, *K* and *E*, representing labour, capital and environment respectively. If the environment is cheap to use (no regulation or low level of regulation) firms will tend to use a good deal of *E*. On the other hand if environment becomes more expensive to use (tight regulation or high Pigouvian fee) firms would substitute other factors, such as capital, in place of *E*.

The famous Say's law states that production is for consumption. Hence not only production but consumption also contributes towards pollution. Thus this make production the primary and consumption the secondary source of pollution as one can consume what is produced first. The following figure provides sub-heads under the main production and consumption heads.

Fig. 2. Sub Sources of Production and Consumption Engaged in Generating Pollution



Source: Tropical-RainForest-Animals.com.

Production is treated as the primary cause of pollution, as it involves the whole cycle of extracting and processing natural resources and then manufacturing and selling processed goods. Manufacturing industries, power generation, road, rail and air transport and agriculture and timber production are the major polluting production sectors which can further be segmented down into many other industries/sub-industries. The secondary source of pollution is consumption, refers to consumption by residential, commercial and social sectors which utilise the goods offered by the production side. Hence any industry belonging to either production or consumption plays its part in polluting the environment. The Figure 2, further, tell us that the pollution generated by production—consumption process was partially recycled to some extent, not fully, and the rest was dumped to pollute the physical environment.

Environmental Pollution is mainly divided into three components, air pollution, noise pollution and water pollution. Air pollution is primarily a by-product of energy consumption. Impurities in fuels lead to emission of sulphur dioxide and particulate matter. Troposphere ozone is not directly emitted from combustion but results chemically from high concentration of nitrogen oxides (from fuel combustion) and organic vapours (from paint dying and gasoline evaporation, among other things), in the presence of sunshine.

Water gets contaminated either from point or non-point sources. Point sources are direct sources of water pollution that can be controlled and monitored such as factories, sewage system, power plants, underground coalmines, oil wells. While non-point sources are indirect from various pollution sources that are relatively inelastic to control. Examples of non-point sources includes rain or snow that moves through the ground picking up pollutants, agricultural runoff of fertilisers from farm animals and crop land, urban run offs, air pollutants getting washed or deposited to earth, storm water drainage from lawns, parking lots, and streets etc. which eventually fall in major water sources. Noise pollution mainly produced from mechanisation of human life including indoor machineries to outdoor traffic.

Environmental pollutants are at their worst in urban areas, due to concentration of people, both as sources of the pollution (directly or indirectly) and as victims of the pollution. Air pollution can lead to health problems, including sickness as well as irritation and reduced human's mental and physical performance. The young and those weakened by other illnesses may be particularly susceptible to the effects of urban air pollutants. Urban air pollution also damages materials (such a buildings), increases the cost of maintenance (such as increased cleaning requirements), and degrades aesthetics (no one likes to live in a brown haze). Similarly water pollution also leaves harmful effect on individual's health. A critical problem of water pollution is groundwater pollution. Groundwater is the source of drinking water for many people. Because of the cleaning ability of the earth above the aquifer, groundwater has traditionally been relatively contaminant free. However, groundwater contamination does occur primarily from leaking storage facilities on the surface, either waste storage or storage of bulk liquids such as gasoline. In the past, chemical wastes have been dumped on the surface, finding their way into the groundwater many years later. Another source of groundwater pollution is the leaching of pesticides and fertilisers into the groundwater.

The best way to evaluate effects of environmental pollution over human environment is to compare it with the well known human development index (HDI) which is designed to account for the basic yardstick indicators of living standard prevailing in a country. HDI is a composite index of human development that includes income (GNI), education and health. Pollution is the cost of economic growth via increased industrialisation especially in developing countries where environmental laws usually do not exist or are relatively less strict. Hence growth and pollution are positively linked in developing countries expectedly Low educational attainment is usually associated with high polluting countries. Finally countries with high pollution level experiences low health conditions and deteriorated health indicators [Naveed, *et al.* (2013)]. Thus on overall basis, HDI index is expected to be inversely related to pollution levels prevailing in a nation.

Following *Human Development Report* (2011) by 2050, projection-scenarios exercises recommends that facing current “environmental challenge” it was estimated that HDI would be declined by 8 percent worldwide from the baseline figure while the decline for South Asia and Sub-Saharan Africa will be 12 percent. As in the case of “environmental disaster” scenario the global HDI is expected to fall 15 percent down from the projected baseline. “Environmental challenge” is one that accounts for negative global warming effects on agro-based production, clean water accessibility, sanitation facilities improvement and finally on pollution. While “environmental disaster” scenario deals with the adverse disaster effects caused by deforestation, degradation of land, sharply deteriorating biodiversity and boosting extreme weather occurrences.

3. REVIEW OF EMPIRICAL LITERATURE

It is observed that majority of the existing research on pollution considers a single type of pollution either air, water or noise rather considering it from production and consumption point of view. Few studies report its impact on human health or growth but not specifically related it with the human development index. Some studies are summarised below from the existing literature.

Lean and Smyth (2009) investigate the relationship between carbon dioxide emissions, electricity consumption and economic growth .The methodology used in this study is panel vector error correction model. The sample of the study is based on ASEAN countries from 1980 to 2006. The results indicate that there is statistically significant positive relationship between electricity consumption and CO_2 emission, and also a non-linear significant relationship between CO_2 emission and output.

The study proposed by Azomahou, *et al.* (1997) examines the relationship between greenhouse gas emissions and economic growth. This panel study samples the period from 1960 to 1996. The outcome of this study is existence of a constant relationship between per capita CO_2 emissions and per capita GDP. In the same way, Grubb, *et al.* (2002) examine the national level CO_2 emissions and GDP linkages for advanced economies. The sample period used in their study starts from 1950 to 2001. They also reached at the same conclusion.

In the broader context, [Liu (2006)] examine the relationship between different gasses emissions including CO_2, CO, SO_2, and NO_x and the per capita real GDP on the Norwegian Countries. The study covered the sample period from 1973 to 2003 and discussed the existence of unidirectional relationship between the emissions of air gasses and per capita real GDP. It is found that the relationship between CO_2 and CO existed a long-term relationship with GDP, while SO_2, and NO_x has short-term relationship with per capita GDP. Coondoo and Dinda (2002) examine the relationship between the CO_2 emissions and income for North America, Eastern and Western Europe and found the existence of unidirectional relationship between the CO_2 emissions and national income as well.

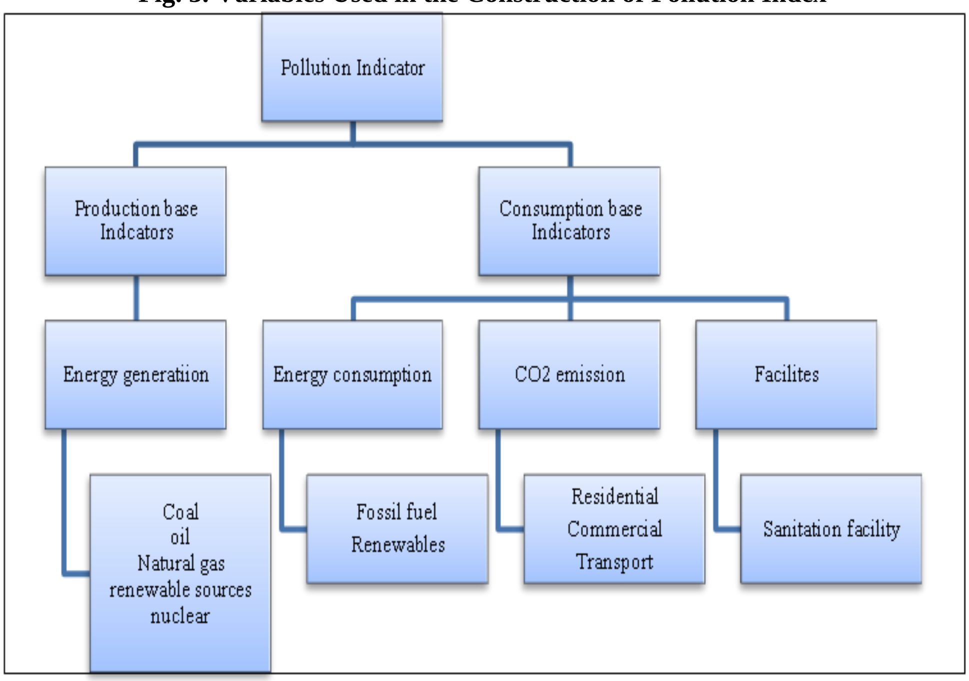
4. RESEARCH PLAN

Our research plan is divided into three parts. The first part explain the construction and the variables used for generating production and consumption side pollution indices (PI^P and PI^C respectively) which are then added to generate a combined pollution index (PI) along with the human development index. In the second part methodology adopted is discussed in sub-Section 4.2 and finally in the third part dataset and its sources are stated.

4.1. Generating an Index for Pollution

As stated above there are two major sources of pollution that is pollution generated from primary sources (production process) and secondary sources (consumption process). Production side pollution index is generated using production side variables and like-wise consumption side pollution index is developed using consumption side variables. The following figure presents the variables selected from production and consumption sides used in the construction of the pollution index.

Fig. 3. Variables Used in the Construction of Pollution Index



Source: Author's flow for variables used for constructing pollution index.

As per the flow, production side is captured from energy generation processes with more weight given to non-renewable source as they participate more in polluting the environment. For representing consumption side, we took energy consumption from fossil fuel and renewable sources, carbon dioxide emission from residential, commercial and transport sectors and sanitation facilities to account for waste management. From production side 5 variables and from consumption side 6 variables are selected. Two of these eleven variables are negatively linked to the negative outcome i.e. pollution, namely energy consumption from renewable sources as this accelerates the demand for renewable energy and the improved sanitation facilities that reflect organised waste disposal.

4.1.1. *Production-Based Pollution Index (PI^P)*

Production based pollution index (PI^P) is a dimension index based on a combination of various variables. The formula used for this index is as follows

$$PI_{it}^{p} = \frac{w_1 EP_{it}^{coal} + w_2 EP_{it}^{renewable} + w_3 EP_{it}^{nuclear} + w_4 EP_{it}^{oil} + w_5 EP_{it}^{n.gas}}{W} \quad \ldots \quad (2)$$

Where *i* and *t* reflect countries and time respectively

EP_{it}^{coal}	Electricity production from coal sources (% of total)
$EP_{it}^{renewable}$	Electricity production from renewable including hydroelectric sources (% of total)
$EP_{it}^{nuclear}$	Electricity production from nuclear sources (% of total)
EP_{it}^{oil}	Electricity production from oil sources (% of total)
$EP_{it}^{n.gas}$	Electricity production from natural gas sources (% of total)
w_i= 1,2,…5	individual weights given to variables in equation 2[1]
W	sum of all individual weights (w_i)

4.1.2. *Consumption-Based Pollution Index (PI^C)*

Consumption based pollution dimension index (PI^C) take into account variables responsible for polluting the environment via consumption. Consumption based pollution index is designed to cover energy consumption variables, *CO*2 emission from various sources and an improved facility provision (sanitation). This index was calculated using the formula stated below.

$$PI_{it}^{C} = \frac{EC_{it}^{X} + CO_{it}^{Y} + IP_{it}^{sanitation}}{W} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

provided $EC_{it}^{X} = EC_{it}^{fossil\,fuel} + EC_{it}^{renewable} / 2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$

and $CO_{2it}^{Y} = CO_{2it}^{transport} + CO_{2it}^{residentid} + CO_{2it}^{mfg\,\&\,cnstr} / 3 \quad \ldots \quad \ldots \quad \ldots \quad (5)$

where *i* and *t* represent countries and time period respectively.

[1]Coal is given the highest weight followed by oil, natural gas, nuclear and renewable sources.

$EP_{it}^{fossil\,fuel}$	Fossil fuel energy consumption (% of total)
$EP_{it}^{renewable}$	Renewable energy consumption (% of total final energy consumption)
$CO_{2it}^{transport}$	CO2 emissions from transport (% of total fuel combustion)
$CO_{2it}^{residentid}$	CO_2 emissions from residential
$CO_{2it}^{mfg\,\&\,cnstr}$	CO_2 emissions from manufacturing industries and construction (% of total fuel combustion)
$IF_{it}^{sanitation}$	Improved sanitation facilities (% of population with access)
W	Total number of variable included in Equation 3.

Combined Pollution Index (PI) Based on Production and Consumption

Dimension indices of production (PI^P) and consumption (PI^C) are combined to form an overall index for pollution (PI). Combined pollution will be the sum of individual indices obtained from production and consumption processes. Symbolically,

$$PI_{it} = PI_{it}^{P} + PI_{it}^{C} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (6)$$

Where *i* and *t* indicates countries and time as stated before

PI_{it} = Combined pollution index

PI_{it}^{P} = Production based pollution index

PI_{it}^{C} = Consumption based pollution index

To examine causality among the generated pollution index (PI_{it}) and human development index developed by UNDP a cause and effect model will be used that aims at evaluating of relationship between human development index and the pollution index. Symbolically the model is represented as

$$HDI_{it} = f(PI_{it}) \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (7)$$

$$PI_{it} = f(HDI_{it}) \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (8)$$

Where

HDI_{it} = Human development index of country *i* at time *t*
PI_{it} = Pollution index generated for country *i* at time *t*

Methodology

For construction of pollution indices we followed the methodology adopted in generating Physical Quality Life Index (PQLI) proposed by Morris (1979). The rationale for adopting this approach is that we have variables which are positively as well as negatively linked with pollution. Unlike HDI in whose construction all variables are positively linked with human development. The formula used for individual dimension index for variables that are positively linked with a negative desired outcome (pollution) is as follows:

$$DI_{it}^{Z} = \frac{Maximum\ Value - Actual\ Value}{Maximum\ Value - Minimum\ Value} \quad \dots \quad \dots \quad \dots \quad \dots \quad (9)$$

While for the variables that are negatively related to the negative outcome (pollution) is

$$DI_{it}^{Z} = \frac{Actual\ Value - Minimum\ Value}{Maximum\ Value - Minimum\ Value} \quad \dots \quad \dots \quad \dots \quad \dots \quad (10)$$

HDI index is interpreted as the more the index value is closer to 1, greater the human development is. While when it comes to pollution index, it is interpreted as the more the index value moves closer to 1, the higher the level of pollution it reflects.

Next for causality analysis between HDI and the generated PI, first stationarity of the two series is tested whether they contain a unit root processes or not. If the series have a unit root it's a non-stationary series and we have to first make it stationary before going for causality.

If the two series are not found to be stationary at level, their individual integration order would be checked. In case both series are stationary at first difference that is they are integrated of order 1 denoted as I (1).The panel co-integration test performed as per Pedroni (2004) approach and afterwards panel causality analysis carried out.

Dataset and Data Sources

The data set comprises of 32 developing countries (cross-sectional units) and 14 years period from 2000 to 2013. Developing countries included are selected on the basis of their data availability both from WDI and UNDP website. List of the selected countries by their region are tabulated in the appendix at the end.

The data for all of the variables except HDI, explained earlier is extracted from the World Development Indicators (WDI)at country level for sample countries. Data for human development index is gathered from United Nation Development Programme (UNDP) website.

Empirical Results

Following methodology defined earlier first stationarity of the two series are tested and the results are presented in Table 1. For this purpose Im, Paseran, and Shin (2003) unit root test is applied to our panel under the null hypothesis that the series do have a unit root process. The test was performed considering intercept and intercept plus trend both.

Both the series are non stationary at level as seen from insignificant coefficient probabilities in the table. Though at first difference they are stationary hence the two series are integrated of order 1. Descriptive summary and graphical representation of individual series are presented in the appendix.

Further panel co-integration is conducted following Pedroni's panel co-integration test considering intercept and intercept plus trend. The test states eleven statistics, 8 for within dimensions and 3 for between dimensions. The outcome of this test is tabulated below in Table 2.

Table 1

Results of Panel Unit Root Test

IPS Panel Unit Root Test			
Log HDI		Intercept	Interceptand Trend
At level [I(0)]	Coefficient	–5.41459	–1.03375
	Probability	1	0.1506
At 1st Difference [I(1)]	Coefficient	–3.94366	–2.48204
	Probability	0	0.0065
Log PI		**Intercept**	**Intercept and Trend**
At level [I(0)]	Coefficient	–0.82619	–0.08066
	Probability	0.2043	0.4679
At 1st Difference [I(1)]	Coefficient	–7.24905	–4.07594
	Probability	0	0

Table 2

Panel Co-integration Test Results

Peroni Panel Cointegration Test
Ho: No Cointegration

Test	Statistic	Prob.	Weighted Statistic	Prob.
C (With Intercept)				
Alternative Hypothesis: Common AR Coefs. (within-dimension)				
Panel v-Statistic	–0.46692	0.6797	–0.406769	0.66
Panel rho-Statistic	–4.73123	0	0.226185	0.59
Panel PP-Statistic	–6.9592	0	–0.849225	0.2
Panel ADF-Statistic	–6.83485	0	–0.08727	0.47
Alternative Hypothesis: Individual AR Coefs. (between-dimension)				
Group rho Statistic	1.73063	0.9582		
Group PP-Statistic	–0.0453	0.4819		
Group ADF-Statistic	1.524532	0.9363		
C and T (With Intercept and Trend)				
Alternative Hypothesis: Common AR Coefficients. (within-dimension)				
Panel v-Statistic	0.115263	0.4541	18.73086	0
Panel rho-Statistic	–6.33794	0	–0.438462	0.33
Panel PP-Statistic	–17.5429	0	–4.987027	0
Panel ADF-Statistic	–16.3816	0	–5.513152	0
Alternative Hypothesis: Individual AR Coefficients. (between-dimension)				
Group rho Statistic	1.966385	0.9754		
Group PP-Statistic	–6.05836	0		
Group ADF-Statistic	–3.87748	0.0001		

As can be seen majority of the statistics while considering only intercept are insignificant indication acceptance of the null hypothesis of no co-integration between the two series. But once deterministic trend is considered along with the intercept, eight out of eleven statistics are statistically significant reflecting strong long-run relationship among HDI and PI series at 5percent level of significance.

There may have a possibility of existence of homogenous or heterogeneous causality across cross-sections when considered individually. For checking this, the study performs Dumitrescu and Hurlin Test (2012) of causality in heterogeneous panels where all coefficients are allowed to vary across cross section. Null hypothesis under Dumitrescu and Hurlin Test (2012) is homogenous non-causality that is there is no causality among the two series for any cross-sectional unit in the panel. While the alternative hypothesis is of heterogeneous non-causality under which two subgroups of cross- sectional units are allowed. For one subgroup of cross-sectional units there exists causality among theseries while for the other group there is not. Here heterogeneous panel with fixed time coefficients is considered. The outcomes to this test are reported in Table 3.

Table 3

Dumtrescu and Hurlin Test Results

Pairwise DumitrescuHurlin Panel Causality Tests			
Sample: 2000 2014	Lags: 2		
Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
DLOGPI does not Homogeneously Cause DLOGHDI	6.01341	4.99158	6.00E-07
DLOGHDI does not Homogeneously Cause DLOGPI	7.58533	7.339	2.00E-13

The empirical results reject the null hypothesis of homogenous non-causality and accept the alternative one. Thus there exist a bilateral causality flow between the generated pollution index and human development index in heterogeneous panel considered by this study. On the basis of the probability, it is concluded that the direction of causality is stronger from growth (HDI) to pollution (PI) in the context of developing countries. This is justified on the basis that in most developing countries production technologies adopted are majorly profit motivated in the absence of or flexible environmental control policies for production and consumption. As a result pollution as an input to production becomes relatively cheap and producers opted for technologies that substitute other input with this relatively cheaper input. Hence growth and pollution goes side by side.

Conclusions and Policy Suggestions

Growing industrialisation, urbanisation, mechanisation, use of fertiliser and pesticides in agriculture and mismanagement to dump human waste is costing economic growth in the form of increased pollution and environmental degradation, especially in developing countries where environmental laws usually don’t exist or are relatively less strict. Though pollution and growth go side by side do not imply that countries should stop developing or compromise their pace of growth for controlling pollution, by any means. Combating pollution and enhancing growth can be attained together by analysing what factors or technologies responsible in the growth process that cause pollution, and by replacing such pollution boosting technologies by relatively more environment friendly ones. Energy is crucial for growth and is demanded for both production and consumption purposes by economic agents (industries, households etc.). If energy is produced from non-renewable resources like coal, oil etc. it will contribute greatly in polluting the environment. The more you use non-renewable resources for meeting the growing energy demand for growth, the greater will be your environment on stack. One can grow at the cost of pollution for now but cannot sustainably grow because the consequences of pollution will not only lower individual productivity but also individual's life span that will result in loss of their productive life years as well. For example adverse health effects will cause frequent illness of individuals, lowering their productivity on one hand while on the other it will cause diseases that may decrease their average age of living, resulting in loss of their productive years which they could have worked in absence of such diseases. On the contrary, if one switches from non-renewable to renewable sources for energy production, the rising pollution proportion can be potentially decreased especially if sustainable development is the prime goal to be achieved.

This study aimed at analysing the causal association between pollution and sustainable growth. For this purpose, first production and consumption based pollution indices are generated which then are summed to form a combined pollution index. Afterwards, causality analysis is performed for the generated combined pollution index series and human development index series. The results indicate that the two series are co-integrated an indicated by panel co-integration test a 5 percent significance level. Further, two way causality is found between the pollution and development with stronger causality flowing from HDI to PI which is justified in the case of developing countries with no or minimal environment friendly production policies as GDP is a part of this index.

Sustainable development can only be attained when all the three economic agents are part of the policy design and all agents contribute towards the goal achievement. Government can use both voluntary and involuntary measures for this purpose. Voluntary measures include awareness regarding the consequences of increasing pollution, scarcity of resources, Effective waste management from both production and consumption point of views, Incentive base persuasion etc. Involuntary measures includes regulation for curtailing pollution leading to sustainable production and consumption by restricting pollutant emission and waste, Progressive taxation on emission and waste, Maintaining pollution standards etc. The Government can then use the funds from this taxation for installation of waste management and recycling processes.

Government should promote shifting of consumption patterns towards groups of goods and services with lower energy and material intensity and for that government should make sure availability and affordability of energy-efficient products and services. Sustainable consumption thus requires action by industry and by governments as well as by consumers.

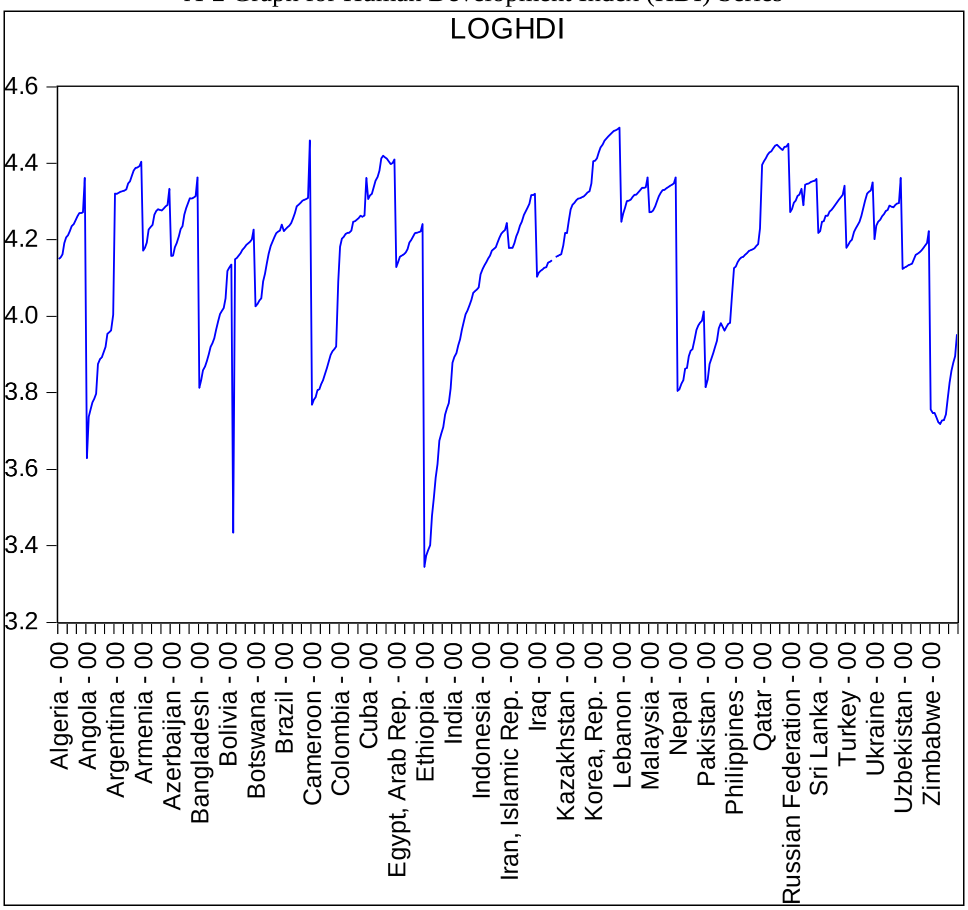
Energy is a major element for sustainable development. Energy production is highly pollutant if generated using non-renewable resources which is usually the case with developing countries.

APPENDIX

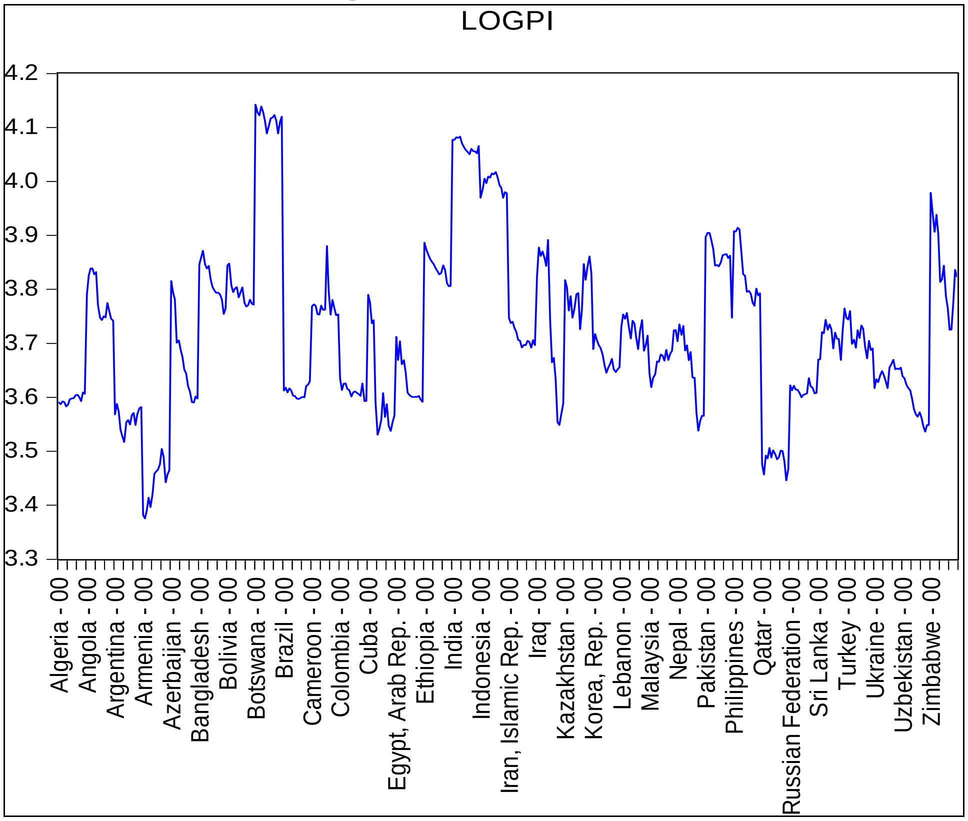
A-1 Descriptive Summary

Descriptive	LOGPI	LOGHDI
Mean	3.723634	4.160764
Median	3.705677	4.217447
Maximum	4.142515	4.493121
Minimum	3.375549	3.344728
Std. Dev.	0.15501	0.210096
Skewness	0.635884	–1.15133
Kurtosis	3.253464	4.237615
Jarque-Bera	33.63275	136.3939
Probability	0	0
Sum	1787.344	1993.006
Sum Sq. Dev.	11.50951	21.09916
Observations	480	480

A-2 Graph for Human Development Index (HDI) Series



A-3 Graph for Pollution Index (PI) Series



A-4 Lag Selection as per Various Criteria

Lag Selection for Panel Causality Analysis		
Criteria Selected	Log HDI	LogPI
Akaike Info Criterion	2	2
Schwarz Info Criterion	2	2
Hannan-Quinn Criterion	2	2
Modified Akaike Info Criterion	2	2
Modified Schwarz Info Criterion	2	2
Modified Hannan-Quinn Criterion	2	2
t-statistic	2	2

A-5 List of Developing Countries included in this Study

S. No.	Region	Name of Countries	Count
1.	South Asia	Bangladesh, India, Nepal, Pakistan and Sri Lanka.	5
2.	East Asia and Pacific	Indonesia, Korea, Malaysia and Philippines.	4
3.	Europe and Central Asia	Armenia, Azerbaijan, Kazakhstan, Russian Federation, Uzbekistan and Ukraine.	6
4.	Sub-Saharan Africa	Angola, Botswana, Cameron, Ethiopia and Zimbabwe	5
5.	Middle East and North Africa	Turkey, Qatar, Egypt, Iran, Iraq, Lebanon and Algeria.	7
6.	Latin America and Caribbean	Bolvia, Brazil, Colombia, Cuba and Argentina.	5
	Total	**32**	

REFERENCES

Azomahou, T., F. Laisney, and P. V. Nguyen (2006) Economic Development and CO2 Emissions: A Nonparametric Panel Approach. *Journal of Public Economics* 90: (6-7), 1347–1363.

Banister, J. (1998) Population, Public Health and the Environment in China. Special Issue: China's Environment, 986-1015.

Chu, C. Y. C. and R. Yu (2002) Population Dynamics and the Decline in Biodiversity: A Survey of the Literature, in Population and Environment: Methods of Analysis. *Population and Development Review* 28, 126–143.

Coondoo, D. and S. Dinda (2002) Causality between Income and Emission: A Country Group-Specific Econometric Analysis. *Ecological Economics* 40:3, 351–367.

Dumitrescu, E. and C. Hurlin (2012) Testing for Granger Non-causality in Heterogeneous Panels. *Economic Modelling* 29:4, 1450–1460.

Eskeland, G. A. and A. E. Harrison (2003) Moving to Greener Pastures? Multinationals and the Pollution Haven Hypothesis. *Journal of Development Economics* 70:1, 1–23.

Greenstone, M. and R. Hanna (2014) Environmental Regulations, Air and Water Pollution, and Infant Mortality in India. *American Economic Review* 104:10, 3038–3072.

Grubb M., B. Muller, and L. Butler (2002) The Relationship between Carbon Dioxide Emissions and Economic Growth. Oxbridge Study on CO2-GDP Relationships.

Gull, N., Y. Nawaz, M. Ali, N. Hussain, R. Nawaz, and S. Mushtaq (2013) Industrial Air Pollution and Its Effects on Human's Respiratory System (A Sociological Study of Bhoun Shugar Mill District Jhang, Pakistan).

Im, K., M. Pesaran, and Y. Shin (2003).Testing for Unit Roots in Heterogeneous Panels. *Journal of Econometrics* 115:1, 53–74.

Lean, H. H. and R. Smyth (2009) CO2 Emission, Electricity Consumption and Output in ASEAN. Development Research Unit. (Discussion Paper DEVBP, 09-13).

Liu, G. (2006) A Causality Analysis on GDP and Air Emissions in Norway. Statistisk Sentralbyra. (Discussion Papers No. 447).

Mahmood, H. and A. R. Chaudhary (2012) FDI, Population Density and Carbon Dioxide Emissions: A Case Study of Pakistan. *Iranica Journal of Energy and Environment* 3:4, 355–361.

Morris, M. D. (1979) *Measuring the Condition of the World's Poor: The Physical Quality of Life Index.* New York: Pergamon Press.

Pedroni, P. (2004) Panel Co-integration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests with an Application to the PPP Hypothesis. *Economic Theory* 20:03, 597–625.

UNDP (2011) *Human Development Report*. UNDP.

Weng, Y., S. Liang, L. Huang, F. Lin, and N. Kao (2009) Does Economic Growth Hurt The Environment? Let's Talk. Department of International Business, National Chengchi University, Taipei, Taiwan.