ENVIRONMENT-DEVELOPMENT RELATIONSHIP: EXISTENCE OF ENVIRONMENTAL KUZNETS CURVE — AN INDIAN PERSPECTIVE

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[India as a growing economy faces trade-off between economic growth and conservation of environment. Improving environmental quality without affecting economic growth is necessary to achieve sustainable development. Before adopting major policy options it is important to know the existing pattern of growth-environment relationship in India. In the present paper this relationship is found in terms of the Environmental Kuznets Curve. In this analysis, three major pollutants (CO_2, NO and SO_2) are taken as the indicators of environmental degradation whereas, the growth rate of Net Domestic Product (at factor cost), represents economic growth. The data of emissions of pollutants and growth rate of NDP are taken for the years 2001-2008. The result shows that higher economic growth in India is accompanied with higher emissions of pollutants. On the basis of the given data set it may be concluded that India is at the rising portion of the Environmental Kuznets Curve.

Keywords: *Economic Growth, Environment, Sustainability, Environmental Kuznets Curve]*

Introduction

In India the livelihoods of majority of economically active population directly depend on environment through agriculture as well as forestry, fishing, hunting and animal husbandry. The share of total working population engaged in agriculture alone from 2004-05 to 2009-10 was 52.9% (GOI, 2014). This makes it single largest private sector occupation. It is therefore one of the major goals of the policymakers to ensure environmental sustainability in countries like India.

The term 'Sustainability,' (Todaro and Smith, 2012, p.485) first came into light in 1980's by the International Union for the Conservation of Nature and Natural Resources. It reflects the need for a balance between economic growth and environmental preservation. The World Commission on the Environment and Development (1987, p.4) defined the

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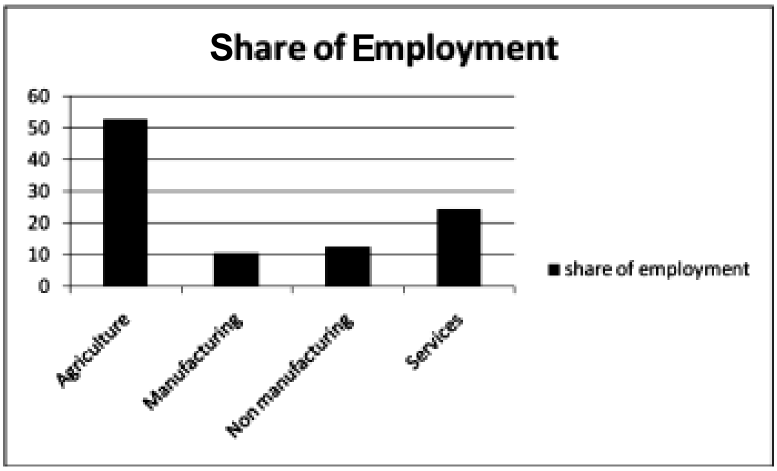
Figure 1: Distribution of Working Force in India (2004-05 to 2009-10)



Source: Planning Commission, 2014

concept as "development that meets the needs of the present generation without compromising the needs of future generations" (cited in Todaro and Smith, 2012, p.485). Sustainable development can be achieved only if the environment is conserved and improved. Pearce and Warfold (1993) define that a development path is sustainable "if and only if the stock of over all capital assets remains constant or rises over time" (cited in Todaro and Smith, 2012, p.485). Overall capital assets include not only manufactured capital (machines, factories) but also human capital (knowledge, skill) and the environmental capital (forest, soil quality). The basic focus of sustainable development is to achieve improvement in living standards without sacrificing the ability of future generations to enjoy at least the same standards. The main objectives of sustainable development are-

1. Meeting the basic needs
2. Achieving higher economic growth
3. Improving environmental quality
4. Accounting for the environment in economic decision making

It is important to get a correct measure of sustainability. By the broad definition, sustainable development requires that the overall capital stock not be decreasing over time. "The correct measure of sustainable net national income (NNI*) is the amount that can be consumed without diminishing the capital stock" (Todaro and Smith, 2012, p.485). Symbolically, NNI*= GNI- Dm-Dn where NNI* is the sustainable national income, Dm is depreciation of manufactured capital assets, Dn is the depreciation of environmental capital measured in monetary terms.

But achieving sustainability is not easy as the growth process is accompanied with higher environmental degradation. Like any other developing country, India also faces the tradeoffs between economic growth and environmental quality due to following reasons-

1. India, being a growing economy, its percentage share of GDP is switching from primary (agricultural) sector to tertiary (service) sector. In the year 1991, percentage contribution to Indian economy by primary, secondary and tertiary sectors were 32.8%, 28.4%, and 39.8% respectively where as those in 2008 have become 17.2%, 29.1%, and 52.7% respectively (cited in Ghatak, S.D, November, 2009, p.1). This sectoral shift on the one hand is regarded as increasing economic growth but accelerates the process of urbanization and industrialization at the other. This continuous pressure on population has become a threat to natural resources affecting environment adversely.

2. With the expansion of industries India has become one of the major contributors to the emissions of pollutants such as CO, Methane, Chlorofluorocarbon (CFC) etc which are regarded as the main causes of Greenhouse effect, and Global Warming. It has the major consequences including severe heat waves, floods, crop and fish losses etc.

3. Modern agriculture also influences environmental degradation. Greater application of pesticides, chemical fertilizers, and multi-cropping system reduces the fertility of the soil. Overgrazing in India has resulted in destruction of grazing lands, forests, and soil. The carrying capacity of the natural environment has been reduced.

4. Exploitation of natural resources is also caused by the richer section of population. Luxurious living standard brings environmental degradation.

5. Indian economy contains the feature of dualism having both richer and poorer sections of population. Poorer section due to poor income, and lack of environmental education, aggravates the problem of pollution.

In a poverty stricken country like India, it is possible to reduce environmental destruction by increasing the incomes of the poor. As the poor causes substantial environmental degradation as a direct result of poverty, increasing their income would provide a better environment e.g. higher income level enables them to use improved sanitary. But as the income and consumption level of everyone in the economy rises, there will be a net increase in environmental pollution.

Therefore the question that automatically arises in front of the policymakers is how to reduce the environmental degradation without affecting the economic growth. Solutions can not be prescribed without knowing the pattern of growth-environmental relationship in India.

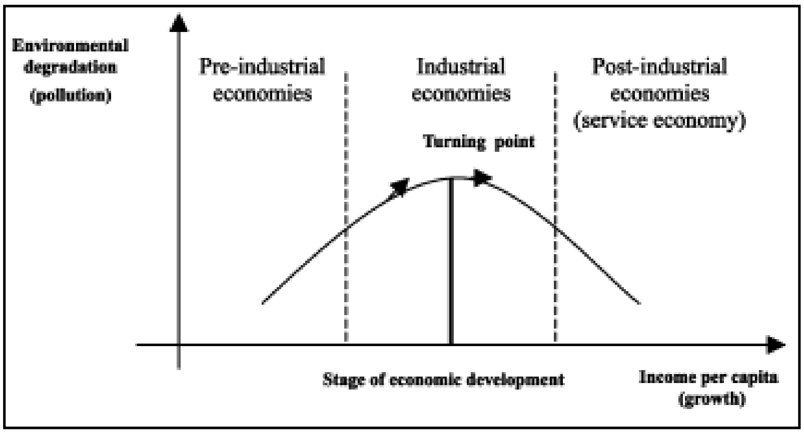
There is a long standing debate on the relationship between economic growth and environmental quality. The Growth-Environment relationship was specified and tested in several studies. Simon Kuznets (1955) introduced curves showing how income inequality changed as per capita income (PCI) of a country increased. He found that income inequality initially increased but after a certain level of income achieved, it started declining. The similar type of relationship is found between PCI and environmental quality which shows that in the initial stage of development, environmental degradation increases with the rise in PCI but it starts declining later. This income-environment relationship has been captured by a curve, which looks like inverted-U and is known as Environmental Kuznets Curve (EKC), (Todaro and Smith, 2012, p.487).

The possible reasons behind the inverted-U shape of EKC are-

1. Technological progress- Technological change increases efficiency and leads to higher income growth and also reduces the emissions per unit of output.
2. Composition of output- Economic growth involves the sectoral shift of output from agriculture to industry. This shift towards secondary sector leads to higher environmental degradation. But the movement of the economy towards the service sector reduces pollution indicating the existence of downward sloping portion of EKC.
3. Rise in living standard- Rising living standard reflects a better consumption pattern and hence an increased demand for cleaner environment. Richer country can enforce environmental regulation to improve environmental quality.

In the present paper, the relationship between economic growth and environmental degradation in India is found in terms of the EKC. This study

Figure 2: Environmental Kuznets Curve - A Development-Environment Relationship



Source: Panayotou (1993)

contains the following successive sections-

- 'Questions of the study', stating the major issues.
- 'Literature Review', showing the theoretical background.
- 'Methodology', stating the objectives, hypotheses and data sources.
- 'Data Analysis', explaining the data set.
- 'Result', showing the major findings.
- 'Conclusion'.

Questions of the Study

The present paper discusses the following issues:

1. The actual pattern of growth-environment relationship in India and its correspondence with inverted-U hypothesis.
2. Empirical evidence of EKC in Indian context.
3. The major policy options that can reduce the level of environmental degradation in India.

Literature Review

The growth-environment relationship as suggested by Kuznet (1955) is discussed by several economists. "There is good evidence that this inverted-U relationship holds for some local pollutants such as particulate matter in the air, sulfur dioxide, and nitrogen oxides. However, there is no convincing evidence that other environmental damage decreases with higher incomes" (Todaro and Smith, 2012). Meier and Rauch (2005) claim that "the upswing of the inverted-U is simply that greater output per head generates more emissions, all else equal. The cause of the downswing is more controversial". However there are also other views regarding the growth-environment relationship some of which are discussed below.

In the early stage of debate, economic growth was considered to be a threat to the environment. The view of some social and physical scientists such as Ehrlich and Holdren (1973) and Meadows and Randers (1992) was that the world will not be able to maintain endless economic growth. They viewed that higher economic growth can be achieved only at the expense of environmental quality, that is, growth may spoil the environment beyond repair (cited in Mishra and Chatterjee, 2007, p. 251).

But the theoretical explanations are mixed. Another view regarding the growth-environment relationship was that, the economic growth may also benefit the environment. This view claims that in the long run, the surest way to improve environment is to achieve economic development. There are number of theories that claimed environment will be less affected as income rise.

Environmental quality is considered a normal good if not even a luxury good. So surely the income elasticity of environmental quality is greater than zero, possibly even greater than one. Therefore as income increases, environmental concern increases as well (Beckerman, 1992) (cited in Alstine and

Neumayer, 2008). Grossman and Krueger (1995) views that "Economic growth means the higher possibility of introducing more modern and less pollution intensive man made capital and technology" (cited in Alstine and Neumayer, 2008). Janicke et al. (1997) state that "As economic development progresses and income grows, the share of industry will go down as services go up, thus sectoral changes may favor less polluting sectors" (cited in Alstine and Neumayer, 2008). It is also suspected that high income countries have become cleaner because they exported their pollution intensive industries to LDCs, which is also known as "Pollution Haven-Hypothesis".

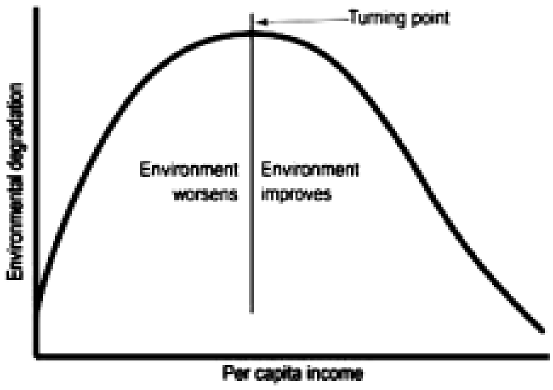
But the above debate did not have empirical evidence for a long time mainly because of the unavailability of environmental data. Another difficulty was regarding the measurement of environmental quality, although a number of indicators of environmental degradation were used to measure the growth-environment relationship.

In last few years, several studies have tried to find that whether there is an inverted-U relationship between per capita income and environmental degradation, as suggested by Simon Kuznets (1955). Some works on this topic tried to investigate whether the EKC is empirically observed and also its policy implications. According to these theories, the growth-environment relationship whether positive or negative is not fixed along a country's development path, but switches from positive to negative as the country reaches to that level of income from which demand for cleaner environment starts to increase. This is also known as the 'Turning Point' of EKC.

Grossman and Krueger (1991) estimated EKCs for SO_2, dark matter, and suspended particles for 52 cities in 32 countries during 1977-88. They used panel data of Global Environmental Monitoring System (GESM) and per capita GDP were in Purchasing Power Parity (PPP) terms. Turning point for SO_2 and dark matter were found to be at $4000-$5000 per capita. But both pollutants began to increase again at income levels more than $10000. Suspended particles although declined continually at low income levels started increasing at an income level over $10000-$15000 (cited in Panayotou, 2003, p. 50). Shafik and Bandyopadhyay (1992) worked on this subject and fitted EKCs for ten different indicators of environmental degradation (cited in Mishra and Chatterjee, 2007, p. 253). Panayotou (1993) in his working paper as a part of a study for the International Labour Force used cross section data and found the turning points for several pollutants (SO_2, NOx, SPM) in an income range of $3000-$5000 per capita. He also found that deforestation conformed EKC hypothesis, with a turning point $800 per capita (cited in Panayotou, 2003, p. 50). In the context of urban environmental quality, large number of studies has been made focusing on airborne pollutants. Seldon and Song (1994) estimated EKCs for SO_2, NOx, SPM and CO emissions using longitudinal data from the World

Resource Institute (cited in Mishra and Chatterjee, 2007, p. 253). Cole et al. (1997) investigated income-environment relationship for many environmental indicators. Some of them are, total energy used, traffic volumes, CFC and Methane emissions. According to their findings, inverted-U shaped curve exists for local air pollutants and CFCs. But the indicators with more global, more indirect environmental impact may increase with income (cited in Panayotou, 2003, p.51).

Figure 3: Turning Point of Environmental Kuznets Curve



Source : Kiran (2010)

It may be stated that EKC studies emphasize on two important questions:

1. Whether an inverted-U relationship exists between income and environmental degradation.
2. Level of income that can be considered as the turning point of EKC.

The answer is puzzling and the turning point depends on the pollutant considered. However in the case of air quality indicators, inverted-U relationship exists. But for water quality indicators, the empirical evidence of EKC is mixed. Shafik (1994), Grossman and Krueger (1995) also found the existence of an N-shaped curve for some indicators (cited in Mishra and Chatterjee, 2007, p. 254).

In the recent years the subject is also analyzed in some developing countries. Choudhury and Pfaff (2004) found the evidence for existence of EKC in measuring indoor air pollution emissions (cited in Kiran, 2010, p.9). They studied the emissions from cooking fuels used by the households in Pakistan. Llorca et al. (2008) aimed at estimating the EKC for SO_2 emissions in a panel of 28 Chinese provinces (cited in Kiran, 2010, p.11). In Indian context, a number of works on this topic has been done which helps to understand the environment-development relationship in India. Barua and Hubacek (2008) studied the relationship between economic growth and water pollution for 16 states in India.

They found that 4 states out of 16 did not show any relationship between water pollution and economic growth, 4 states followed inverted-U shaped curve and other 2 followed U-shaped curve, and remaining 6 states followed N-shaped curve (cited in Kiran, 2010, p.9). Kiran (2010) found the EKC for some indicators such as SO_2, NO_2, SPM etc in different states in India. Mandal and Chakraborty (2012) made a time series analysis to find the existence of EKC with special reference to CO_2 emission.

The present paper finds the existence of EKC in Indian context and reflects the existing pattern of growth-environment relationship in this economy.

Objectives of the Study

1. To find whether the relation between economic growth and environmental pollution in India, satisfies the inverted-U hypothesis, that is whether EKC is empirically observed in Indian context.
2. The relation between different indicators of environmental degradation, such as Carbon Dioxide (CO_2), Nitric Oxide (NO), and Sulfur Dioxide (SO_2) with Net Domestic Product (NDP).

Hypotheses

H_1: Higher economic may lead to greater emissions of CO_2, NO, and SO_2.

H_2: Environmental degradation initially rises as NDP rises.

H_3: Environmental degradation falls after a certain level of NDP achieved.

Methodology

1. Annual average concentrations of CO_2, NO, SO_2 in India are calculated.
2. Inter period comparison is made for CO_2, NO, SO_2 related to the NDP of Indian economy.
3. Annual average concentrations of SO_2 and NDP growth rates are calculated for the states and a state wise comparison is made.
4. Conclusion is drawn on the basis of the comparisons.

Data Sources

The present analysis is based on the secondary data. They are taken from-

1. United State Statistics Division, (2011).
2. Estimates of Emissions from Coal Fired Thermal Power Plants in India, Moti.L. Mittal, (August, 2012).
3. Central Statistical Organization, (2009).
4. Economic Growth in India and Environmental Kuznet Curve: State Wise analysis Kiran (2010).
5. Planning Commission, 2014.

Data Analysis

The relationship between environmental degradation and economic development in an economy depends on the structural changes accompanying economic growth. The following analysis gives detailed account of CO_2, NO, SO_2 emissions and NDP growth rate in India during 2001-2008.

Carbon Dioxide (CO_2)

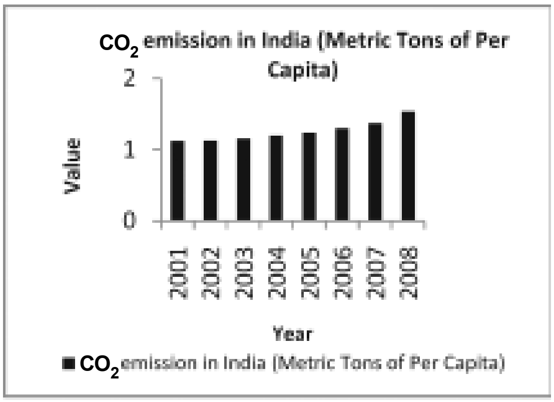
CO_2 is a naturally occurring chemical compound. It is composed of two oxygen and one Carbon atoms. Since the industrial revolution, human activities such as burning of oil, coal and gas, and also deforestation have increased. As a result CO_2 concentration in the atmosphere became larger. Almost all CO_2 emissions come from fossil fuel such as coal, natural gas and petroleum. When fossil fuels are combusted, the carbon stored in them is emitted almost entirely as CO_2. The most important source of CO_2 emission is transportation of goods and people. The emission caused by people traveling is the example of direct emission where as transportation of goods cause indirect emission. Manufacturing and industrial processes also produce large amounts of CO_2 because they use fossil fuel to create heat and stem needed for production, and their energy intensive activities use more electricity. Electricity that we use in home and work has considerable impact on greenhouse gas emission.

CO_2 emissions in India (Metric Tons of CO_2 per capita) by CDIAC during 2001-2008 is given below-

Table 1: CO_2 Emission in India (Metric Tons of CO_2 per Capita)

2001	1.1236
2002	1.1268
2003	1.1592
2004	1.2008
2005	1.2378
2006	1.3002
2007	1.3726
2008	1.5333

Figure 4: CO_2 Emission in India (Metric Tons of CO_2 per Capita)



Source: United State Statistics Division, (2011)

Emission of Greenhouse gas is one of the major sources of pollution in the world. The most harmful effect of greenhouse gases is Global Warming. Among the five major greenhouse gases, CO_2 is the most abundant in nature (Ghoshal and Bhattacharya, 2008).There is also adverse effects of CO_2 emission on human health. In this context it can be mentioned that India is the 4th largest CO_2 emitter in the world (Ghoshal and Bhattacharya, 2008). Unlike other pollutants, we can get consistent yearly estimates of CO_2 for all countries. The Carbon Dioxide Information Analysis Center (CDIAC) of the Oak Ridge National Laboratory (ORNL) provides these estimates which appear to be very useful to the researchers.

Oxides of Nitrogen (NOx) - Nitrogen Dioxide (NO_2) and Nitric Oxide (NO)

NO_2 and NO, also known as Oxides of Nitrogen (NOx) are the two of the major gasses in the atmosphere. NOx is produced from the reaction of Nitrogen and Oxygen gasses in the air, at a very high temperature. A significant amount of NOx is emitted from large cities and from the areas of high motor vehicle traffic. Agricultural fertilization also produces NOx in the atmosphere. NOx plays a major role in the formation of ozone. Presence of NOx in the atmosphere has many adverse effects. It affects both environment and human health. NOx reacts with ammonia and moisture and forms nitric acid vapor and related particles, which damages the lungs tissue causing premature death. It also destroys the ozone in the atmosphere. As mentioned before, the major two oxides of Nitrogen are NO_2 and NO.

NO_2 is a large scale pollutant million tons of which are produced each year. It is produced naturally during electrical storms. NO_2 along with particulates is seen as a reddish brown layer over urban areas. It irritates nose and throat and increases the respiratory infections.

On the other hand, NO is naturally produced during thunderstorms due to the extreme heat of lightning. It is a predominant air pollutant. It can convert to Nitric Acid which is implicated in acid rain. Acid rain is tremendously harmful both for human beings and natural ecosystem of the world.

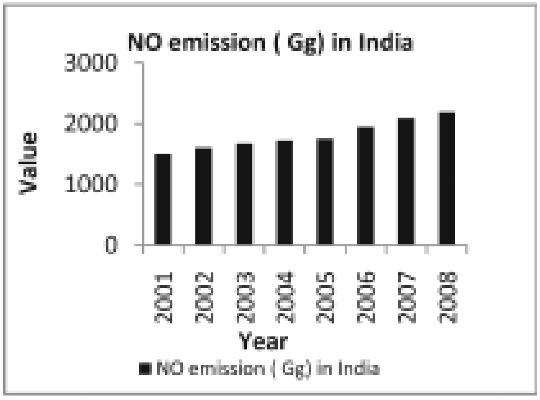
NO emission (Gg) in India during 2001-2008 is given below-

Table 2: NO Emission (Gg) in India During 2001- 2008

2001	1502.07
2002	1601.25
2003	1676.42
2004	1717.56
2005	1743.78
2006	1948.03
2007	2089.02
2008	2190.91

Sources: Mittal, (2012)

Figure 5: NO Emission (Gg) in India During 2001-2008



Sulfur Dioxide (SO_2)

SO_2 is emitted in significant amount from petroleum refining processes, and also from thermal power plants. The diesel driven vehicles are also the major sources of SO_2. SO_2 is formed when, fuel containing Sulphur is burned. Raw materials such as, crude oil, coal contains Sulphur. SO_2 reacts with the other gases of the atmosphere and forms Sulphet that is harmful for human health. It also causes acid rain, respiratory illness, and aesthetic damage. The world "Health Organization (WHO) established the Global Environment Monitoring system (GESM) in which 14 countries has participated. The values showed a range of annual averages of SO_2 concentrations from about 3µg/m^3 to 500 µg/m^3 measured at multiple sites within cities through the world for the period 1980-1984.Carmichael et al. (1998) have calculated annual SO_2 emissions in Asia for 1990 which shows that China and India have the largest contributions in Asia accounting for 65% and 13% respectively," (cited in Mitra and Sharma, 2001). "In India, the SO_2 emissions due to consumption of coal have been calculated for various years in different sectors. These values show that SO_2 emissions are doubling in about 10 years time period," (Mitra and Sharma, 2001, p. 1179). An estimation of SO_2 emission for district and sector level in India(Garg et al. 2001) shows values of 3542 Gg for 1990 and 4638 Gg for 1995, representing an annual growth rate of 5.5% (cited in Mitra and Sharma, 2001, 1179).

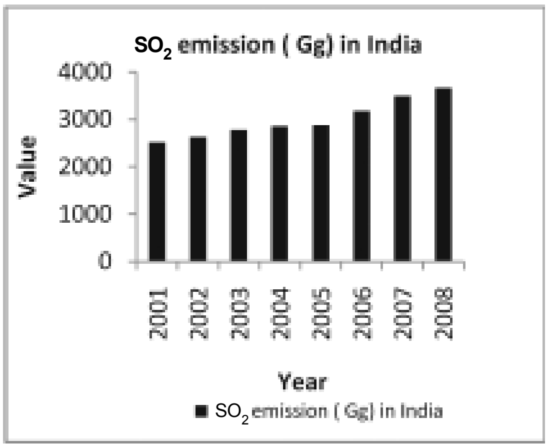
SO_2 emission (Gg) in India during 2001-2008 is given below-

Table 3: SO_2 Emission (Gg) in India During 2001-2008

2001	2519.93
2002	2630.52
2003	2772.54
2004	2853.24
2005	2874.86
2006	3176.43
2007	3501.41
2008	3663.99

Source: Mittal, (2012)

Figure 6: SO_2 Emission (Gg) in India During 2001-2008



To find the relationship between environment and economic growth in India, we can compare the emissions of the above mentioned pollutants (CO_2, NO, SO_2) (representative of environmental degradation) with the growth rate of NDP at factor cost (crores) at constant prices during 2001-2008 (representative of economic growth).

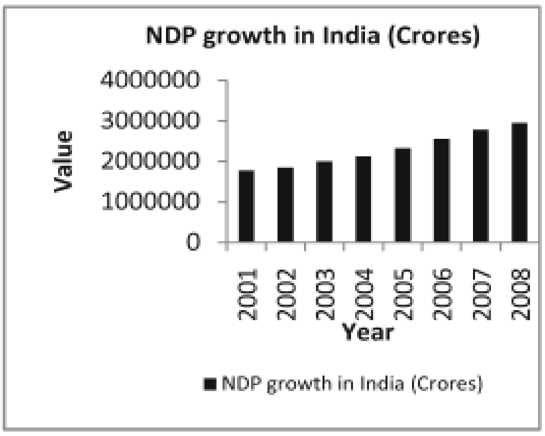
NDP growth in India during 2001-2008 is given below-

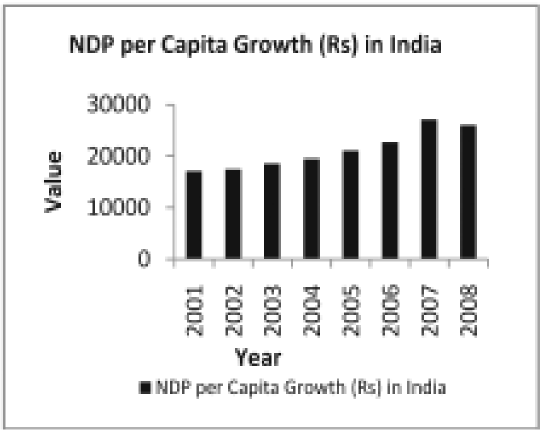
Table 4: NDP (at factor cost) in India During 2001-2008

Year	NDP in Crore (Rs.)	Per Capita NDP (Rs.)
2001	1775951	17109
2002	1841931	17459
2003	2004703	18603
2004	2125299	19498
2005	2326581	21036
2006	2549649	22729
2007	2779648	27084
2008	2957698	25990

Source-Central Statistical Organization, (2009)

Figure 7: NDP (at factor cost) in India During 2001-2008





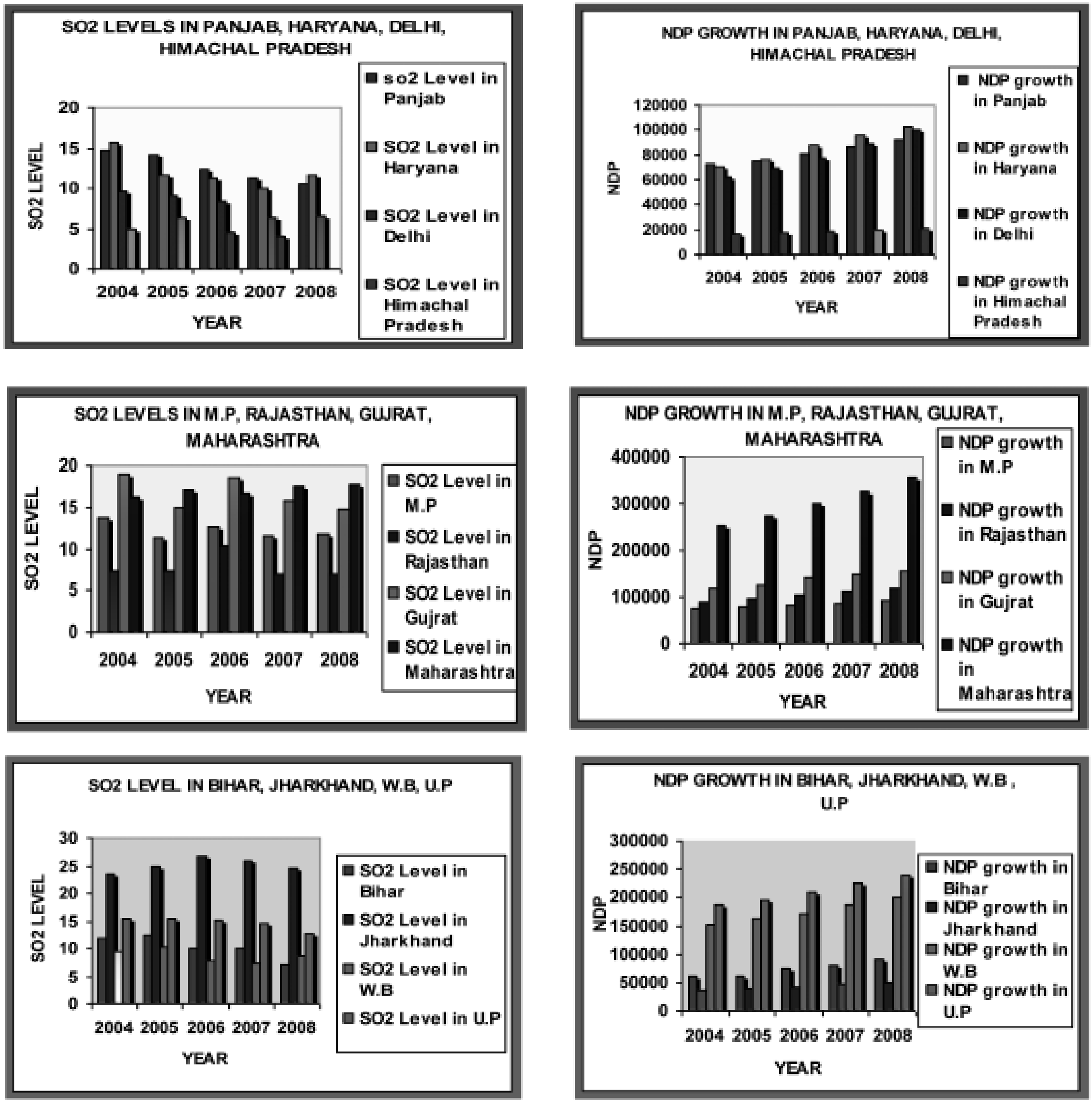
To get a more reliable result a state wise analysis is also made considering only one pollutant, SO_2. The data shows SO_2 emission in various states in India during 2004-2008 and also the NDP growth rates in these states during the same time period.

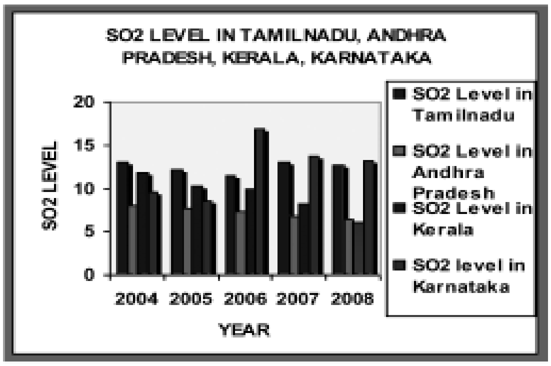
Table 5: SO_2 levels (annual average concentration μg/m^3) during 2004-2008 and Net State Domestic Product at factor cost (at constant price) for different states in India

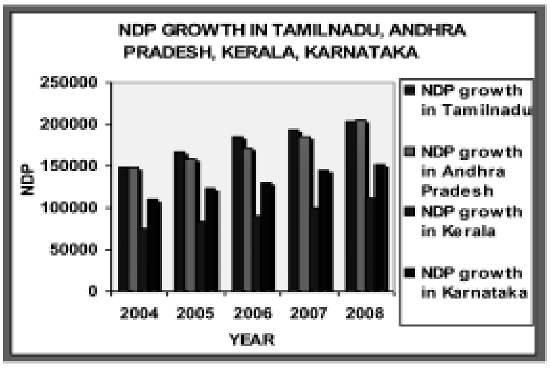
Sl.no.	States	2004	2005	2006	2007	2008	2004	2005	2006	2007	2008
1	Assam	4	5.25	6	6.71	6.45	39207	41103	43782	46433	49226
2	Manipur	BDL	BDL	BDL	BDL	BDL	3240	3540	3668	3866	4000
3	Mizoram	BDL	BDL	BDL	BDL	BDL	1839	1858	1967	2073	2205
4	Meghalaya	5	BDL	4	4	BDL	3993	4270	4548	4800	5060
5	Nagaland	BDL	BDL	BDL	BDL	BDL	3677	4053	4304	4566	-
6	Panjab	14.75	14.2	12.3	11.19	10.59	72587	75471	81060	86400	92795
7	Haryana	15.67	11.6	11.2	10	11.6	69988	76304	87944	95499	103236
8	Delhi	9.63	9.11	8.3	6.44	6.56	62694	69479	77389	89309	100877
9	Chandigarh	6	BDL	BDL	BDL	BDL	5804	6397	7142	7986	9035
10	Himachal Pradesh	5	6.33	4.6	4	BDL	15596	17099	18176	19308	20990
11	Bihar	12	12.5	10	10	7	60045	60579	74831	80998	90566
12	Jharkhand	23.5	24.83	26.8	26	24.67	36886	37706	42139	45922	49595
13	Orissa	4.75	5.2	6.67	6.67	7.43	51086	54057	60746	63899	67821
14	West Bengal	9.5	10.3	7.85	7.38	8.58	152384	162491	171482	186569	201296
15	U.P	15.5	15.44	15.2	14.54	12.69	185920	195661	210044	225413	240039
16	M.P	13.7	11.45	12.72	11.67	11.89	75400	77874	82830	86425	90786
17	Rajasthan	7.39	7.42	10.31	6.95	7	90445	96069	103616	111070	117423
18	Chhattisgarh	14.7	15	13.67	14.78	16.55	31377	33356	36176	39340	42087
19	Goa	BDL	4	BDL	BDL	BDL	6225	6891	7694	8498	9444
20	Gujrat	18.93	15	18.57	15.7	14.74	118525	125599	139265	149933	155667
21	Maharashtra	16.13	17.03	16.66	17.4	17.65	250989	272860	298759	327599	357402
22	Tamilnadu	13	12.19	11.56	13.06	12.63	147994	165953	185310	194099	203485
23	Andhra Pradesh	7.92	7.64	7.25	6.71	6.45	149067	157579	171462	185462	205486
24	Kerala	11.86	10.22	10	8.22	6.08	75467	82575	90244	100427	111059
25	Karnataka	9.6	8.53	16.9	13.8	13.3	109808	122697	130018	144527	151937
26	Pandicherry	22.33	15.67	9.67	4.33	4.67	4125	3633	3864	4164	4512

Source-Kiran, (2010) (BDL- Below Detectable Level- concentration less than 4μg/m^3)

Figure 8: SO_2 levels (annual average concentration μg/m³) during 2004-2008 and Net State Domestic Product at factor cost (at constant price) for major states in India







Result of the Data Analysis

This section of the study shows the major findings from the above data analysis. The main objective of the present study is to show whether the inverted-U relationship between economic growth and environmental degradation exists in India and its states. To fulfill the above objective, the following hypotheses have been proposed.

H_1: Higher economic growth may lead to greater emissions of pollutants

To examine the validity of the above hypothesis, detailed account on some of the indicators of environmental degradation namely, CO_2, NO, SO_2 and their emissions in India during 2001-2008 is provided. It represents the level of environmental degradation in India. To compare these data with the economic growth, an account of NDP (at constant price) growth during 2001-2008 is also presented. Examining all the data, it is found that, India experienced a rapid increase in NDP (crores) during 2001-2008. But at the same time the emissions of pollutants also increased reflecting higher environmental degradation. Therefore, the hypothesis that higher economic growth may lead to greater emissions of pollutants is valid for the given data set in the context of Indian economy.

H_2: Environmental degradation initially rises as NDP rises

The given data reflects that, in India, the growth (rise in NDP) and pollution (higher emissions of CO_2, NO, SO_2) occurred simultaneously during 2001-2008. Therefore, it is clear that growth led to environmental degradation in India. So the hypothesis that environmental degradation initially rises as NDP rises is valid for Indian economy.

H_3: Environmental degradation falls after a certain level of NDP attained

The present study is based on the data during 2001-2008. These data clearly reflects that India experienced a rapid increase in NDP along with acceleration in environmental pollution. There is no indication of reduction of the level of pollution. From this point it can be stated that India is still to achieve that certain level of growth, from which pollution starts to decline. Therefore being at the initial stage of development, India experiences a higher level of environmental degradation and the hypothesis that Environmental degradation falls after a certain level of NDP attained is not supported by the given data set.

The state wise data includes only one pollutant. The analysis is based on the data of SO_2 (annual average concentration µg /m^3) emission and growth rate of NDP at factor cost (at constant price) for different states in India during 2004-2008.

It shows, in some states SO_2 concentration is of significant level where as some states have succeeded to reduce it. But one thing is clear from the given data set, that almost all the states in India experienced higher economic growth, that is, a continuous rise in NDP in each year during 2004-2008.

Conclusion

Since the given data set exhibits a positive relationship between growth and environmental degradation, it is concluded that India as a growing economy is on the rising portion of the Environmental Kuznets Curve.

But the positive relationship between growth and pollution is not so vivid in the context of the state-wise analysis. Although all the states experienced a higher economic growth during 2004-2008, some states e.g. Orissa experienced a continuous increase in SO_2- emission at the same period. On the polar opposite, there exist states such as Andhra Pradesh, Punjab, Hariyana who experienced a steady decrease in SO_2 level. The existence of EKC for SO_2 is found only in Jharkhand. Some other states such as Maharashtra, Gujrat, Tamilnadu, and West Bengal do not follow any consistent relation between economic growth and pollution.

The major policy options that India as well as any developing country can take to improve the environmental quality are as follows.

1. **Industrial emissions abatement policies:** Government can impose a range of policy actions to limit industrial pollution for example, taxation of emissions, quotas and standards etc. The former policy is market based and more effective because it is easier to impose and allows more flexibility for firms.
2. **Programmes to improve the economic alternatives of the poor:** Investment in irrigation, sustainable farming techniques, use of alternative fuel are necessary to avoid the environmental degradation in rural areas. It is also necessary to create alternative employment opportunities for the very poor so that they can avoid cultivating marginal lands.
3. **Providing the economic status of women:** Providing higher education and better economic opportunities of the women may lead to a reduction in the family size. Education makes women more concerned about child nutrition. Therefore to reduce the

population pressure on the environment, government programmes should be arranged so that the women can be socially more active.

4. **Proper resource pricing:** Government Pricing Policy can exacerbate resource shortage or encourage unsustainable methods of production. The programmes taken to improve the conditions of the poor may lead to greater poverty and higher inequality. Often the high income households get the entire benefit of agricultural subsidies. The result is nothing but the unsustainable use of resources. So proper resource pricing is necessary.

5. **Proactive stance toward Climate Change and Environmental Degradation**: Proactive policy will make the poor more resilient to climate change. Government can implement early warning systems to predict environmental emergencies; promote reforestation; construct storm shelters and flood barriers. It may be effective to employ the poor as guardians of these resources. More government transparency and accountability is also needed.

Developed countries can also help the India to improve the environmental quality in the following ways-

1. **Favorable trade policies:** Increasing protection by MDCs may shrink the international markets for Indian product and hence the earning capacity. Elimination of trade barriers, creation of new jobs, and encouragement towards economic growth can reduce the level of absolute poverty.

2. **Development assistance and debt relief:** Development assistance is necessary for India to achieve sustainable development. These investments may be used for variety of programmes such as alleviation of poverty, environmental improvement etc. Debt forgiveness is also required to bring sustainable development in this economy.

With the correct policy adoption accompanied with foreign cooperation, India can reduce the level of environmental degradation without hurting the economic growth, and can switch towards the downward sloping portion of Environmental Kuznets Curve indicating its movement towards achieving sustainable development.

References

- Alstine, J.V. and E. Neumayer (2008), "The Environmental Kuznets Curve", in Gallagher K.P. (Eds.), Handbook on Trade and the Environment, Edward Elgen Publishing Ltd, UK.
- Ghatak, S.G. (2010), "Trade-off between conservation of environment and economic development? A case study of East Kolkata Wetland", (oaithesis.eur.nl, accessed on 2013-03-08) Erasmus University, p.1
- Ghoshal, T. and R. Bhattacharya (2008), "State Level Carbon Dioxide Emissions of India 1980-2000", Contemporary Issues and Ideas in Social Sciences, p.1

- Kiran, R. (2010), "Economic Growth in India and Environmental Kuznet Curve: State-wise analysis", (dspace.thapar.edu:8080/dspace/bitstream/10266/1142/3/1142.pdf, accessed on 2013-03-08), Patiala, pp. 18-205.
- Mandal, T. and P. Chakraborty (2012), "Environmental Kuznets Curve Revisited With Special References to CO_2 Emission: A Time Series Analysis Since Colonialism", International Journal of Social Sciences and Interdisciplinary Research, Vol.1, No.5.
- Meier, G.M. and J.E. Rauch (2005), "Development and the Environment", Leading Issues in Economic Development, 8th edition, Oxford University Press, United Kingdom, pp.588-598.
- Mishra, S.K. and V.K. Puri (2011), "The Environment and Development", Indian Economy, 29th edition, Himalaya Publishing House Pvt. Ltd, Mumbai, pp.30-31
- Mishra, T. and B. Chatterjee (2007), "Economic Development and Environmental Degradation in India", Economic Reforms, Human Welfare and Sustainable Development in India, N. C. Nayak, K. Goswami and B. Chatterjee (eds.), New Century Publications, New Delhi, pp. 250-262
- Mitra, A.P. and C. Sharma (2001), "Indian Aerosols: Present Status", (www.ncbi.nlm.nih.gov/pubmed/12492171, accessed on 2013-03-08), p. 1179
- Mittal, M.L. (2012), "Estimates of Emissions from Coal Fired Thermal Power Plants in India",(www.epa.gov/ttnchie1/conference/ei20/session5/mmittal.pdf, accessed on 2013-03-08), New Delhi, pp. 14-16
- Mukherjee, et al. (2007), "The Environment and Development", Contemporary Development Economics, 2nd edition, New Central Book Agency Pvt.Ltd. Kolkata, pp-250-289
- Panayatou, T. (2003), "Economic Growth and the Environment", Economic Survey of Europe, No.2, pp-50-51
- Todaro, M.P. and Stephen C. Smith (2012), "The Environment and Development", Economic Development, 10th edition, Dorling Kindersley (India) Pvt.Ltd., Pearson Education , New Delhi, India, pp. 483-516.