Is there any relationship between Environmental Quality Index, Human Development Index and Economic Growth? Evidences from Indian States

Sacchidananda Mukherjee and Debashis Chakraborty

National Institute of Public Finance and Policy (NIPFP), New Delhi, Indian Institute of Foreign Trade (IIFT), New Delhi

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IS THERE ANY RELATIONSHIP BETWEEN ENVIRONMENTAL QUALITY INDEX, HUMAN DEVELOPMENT INDEX AND ECONOMIC GROWTH? EVIDENCES FROM INDIAN STATES

Sacchidananda Mukherjee*(1) and Debashis Chakraborty(2)

* *Corresponding author*

(1) *Consultant, National Institute of Public Finance and Policy (NIPFP), 18/2, Satsang Vihar Marg, Special Institutional Area, New Delhi – 110 067, INDIA. Telephone: +91 11 2656 9780; +91 11 2696 3421; Mobile: +91 9868421239; Facsimile: +91 11 2685 2548. E-mail: sachs.mse@gmail.com*

(2) *Assistant Professor, Indian Institute of Foreign Trade (IIFT), IIFT Bhawan, B-21, Qutab Institutional Area, New Delhi 110016, India. Fax: +91 11 2685 3956. E-mail: debchakra@gmail.com*

Abstract

Economic growth does not necessarily ensure environmental sustainability for a country. The relationship between the two is far more complicated for developing countries like India, given the dependence of a large section of the population on natural resources. Under this backdrop, the current study attempts to analyze the relationships among Environmental Quality (EQ), Human Development (HD) and Economic Growth (EG) for 14 major Indian States during post liberalisation period (1991-2004). Further, for understanding the changes in EQ with the advancement of economic liberalisation, the analysis is carried out by dividing the sample period into two: Period A (1990–1996) and Period B (1997–2004). For both the sub-periods, 63 environmental indicators have been clustered under eight broad environmental groups and an overall index of EQ has been constructed using the HDI methodology. The EQ ranks of the States exhibit variation over time, implying that environment has both spatial and temporal dimensions. Ranking of the States across different environmental criteria (groups) show that different States possess different strengths and weaknesses in managing various aspects of EQ. The HDI rankings of the States for the two periods are constructed by the HDI technique following the National Human Development Report 2001 methodology. We attempt to test for the Environmental Kuznets Curve hypothesis through multivariate OLS regression models, which indicate presence of non-linear relationship between several individual environmental groups and per capita net state domestic product. The relationship between EQ and economic growth however does not become clear from the current study. The regression results involving individual environmental groups and HDI score indicate a slanting N-shaped relationship. The paper concludes that individual States should adopt environmental management practices based on their local (at the most disaggregated level) environmental information. Moreover, since environmental sustainability and human well-being are complementary to each other, individual States should attempt to translate the economic growth to human well-being.

Keywords: Environmental Quality Index (EQI); Human Development Index (HDI); Economic Liberalisation; Economic Growth; India.

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1. Introduction

The economic reform process initiated in 1991 has played a major role in shaping India's overall as well as its sub-regional economic growth. First, the unshackling of domestic industries, coupled with the shift towards export-oriented economic philosophy caused an industrialisation drive across the Indian States. Second, the easing of FDI approval system provided ample scope for States with enterprising governments to strike their own growth curves by encouraging investment and thereby ensuring industrialisation within their territories. Third, in the post-1991 period the policy objective of achieving balanced growth no longer remained a driving concern, and thus enhanced the possibility of increasing industrial concentration in strategic locations.

Enhanced economic growth (EG) is likely to raise the general level of human development (HD) in the current period, which in turn may influence future EG potential positively. However, increasing industrialisation or urbanisation on the other hand, if not associated with requisite level of governance, can considerably influence the environmental sustainability of a region in question (Maiti and Agrawal, 2005). The adverse impact could either come through natural resource depletion and/or adverse health consequences of environmental degradation, e.g., air or water pollution (Brandon and Hommann, 1995).

It can be further argued that with increasing level of HD, public awareness on environmental sustainability increase in a particular State, which in turn will influence its pattern of governance.[1] In other words, States with higher HDI should ideally be ranked higher in terms of environmental performance. The relationship between economic growth, measured through per capita net state domestic product (PCNSDP), and environmental performance might be more complex in nature. In general, higher income level is conducive for ensuring higher HD, and therefore should ideally be favourable for maintaining environmental sustainability (World Bank, 2006). However, some States might also choose

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[1] Jalan et al. (2003) show that raising the level of schooling of woman in an urban household from 0 to 10 years approximately doubles willingness to pay for improved drinking water quality.

to grow in the short run by hosting a number of environmentally damaging but fast-growing industries within their territories, with obvious consequences on local environment.

Globally, the environmental regulation-avoiding attitude of producers often leads to concentration of polluting industries in locations characterised by lax environmental norms ('Pollution Haven Hypothesis - PHH'). Usually it is argued that the developed country producers relocate their polluting units in newly industrialising developing countries (Eskeland and Harrison, 2003).[2] Similarly within a country, relocation along that line from 'cleaner' States to the 'dirtier' States may be noticed for various reasons (Dastidar, 2006).[3]

Working with the Indian scenario, while negative environmental performance by transnational corporations during 1980s (Jha, 1999) and higher FDI inflow in relatively more polluting sectors in the post-liberalisation period have been reported (Gamper-Rabindran and Jha, 2004); several studies rejected the existence of PHH (Dietzenbacher and Mukhopadhyay, 2007; Jena et al., 2005). In long run the PHH may or may not become a reality in some Indian States. However, that is beyond the scope of the current exercise.

The efficiency of environmental governance and pollution-abatement is currently a much-researched area (Costantini and Salvatore, 2006; Kathuria and Sterner, 2006; Sankar, 1998). The intervention of Supreme Court in India has been quite successful in this regard (Antony, 2001; World Bank, 2006), although the limitation of that approach has also been highlighted (Venkatachalam, 2005).[4] Programmes like joint forest management (JFM) can also be mentioned here, with direct involvement of stakeholders, which has helped natural

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2 Gallagher (2004) cautioned that without environmental laws, regulations, and the willingness and capacity of enforcement, trade-led growth will lead to increase in environmental degradation.

3 Maharashtra is the biggest producer of electronic waste in India, however the more hazardous recycling of these products (e.g. – extraction of copper, gold, breaking-up of cathode-ray tubes etc.) is actually undertaken in Delhi. This particular choice of recycling location comes from the fact that the extracted materials are important inputs for the copper and gold business in Moradabad and Meerat respectively, both close to Delhi (Dastidar, 2006).

4 For instance, setting up of the Local Area Environmental Committees (LAECs) with the active participation of the local people for inspection, monitoring of day-to-day development in hazardous waste affected sites; the Supreme Court Monitoring Committee (SCMC) on hazardous waste has ensured strict compliance of the *Hazardous Wastes (Management and Handling) Rules, 1989* on the part of the industries or any other agency involved in hazardous waste generation, collection, treatment and disposal.

resource management to a great extent (CBD, undated; Balooni, 2002).[5] World Bank (2006) has noted that India's environmental institutions and regulatory regime need to be strengthened through incentives to the industries complying with greener norms on one hand and devolution of more powers to local governments on the other. In addition, Chopra and Gulati (1997) argued that strengthening property rights can also arrest environmental degradation.

Apart from the internal factors like economic liberalisation, external factors have also influenced the environmental scenario in India significantly. Trade and Environment remained an important issue for discussion at the WTO forums since the inception of the multilateral body in 1995 and standard-setting has been a continuous process. Indian firms, especially doing business in sectors like textile, marine products, leather, chemicals etc., have often complained that the environmental compliance norms for exporting to EU and US are too stringent (Chakraborty and Singh, 2005). Nonetheless, owing to sanctions and regular factory visits by importing country officials, the compliance level in India has increased over the years for several industries (Tewari and Pillai, 2005; Sankar, 2006; Schjolden, 2000), with obvious positive implications on the domestic environment.

In this background, on the basis of a secondary data analysis, the current paper attempts to analyze the relationship of environmental quality with human development and economic growth separately for 14 major Indian States over 1991-2004. For a closer analysis of the impact of the reform element on environmental quality of the States, the sample period is bifurcated into two sub-periods - Period A (1990–1996) and Period B (1997–2004) respectively. This period marks an evolving attitude of the country towards environment, although in a gradual manner.[6] The paper is organised as follows. A brief literature survey on environmental sustainability, human development and economic growth is followed by the discussion on the methodology adopted in this paper, the results and the policy observations respectively.

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5 Sankar (1998) argues that the government may ensure participation of community based organisations in management of local commons as well as in the enforcement of environmental laws and rules.

6 India introduced *Environment (Protection) Act* and *Hazardous Waste (Management and Handling) Rules* in 1986 and 1989 respectively and became a member of *Basel Convention* in 1992. However, the national rules on hazardous waste were brought into conformity with Basel norms only in 2000 (Sharma, 2005; Divan and Rosencranz, 2002).

2 Literature Review

2.1 Environmental Sustainability

Determining the appropriate methodology for arriving at meaningful environmental indices is a debated research question (Ebert and Welsch, 2004; Zhou et al., 2006). It has generally been observed that using a composite environmental index summarises the environment condition of a region or country or state,[7] and is more meaningful than individual indicators (Rogers et al., 1997; Adriaanse et al., 1995; Adriaanse, 1993, Esty et al., 2005; Jones et al., 2002; Mukherjee and Kathuria, 2006). However the methodology and selection of variables for construction of environmental index vary considerably across these studies.

Table 1 summarises the Environmental Performance Index (EPI), Human Development Index (HDI) and Per Capita GDP scenario for a few select economies. The EPI data is obtained from Esty et al. (2006). By using 32 indicators classified into 6 environmental groups, Esty et al. (2006) provide the EPI scores and ranks for 133 countries. HDI scores and ranks are taken from the latest Human Development Report 2007/2008 (UNDP, 2007), covering 177 countries. It is observed from the table that countries with higher HDI scores (e.g. New Zealand) generally have higher values of EPI as well. However Malaysia, despite having a medium HDI score, possesses a high EPI. The Per Capita GDP (in PPP USD) for the two countries is found to be higher compared to the remaining countries. In contrast, the South Asian countries with medium HDI performance (e.g. India, Pakistan) have performed moderately on the EPI front. The countries further down the HDI list (e.g. Niger) are ranked lower in the EPI list as well.

[7] It is argued that environmental degradation or pollution level cannot by merely measured by actual emissions of certain hazardous materials; but other factors influencing its spread and intensity also need to be considered (Mukherjee and Kathuria, 2006).

Table 1: Environmental Performance Index, Human Development Index and Per Capita GDP – A Cross Country View

Country	Environmental Performance Index Score: 2006		Human Development Index Score: 2005		Per Capita GDP (PPP USD): 2005
Bangladesh	43.5	(125)	0.547	(140)	2,053
China	56.2	(94)	0.777	(81)	6,757
India	***47.7***	***(118)***	***0.619***	***(128)***	***3,452***
Indonesia	60.7	(79)	0.728	(107)	3,843
Malaysia	83.3	(9)	0.811	(63)	10,882
Myanmar	57.0	(88)	0.583	(132)	1,027
Nepal	60.2	(81)	0.534	(142)	1,550
Pakistan	41.1	(127)	0.551	(136)	2,370
Philippines	69.4	(55)	0.771	(90)	5,137
Sri Lanka	64.6	(67)	0.743	(99)	4,595
Thailand	66.8	(61)	0.781	(78)	8,677
Niger	25.7	(133)	0.374	(174)	781
New Zealand	88.0	(1)	0.943	(19)	24,996

Note: Figure in the parenthesis shows the rank of the country for the corresponding score

Source: Esty et al (2006), UNDP (2007/2008)

2.2 Relationships between Environmental Quality and Economic Growth

The literature on the relationship between Per Capita Income (PCI) or the PCNSDP in case of States within a country, and pollution or environmental degradation generally attempts to verify the existence of an inverted U-shaped curve in the PCI vs. pollution plane ('Environmental Kuznets Curve'). The relationship implies that with the rise in PCI, environmental degradation continues up to a certain level of PCI, but improves afterwards as with prosperity, countries shift to cleaner production technologies or spend more resources on pollution abatement (Esty and Porter, 2001-02; Andreoni and Levinson, 2001). Recent empirical studies show that while some local pollutants like Sulphur dioxide (SO_2), Suspended Particulate Matter (SPM), Carbon monoxide (CO) etc. support EKC hypothesis; other pollutants exhibit either monotonicity or N-shaped curve (Dinda, 2004; Stern, 1998). Studies based on both ambient concentration of pollutants (Baldwin, 1995; Grossman and Krueger, 1995; Selden and Song, 1994; Panayatou, 1993; Shafik and Bandyopadhyay, 1992; Pezzey, 1989) or the actual emissions of pollutants (Bruvoll and Medin, 2003; de Bruyn et al., 1998; Carson et al., 1997) also support the EKC hypothesis.

It is argued that working with a composite indicator of pollutants, as a proxy of actual EQ scenario, scores over selection of a single pollutant in determination of the EKC relationship (Mukherjee and Kathuria, 2006), although only a handful of studies have adopted that approach so far. Jha and Bhanu Murthy (2001) created an Environmental Degradation Index (EDI) for 174 countries and compared that with the Human Development Index (HDI) instead of the PCI. The study found an inverse link between EDI and HDI, which supported the existence of an inverted N-shaped global EKC rather than an inverted U-shaped one.

In Indian context, Mukherjee and Kathuria (2006) explored the EKC relationship for 14 major Indian States over 1990-2001 by considering 63 environmental variables, arranged under eight broad environmental groups. The ranking of the States on a constructed Environmental Quality Index (EQI) were determined by using the factor analysis method. The results indicate that the relationship between EQ and PCNSDP is slanting S-shaped, indicating that the economic growth has occurred in Indian States mostly at the cost of EQ. It was observed that except Bihar, all the States are on the upward sloping portion of the EKC. Kadekodi and Venkatachalam (2006) noted evidence of a strong linkage between various natural resources and environment with income and the status of livelihood and concluded that the causal relationship between poverty and environment works in both directions. The research has also highlighted the importance of poverty alleviation while minimising the human health and environmental costs of economic growth (Nadkarni, 2000; Nagdeve, 2007) and the possibility of entering into a long-run vicious circle of environmental degradation, greater inequality and lower growth (Dutt and Rao, 1996) in that process. However Bhattacharya and Innes (2006) argued that the poverty-environment nexus (vicious-cycle) hypothesis does not hold in rural India.

2.3 Relationship between Environment and Human Well-being

It is observed from the literature on environmental impacts of structural adjustment programme that if the victims of depletion and degradation of natural environment are not identified and compensated by the beneficiaries, the vulnerable sections face additional economic hardship, which may fuel inequality further (Dasgupta, 2001). It has been argued by Boyce (2003) that, "social and economic inequalities can influence both the distribution of the costs and benefits from environmental degradation and the extent of environmental protection. When those benefit from environmentally degrading economic activities are powerful relative to those who bear the costs, environmental protection is generally weaker than when the reverse is true." The analysis suggests that socio-economic inequality leads to environmental inequality, which may consequently affect the overall extent of environmental quality. Therefore any attempt to reduce inequalities would eventually result in environmental protection (Sagar, undated).

It is increasingly believed that environmental problems should no longer be viewed as the side effects of development process. On the contrary, a new approach focusing on promotion of their integration need to be adopted (van Ginkel et al., 2001). The objective has been met through Target 9 of the United Nations' Millennium Development Goals (MDGs),[8] which demands that environmental conservation and conservation of natural resources from quantitative depletion and qualitative degradation, should be an integral part of any economic and development policy.

Melnick et al. (2005) highlight the critical importance of achieving environmental sustainability to meet the MDGs with respect to poverty, illiteracy, hunger, gender inequality, unsafe drinking water and environmental degradation. They argue that achieving environmental sustainability requires carefully balancing human development activities while maintaining a stable environment that predictably and regularly provides resources and protects people from natural calamities.

2.4 Relationship between Economic Growth and Human Development

The literature suggests a two-way relationship between EG and HD, implying that nations may enter either into a virtuous cycle of high growth and large HD gains, or a vicious cycle of low growth and low HD improvement (Ranis, 2004). It is also observed that higher initial level of HD corresponds to positive effects on institutional quality and indirectly on EG (Costantini and Salvatore, 2006). The study by Agarwal and Samanta (2006) involving 31 developing countries, observed that EG is not correlated with social progress, structural adjustment or governance. Nevertheless, all of them might have an impact on the EQ within a country like India, where a two-way causality between EG and HD is observed, indicating possibilities of vicious cycles (Ghosh, 2006), which might have environmental repercussions.

The UNDP annually publishes an extensive analysis of global HD situation in the Human Development Report (HDR) along with country rankings. However, it is often argued that the UNDP's HD indicators are perhaps too narrow in nature, and inclusion of certain important socio-economic variables would enrich the analysis further. The Latent Variable Approach adopted by Nagar and Basu (2001) involving 174 countries confirms

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8 "Integrate the principles of sustainable development into country policies and programmes and reverse the losses of environmental resources" - Target 9 of the UN's MDGs.

that with inclusion of additional socio-economic variables, the alternate HD rankings differ significantly from the official UNDP ranking.

While India's HD ranking remained in the low HD category throughout nineties, in 2002 it graduated to medium HD category with the HDI score of 0.577, as compared to the corresponding figure of 0.439 in 1990. India's global HDI rank has improved from 132 in 1999 to 127 in 2003.[9] Recently in association with UNDP, the Government of India has started analysing the State-wise HD status. The National Human Development Report 2001 (Government of India, 2002), brought out by the Planning Commission, is worth mentioning in this regard. While the report ranked Kerala, Punjab and Tamil Nadu as the toppers; Bihar, Madhya Pradesh and Uttar Pradesh were at the other extreme in HD scale. The alternate index developed by Guha and Chakraborty (2003), in line with Nagar and Basu (2001), however showed that inclusion of other socio-economic variables changes the State rankings to some extent. For instance, Tamil Nadu, ranked third by NHDR, slides down the ladder to the eighth place according to the alternate index.

3 Methodology and Data

3.1 Environmental Quality Index (EQI)

The EQI for the States is postulated to be linearly dependent on a set of observable indicators and has been determined by adopting the HDI method, by putting the selected variables under eight broad categories mentioned in **Appendix 1**. The idea is that all the 63 environmental variables, when combined, give a composite EQI ranking of the States, unobservable otherwise. We assume X_{ij} to be the value of the i^{th} indicator for j^{th} State of India with respect to X (or environmental quality), where X consists of a large number of indicators varying from 6 to 12 (**Appendix 2**). As defined earlier, X's are Air Pollution (AIRPOL), Indoor Air Pollution Potential (INDOOR), Green House Gases Emissions (GHGS), Pollution from Energy Generation and Consumption (ENERGY), Depletion and Degradation of Forest Resources (FOREST), Depletion and Degradation of Water Resources (WATER), Nonpoint Source Pollution Potential (NPSP) and Depletion and Degradation of Land Resources (LAND) respectively.

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[9] In relative sense, India's position actually does not look that bad as UNDP considered 130 and 177 countries in 1990 and 2003 respectively.

In line with the HDI method, we transform the indicators into their standardised form to obtain the adjusted values of X_{ij} (i.e., EX_{ij}'s) to be used for the analysis. EX_{ij}'s are obtained by dividing the difference between any X_{ij} and the minimum value of X_i to the difference between the maximum and the minimum value of X_i. Alternatively, EX_{ij}'s are obtained by dividing the difference between the maximum value of X_i and any X_{ij} to the difference between the maximum and the minimum value of X_i.[10]

Now, $EQIX_j$, i.e., the environmental quality index score for the j^{th} State with respect to each individual environmental quality X (which constitutes of n number of indicators, n varies from 6 to 12), is arrived at by summing the EX_{ij}s over *i* and dividing the number of variables (n) selected within that group. In a similar manner, EQI_j, i.e., the overall environmental quality index score for the j^{th} State, is arrived at by summing all the 63 EX_{ij}s and diving it by 63.

The obtained EQIs measure the environmental well-being of the States, i.e., the States with higher score are characterised by cleaner environment. The EQI_js (where j=1 to 14), thus arrived, is therefore used to obtain the $REQI_j$s (the rank of the j^{th} State), where the States having higher EQI_j are assigned higher rank.

3.2 Human Development Index (HDI)

Following the principle of the NHDR 2001 (Government of India, 2002) methodology, for calculation of the Human Development Index (HDI), we consider three variables, namely - per capita consumption expenditure; and composite indicators of educational attainment and health attainment respectively. With this formulation, following the HDI method, the HDI score for the j^{th} State is given by the average of the normalised values of the three indicators, namely - inflation and inequality adjusted per capita consumption expenditure (X_1); composite indicator on educational attainment (X_2) and composite indicator on health attainment (X_3). Like the earlier case, the normalisation is done by dividing the difference between any variable (X_{ij}) within these categories and the minimum value of X_i to the difference between the maximum and the minimum value of X_i.

Although UNDP considers Real GDP Per Capita in PPP USD for generating the HDI, the NHDR (Government of India, 2002) has preferred total inflation and inequality adjusted per capita consumption expenditure of a State (i.e., Rural and Urban Combined)

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10 The variables for which these two alternate formulas are used are specified at the end of Appendix 3.

over that for the analysis. Here the monthly per capita consumption expenditure data obtained from NSSO for two periods (1993-94 and 1999-2000), first adjusted for inequality using estimated *Gini* Ratios, and further adjusted for inflation to bring them to 1983 prices by using deflators derived from State specific poverty line (Government of India, 2002). If GR_{ij} is the Gini Ratio for the jth State for the ith period and $MPCE_{ij}$ is the average monthly per capita consumption expenditure for the jth State for the ith period, inequality adjusted average monthly per capita expenditure for the jth state for the ith period ($IMPCE_{ij}$) is $(1-GR_{ij})*MPCE_{ij}$, where $0 \leq GR_{ij} \leq 1$. After adjustment for inequality for each of the States, we carried out adjustment for inflation. If PL_{ij} is the poverty line for the jth State for the ith period and PL_{1983j} is the poverty line of the jth State for 1983, then inflation and inequality adjusted average monthly consumption expenditure for the jth State for the ith period ($IIMPCE_{ij}$) is $(PL_{1983j}/PL_{ij})*IMPCE_{ij}$. We consider inflation and inequality adjusted average monthly per capita consumption expenditure of a State as indicator of consumption (X_1) to construct Human Development Index.

The composite indicator on educational attainment (X_2) is arrived at by considering two variables, namely literacy rate for the age group of 7 years and above (e_1) and adjusted intensity of formal education (e_2). The idea is that literacy rate being an overall ratio alone may not indicate the actual scenario, and the drop-out rate, needs to be incorporated in the formula. We consider the data on literacy rate for two periods, namely - 1991 and 2001. The adjusted Intensity of Formal Education data is used for two periods – 1993 and 2002. The current analysis assigns weightage of 0.35 to e_1 and 0.65 to e_2 to estimate X_2.

The Intensity of Formal Education is estimated as weighted average of the enrolled students from class I to class XII (where weights being 1 for Class I, 2 for Class II and so on) to the total enrolment in Class I to Class XII. This is adjusted by proportion of total enrolment to population in the age group 6-18 (Government of India, 2002). According to the formula suppose E_i be the number of children (rural and urban combined) enrolled in i^{th} standard in 2002, i= 1 for Class I to 12 for Class XII). Then Weighted Average of the Enrolment (WAE) from Class I to Class XII is calculated as the weighted average of enrolment (E_i) in a particular Class where weights are i = 1 for Class I to 12 for Class XII.

Now, suppose TE_i is the total enrolment of Children from Class I to Class XII in 2002. Then the Intensity of Formal Education (IFE) for children (rural and urban combined) in 2002 becomes WAE expressed as a percentage of TE. Suppose P_C represents the Population of Children (rural and urban combined) in the age group 6 to 18 years in 2001. Then we can determine the Adjusted Intensity of formal education (AIFE) for children (rural and urban combined) in 2002, as the ratio of IFE multiplied by TE and the Population of Children (rural and urban combined) in the age group 6 to 18 years in 2001.

Finally the Composite indicator on health attainment (X_2) is arrived at by considering two variables, namely Life Expectancy (LE) at age one (h_1) and the reciprocal of Infant Mortality Rate (IMR) as the second variable (h_2). For h_1, which measures the life expectancy at age 1 (Rural and Urban Combined), the two data points considered for the two periods are 1990-94 and 1998-2002 respectively. On the other hand, the IMR (Per Thousand) data is considered for two periods, namely - 1992 and 2000. We assign the weightage of 0.65 and 0.35 to h_1 and h_2 respectively to determine the composite indicator (X_3) used for calculation of the HDI.

3.3 Economic Growth (EG)

EG in the current analysis is measured by the PCNSDP of the States at constant (1993-94) prices. PCNSDP for Period A and Period B are the average PCNSDP for the period 1993-94 to 1995-96 and 1997-98 to 1999-2000 respectively. The average is taken to smoothen out uneven fluctuations. To understand the size of the economy and growth pattern of each of the 14 States, we have classified the States into three categories with respect to their Gross State Domestic Product (GSDP) at constant 1993-94 prices: high income States (GSDP: greater than 3rd Quartile), medium income States (GSDP: 1st to 3rd Quartile) and low income States (GSDP: less than 1st Quartile).

Mukherjee and Chakraborty (2007) noted that during 1993-96, on an average middle income states (e.g. - Gujarat, Rajasthan and Karnataka) were growing faster than others. However, during 1997-2000, except for low income States (e.g. – Kerala, Orissa), growth rate slowed down, indicating stagnation. Moreover, during 2000-2004, the difference in EG rate across the States having different level of income has gone down and barring few exceptions (Rajasthan and West Bengal) both for low and medium income States, the growth rate generally slowed down as compared to the late 1990s level.

3.4 Data

In order to obtain State level secondary information on environment and natural resources from published government reports and other databases for both the time periods selected in our analysis, i.e., Period A (1990-96) and Period B (1997-2004), the sample is restricted only to 14 major Indian States, namely - Andhra Pradesh (AP), Bihar (BH), Gujarat (GJ), Haryana (HR), Karnataka (KR), Kerala (KL), Madhya Pradesh (MP), Maharashtra (MH), Orissa (OR), Punjab (PB), Rajasthan (RJ), Tamil Nadu (TN), Uttar Pradesh (UP) and West Bengal (WB). Now the data available for various environmental indicators in India are not always necessarily compatible with the time period selected by us, given the varying date and frequency of their publication. To resolve this issue, we have chosen only those indicators with at least two observations, where one of these observations is located within the boundary of the two sample periods. The selected indicators have then been normalised using appropriate measures of size / scale of the States – geographical area, population and GSDP at current prices.

Here we need to distinguish between two key concepts, namely - endowment effect and efficiency in natural resource management effect. The depletion and degradation of natural resources and occurrence of environmental pollution is chiefly concerned with environmental management. On the other hand, the initial endowments of natural resources (forests, land and water) are determined by geographical, climatic and ecological factors. Quite understandably, the former is comparatively more influenced by human activities. By calculating the change in the natural resource position with respect to a base year we can isolate the two effects.[11] The current study focuses on the environmental management efficiency effect as well as the size effect of the States.

The data sources for our analysis on EQ and descriptions of the actual data series used to construct each group are listed in **Appendix 1** and **2** respectively. A total of 63 variables have been selected for the analysis, placed under eight broad categories, which are summarised in **Appendix 1**.

For the analysis on education, we use the data available from the "*7th All India Educational Survey (AIES): All India School Education Survey (AISES)*", published by NCERT (2002). On the health front, IMR data is taken from Sample Registration System (SRS) Bulletins; Registrar General of India, New Delhi and LE data is taken from Indiastat database website (www.indiastat.com). The data on EG of the States is obtained from

[11] For instance, a higher index for Orissa as compared to Punjab by merely ranking the forest resources of the two States (by taking the percentage of geographical area under forests land) comes from the fact that Punjab possess very little of the selected variable to begin with. Therefore the analysis does not imply that forest conservation practices of the former are in any way better than the same of the latter. Ranking the change in their forest area (as a percentage of geographical area) during any two periods would be the ideal exercise for comparing their forest conservation practices.

Economic and Political Weekly Research Foundation's Database Software and Reserve Bank of India's Database on Indian Economy.

4. The Results

4.1 EQI

In **Table 2**, we present the EQ scores and rankings of the States for Period A, both for individual categories as well as for the composite index. It is observed that Kerala, Karnataka and Maharashtra were the toppers during this period, while Uttar Pradesh, Punjab and Haryana had been the laggards. Interestingly the topper Kerala, despite a good performance in AIRPOL, GHGS, ENERGY, WATER and NPSP, fared among the laggards in case of INDOOR, LAND and FOREST. Karnataka had good performance in case of AIRPOL and GHGS, while maintaining moderate performance in other categories. The third ranking of Maharashtra, an industrialised state, is justified by the fact that the State performed appreciably in several categories like INDOOR, GHGS, LAND and NPSP, however the performance with respect to ENERGY, WATER, FOREST and AIRPOL was not that satisfactory. Looking at the other extreme, we can see that the overall rankings of laggards like Haryana and Uttar Pradesh were influenced by their performance in sub-categories like LAND, NPSP etc. It is observed that while some major States like Madhya Pradesh (tenth) and West Bengal (ninth) placed in the lower segment, others like Gujarat (sixth) and Andhra Pradesh (seventh) had performed moderately well. Interestingly, a relatively poorer State, Orissa, obtained the fourth rank, owing to comparatively better performance in case of AIRPOL, ENERGY and WATER.

Table 3 provides the EQ scores and ranking of the States for Period B. As in the earlier case, we see that Kerala, Karnataka and Maharashtra retained their positions at the top (although the latter two interchange their positions), while Haryana, Bihar and Punjab now turned out to be the laggards. It is observed that the toppers improved their position in certain sub-categories (Kerala in AIRPOL, INDOOR, GHGS, FOREST; Karnataka in ENERGY, FOREST etc.). However, their performance deteriorated in certain key areas as well. For instance, the lower ranking of Karnataka in AIRPOL in Period B can be explained by rapid urbanisation, industrialisation and vehicular pollution. Its relative performance on WATER also raises concern. Among the states at the middle, Andhra Pradesh's performance in WATER is not satisfactory, and degradation in water bodies within its territory has already been highlighted (Reddy and Char, 2004). On the other hand the laggards continued to perform poorly in several sub-categories (e.g. - Punjab –

AIRPOL, GHGS, ENERGY, LAND, WATER and NPSP; Bihar - AIRPOL, INDOOR, GHGS, LAND, FOREST and NPSP; Haryana – ENERGY, LAND, WATER and NPSP). Energy management and forest conservation should be the first two priority areas for environmental management in Maharashtra. For Karnataka, conservation of land and water should be priority areas for environmental management.

Table 2: Environmental Quality Scores and Ranks of the States: 1990-1996

	AIRPOL (1)	INDOOR (2)	GHGS (3)	ENERGY (4)	LAND (5)	WATER (6)	FOREST (7)	NPSP (8)	EQI SCORE (9)
Andhra Pradesh	0.876 (4)	0.320(11)	0.685 (5)	0.524 (8)	0.592 (5)	0.535 (6)	0.506(13)	0.489 (8)	0.544 (7)
Bihar	0.647 (8)	0.129 **(14)**	0.467(11)	0.555 (7)	0.502(10)	0.604 (5)	0.515(12)	0.467(11)	0.480 (11)
Gujarat	0.432(12)	0.643 (3)	0.617 (7)	0.282 (13)	0.616 (4)	0.482 (9)	0.594 (6)	0.630 (2)	0.545 (6)
Haryana	0.783 (6)	0.574 (4)	0.494 (9)	0.450 (12)	0.183(13)	0.381(13)	0.671 (2)	0.333(13)	0.475 (12)
Karnataka	0.912 **(1)**	0.435 (5)	0.901 **(1)**	0.673 (5)	0.535 (7)	0.516 (7)	0.573 (9)	0.541 (6)	0.607 (2)
Kerala	0.874 (5)	0.327(10)	0.870 (3)	0.709 (3)	0.520 (8)	0.696 (3)	0.517(11)	0.559 (5)	0.617 **(1)**
Madhya Pradesh	0.483(11)	0.367 (8)	0.355(13)	0.468 (10)	0.719 **(1)**	0.695 **(4)**	0.158 **(14)**	0.597 (4)	0.493 (10)
Maharashtra	0.653 (7)	0.715 (2)	0.697 (4)	0.473 (9)	0.652 (2)	0.514 (8)	0.581 (8)	0.599 (3)	0.605 (3)
Orissa	0.909 (2)	0.228(12)	0.350 **(14)**	0.771 **(1)**	0.543 (6)	0.760 (1)	0.584 (7)	0.516 (7)	0.578 (4)
Punjab	0.644 (9)	0.803 **(1)**	0.427(12)	0.274 **(14)**	0.181 **(14)**	0.244 **(14)**	0.840 **(1)**	0.267 **(14)**	0.456 (13)
Rajasthan	0.631(10)	0.397 (7)	0.881 (2)	0.622 (6)	0.637 (3)	0.465(10)	0.520(10)	0.642 **(1)**	0.577 (5)
Tamil Nadu	0.896 (3)	0.412 (6)	0.656 (6)	0.458 (11)	0.513 (9)	0.381(12)	0.612 (4)	0.478(10)	0.525 (8)
Uttar Pradesh	0.152 **(14)**	0.222(13)	0.600 (8)	0.682 (4)	0.363(12)	0.447(11)	0.620 (3)	0.478 (9)	0.443 **(14)**
West Bengal	0.248(13)	0.357 (9)	0.473(10)	0.758 (2)	0.369(11)	0.699 (2)	0.611 (5)	0.442(12)	0.508 (9)

Note: Figure in the parenthesis shows the rank of the State for the corresponding Environmental Quality Score

Table 3: Environmental Quality Scores and Ranks of the States: 1997-2004

STATES	AIRPOL (1)	INDOOR (2)	GHGS (3)	ENERGY (4)	LAND (5)	WATER (6)	FOREST (7)	NPSP (8)	EQI SCORE (9)
Andhra Pradesh	0.802 (3)	0.498 (7)	0.553 (5)	0.585 (5)	0.617 (3)	0.479 (9)	0.781 (9)	0.474 (9)	0.580 (6)
Bihar	0.433(12)	0.141 **(14)**	0.428(10)	0.574 (7)	0.436(10)	0.675 (2)	0.480(13)	0.422(12)	0.455 (13)
Gujarat	0.310(13)	0.718 (3)	0.547 (6)	0.231 (13)	0.653 **(1)**	0.539 (8)	0.769(10)	0.599 (4)	0.564 (7)
Haryana	0.715 (5)	0.714 (4)	0.542 (7)	0.362 (10)	0.088 **(14)**	0.332(13)	0.790 (7)	0.278 **(14)**	0.472 (12)
Karnataka	0.684 (6)	0.610 (6)	0.885 **(1)**	0.679 (3)	0.568 (7)	0.465(11)	0.807 (5)	0.563 (6)	0.636 (3)
Kerala	0.791 (4)	0.467 (8)	0.882 (2)	0.644 (4)	0.534 (9)	0.541 (7)	0.942 **(1)**	0.598 (5)	0.656 **(1)**
Madhya Pradesh	0.510(10)	0.453(10)	0.302 **(14)**	0.349 (12)	0.647 (2)	0.689 **(1)**	0.230 **(14)**	0.627 **(1)**	0.497 (10)
Maharashtra	0.676 (7)	0.771 (2)	0.682 (4)	0.428 (9)	0.578 (6)	0.606 (5)	0.731(11)	0.615 (2)	0.641 (2)
Orissa	0.823 (2)	0.189(13)	0.381(11)	0.745 (2)	0.612 (4)	0.673 (3)	0.864 (2)	0.527 (7)	0.593 (5)
Punjab	0.600 (9)	0.812 **(1)**	0.349(13)	0.211 **(14)**	0.118(13)	0.273 **(14)**	0.789 (8)	0.279(13)	0.434 **(14)**
Rajasthan	0.670 (8)	0.459 (9)	0.807 (3)	0.564 (8)	0.603 (5)	0.470(10)	0.804 (6)	0.614 (3)	0.606 (4)
Tamil Nadu	0.949 **(1)**	0.624 (5)	0.376(12)	0.361 (11)	0.567 (8)	0.356(12)	0.842 (3)	0.483 (8)	0.555 (8)
Uttar Pradesh	0.471(11)	0.305(12)	0.518 (8)	0.584 (6)	0.366(11)	0.566 (6)	0.507(12)	0.458(10)	0.473 (11)
West Bengal	0.212 **(14)**	0.417(11)	0.476 (9)	0.794 **(1)**	0.347(12)	0.610 (4)	0.825 (4)	0.422(11)	0.522 (9)

Note: Figure in the parenthesis shows the rank of the State for the corresponding Environmental Quality Score

We can compare the relative performance of the States on EQ scale during the two time periods looking at their ranks. It is observed that although the overall position of the better performing States remained unchanged, there had been some interesting movements of their ranking within the sub-categories. For instance, Maharashtra's rank declined in LAND and FOREST,[12] while it improved its performance in WATER. Karnataka had been subjected to greater variations - while its ranking improved in ENERGY and FOREST, but declined for AIRPOL, INDOOR and WATER. Kerala on the other hand improved its relative performance in a number of sub-categories (notably FOREST).[13] Nonetheless, its score got affected by the decline in its ranking in categories like WATER.[14] Looking across categories, it is observed that Punjab and Uttar Pradesh experienced a sharp decline in their ranking in case of FOREST, indicating degradation on that front.

4.2 HDI

Table 4 provides the HDI scores and rankings of the States in the three sub-categories and the composite index for two periods, Period A and Period B. It is observed that while for the first period, Kerala, Punjab and Maharashtra were holding the top three positions; in the second period, Haryana had replaced Maharashtra at the top three. Looking at the sub-categories, it is observed that Kerala continued to perform well in all categories. Punjab performed comfortably in terms of consumption and health, but was in the mid-level on educational attainments. Looking at the other end of the distribution, we observe that Bihar, UP and MP were consistently at the bottom for most of the categories, which in turn leads to their poor overall HDI ranking.

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[12] Rithe and Fernandes (2002) argued that Maharashtra has achieved the current level of industrialisation at the cost of the loss of much of its forests. However, the findings of Kadekodi and Venkatachalam (2005) do not support this.

[13] Apart from the Government regulations, exporter firms increasingly adopted environment-friendly processes to comply with strict norms in export markets (e.g. - marine industries in Kochi), which had a significant positive influence on the environment of the State.

[14] Nair (2006) noted that depletion of the groundwater table due to indiscriminate sand mining, shrinkage in natural forest cover and reclamation of wetland and paddy fields are major environmental challenges that Kerala is facing today.

Table 4: HDI Scores and Ranks of the States over the Sample Period

States	Consumption				Health				Education				HDI SCORE			
	Period A		Period B		Period A		Period B		Period A		Period B		Period A		Period B	
	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)	
Andhra Pradesh	0.338	(8)	0.196	(10)	0.300	(8)	0.410	(7)	0.136	(11)	0.344	(11)	0.258	(9)	0.317	(9)
Bihar	0.000	**(14)**	0.025	(13)	0.125	(11)	0.143	(11)	0.000	**(14)**	0.000	**(14)**	0.042	**(14)**	0.056	**(14)**
Gujarat	0.575	(5)	0.636	(4)	0.275	(9)	0.374	(9)	0.484	(4)	0.531	(4)	0.445	(6)	0.514	(6)
Haryana	0.610	(3)	0.792	(3)	0.499	(4)	0.614	(3)	0.366	(8)	0.497	(6)	0.492	(4)	0.635	(3)
Karnataka	0.295	(9)	0.402	(8)	0.466	(5)	0.481	(5)	0.371	(7)	0.478	(8)	0.377	(8)	0.454	(7)
Kerala	0.831	(2)	1.000	**(1)**	1.000	**(1)**	1.000	**(1)**	1.000	**(1)**	1.000	**(1)**	0.944	**(1)**	1.000	**(1)**
Madhya Pradesh	0.052	(12)	0.000	**(14)**	0.000	**(14)**	0.000	**(14)**	0.165	(10)	0.396	(9)	0.072	(12)	0.132	(13)
Maharashtra	0.459	(7)	0.490	(6)	0.549	(3)	0.570	(4)	0.541	(2)	0.710	(2)	0.516	(3)	0.590	(4)
Orissa	0.258	(11)	0.069	(11)	0.083	(12)	0.089	(13)	0.235	(9)	0.377	(10)	0.192	(10)	0.178	(11)
Punjab	1.000	**(1)**	0.907	(2)	0.765	(2)	0.837	(2)	0.414	(5)	0.505	(5)	0.726	(2)	0.750	(2)
Rajasthan	0.294	(10)	0.307	(9)	0.241	(10)	0.312	(10)	0.038	(13)	0.317	(12)	0.191	(11)	0.312	(10)
Tamil Nadu	0.489	(6)	0.583	(5)	0.366	(6)	0.454	(6)	0.517	(3)	0.658	(3)	0.457	(5)	0.565	(5)
Uttar Pradesh	0.039	(13)	0.054	(12)	0.050	(13)	0.134	(12)	0.073	(12)	0.238	(13)	0.054	(13)	0.142	(12)
West Bengal	0.583	(4)	0.441	(7)	0.358	(7)	0.383	(8)	0.378	(6)	0.486	(7)	0.440	(7)	0.437	(8)

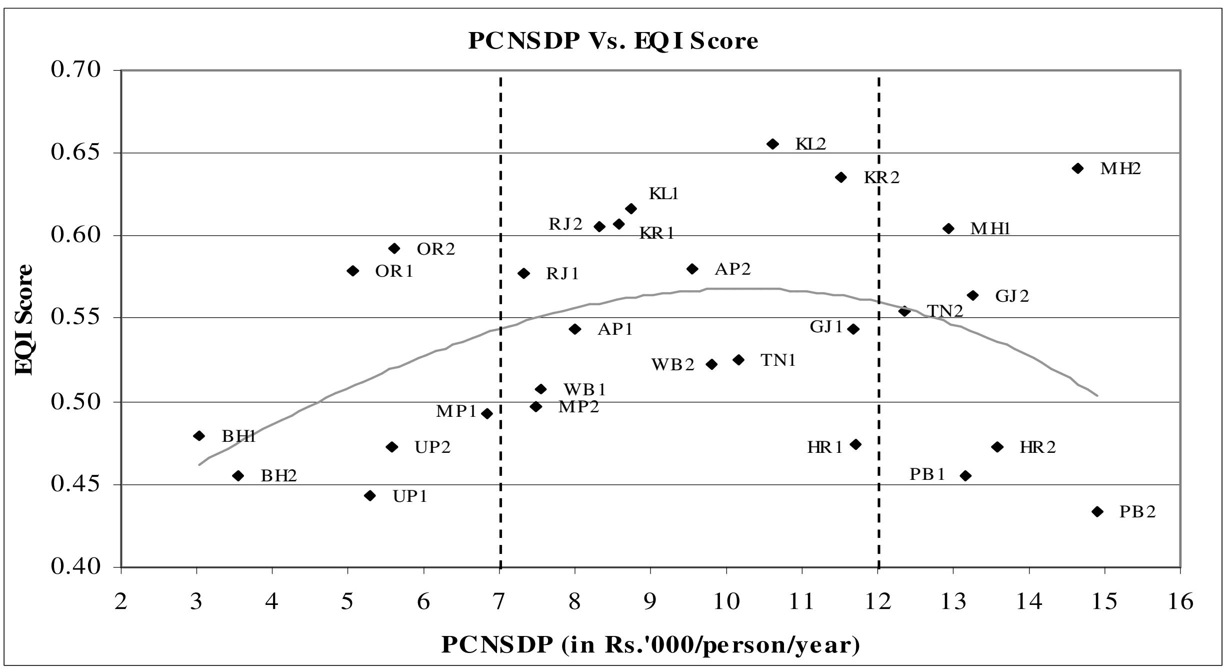
Note: Figure in the parenthesis shows the rank of the State for the corresponding component wise score of HDI and HDI Score

Comparison of the relative performance of the States on HDI during the two time periods covered in our analysis shows interesting results. We observe that there had not been major changes in the overall HDI Score of the States, and in all cases their ranks changed by one unit only. Some changes in the relative positions of the States in terms of consumption can be noted, reflecting their relative growth pattern, but in case of education and health the relative positions of fifty percent of the States remained unchanged. We observe that the aggregate picture do not always show the dynamics of different components of HDI, e.g., for MP aggregate HDI Score had gone up from 0.072 to 0.132, however its consumption score had gone down from 0.052 to 0.000. A declining trend in the HDI is noticed for AP as well. For MP, since health status remained unchanged it is only the improvement in education, which had driven its HDI score up. Movement in consumption expenditure is interesting; it had gone down both for poor States like Orissa (insignificant poverty reduction over NSSO 50th (1993-94) and 55th (1999-2000) round) and moderate performers like West Bengal (9 percent poverty reduction over NSSO 50th and 55th round). One reason may perhaps be that the decline in income inequality (*Gini* ratio) in these two States over 1993-94 to 1999-00 (Government of India, 2002) had been marginal.

4.3 EQI and PCNSDP

Figure 1 plots the EQI Scores and PCNSDP of the States during both Periods (postscript 1 and 2 denote periods A and B respectively), which suggests a convex relationship between the two. While the North-East corner of the Figure characterise States with both high EQI and PCNSDP, States placed in South-West corner represents those with worst performance on both counts. The States positioned in the North-West corner of the figure on the other hand indicates the States performing appreciably in terms of EQI, but not on PCNSDP. It is observed that Maharashtra retains its top position on both counts during the two periods. Bihar during Period B get grouped with UP at the South-West corner. Despite improvement in EQI Score, Orissa however remains at the bottom in terms of PCNSDP (i.e., below the first quartile line). Punjab and Haryana stay in the South-East corner of the Figure, implying their growth may have come at the cost of their environmental degradation. Karnataka, Kerala, Andhra Pradesh and Rajasthan improved their respective positions in both the fronts during Period B and are toppers among the medium income States. West Bengal, Tamil Nadu and Gujarat, the laggards among medium income States in terms of EQ, however improved their respective positions in both the fronts during Period B.

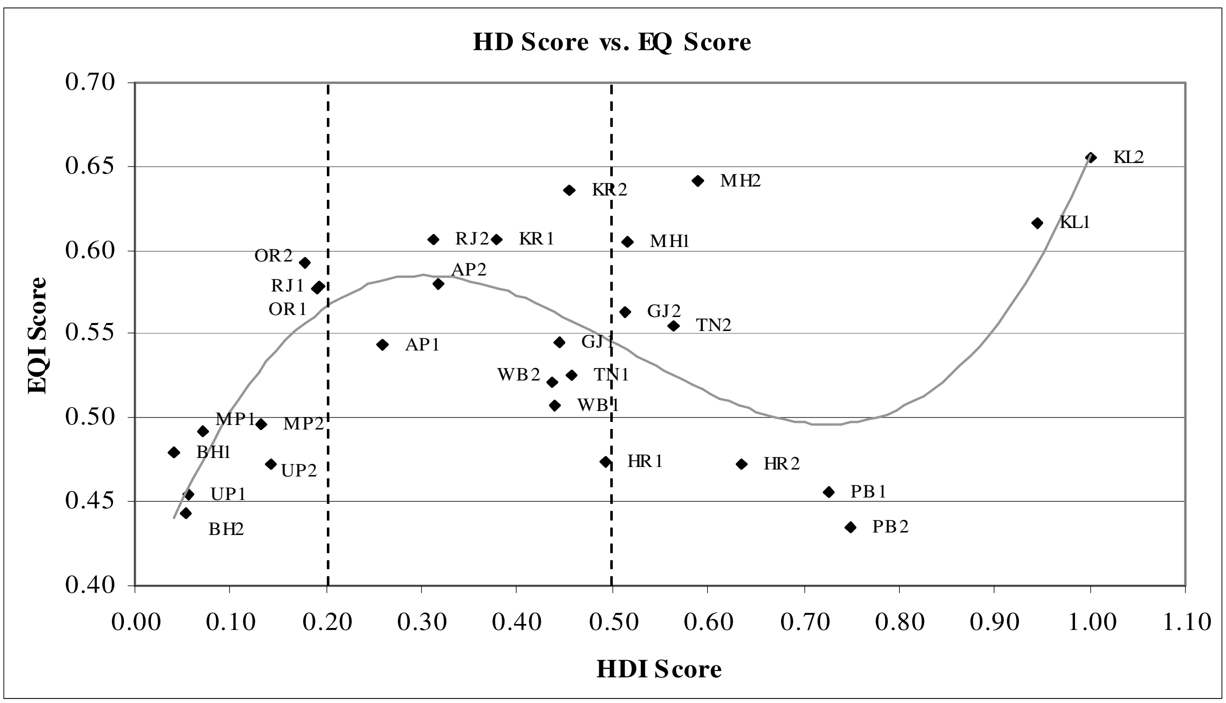
Figure 1: PCNSDP Vs. EQI Score - Period A and Period B



4.4 EQI and HDI

Figure 2 plots the EQI and HDI Scores of the States for the Periods (postscript 1 and 2 denote periods A and B respectively). While the North-East corner of the Figure characterise States with both high EQI and HDI scores, States placed in South-West corner represents those with worst performance on both counts. The States positioned in the North-West corner of the figure on the other hand indicates the States performing appreciably in terms of EQI, but not on HDI scale. It is observed that while Kerala retains its position in the North-East corner during both periods. Haryana, a top performer on HDI front, despite a marginal improvement in EQ still remains a poor performer. Punjab, another top performer in HDI, experienced a decline in EQI Score, primarily owing to overexploitation of natural resources (Bhullar and Sidhu, 2006). Looking at the South-West corner, it is seen that while the EQI Score had declined for Bihar, it had marginally increased for MP and UP. Orissa on the other hand maintains its position in the North-West corner during both periods. Though its performance marginally improved in EQ front, it performed poorly on HD scale (placed below the first quartile). AP and Rajasthan had improved their positions in both the fronts. As compared to Period A, the middle HD category States improved their positions in EQI during Period B. Broadly, the relationship between EQI Score and HDI Score is found to be slanting N-shaped owing to the divergence in performance of States like Punjab, Haryana and Kerala.

Figure 2: HDI Score Vs. EQI Score – Period A and Period B



4.6 Testing the Existence of the Environmental Kuznets Curve (EKC)

For testing the EKC hypothesis, multivariate OLS regression models are estimated for individual environmental groups. Different variants of the models are estimated by assuming a non-linearity between PCNSDP and EQ. Apart from PCNSDP (in Rs. thousand at constant 1993-94 Prices); various other explanatory variables are introduced to capture the dynamic aspects of EQ. **Tables 5** present the regression results which show a mixed picture: while non-linearity exist for a number of environmental groups like ENERGY, GHGS, LAND, NPS; linear relationship is observed for other groups like

INDOOR, WATER and FOREST (**Appendix 3** for graphical representation of the obtained relationships between PCNSDP and various environmental groups). Similarly, with respect to controlling variables, it is observed that share of primary sector in GSDP (PRISHARE)[15] is negatively related to ENERGY, LAND, NPS and FOREST. This is because with the fall in share of primary sector in GSDP; pressure on land, water and forest resources goes down and EQ improves. With the rise in share of secondary sector in GSDP (SECSHARE),[16] ENRGY score falls and the same for WATER increases and as the share of tertiary sector improves, the scores of GHGs and WATER increase. The results imply that composition of income of a State has substantial impacts on its environmental quality. Increased share of workers in agriculture (AGRWRK) shows a mixed trend (positive for GHGS, INDOOR and NPS etc. and negative for LAND and AIRPOL). Population density (POPD) and level of urbanisation (URB) is generally showing a negative relationship with EQ.

4.7 Relationship between HDI Score and Individual Environmental Groups

For analysing the relationship between the HDI score and composite indicator of individual environmental groups, we estimate different specifications of multivariate OLS regression models by assuming the presence of non-linearity. In addition, apart from HDI score, various other explanatory variables are introduced. From **Tables 6**, summarising the regression results for different variants of the models, it is observed that non-linearity exist for all the eight environmental groups (**Appendix 4** for graphical representation of the obtained relationships between HDI score and various environmental groups). The results show that investment in human development will have both direct and cumulative impacts on the natural resources conservation. In addition, with respect to controlling variables, it is observed that share of primary sector in GSDP (PRISHARE) is negatively related to most of the environmental groups, but positively related to INDOOR. The exception can be explained by the fact that the fall in PRISHARE leads to sophistication in domestic energy use, thereby improving INDOOR. With the rise in share of secondary sector in GSDP (SECSHARE), ENRGY and WATER score fall and the same for LAND and NPS increase. As the share of tertiary sector improves, the scores of GHGs, LAND and NPS improve. The findings indicate that composition of income of a State significantly influence its EQ. Like

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[15] Percentage share of Primary Sector in GSDP (at constant 1993-94 Prices), which includes Agriculture, Forestry and Logging and Fishing.

[16] Secondary sector includes Mining and Quarrying, Manufacturing and Construction.

the EKC result, increased share of workers in agriculture (AGRWRK) shows a mixed trend (positive for FOREST, GHGS and INDOOR and negative for AIRPOL). Share of workers in non-agriculture (NAGRWRK) is negatively related to AIRPOL. Population density (POPD) generally shows a negative relationship with EQ (exception: ENERGY). The relationship between level of urbanisation (URB) and EQ however shows a mixed trend (positive for INDOOR, LAND and NPS and negative for ENERGY and FOREST).

Table 5: Testing the Existence of the Environmental Kuznets Curve (EKC)

(Number of observations: 28)

Dependent Variable	ENERGY	ENERGY	GHGS	GHGS	INDOOR	INDOOR	LAND	LAND	NPS	NPS	WATER	WATER	FOREST	FOREST	AIRPOL
Explanatory Variable	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
Constant	0.2827 (0.1782)	0.9792 * (0.245)	-0.7672 * (0.2798)	-1.0282 * (0.2474)	-0.1426 * (0.0439)	0.1144 * (0.0575)	1.5019 * (0.105)	1.6652 * (0.1515)	0.9442 * (0.0991)	0.8553 * (0.084)	0.2996 * (0.1683)	1.0884 * (0.0969)	-0.0640 (0.214)	1.0679 * (0.2948)	1.5312 * (0.2477)
PCNSDP	0.0794 * (0.0352)	0.0725 * (0.0418)			0.0440 * (0.0101)	0.0245 * (0.0117)	-0.0389 * (0.0062)	-0.0439 * (0.0068)	-0.0172 * (0.0043)		-0.0331 * (0.0064)	-0.0353 * (0.0043)	0.0724 * (0.017)	0.0715 * (0.0205)	-0.0197 (0.0118)
$PCNSDP_2$	-0.0059 * (0.0019)	-0.0053 * (0.002)	0.0102 * (0.0024)	0.0072 * (0.0033)	0.0010 * (0.0006)	0.0018 * (0.0007)				-0.0009 * (0.0002)					
$PCNSDP_3$			-0.0006 * (0.0002)	-0.0005 * (0.0002)											
PRISHARE		-0.0087 * (0.0033)					-0.0162 * (0.0022)	-0.0143 * (0.002)	-0.0123 * (0.0013)	-0.0118 * (0.0014)		-0.0075 * (0.0022)		-0.0116 * (0.0054)	
SECSHARE		-0.0136 * (0.0055)									0.0058 * (0.003)				
TERSHARE			0.0184 * (0.0041)	0.0183 * (0.0036)							0.0089 * (0.0029)		0.0132 * (0.0045)		
POPD	0.0002 * (0.0001)					-0.0001 * (0.00003)	-0.0003 * (0.0001)	-0.0005 * (0.0001)							-0.0007 * (0.0002)
URB													-0.0202 * (0.0076)	-0.0265 * (0.0113)	
AGRWRK			0.0066 * (0.0034)	0.0103 * (0.003)	0.0030 * (0.0006)			-0.0038 * (0.002)	0.0031 * (0.0014)	0.0031 * (0.0014)					-0.0130 * (0.0036)
NAGRWRK				0.0072 * (0.0037)											
Adj. R^2	**0.495**	**0.524**	**0.264**	**0.315**	**0.955**	**0.941**	**0.749**	**0.774**	**0.591**	**0.597**	**0.490**	**0.502**	**0.425**	**0.393**	**0.273**
F-Stat	9.823	8.431	3.427	3.478	192.002	145.550	27.799	24.053	13.979	14.338	9.649	14.583	7.646	6.820	4.378
D-W Stat	2.104	1.882	1.873	1.690	2.069	2.105	1.679	1.900	1.282	1.283	1.323	1.245	1.557	1.590	2.156
1st Turning Point (in Rs.'000)	6.729	6.840	11.333	9.600	--	--	--	--	--	--	--	--	--	--	--

Note: Figure in the parenthesis shows the White Heteroskedasticity-Consistent Standard Errors
* - implies coefficient is significant at most at 0.10 level.

Table 6: Relationship between HDI and Environmental Quality

(Number of observations: 28)

Dependent Variable	AIR	ENERGY	ENERGY	FOREST	GHGS	INDOOR	INDOOR	LAND	LAND	NPS	NPS	WATER	WATER
Explanatory Variable	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
Constant	1.4445 * (0.2587)	1.4238 * (0.3788)	0.1977 * (0.0919)	0.3321 * (0.1214)	-1.0008 * (0.254)	-0.1518 (0.1536)	-0.0311 (0.122)	-0.3019 (0.1865)	1.2517 * (0.0836)	-0.0512 (0.0959)	0.7769 * (0.1097)	0.8395 * (0.0807)	1.0513 * (0.2165)
HDI	4.2322 * (1.3751)	2.7629 * (1.2293)	3.2469 * (0.648)	1.3688 (0.69)	3.0151 * (0.9611)								
HDI_2	-7.2035 * (2.8178)	-5.8169 * (2.7605)	-8.8858 * (1.5277)	-1.3020 * (0.5882)	-6.1352 * (2.2971)	1.7530 * (0.4173)	2.2598 * (0.436)	-2.9027 * (0.7745)	-2.2677 * (0.3768)	-1.7022 * (0.2622)	-1.8293 * (0.3335)	-1.8201 * (0.3755)	-1.5433 * (0.5667)
HDI_3	5.0476 * (1.8388)	3.3176 (1.751)	5.8978 * (1.0053)		3.9813 * (1.4975)	-1.5379 * (0.4299)	-1.9498 * (0.437)	2.7043 * (0.755)	2.2011 * (0.3627)	1.685 * (0.2704)	1.7538 * (0.3223)	1.749 * (0.4138)	1.4337 * (0.6239)
PRISHARE		-0.0127 * (0.0049)				0.0062 * (0.0025)			-0.0147 * (0.0022)		-0.0083 * (0.0018)	-0.0053 * (0.002)	-0.0081 * (0.0037)
SECSHARE		-0.0188 * (0.0071)						0.0139 * (0.0046)		0.014 * (0.0021)			-0.0057 (0.0055)
TERSHARE					0.0172 * (0.0045)			0.0114 * (0.004)		0.0077 * (0.002)			
POPD	-0.0003 (0.0002)		0.0003 * (0.0001)			-0.0002 * (0.0001)	-0.0001 (0.0001)		-0.0003 * (0.0001)				
URB		-0.0123 (0.0067)		-0.0112 (0.0063)		0.0127 * (0.0038)	0.0077 * (0.0027)	0.0072 (0.0051)			0.0049 (0.0029)		
AGRWRK	-0.0078 * (0.0037)			0.0097 (0.0056)	0.0118 * (0.0025)		0.0039 * (0.0017)						
NAGRWRK	-0.0330 * (0.0078)												
Adj. R^2	**0.543**	**0.546**	**0.490**	**0.429**	**0.432**	**0.838**	**0.836**	**0.627**	**0.758**	**0.660**	**0.642**	**0.374**	**0.370**
F-stat	6.337	6.400	7.496	6.073	5.102	28.832	28.505	10.085	22.178	14.106	13.117	6.377	4.972
D-W stat	2.209	1.301	1.751	1.906	1.449	1.550	1.683	1.640	2.228	2.077	1.847	1.878	1.877

Note: Figure in the parenthesis shows the White Heteroskedasticity-Consistent Standard Errors
* - implies coefficient is significant at most at 0.10 level.

5 Policy Conclusions

A number of developing countries located in Asia, Africa and Latin America witnessed economic stagnation or crisis during eighties, and had to undergo structural adjustment in the subsequent period, either unilaterally or as part of policy package offered by external development agencies. Given the focus on growth in the short run, many developing countries created little room to accommodate environmental and natural resource concerns in their economic policy. A similar picture emerges if one analyses the cross-region scenario within a country as well. However, despite the attempts by various studies to evaluate different environmental parameters, determination of a composite overall environmental quality index is still lacking. The current study makes an attempt to bridge that gap by constructing an index of EQ for India by using 63 environmental indicators.

Based on inter- and intra-sectoral differences in economic activities, different States in India in the post-1991 period have different levels of stress on their natural resources. To understand the impacts of economic growth on environmental quality, the current analysis first constructs the environmental quality index for the 14 major Indian States and look for its possible relationship with economic growth. This paper also attempts to capture the relationship between environmental sustainability and human well-being – as measured by the Human Development Index. To capture the temporal aspects of environmental quality and to understand the dynamics of economic liberalisation process, the entire period of our study has been divided into two broad time periods – Period A (1990-1996) and Period B (1997-2004).

It is observed that different States possess different strengths and weaknesses in managing various aspects of EQ. For instance, while Maharashtra is in the second position in terms of EQI during period B, and fares satisfactorily in terms of INDOOR and NPSP; it's performance on ENERGY and FOREST is not that satisfactory. On the other hand, Punjab, the state at the bottom in terms of overall EQI and ENERGY and WATER, is actually topper for INDOOR. It also shows that there are scopes for the States to learn from each other about different aspects of environmental management. Therefore, adoption of a 'one-size-fits-all' National Environmental Policy at the country-level might have limited impact on the local environmental quality. In other words, individual States should adopt environmental management practices based on their local (at the most disaggregated level) environmental information. Furthermore, over time performance of an individual State varies across the environmental criteria, which shows that environmental management practices should take into account this dynamic nature of environment, and review their environmental status or achievement regularly.

The analysis on the relationship between economic growth and EQ does not reveal a very clear picture during the two time periods under consideration. For different States, the impacts of economic restructuring process, as adopted by them during 1990s, have affected the environmental quality differently. It is observed that while States like Maharashtra has performed well on both counts, growth in northern States like Punjab and Haryana has taken place mostly at the cost of EQ. On the other hand Orissa, despite being a low-income State, performed well during both period A and B in terms of EQ. The results indicate that laggards like Bihar and MP have also achieved their economic growth at the cost of their EQ. On the other hand a few States like Karnataka and Rajasthan have achieved economic growth and also maintained their environment well. The obtained results again indicate that individual States should adopt special environmental measures, based on their environmental impacts assessment of major economic activities, to achieve sustainable economic growth.

The formal testing for the existence of Environmental Kuznets Curve (EKC) through multivariate OLS regression models are estimated by assuming non-linearity in the relationship between PCNSDP and the composite score of the defined environmental sub-categories. It is observed that while for a few categories an inverted U-shaped relationship exists between PCNSDP and individual indicator of environmental quality (e.g. – GHGS, LAND, ENERGY, NPS),[17] a linear relationship exist for other categories (INDOOR, WATER, FOREST) and no relationship in case of AIRPOL. The absence of the EKC in the Indian framework can be explained by the mixed performance of the States across environmental groups – e.g., worse EQ for economically advanced Punjab and better EQ for economically lagging Orissa.

Estimation of multivariate OLS regression models between individual EQ Scores and HDI Score indicate presence of non-linear relationships (in most cases, slanting N-

[17] However it goes against the popular EKC hypothesis, which shows inverted U-shaped relationship between PCI and environmental degradation (pollution) instead of environmental quality.

shaped and parabolic in case of FOREST). The results originate from the concentration of several States in low HDI-Low EQ category (Bihar, UP) and high EQ-mid HDI category (AP, Rajasthan) on one hand, and presence of the outliers like Orissa (high EQ-Low HDI) on one hand and Punjab and Haryana (high HDI-Low EQ) on the other. The result indicates the need to re-examine the methodology for calculating the HD achievements of the States. Perhaps, the HD ranking of States like Punjab and Haryana has been influenced too heavily by their high per capita consumption expenditure. Broad-basing the HD index by incorporating other social achievements might reveal interesting results.

Finally, a few limitations of the study are as follows. We have confined our analysis only to 14 major Indian States, the constraint being the availability of various secondary environmental information for both the time periods under consideration. Given the fact that a number of Indian States are currently in the process of preparing their environmental profile, one future area of research would be to extend the analysis to the remaining States. The analysis can be further extended by dividing the post-1997 period into more sub-groups, as permitted by availability of newer data points.

A few policy issues need to be highlighted here. First, the increment in HD indicators and economic growth can effectively increase the demand for a better environment, and therefore provide a demand side solution to the problem of environmental sustainability. Second, in contrary to popular belief, industrial pollution is not the source of all the problems. In Punjab and Haryana, it seems that the thrust on agriculture is increasingly becoming a serious concern. Third, given the need to arrive at local State-level solutions, there seems to be enough scope to involve local communities with direct interest in certain initiatives (e.g. - JFM). Fourth, it is difficult to comment on the choice of optimal level of income and its composition for a State, which would be in line with the objective of sustainable development. For instance, we observe a high level of EQ for a poor State like Orissa, which clearly is a result of unutilised resources. Fifth, as has been observed, improved governance can play a key role (e.g. – Supreme Court intervention) in ensuring sustainable development, and there is increasing need for implementing that in environmentally vulnerable States. Finally, here we focus only on the economic growth of the Indian States during the two periods (1990-96 and 1997-2004) and look into its relationship with EQ. However, income inequality varies across Indian States and it has often been observed that inequality has increased in the post-reform period (Deaton and Dreze, 2002). An area of future research can be to analyse the relationship between income inequality of the States, their EQ and HD achievements.

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Appendix 1: Description of the Environmental Groups and Data sources

Groups	Description	Number of Variables	Data Sources*
AIRPOL	Air Pollution	6	8
INDOOR	Indoor Air Pollution Potential	9	2, 3, 13, 14
GHGS	Green House Gases (GHGs) Emissions	6	12, 15, 16
ENERGY	Pollution from Energy Generation and Consumption	6	2, 12, 14, 15
FOREST	Depletion and Degradation of Forest Resources	8	3, 4, 6, 10, 12, 15
WATER	Depletion and Degradation of Water Resources	12	1, 2, 3, 7, 9, 11
NPSP	Nonpoint Source Water Pollution Potential	10	1, 5, 7, 13
LAND	Pressure and Degradation of Land Resources	6	1, 3, 4, 7, 12
	Total	**63**	

Note: * - implies that details of the data sources are provided below

1 Centre for Monitoring Indian Economy, Mumbai: India's Agriculture Sector – Various Years

2 Centre for Monitoring Indian Economy, Mumbai: India's Energy Sector – Various Years

3 Centre for Science and Environment, New Delhi: State of India's Environment: The Citizens' Fifth Report (Part II: Statistical Database)

4 Central Statistical Organisation, Ministry of Statistics and Programme Implementation, Government of India (GoI), New Delhi: Compendium of Environmental Statistics – 2000 and 2002

5 Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, GoI, New Delhi: Livestock Census Data – 1992, 1997 and 2003

6 Forest Survey of India, Ministry of Environment and Forest, GoI, Dehradun: State of Forest Reports – 1997, 1999 and 2001

7 Ministry of Agriculture, GoI, New Delhi: Annual Report – Various Years

8 Central Pollution Control Board, Ministry of Environment and Forests, GoI, New Delhi: National Ambient Air Quality Monitoring Programme Database – Various Years

9 Central Pollution Control Board, Ministry of Environment and Forests, GoI, New Delhi: National Rivers Water Quality Monitoring Programme Database – Various Years

10 Ministry of Environment and Forests, GoI, New Delhi: The State of Environment – India: 1999 and 2001

11 Ministry of Water Resources, GoI, New Delhi: Annual Report – Various Years

12 Office of the Registrar General, Director of Census Operation, Ministry of Home Affairs, GoI, New Delhi: Census of India 2001 – CensusInfo India 2001 (Version 1.0) – Database Software

13 Office of the Registrar General, Director of Census Operation, Ministry of Home

Affairs, GoI, New Delhi: Census of India 2001 – Tables on Houses, Amenities and Assets (Database Software)
14 The Energy and Resources Institute, New Delhi (TERI): TERI Energy Data Directory and Yearbook (TEDDY) – Various Years (Database Software)
15 Economic and Political Weekly Research Foundation (EPWRF), Mumbai: Domestic Product of State of India: 1960–1961 to 2000–2001, Database Software, 2003.
16 Garg, A. and P.R. Shukla (2002), "*Emission Inventory of India*", Tata McGraw-Hill Publishing Company Limited, New Delhi.

Appendix 2: Descriptions of Environmental Groups (Variables) & Indicators

AIR POLLUTION (12 indicators)

- Maximum Concentration of NO_2, SO_2 and SPM in Residential and Industrial Area (`g/m^3): 1990-1995 and 1996-2000 *

INDOOR AIR POLLUTION POTENTIAL (18 indicators)

- Monthly Per-Capita Expenditure (MPCE) on Fuel & Lighting (Rs./month/head) Rural and Urban Areas: 1993-94 and 1999-2000 $
- Percentage of Rural Households using Bio-fuels (Firewoods and chips, Dung cake) as primary source of energy (Traditional & Commercial) for cooking (%): 1993-1994 and 1999-2000 *
- Percentage of Urban Households using Bio-fuels (Firewoods and chips) as primary source of energy (Traditional) for cooking (%): 1993-1994 and 1999-2000 *
- Percentage of Rural and Urban Households Do Not Have Access to Electricity: 1991 and 2001 *
- Achievement in Installation of Biogas Plants: Upto 1994-95 and Upto 2001-2002 $
- Kerosene as a Primary Source of Energy for Lighting for Rural and Urban Households (%): 1993-94 and 1999-2000 *

GREEN HOUSE GASES EMISSIONS (12 indicators)

- CO_2 Equivalent GHGs (CO_2, CH_4, N_2O) Emissions (Kg. /Person): 1990 and 1995 *
- CO_2 Equivalent GHGs (CO_2, CH_4, N_2O) Emissions (Tons/Rs. Lakh of GSDP at Constant 1980-81 Prices): 1990 and 1995 *
- CO_2 Equivalent GHGs (CO_2, CH_4, N_2O) Emissions (Tons/hectare of Reporting Area of Land Utilisation): 1990 and 1995 *
- Other GHGs (NOx, SO2) Emissions (Kg. /Person): 1990 and 1995 *
- Other GHGs (NOx, SO2) Emissions (Tons/Rs. Lakh of GSDP at Constant 1980-81 Prices): 1990 and 1995 *
- Other GHGs (NOx, SO2) Emissions (Tons/hectare of Reporting Area of Land Utilisation): 1990 and 1995 *

POLLUTION FROM ENERGY GENERATION AND CONSUMPTION (12 indicators)

- Annual Percentage Increase in Motor Vehicles Number (given geographical area) during 1991-92 to 1995-96 and during 1995-96 to 2000-2001 *
- Average Per Capita Consumption of LPG, MG, Kerosene, HSD & LDO (in Kg. per person): 1993-94 to 1996-97 and 1997-98 to 2000-2001 *
- Average Petroleum Consumption (in tonnes) Per Rs. Lakh of GSDP (at constant 1993-94 Prices): 1993-94 to 1996-97 and 1997-98 to 2000-2001 *
- Average Thermal Electricity Generation as a Percentage of Total Electricity Generation (%): 1990-91 to 1995-96 and 1996-97 to 1999-2000 *
- Average Electricity Consumption (in KwH) per Rs. Lakh of GSDP at Constant (1993-94) Prices: 1993-94 to 1995-96 and 1996-97 to 1999-2001 *
- Average Per Capita Consumption of Electricity (in KwH/Person): 1990-91 to 1995-96 and 1996-97 to 1999-2000 *

DEPLETION AND DEGRADATION OF FOREST RESOURCES (16 indicators)

- Change in Forest Cover (Dense and Open Forest) as Percentage of Geographical Area (in percentage points): 1995 to 1997 and 1999-2001 $
- Change in Per Capita Forest Cover (Dense Forest, Open Forest, Mangrove, Scrub) (in

Hectare): 1995 to 1997 and 1999 to 2001 $

- Change in Recorded Forest Area as a Percentage of Total Geographical Area: 1997 to 1999 and 1999 to 2001 $
- Change in Common Property Forest Area[@] as Percentage of Total Recorded Forest Area: 1997 to 1999 and 1999 to 2001 $
- Change in Common Property Forest Area[@] as a Percentage of Geographical Area: 1997 to 1999 and 1999 to 2001 $
- Change in Per Capita Availability of Recorded Forest Area (Person/ha): 1997 to 1999 and 1999 to 2001$
- Change in Per Capita Availability of Common Property Forest Area (in Person/ha): 1997 to 1999 and 1999 to 2001$
- Change in Protected Area (National Park & Sanctuary) as a Percentage of Total Geographical Area: 1997 to 1999 and 1999 to 2001 $

Note: [@] - Common Property Forest Area = Protected + Unclassed Forest Area

DEPLETION AND DEGRADATION OF WATER RESOURCES (24 indicators)

- Level of groundwater development (%): 1996 and 2004 *
- Percentage of Irrigated Area Irrigated by Surface Water Sources (Canals & Tanks): 1992-93 and 1998-99 $
- Inland Surface Water Resources (% of geographical area): 1995 and 2001 $
- Major & Medium Irrigation Potential Created (Developed) upto the end of the 8th Plan (1992-1997) as a Percentage of Ultimate Irrigation Potential of the State *
- Major & Medium Irrigation Potential Utilised as a Percentage of Irrigation Potential Created Upto March 1997 *
- Minor Irrigation Potential Created (Developed) upto the end of the 8th Plan (1992-1997) as a Percentage of Ultimate Irrigation Potential of the State *
- Minor Irrigation Potential Utilised as a Percentage of Irrigation Potential Created Upto March 1997 *
- Major & Medium Irrigation Potential Created (Developed) upto the end of the 9th Plan (1997-2002) as a Percentage of Ultimate Irrigation Potential of the State *
- Major & Medium Irrigation Potential Utilised as a Percentage of Irrigation Potential Created Upto March 2002 *
- Minor Irrigation Potential Created (Developed) upto the end of the 9th Plan (1997-2002) as a Percentage of Ultimate Irrigation Potential of the State *
- Minor Irrigation Potential Utilised as a Percentage of Irrigation Potential Created Upto March 2002 *
- Average Gross Irrigated as a Percentage of Total Cropped Area (%): 1992-93 to 1995-96 and 1996-97 to 1999-2000 *
- Average Area Irrigated more than Once as a Percentage of Gross Irrigated Area (%): 1992-93 to 1995-96 and 1996-97 to 1999-2000 *
- Average Agricultural Consumption of Electricity (in KwH) Per Rs. Lakh of Agricultural GSDP at Constant (1993-94) Prices: 1993-94 to 1995-96 and 1996-97 to 1999-2001 *
- Number of Energised Pumpsets Per Hectare of Gross Irrigated Area (No./ha): 1995-96 and 1999-2000 *
- Change in Number of Energised Pumpsets Per Hectare of Gross Irrigated Area (No./ha)/: 1992-93 to 1995-96 and 1995-96 to 1999-2000 *

NON-POINT SOURCE WATER POLLUTION POTENTIAL (20 indicators)

- Population Density (Person Per Km^2 of Geographical Area): 1991 and 2001*

- Percentage of Rural and Urban Households Without Latrine: 1993 and 1998 *
- Average Fertilisers Consumption (Kg./hectare): 1992-93 to 1995-96 and 1996-97 to 2000-01 *
- Average Annual Rainfall (in mm): 1990-95 and 1996-2000 $
- Pesticides Consumption: (Kg./hectare) 1995-96 and 1999-2000 *
- Area under Pulses as a Percentage of Gross Cropped Area: 1990-91 and 2000-2001 $
- Livestock Per Head of Person (No. in Cattle unit Per Person): 1992 and 1997 *
- Poultry Birds Per Head of Person (No. Per Person): 1992 and 1997 *
- Average Total Cropped Area as a Percentage of Reporting Area of Land Utilisation (%): 1992-93 to 1995-96 and 1996-97 to 1999-2000 *

PRESSURE AND DEGRADATION OF LAND RESOURCES (12 indicators)

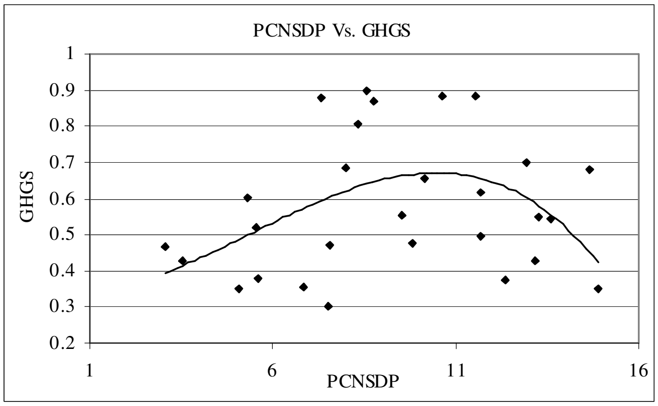
- Average Forest Area as a Percentage of Reporting Area of Land Utilisation (%): 1992-93 to 1995-96 and 1996-97 to 1999-2000 $
- Average Non-Forest Common Property Land as a Percentage of Reporting Area of Land Utilisation (%): 1992-93 to 1995-96 and 1996-97 to 1999-2000 $
- Average Non-Forest Common Property Land Per Capita (in ha/person): 1992-93 to 1995-96 and 1996-97 to 1999-2000 $
- Average Area Sown more than Once as a Percentage of Total Cropped Area (%): 1992-93 to 1995-96 and 1996-97 to 1999-2000 *
- Average Gross Irrigated as a Percentage of Total Cropped Area (%): 1992-93 to 1995-96 and 1996-97 to 1999-2000 *
- Land Degradation as a Percentage of Geographical Area: 1994 and 2001 *

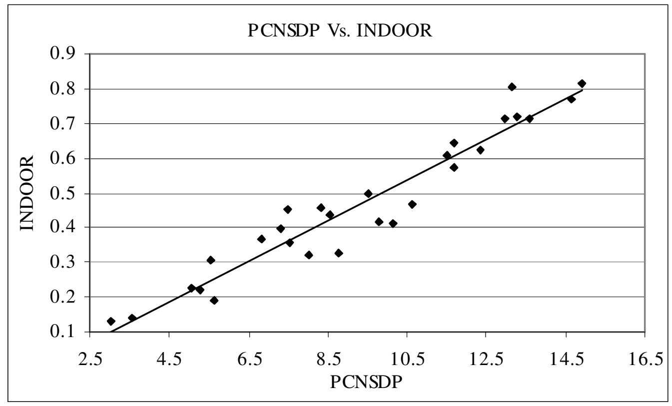
Note:

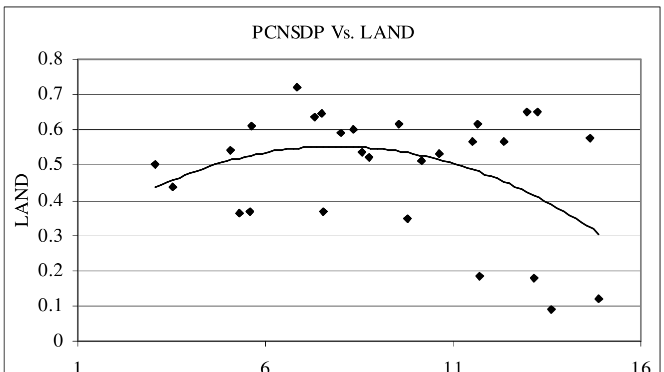
* - implies that for the environmental indicator we have used (Maximum – Actual) / (Maximum – Minimum) for standardisation.

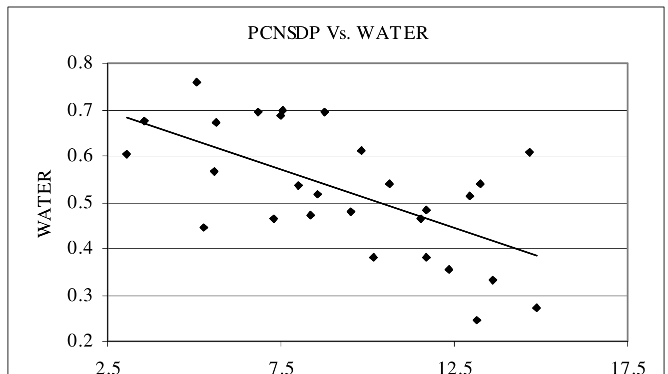
$ - implies that for the environmental indicator we have used (Actual – Minimum) / (Maximum – Minimum) for standardisation.

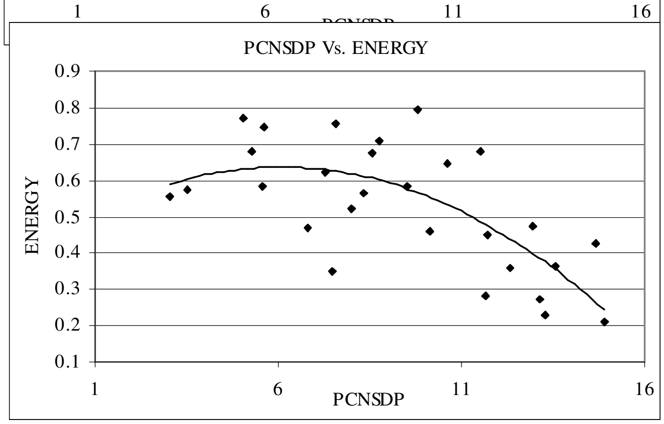
Appendix 3: Graphical Relationship between PCNSDP and Various Components of Environmental Quality Scores

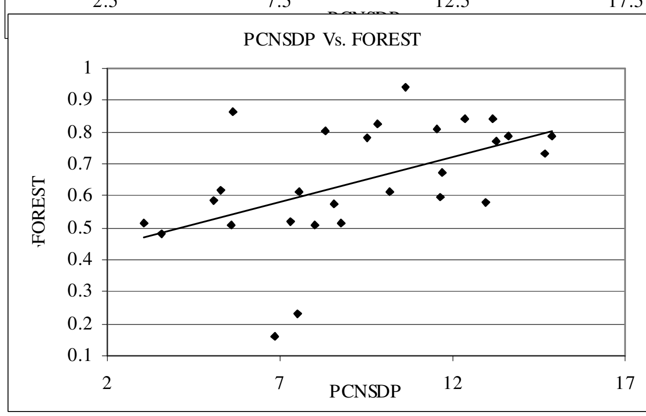


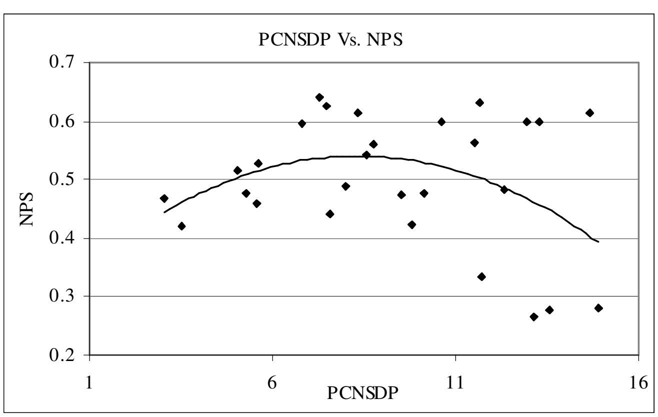


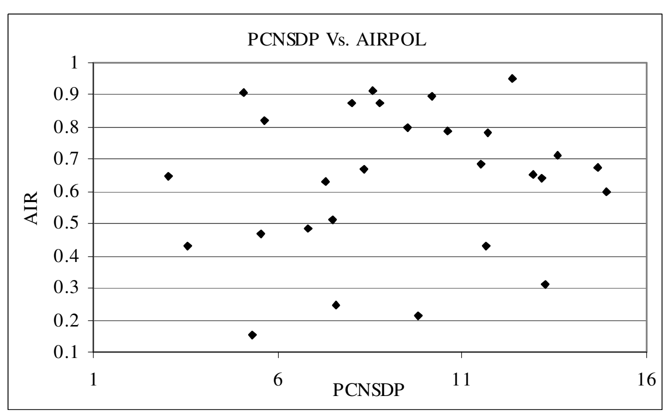












Appendix 4: Graphical Relationship between HDI Score and Various Components of Environmental Quality Scores