Is Human Development Index (HDI) a reflector of quality of air? a comparative study on developed and developing countries

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Is Human Development Index (HDI) a Reflector of Quality of Air? A Comparative Study on Developed and Developing Countries

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Abstract- Economic Indicators alone cannot capture the totality of 'Quality of Life' (QOL). The Most acceptable Measure of QOL is the 'Human Development Index' (HDI) of UNDP[1]. HDI is a composite Index of three Indicators of three essential dimensions of life. These three indicators are of per capita GDP adjusted to purchasing power, life expectancy at birth, and adult literacy rate (including the gross school enrollment ratios). While, the measurement of HDI is considered as a measure of Human well-being, it ignores the other dimension of life, which is the quality of natural environment. Human being lives within this natural environment. In a polluted environment, human being cannot be stay well. In this study, it was examined whether the Quality of Air is Reflected through the HDI or not. In this study, the result has been come out that the Quality of Air is reflected through the HDI only for the Developing Countries. But, in case of Developed Countries, the Quality of Air is not reflected through the HDI.

Index Terms- Composite Index for Quality of Air (CIQA), Human Development Index (HDI), Principal Component Analysis (PCA), Spearman's Rank correlation Coefficient

I. INTRODUCTION

In this universe, Lives come only on this earth, because of the favorable natural environment to sustain its life. That is why we only found Human beings on this earth only, till now. Human born here, utilized the earth's natural resources for his/her livelihood and release some particles, which are toxic for his/her health, to the nature. The nature has its own power to purify itself, but at certain limit. With the progression of human civilization, human activities increase rapidly day by day and human being is crossing the nature's limit. Thus, the concept of environmental pollution had come out. Now people suffering from its own created polluted environment. Once upon a time, we were concerned about the per capita GDP only as a measure of Human development. In second half of the last century, the development economist incorporated the issues of social dimensions with the per capita GDP for calculating the measures of Human Development. Now with the growing awareness of the environment the time has come to look at the natural environment too in calculating the Human Development. Because, by ignoring the environment no development would be Human Development. Therefore, we should incorporate the issues of natural environment in Human Development Index (HDI) (Basak and Kamdar, 2005).

Human Development Index (HDI): The concept of human development has come to the surface of development economics. Human development broadly focuses on the overall human well-beings. The process of development should create an environment to enable people to have full access to resources needed for a decent standard of living. The economic Indicators alone do not capture the totality of 'Quality of Life' (QOL)[2]. The most accepted measure of QOL is the 'Human Development Index' (HDI) of United Nation Development Programme (UNDP), measuring since 1991. HDI is a composite index of three Indicators of three Dimensions of Life (Bhattacharya, 2001). A long and healthy life is measured by the Life expectancy at birth. The Knowledge is measured by the combined education index of Adult literacy rate (with 2/3 weight) and the combined primary, secondary and tertiary gross enrollment ratio (with 1/3 weight). And a decent standard of living is measured by GDP per capita (PPP US$). Therefore the three Indicators for measuring HDI are:

- Per Capita GDP adjusted to Purchasing power (i.e., PPP US$),
- Adult Literacy Rate (including gross school enrolment), and
- Life Expectancy at birth (years).

However, While HDI measures changes in Human Welfare; it ignores the 'Quality of Ambient Environment'. There is a profound relation between human health and well-being from the one side and air pollution levels from the other. The polluted environment affects health and thus it affects the life expectancy (Kyrkilis et. Al., 2007). And through life expectancy HDI is affected

[1] UNDP stands for United Nations Development Programme.
[2] Quality of life (QOL) references the general well-being of individuals and societies.

by the polluted environment. For inadequacy of data, the study was concentrated only with air pollution. Is the polluted air is reflected through the HDI or not? This is the main asking of this study. So, now we look at the Air pollution and its effect on human health.

Air pollution: Air is a precious natural resource and without which life cannot be sustained, even for more than a few minutes. Human activities like industrial production, Motor transport and domestic burning of fuels, large amounts of harmful pollutants to the atmosphere were added by the human being. According to the World Health Organization (WHO) definition, "Air pollution is as a situation in which the outdoor atmosphere contains certain materials in concentrations which are harmful to people or their environment". Worldwide air pollution is responsible for large numbers of deaths and cases of respiratory disease. While major stationary sources are often identified with air pollution, the greatest source of emissions is actually mobile sources, mainly automobiles (Barrege et. Al., 2006). Gases such as carbon dioxide, which contribute to global warming, have recently gained recognition as pollutants by some scientists. Air pollution can affect the health in many ways with both *short-term* and *long-term* effects. Different groups of individuals are affected by air pollution in different ways. Young children and elderly people often suffer more from the effects of air pollution. People with health problems such as asthma, heart and lung disease may also suffer more when the air is polluted. Examples of short-term effects include irritation to the eyes, nose and throat, and upper respiratory infections such as bronchitis and pneumonia. Other symptoms can include headaches, nausea, and allergic reactions. Short-term air pollution can aggravate the medical conditions of individuals with asthma and emphysema. Long-term health effects can include chronic respiratory disease, *lung cancer*, *heart disease*, and even *damage to the brain*, *nerves*, *liver*, or *kidneys*. Continual exposure to air pollution affects the *lungs* of growing children and may aggravate or complicate medical conditions in the elderly.

The Major pollutants: The major pollutants in air, are identified by the physical scientists, are as follows: Carbon dioxide (CO_2), Carbon monoxide (CO), Sulfur dioxide (SO_2), Oxides of Nitrogen (NO_x), Suspended Particulate Matter (SPM), Hydro Carbons, metallic traces, Ozone (O_3), etc. However, due to the lack of adequate data, I have selected only three Pollutants in the present study. There are; Carbon dioxide (CO_2), Oxides of Nitrogen (NO_x) and Sulfur dioxide (SO_2). Nitrogen oxides are produced during most combustion processes. Mobile sources and power plants are the major contributors in Southern California. About 80 percent of the immediately released nitrogen oxide is in the form of nitric oxide (NO). Small amounts of nitrous oxide (N_2O) are also produced. Nitrous oxide is a "greenhouse" gas that is suspected of playing an important role in global warming. Nitrogen dioxide is the most important nitrogen oxide compound with respect to acute adverse health effects. Children living in areas with high nitrogen dioxide concentrations had greater incidences of lung-related illness than children living in areas with lower concentrations did. Some studies also have suggested that children younger than five years old may be more severely affected by nitrogen dioxide than older children. Many studies show significant associations between outdoor nitrogen dioxide concentrations and adverse health outcomes (Campbell, 1997). Most man-made emissions of the gas sulfur dioxide (SO_2) come primarily from the combustion of fossil fuels such as coal, oil, and diesel fuel. For those with asthma, even relatively short-term, low-level exposures to sulfur dioxide can result in airway constriction leading to difficulty in breathing and possibly contribute to the severity of an asthmatic attack. A number of epidemiological studies have shown associations between ambient sulfur dioxide and rates of mortality (death) and morbidity (illness) (Zhang et. Al., 2006). Carbon dioxide is a chemical component composed of two oxygen atoms covalently bonded to a single Carbon atom. In general, it is exhaled by animals and utilized by plants during photosynthesis. Additional Carbon dioxide is created by the combustion of fossil fuels. Carbon dioxide is an important greenhouse gas; it causes Global warming (Jurado, and Southgate, 1999). Though it is not so dangerous to health, it affects health if we inhaled it in high concentrations (greater than 5% by volume). Carbon dioxide causes Drowsy, Headaches.

The Urban concentrations of health-damaging pollutants are often among the highest in the middle-income countries, and preventive and protective measures are still at an early stage. It is also relevant to low income countries, where air pollution problems tend to be more localized, but can very sever when they do arise (McGranahan and Murray, 2003). A review of evidence from Developed nations substantiates the harmful effects of air pollutants on health, even at levels considerably lower than those observed in many mega cities of the developed world. Difference in relation to the level of exposure and co-exposure to different pollutant mixture, the pollution structure, the Nutritional Status and the lifestyle observed in developing nations suggest that the adverse effects of air pollution may be even greater than those observed in developed nations (Romieu, 2003).

II. OBJECTIVE OF THE STUDY

HDI has three components; Per Capita GDP adjusted to Purchasing Power, Education and Life Expectancy. The Quality of Air may only affect HDI through the Life expectancy, only. The objective in this study is whether the Quality of Air is reflected through the HDI or not. The hypothesis in this study is that Quality of Air is reflected through the HDI only for Developing Countries, but not for the Developed countries.

III. METHODOLOGY

In this Study, it was examined that whether HDI reflects the Quality of Air or not. To do that job, 15 developed countries (such as Australia, Belgium, Denmark, Finland, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Spain, Sweden, United Kingdom, and United States of America) were selected and 15 developing countries (such as Algeria, Bolivia, Bulgaria, Chile, Colombia, Ethiopia, Guatemala, Jamaica, Lebanon, Lithuania, Morocco, Philippines, Sri Lanka, and Uzbekistan, and Yemen) were

selected also. The Countries are collected based on availability of the relevant data and information. After collecting the data, the following steps were taken:

- ❖ Step-1:- After collecting, the data on the values of HDI for each developed countries and rank the countries according to their HDI values. Higher the values of HDI will get higher rank, i.e., 1st, 2nd, 3rd and so on.
- ❖ Step-2:- Collecting the data on quality of air (only SO_2, CO_2 and NO_x data are available) for all the selected developed countries, the method of Standardization was done. Then, the Composite Index for Quality of Air (CIQA) was calculated based on the Principal Component Analysis (PCA)[3]. After that the corresponding rank is given for each country. In this case, lower the value of CIQA would have been given higher the rank.
- ❖ Step-3:- Now with these two sets of Ranks, i.e., Ranks of HDI values and that of CIQA, the Spearman's Rank Correlation Coefficient was calculated. The high value of Rank Coefficient can say that HDI is a good Reflector of Quality of Air.
- ❖ Step-4:- After collecting the data of Life Expectancy at birth (LIEX) for all the developed countries, they were ranked according to their values. Higher the value of LIEX, it will get higher rank.
- ❖ Step-5:- With the two sets of Ranks, i.e., Ranks of LIEX and that of CIQA, the Spearman's Rank Correlation Coefficient was calculated.
- ❖ Step-6:- All the above steps are done for the Developing Countries, as well.

IV. DATA COLLECTION

Data for Quality of Air (QOA) is collected from the Official web site of United Nation Statistical Division and World Development Report, 2006. And, the data on the HDI and its three components are collected from Human Development Report, 2004. The comparability of sources of data is one most challenging task in this paper. Data on other pollutants are not available properly. The threshold levels of each pollutants of every country are not available. And all of calculations were done with the statistical software, SPSS 14.0.

V. FINDINGS AND DISCUSSION

As it is mention in the Methodology Section that the study would be comparative study of Developed countries and Developing countries.

For Developed Countries: The per capita air pollution emission of three major pollutants, SO_2, CO_2 and NO_x, were tabulated for 15 most developed countries in Table-1. And these values were standardized[4]. The Composite Index for Quality of Air has been calculated through the method of PCA through the SPSS software. The values for first component, FAC1 were taken and these are ranked accordingly among these 15 developed countries. The ranking for HDI and the life expectancy were also done separately for all 15 developed countries. The values and ranks of Composite Index for Quality of Air (CIQA), HDI, and Life Expectancy (LIEX) at birth and their Ranks of all 15 developed countries are shown in table-1, below.

Table-1: - DEVELOPED COUNTRIES

	Air Pollution (emission per capita)			Standardized values			Composite Index for Quality of Air (CIQA)		HDI (2004)		Life expectancy (LIEX) at birth 2004	
Country	SO2 (kg)	CO2 (ton) 2000	NOx (kg)	SO2	CO2	NOx	FAC1	Rank	value of index	Rank	Values	Rank
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Australia	38.4	18.0	82.4	1.5	2.0	2.0	2.15	15	0.957	2	76.1	15
Belgium	12.8	10.0	74.3	-0.3	-0.1	1.7	0.52	12	0.945	9	78.7	5.5
Denmark	4.6	8.4	36.8	-0.8	-0.5	-0.2	-0.58	6	0.943	10	76.6	14
Finland	14.1	10.3	40.5	-0.2	0.0	0.0	-0.07	10	0.947	8	77.9	11
Germany	6.5	9.6	16.8	-0.7	-0.2	-1.1	-0.78	4	0.932	15	78.2	8.5
Ireland	24.6	11.1	31.0	0.5	0.2	-0.4	0.12	11	0.956	3	76.9	13

[3] Principal component analysis (PCA) is a statistical procedure that uses orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. PCA is also used to make composite index.

[4] The process of standardization is done by subtracting from mean and then it is divided by the standard deviation of a series of values.

Italy	10.4	7.4	21.6	-0.4	-0.7	-0.9	-0.78	3	0.940	11	78.7	5.5
Japan	6.0	9.3	14.5	-0.7	-0.2	-1.2	-0.82	2	0.949	5	81.5	1
Netherlands	4.8	8.7	26.8	-0.8	-0.4	-0.7	-0.74	5	0.947	7	78.3	7
New Zealand	13.5	8.3	51.5	-0.2	-0.5	0.5	-0.07	9	0.936	14	78.2	8.5
Norway	2.0	11.1	43.7	-1.0	0.2	0.2	-0.22	8	0.965	1	78.9	4
Spain	46.6	7.0	45.6	2.0	-0.8	0.3	0.57	13	0.938	13	79.2	3
Sweden	4.6	5.3	25.8	-0.8	-1.3	-0.7	-1.09	1	0.951	4	80.0	2
UK	16.2	9.6	26.7	0.0	-0.2	-0.7	-0.35	7	0.940	12	78.1	10
USA	42.8	19.8	65.4	1.8	2.5	1.2	2.15	14	0.948	6	77.0	12
Mean	16.5	10.3	40.2									
S.D.	14.8	3.8	20.6									
Source:- For Air Pollution, Data are collected the from web-site of UN Statistical Division												
For HDI and Life expectancy at birth, from Human Development Report,2004,(UNDP)												

Then, the Spearman's Rank Correlation Coefficient between Rank of HDI and Rank of Air Pollution for developed countries was calculated and this is shown in the Table-2, as below. Here The Spearman's Rank correlation Coefficient is only 0.129 which is very much statistically insignificant. That means, it can be concluded that HDI is not a good reflector of Quality of Air (QOA) for the Developed Countries.

Table-2:
Spearman's Rank correlation Coefficient between Rank of HDI and Rank of Air Pollution

	Rank of HDI	**Rank of Air Pollution**
Rank of HDI	1	**0.129**
Rank of Air Pollution	**0.129**	1

Now the Spearman's Rank Correlation Coefficient between Rank of Life Expectancy and Rank of Air Pollution for developed countries is done for the developed countries and the Result is shown in the Table-3, as below:

Table-3: Spearman's Rank correlation Coefficient between Rank of (LIEX) and Rank of (CIQA)

	Rank of Air Pollution	**Rank of Life expectancy**
Rank of Air Pollution	1	**0.512**
Rank of Life expectancy	**0.512**	1

Here we see that, the Quality of Air (QOA) is not reflected through HDI as well as through the life expectancy (LIEX), because the Spearman's Rank correlation Coefficient between Rank of life expectancy and Rank of Composite Index of Quality of Air is 0.512, which is also insignificant at 95% significance level.

For Developing Countries: In Table-4, the values of Composite Index for Quality of Air (CIQA), HDI, and Life Expectancy (LIEX) at birth and their Ranks of all 15 developed countries are shown.

Table-4: - DEVELOPING COUNTRIES

	Air Pollution (emission per capita)			***Standardized values***			***Composite Index***		***HDI (2004)***		***Life expectancy at birth 2004***	
Country	**SO2 (kg)**	**CO2 (ton) 2000**	**NOx (kg)**	**SO2**	**Co2**	**NOx**	**FAC1**	**Rank**	**value of index**	**Rank**	**Values**	**Rank**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**
Algeria	1.8	2.9	6.4	-0.5	0.3	-0.4	-0.21	9	0.728	8	69.5	9.5
Bolivia	1.2	1.3	5.5	-0.5	-0.6	-0.6	-0.64	6	0.692	11	63.7	13

Bulgaria	121.4	5.3	14.3	3.4	1.7	1.2	2.29	15	0.816	3	70.9	7
Chile	10.4	3.9	11.6	-0.2	0.9	0.6	0.52	10	0.859	1	76.0	1
Colombia	4.3	1.4	6.1	-0.4	-0.5	-0.5	-0.53	7	0.790	4	72.1	6
Ethiopia	0.2	0.1	1.5	-0.6	-1.3	-1.4	-1.26	1	0.371	15	45.5	15
Guatemala	8.4	0.9	4.2	-0.3	-0.8	-0.8	-0.73	4.5	0.673	12	65.7	12
Jamaica	40.4	4.2	12.6	0.8	1.1	0.8	1.01	13	0.724	9	75.6	2
Lebanon	26.0	3.5	17.5	0.3	0.7	1.8	1.06	14	0.774	5	73.5	3
Lithuania	13.2	3.4	16.6	-0.1	0.6	1.6	0.81	12	0.857	2	72.5	4.5
Morocco	10.8	1.3	5.8	-0.2	-0.6	-0.5	-0.50	8	0.640	13	68.5	11
Philippines	6.5	1.0	4.4	-0.3	-0.8	-0.8	-0.73	4.5	0.763	6	69.8	8
Sri Lanka	2.3	0.6	3.3	-0.5	-1.0	-1.0	-0.95	2	0.755	7	72.5	4.5
Uzbekistan	11.1	4.8	10.8	-0.2	1.4	0.5	0.68	11	0.696	10	69.5	9.5
Yemen	0.2	0.5	5.8	-0.6	-1.1	-0.5	-0.83	3	0.492	14	59.8	14
Mean	17.2	2.3	8.4									
S.D.	30.8	1.7	5.0									
Source:- For Air Pollution, Data are collected the from web-site of UN Statistical Division												

The Spearman's Rank correlation Coefficient between Rank of HDI and Rank of Air Pollution for developing countries was calculated and it was shown in Table -5, as below: Here, the Spearman's Rank correlation Coefficient is **0.579**, and which is statistically significant. That means, it can be concluded that HDI is a reflector of Quality of Air (QOA) for the Developing Countries.

Table-5: Spearman's Rank correlation Coefficient between Rank of HDI and Rank of Air Pollution

	Rank of Air Pollution	Rank of HDI
Rank of Air Pollution	1	**0.579**
Rank of HDI	**0.579**	1
**Correlation is significant at the 0.05 level (2-tailed).*		

Now, the Spearman's Rank correlation Coefficient between Rank of Life Expectancy and Rank of Air Pollution for developing countries is done for the developed countries and the Result is shown in the Table-6, as below: The Spearman's Rank Correlation Coefficient between Rank of life expectancy and Rank of Composite Index of Quality of Air is 0.512, which is significant at 95% significance level. There we see that the Quality of Air (QOA) is reflected through HDI as well as the life expectancy.

Table-6: Spearman's Rank correlation Coefficient between Rank of (LIEX) and Rank of (CIQA)

	Rank of Air Pollution	Rank of Life Expectancy
Rank of Air Pollution	1	**0.605**
Rank of Life Expectancy	**0.605**	1
**Correlation is significant at the 0.05 level (2-tailed).*		

Thus, it is clear from the above study that the HDI is a reflector of Quality of Air (QOA) for developing countries. But, HDI is not a good reflector of QOA for developed countries.

VI. CONCLUSION

From the Above Result, it can be concluded that in case of developing countries, HDI also reflects the Quality of Air through affecting the Life Expectancy at birth. However, the result for the developed countries came in the contradictory. In case of developed countries, HDI does not reflect the Quality of Air. The Quality of Air is also does not affect the Life of Expectancy at birth for the developed countries. Since, among the three component, Quality of Air affect only Life Expectancy at birth and since, it is not a good respondent with the change of Quality of Air, the HDI also does not change for developed countries. One of the major probable cause is that developed countries have high per capita income, high per capita expenditure (private and govt., both), well connection of safe drinking water and good sanitation facilities etc. The people the developed countries may cope up with the high level of pollution with the both adoptive and mitigation method. And in this way they can maintain good health and high life expectancy. However, in developing countries all the facilities are either absent or in adequate for the entire citizen or beyond the ability of purchasing power.

The people of developing countries cannot prevent themselves to suffering from polluted air. That is why, the people of Developing Countries, has a low level of Life Expectancy at birth.

Limitation of this study: This study is not the beyond of any criticism. It is a preliminary attempt to associate air quality with the HDI. In this study, Carbon Monoxide (CO) and Suspended Particulate Matters (SPM) were excluded due to the lack of adequate data, though these two pollutants have much effect on human health. Moreover, Ranking process itself has a limitation. A lot of research can be done here.

Future Prospect: There is a huge scope for research in different aspects out of this paper. The outcome of this paper shows that the life expectancy is not affected by the bad quality of air pollution for developed countries. One can go for further research to find out causes of it. One can also want to investigate the basic factor of these differential results in developed countries. Life expectancy at birth not only depends on the air pollution only, the effects of overall environmental pollution level (i.e., Air, water, Noise, Municipality's solid waste, biological solid waste etc.) can also be the areas of interest. However, the effect of food and nutrition is also importance in this respect. Moreover, the threshold level of each pollutant is also crucial, because the pollutants harm human beings only if it reached beyond certain limit.

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